GLOBAL TREES CAMPAIGN

BRIEF 3

How to make a monitoring plan for threatened tree species

Abies ziyuanensis population monitoring. Credit: Lin Wuying/FFI

"Monitoring is a critical component of any conservation project."

A. Newton (2007)

This brief was written by Dave Gill and Dr Jenny Daltry

Introduction

Monitoring should be an important part of any conservation project. Monitoring allows you to measure changes in the number or condition of threatened trees at your project site, track threats and evaluate the success of management actions. However, without careful planning, monitoring can also be time-consuming and difficult to sustain. In this brief, we provide advice on how to develop a basic monitoring plan and include two short examples of plans used in the field by threatened tree conservation projects.

Who is this guidance for?

Individuals (including students) or organisations (e.g. NGOs, foresters, protected area managers, universities) tasked with the in-situ conservation of particular tree species. In particular, this brief is for non-specialists with limited experience in monitoring tree species in their wild habitats.

The Global Trees Campaign is a partnership between:

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Before you start

Monitoring is an essential part of any conservation programme. Set up in the right way, monitoring can tell you whether the population size or condition of one or more tree species is changing over time and why these changes are taking place. Monitoring also allows you to measure the success of conservation actions and provide information that can be used to guide better management.

However, a common mistake is to begin collecting information about the species or habitat without considering why you are doing it and what types of information are most useful.

Without careful planning, monitoring can generate a huge amount of data that are difficult to analyse and use in the short-term and could be too difficult and expensive to replicate in the long-term. Because conservation actions for tree species may take many years to show a desired effect, it is important to develop monitoring programmes that are **simple, replicable** and **cost-effective**.

It is worth taking time to prepare a monitoring plan before you collect any data. This can help you to: (a) define clear monitoring objectives that are understood by your team and other stakeholders, (b) identify which data you need to achieve these objectives and (c) outline where monitoring will take place, how often and who is responsible for data collection, analysis and presentation.

Writing a monitoring plan can be daunting. It is not easy to know where to start, decide which data to collect or know which methods to use. Therefore, **before you begin,** we recommend taking a few preparatory steps that will make writing a monitoring plan much easier in the long run. These first steps include:

1) **Know your target species (see Page 3).** Existing information on the species' ecology, threats and conservation can be used to identify suitable monitoring sites, methods and research questions.
2) **Understand why you are collecting the data (see Page 4).** Who you are collecting data for, and why, should guide what you choose to monitor and how to present your data. How can your data guide better management for the species?
3) **Develop research questions (see Page 4).** Good research questions will help you focus data collection on the areas and issues most relevant to the conservation of your target species.

What's the difference between surveying and monitoring trees?

Surveys are generally used to record presence, distribution or abundance of one or more tree species within an area at one point in time. (More information on how to survey an area for threatened tree species is provided in GTC brief 1)

Surveys in Vietnam are identifying locations of rare mangnolias. Credit: Hieu Nguyen.

Monitoring is a repeated series of surveys. Regular monitoring helps you to identify whether the condition or population of your target species is changing over time and to investigate the reasons for this change.

Regular monitoring in China is revealing how threats faced by the Ziyuan fir are changing over time. Credit Lin Wuying/FFI.

TOP TIP

Invite your project team and other stakeholders to take part in the planning process through meetings or workshops, or reviewing draft plans. This can improve the feasibility, understanding and ownership of the monitoring scheme. But don't allow the plan to become too ambitious and complicated to keep everyone happy!

STEP 1: Know your species in advance

The more you learn in advance about your target species, the easier it will be to develop suitable objectives for your monitoring plan (see Step 3). But don't be discouraged if you cannot find much information — not all tree species have been studied before.

To begin, try to find out where and how your target species lives and reproduces in its natural habitat (see 'Ecology') and what factors influence its survival in the wild (see 'Threats and Conservation').

You might be able to obtain this information from published literature, national or regional Red Lists, field guides and survey reports, by visiting herbaria (places where botanical specimens are stored) or by consulting botanists, foresters, villagers and conservation groups who may know or use the target species.

General information may also be available online. Try entering species names into databases managed by the Global Biodiversity Information Facility **(http://www.gbif.org/species)** or the IUCN Red List of Threatened Species **(www.iucnredlist.org).**

You should also carry out an initial reconnaissance survey before starting any regular monitoring, to familiarise yourself with the species and field site(s) (see GTC Brief 1 for further guidance on carrying out a tree survey). This preliminary field trip can provide you with baseline data, identify logistical issues and help fine-tune the research questions you want your monitoring programme to answer.

ECOLOGY

The natural history of your tree species may influence which types of data you aim to collect during monitoring. Useful areas of preliminary research include:

- **Taxonomy and identification. Are there any other tree species that might be mistaken for this species in the area? How do you tell them apart?**
- **Known distribution range, habitat type, elevation and preferred climate.**
- **Phenology. What times of year does it flower, fruit or drop its leaves?**
- **Modes of reproduction. How is it pollinated and how are seeds dispersed?**

THREATS AND CONSERVATION

Understanding existing threats and conservation measures can help you to develop useful research questions. Consider studying:

- **Threats known or suspected to have an immediate impact on your target species e.g. logging, forest conversion, bark harvesting, climate change.**
- **Factors that drive or influence these threats e.g. increasing demand for timber, new policies, development of roads.**
- **Conservation actions carried out for the species or its habitat so far (if any) e.g. anti-logging patrols, grazing management, tree planting.**

TOP TIP

Contact groups who have already carried out surveys for your target species or similar species, especially within your study site. They may be willing to share their survey reports, information on the methods they used or the data they have collected.

STEP 2: Understand why you are collecting data

Before developing a full monitoring plan, identify **who** you want to communicate your results to (this may simply be your project team) and **what** they need to know?

In many cases, the reason for monitoring will be to inform **adaptive management** of the tree species or the area where it occurs. These may be members of your own project team or other people working for a protected area, government department or NGO. Monitoring results may support decision-making in the field. For example, local rangers may benefit from information on the severity, location and frequency of particular threats. Others may require information on the success of management actions, such as growth and survival rates of seedlings planted out.

Other audiences include donors or other project supporters who may want to see evidence of progress towards project objectives.

Stakeholders, including local community groups or landowners may simply appreciate regular updates.

Do not guess which audiences are interested and what information they can use: ask them! Whoever your audiences are, understanding what they need to know can help guide the type and level of monitoring you aim to carry out.

STEP 3: Develop research questions

Developing one or two research questions can help you and your team express the purpose of your monitoring **programme**. What is the main question(s) you want the monitoring programme to answer?

Research questions can help you to (a) articulate exactly what you want to find out and (b) guide your choice of sampling design and method (see page 5-9).

A good question will address something that can ultimately be measured and should therefore be relatively focussed and specific. In monitoring programmes, research questions often fall into one of three types:

- **Tracking changes over time**
  - *E.g. Will the number of baobab trees in the national park increase, decrease or stay the same over the next 10 years?*
- **Comparing differences**
  - *E.g. Do zebrawood trees seedlings show higher rates of growth and survival in open canopy forest (Treatment A) or closed canopy forest (Treatment B)?*
- **Investigating cause and effect**
  - *E.g. Will the new road lead to an increase in logging pressure in the protected area?*

To help you develop your research questions, look back at the information you have gathered under Steps 1 and 2. The main research questions may be obvious. If not, consult your colleagues and other stakeholders for help to identify and prioritise questions for your plan.

Monitoring methods

After defining your research questions, your monitoring plan should describe (a) the factors or variables you will measure and (b) the techniques you will use.

What you decide to measure will depend on your research questions, the local context and available resources (e.g. cost, time and technical capacity). Here we provide a brief introduction to the factors most commonly measured for trees.

For more detailed information on these techniques or other methods used to monitor relevant factors (e.g. important pollinating insects) or tree conservation actions (e.g. ranger patrols), see Newton (2007) and other additional references provided on Page 16.

TOP TIP

Do not attempt to measure everything! Most programmes monitor only one or two factors and require only one or two simple techniques.

Factor	Common Techniques
Size and growth of individual trees	Measure **DBH** (Diameter at Breast Height) and/or the **height** of individual trees, and then returning after a period of time to measure changes. To measure DBH of larger trees, take readings from a diameter tape wrapped around the tree stem (at 1.3 metres above the ground) or use an ordinary measuring tape and divide the girth by Pi (3.14). DBH of saplings and small trees is typically measured using callipers. Height of tall trees can be measured using a hypsometer or clinometer and shorter trees can be measured using a measuring pole.
Abundance (Number of individuals in an area)	Count the number of trees in small areas (e.g. within 100 m x 100 m fixed area plots) and extrapolate the results across the entire area. To measure tree abundance, it is common practice to exclude trees below a certain height or diameter (e.g. 5 cm DBH) or perform separate counts for seedlings, saplings and other size classes.
Density (Number of individuals per unit area)	Like abundance, this requires counting trees within defined areas or plots of known size. Divide the total number of trees recorded by the size of the area in hectares or square kilometres (e.g. “97 trees per hectare”).
Species richness or diversity (Number of species present)	Identify every species within a number of fixed area plots (these data can form a ‘species discovery curve’ to estimate how many more species may remain to be discovered) or by walking all over an area, recording every species found. Identifying species requires botanical expertise and can be supported through collecting voucher specimens (see GTC Brief 2 for further guidance).
Survival or mortality rate	Record the location of individual trees and return after a period of time to record if these same trees are still alive. Overall rate of survival for a sampled population is the number of trees alive at the end of the census divided by the number of trees alive at the beginning.

Factor	Common Techniques
Stand size structure (the frequency of different size classes within the population)	Measure the DBH of individual trees of each species within a plot and assign a size class to every individual (e.g. ranging from 1 for the smallest trees to 10 for the largest trees). Calculate the frequency of different trees sizes within an area to indicate population structure.
Condition of the crown (uppermost branches) (a useful indicator of tree health)	Assessed using the following scores for each tree: **0** ('Dead'), **1** ('Very Poor': degenerating and badly damaged, and probably incapable of supporting growth), **2** ('Poor': extensive die-back and strong asymmetry, but probably capable of surviving), **3** ('Tolerable': distinctly asymmetrical or thin), **4** ('Good': with only minor defects in symmetry or a few dead tips) and **5** ('Perfect': wide, circular and symmetrical).
Other indicators of disease or damage	Record the percentage number of trees showing damage or disease, or create your own scoring system to rank the intensity. Possible factors to record may include cavities in the trunk, termite trails, cankers, fungal growths and the condition of the leaves.
Effects of harvesting timber	Measure by (1) returning to marked trees to record incidences of logging, or (2) comparing the density, stand size structure or other characteristics of tree populations in field plots **before** and **after** harvesting and/or **within** and **outside** areas subject to harvesting.
Effects of harvesting Non-Timber Forest Products (NTFP)	Monitor the impact of NTFP-harvesting (e.g. the collection of bark, latex, roots, leaves or fruits) by assessing growth rate, condition and/or mortality rate of known trees **before** and **after** harvesting and/or compare trees **within** and **outside** areas subject to harvesting.
Natural regeneration	Set up small plots (e.g. 5 m x 5 m), tag and measure individual seedlings, sprouts and saplings of one or more species, then return to assess growth and survival. These may be complemented by qualitative assessments of the health or condition of every seedling: **0** ('Dead'), **1** ('Poor condition' with discoloured leaves and insect damage), **2** ('Some signs of damage', but healthy foliage) and **3** ('Near perfect or perfect health').
Effects of grazing pressure	Compare differences in frequency of damage or mortality of seedlings or trees in grazed versus ungrazed areas (grazing animals may be excluded by placing fencing around some plots, which can then be monitored over time). Qualitative measures of grazing intensity can also be assessed using this scoring system: **0** ('None': well developed shrub layer, very few gaps for saplings, no dung or herbivore tracks, no bark stripping), **1** ('Light': well-developed shrub later, ground vegetation covers 30-50% of the ground, tree saplings common in gaps, difficult to find dung or tracks from grazing animals, **2** ('Moderate': patchy shrubs with evidence of pruning, ground vegetation variable in height <30cm tall, patches of bare soil small and rare, some saplings reaching above ground vegetation, some dung, no bark stripping), **3** ('Heavy': shrubs absent or dying, ground vegetation <20cm tall, few patches of bare soil, seedlings never growing above ground vegetation, abundant dung from grazing animals and occasional bark stripping), or **4** ('Very heavy': no shrub layer, ground vegetation <3cm tall, many patches of bare soil, absence of tree seedlings, very abundant dung from grazing animals and bark stripped from young trees).

Factor	Common Techniques
Micro-climate	Various types of equipment can be used to measure light (e.g. photometers), temperature (e.g. thermocouples), relative humidity (e.g. hygrometers) and soil moisture (e.g. tensiometers) in the study site.
Reproductive condition (useful information for seed collection)	Record the presence of flowers, immature fruits and mature fruits or cones. Seed or fruit traps (such as fine nets suspended beneath the tree) can also be used to quantify the tree's productivity, but need to be checked at least once a week (because traps tend to fill up with leaves and other debris, get raided by animals or shaken by storms).

TOP TIP

Record the locations of your trees and sites using a GPS or map, but avoid marking them physically *if you are studying the effects of human activities.* Marks could either attract more attention or put people off carrying out their usual activities, especially if they are breaking the law. If this concern doesn't apply to your study, your study plots and trees can be marked using flagging tape and spray paint or, for longer studies, use metal posts and aluminium tree tags, to make it easier to find them again.

Sampling design

Deciding where and how to carry out monitoring can be straightforward for tree species with tiny populations. Monitoring may simply involve periodic data collection for every individual tree in a particular site, with field teams following an established trail between all known trees.

However, in most cases it is not practical to visit and study the entire population of trees. For this reason, monitoring often involves data collection from a representative sample of the population. **The sampling design is very important.** A good sampling design is necessary to ensure the findings from your study are representative of a larger population. Sampling design refers to:

1) **The type of sampling unit you choose to monitor (for trees, these are usually plots or transects)**
2) **The size of each sampling unit (e.g. the dimensions of each plot or transect)**
3) **The number of samples (the more samples you examine, the more likely they are to be representative of the wider population)**
4) **Which sites you choose to sample (e.g. randomly, based on how easily you can access them, or other criteria)**
5) **When and how often you will monitor the trees (and whether you intend to re-examine the same plots or transects, or make new ones)**

1) What type of sampling unit should you use?

The main types of sampling unit used for trees are fixed area plots or transects.

Plots are square, rectangular or circular boundaries used to delimit areas, within which all trees above a certain size threshold are recorded. They vary in size, but many forest monitoring programmes select plots of around 1 hectare (100 x 100m) or smaller.

For monitoring programmes, **fixed area plots** are commonly used to measure differences in abundance, species richness, the condition of individual trees or the factors affecting growth or survival over time and/or between different plots.

Advantages

- **Easy to count trees within each plot and calculate their density and abundance**
- **Being a commonly used method, it's easy to compare results with other surveys**
- **Clear boundaries: little risk of trees being wrongly included or excluded**

Disadvantages

- **Takes a lot of time to make a large plot in dense forest**
- **Large plots are almost impossible to create and survey in rugged terrain**
- **Even large plots may miss species with a patchy or clumped distribution**

Transects are linear plots that are usually straight, but may follow a natural course such as an existing footpath or river. They can be treated as a long thin plot, e.g. 1 km long by 20 metres wide, and only trees within the **transect** boundary are counted and measured. A more complex method, distance sampling, involves (a) measuring the distance of observed trees from a straight transect line. Formulae or the software DISTANCE™ are used to calculate density. **Distance sampling** is more commonly used for animal populations, but can be used for trees, especially in more open habitats.

Advantages

- **Cover ground more quickly**
- **Better than plots for detecting trees that are scarce or patchy in distribution**
- **Easy to make— transects may be set along existing paths and streams**

Disadvantages

- **Results from using existing trails and waterways may not be typical of the whole study site**
- **Measuring distance between trees may not be feasible for sparsely distributed species or on steep terrain or in dense forest habitats.**

2) How big should plots or transects be?

The size of your sampling unit should be driven by your monitoring objectives, the size and density of your species, and what is feasible on the ground.

Standard plot methods include the 1 ha method (a census of all stems ≥ 10 cm DBH within 100 x 100m plot) or the 0.1 ha method (a census of all stems ≥ 2.5cm DBH in a 20 x 50m rectangular plot). Within each plot, it may be helpful to establish smaller sub-plots for measuring smaller shrubs or seedlings. These standard plot methods can work well for relatively widespread or abundant species.

However, such plots may miss species which are naturally rare or which have a clumped distribution. Using transects (e.g. 2m x 500m or 20 x 1,000m) can help increase your chances of detecting such species. The longer the transect, the greater the chance of detecting patchy species.

Transects can also allow you to sample a number of different conditions and habitats in one go. However, plots may be more suitable if you aim to explicitly compare the status of a species between two different habitats. To do this, each sampling unit must be small enough to fit within a particular habitat.

Remember, the dimensions of your plot or transect will affect the results. Therefore, ensure all sampling units are **uniform** in size and shape to allow meaningful comparisons between them.

3) How many plots or transects do you need?

This will depend on your resources (and your audience's information needs) but the more samples you have, the more representative they will be of the larger study site.

If you want data to represent the natural variability of a species (e.g. growth rates) then having multiple sampling units throughout the site is preferable to having only one or two large sampling units.

If you are comparing samples between two conditions (e.g. two areas under different management actions) aim to at least have 6 samples (e.g. 6 plots) representing each condition. This is especially necessary if you want to use statistical tests and present findings to a scientific audience.

4) Where should you put your plots or transects?

Plots or transects can be placed randomly or non-randomly.

Random Sampling is the unbiased selection of sites without personal preference. There are various ways to randomly pick sites on a map, but beware that finding the sites on the ground requires good navigational skills and, in most cases, a GPS.

- **Simple Random Sampling** gives all parts of the survey area an equal chance of being sampled, but this approach might miss rare but important habitats for threatened trees within your site.
- **Stratified Random Sampling** involves dividing the area into zones (usually habitat or land cover types) and placing samples randomly in each zone. This is often considered the best approach when surveying in areas with different habitat types.

Non-Random Sampling selects sites by personal preference e.g. because you think the sites look typical of the overall study area or because the sites are safe and easy to reach, such as beside a road or trail. Selecting sites in this way is likely to lead to biased results that are not typical of the whole area: some habitats may be missed out, while others may be over-represented. This approach is considered less scientific and the data are usually less suitable for statistical analysis, but sometimes this is unavoidable.

5) How often and when should you sample?

How often you sample depends on your research question, the likely rate of change and available resources. If you need data to support immediate decision-making (e.g. to tackle illegal logging) then you will need to collect data more frequently than if you are measuring the growth of mature trees. The interval between visits may therefore range between once every few weeks to once every five or ten years.

For all monitoring programmes, it is absolutely vital that the sampling design remains **consistent**, even if there are changes in the persons collecting the data. For example, if you aim to compare data between different years, aim to return to the same sites, use the same sampling units and collect data **at the same time of year.**

Data management, analysis and presentation

It is a common mistake not to think about data management before monitoring begins. However, how you store, analyse and present your data is essential for answering your research questions and communicating your findings to others. To prepare for data analysis and presentation, think about the following questions:

1) Do I need datasheets and databases?

Most researchers find it helpful to create a form to record information in the field, to make sure they don't miss anything out.

To aid analysis, handwritten data usually need to be transferred from the sheets into a computer. Computer spreadsheets (e.g. MS Excel) often suffice, but if you are collecting a lot of variables from multiple sites you may find it helps to use a more sophisticated data management program (e.g. MS Access). Enter data into the computer regularly, ideally as soon as you return from the field. This will prevent a backlog and will give you time to spot any mistakes or gaps on the data forms.

2) When should data analysis and presentation take place?

Do you need to provide information to conservations managers to make urgent decisions (e.g. in response to fire, or a sudden increase in illegal logging) or do you have obligations to provide results by a certain time for project partners or donors? Avoid missing important deadlines by allocating sufficient time for analysis in your workplan.

3) Which data analysis technique(s) is suitable?

The research question you are addressing will influence how to analyse your data. If you are examining basic trends (e.g. increasing incidences of illegal logging), you may require only descriptive statistics or simple graphs to show how the particular variable is changing over time.

For some questions, you may find it useful to examine and demonstrate the reliability of your results with statistical tests. For example, if you aim to detect whether there are real differences between different treatments (e.g. differences in rates of tree growth between different habitats) or if there appears to be a relationship between the condition of the trees and their environment, threats or conservation actions. Among the most commonly used tests are the Student's t test, Pearson's chi-square test, Analysis of Variance (ANOVA) and Mann-Whitney U test. It is a good idea to look up appropriate statistical tests (see Page 16 for suggested reading) before you start collecting data to make sure your study design is suitable.

4) How should data be presented and disseminated?

Tailor the presentation of your data to particular audiences. Look back at your target audiences (see page 4) and remind yourself (a) who they are (your project team, donors, policy makers, scientists, forest managers, rangers or the local communities you are working with), (b) what they want or ought to know and (c) what is the best way of getting that information across to them. Meetings to present and discuss your findings are often more effective than simply sending them a technical report.

Planning in advance how you will present your data will also help you to ensure you have the right people and equipment in place before monitoring begins. For example, if you want to present your data using maps you may need to organise mapping software and ensure that expertise is in place.

Four common types of findings are described on Page 12. These may be incorporated into a technical report, scientific paper, PowerPoint presentation or other means of disseminating information, depending on your target audience. In the cases of scarce and valuable trees, however, be careful not to reveal their locations to persons who may cause the trees harm, such as illegal loggers.

Findings	Comments
Results from statistical tests	- Adds scientific credibility to your results (and is often necessary if you want the results to be accepted by a scientific journal). - May be confusing or of little interest for people with no understanding of statistical tests.
Graphs and tables	- An effective way of presenting trends, differences between treatments or relationships between factors. - More easily understood than statistical tests. - May not be understood by groups with limited literacy or education.
Photographs and video footage	- A visually powerful way of showing results. - Fixed-point photographs show changes in vegetation or habitat structure for specific areas (e.g. the results of tree planting projects or the effects of roads). - Easily understood by all audiences and can bring project results to life.
Maps and satellite images	- Extremely effective way of demonstrating wider changes in the habitat or the distribution of the species - Visually appealing and easily understood by most audiences.

Monitoring plan checklist

You are almost ready to develop a basic monitoring plan. Before you do, double-check whether:

- ✓ You have carried out a reconnaissance visit to the study area(s).
- ✓ You have developed one or two priority research questions based on the reason for monitoring and your understanding of the target species
- ✓ You have identified which data you want to collect and have chosen suitable methods that are — as much as possible — accurate, reliable, cost-effective, feasible and appropriate to local circumstances.
- ✓ You have reviewed and chosen a sampling design suitable to your research questions, identifying the type, number and size of sampling unit, their location and when data collection will take place
- ✓ You have planned how you will analyse and present your data

As part of your monitoring plan you should also assign responsibilities to different team members and calculate the financial cost and time requirements of each monitoring activity. At this stage, it's important to ensure you have, or expect to have, the resources to carry out fieldwork throughout the duration of your monitoring programme.

To help you visualise different types of monitoring plan we have provided two shortened examples of monitoring plans from the field on Page 12-15.

Example Monitoring Plans

1) Monitoring populations of Niedzwetsky's apple in Sary-Chelek nature reserve, Kyrgyzstan

Summary Information: Kyrgyzstan's Sary-Chelek Nature Reserve hosts important populations of several threatened tree species, including Niedzwetsky's apple *Malus niedzwetzkyana* – an extremely rare wild relative of the domestic apple tree. Fewer than 120 mature Niedzwetsky's apple trees remain in the reserve, and the species is threatened by habitat loss and over-grazing (which damages mature trees and causes high mortality of young saplings). A monitoring plan has been developed by the reserve to record the condition of adult Niedzwetsky's apple trees within the core and buffer zone of the reserve. The monitoring plan also records grazing pressure and the condition of habitat around the trees.

Target Audience:	Implemented by:
Sary-Chelek Nature Reserve staff	Sary-Chelek Nature Reserve
Forestry Agency	Fauna & Flora International
Local grazers	
Project sponsors	

Research Question: Is the number and condition of Niedzwetsky's apple trees in the reserve changing over time?

Data Collection Plan and Sampling Design

- **Carry out reconnaissance surveys** to identify where Niedzwetsky's apple trees are in the reserve. For every tree, or cluster of trees, that you observe, record their location using a GPS and mark their position with tape to help returning field workers find them.
- After survey data have been entered, **mark the positions of trees on a map.**
- Select 20 trees or tree clusters (where several trees from the same species are found very close together) for **long term monitoring sites**. To ensure the sites are representative of the reserve, select 10 sites inside the reserve's core area and 10 sites in the buffer zone. Ideally trees will be selected randomly, but because the patrol team has limited resources to cover the whole reserve, monitoring sites may need to be positioned near the patrol routes.
- For every tree or tree cluster included in the monitoring programme, mark out a square plot (20 x 20m) with long pegs or poles, around the tree or tree cluster.
- In every 20 x 20m plot, **record for each individual tree** its: size (height and DBH), condition (whether dead branches are absent, few or common), and evidence of damage from livestock for individual trees ('absent', 'weak' or 'strong').

Data Collection Plan and Sampling Design (cont.)

- In each 20 x 20 m plot, **estimate overall level of grazing pressure** (ranging from none, to low, medium, high or very high), record the number, size and condition of any seedlings or saplings present and take notes on the general condition of the site (including percentage cover of grass, understorey, shrubs and trees).
- Finally take four fixed-point photographs from each corner of the plot towards the centre.
- **Revisit monitoring sites once a year** (at the same time of year) and re-measure (a) the size, condition, livestock damage for each mature tree and (b) the level of grazing pressure and number, size and condition of any seedlings within in each plot. Re-take photographs from the same corners of each plot.

Staff and resources required

STAFF:

Senior Researcher of the Reserve, responsible for overseeing data collection and data analysis

Two technicians or students to assist with data collection.

EQUIPMENT:

- Transport to monitoring site
- Diameter tape (to measure DBH)
- Measuring tape, pegs or poles for marking plots
- A compass and map
- GPS (record and map location of trees)
- Batteries
- First aid kit
- Datasheets (data entry in field)
- Digital camera (document methods and tree condition)
- Computer and software for data entry and analysis (e.g. MS Excel)

Data analysis and dissemination

ANALYSIS:

- Simple descriptive statistics and graphs used to (a) demonstrate trends in tree survival, growth and grazing pressure within the reserve and (b) the differences between these variables in the core and buffer areas of the reserve.

DISSEMINATION PLAN:

- Technical report containing full details of methods and results, including maps (showing location of study site and trees), graphs and fixed point photographs.
- Meetings with local grazers, Forestry Department staff and other stakeholders to present findings, using PowerPoint presentation or photographs to display key changes in the reserve and to the Niedzwetsky's apple tree. Discuss ideas for solutions during meetings.

Note: This case study represents one component of a larger monitoring plan being implemented by the Sary-Chelek Nature Reserve. With support from Fauna & Flora International, the reserve team are also monitoring populations of other threatened trees (e.g. Korshinsky's pear *Pyrus korshinskyi* and the Persian rowan Sorbus persica) as well as the general condition of the forest. Results are being used to identify areas of the reserve most under threat.

In the future the reserve staff hope to monitor the effectiveness of conservation actions. They will place dead hawthorn branches around 20 Nedvezky's apple trees – to act as a living fence to keep livestock out - and will leave a further 20 trees untouched to act as a 'control'. Comparing grazing pressure and levels of natural regeneration between the two groups will help the reserve identify whether the conservation actions are successful or not.

2) Monitoring the effects of extracting resin on the health and survival of a globally threatened tree

Summary Information: The West Indian tree *Protium attenuatum* produces lansan resin, an economically and culturally important resource that is used chiefly as incense for religious purposes. The tree has declined across its range, reputedly due to overexploitation, and is now globally threatened. As part of a project to design a sustainable method of extracting resin, monitoring was carried out to understand the effects of current tapping practices upon the condition and survival of lansan trees on Saint Lucia.

Target Audience:	Implemented by:
Resin tappers	Saint Lucia Forestry Department
Forestry Department	Fauna & Flora International
Government of Saint Lucia	
Consumers (churches, public)	
Other conservationists and scientists	
Sponsors	

Research Question: Do current methods of extracting resin have any significant effect upon the health and survival of lansan trees?

Data Collection Plan and Sampling Design

- **Identify a study site** where tappers actively harvest tree resin
- **Randomly select** 40 lansan trees within this site that show no evidence of being tapped **(Control sample)**. These trees are evenly distributed across four different size classes: small trees (15.0–19.9 cm DBH); medium trees (20.0–24.9 cm DBH); large trees (25.0–29.9 cm DBH); and very large trees (≥30.0 cm DBH).
- **Randomly select** 40 lansan trees that are tapped by local tappers **(Tapped sample),** ensuring they are evenly distributed across the four size classes.
- Do not mark the trees, so the tappers are unaware which individuals are under observation.
- At the beginning of the study, **measure the size** (DBH) of every Tapped and Control tree and record indicators of its **condition:** tree crown form, number of termite trails, number of cankers and number of cavities on the trunk.
- **Repeat** measurements of size and condition twice a year for two-and-a-half years.
- Inspect the trees every two weeks to **verify** that the tapped trees are still being harvested by local tappers and the control trees remain untapped. Record any trees that are broken or dead.
- A number of personnel conduct the two-weekly inspections, but make sure that the **same two observers** record the six-monthly DBH and indicators of tree condition.

Staff and resources required

STAFF:

8 personnel, working in rotation, inspecting the trees and entering data **every two weeks.**

Of these, 2 personnel are also responsible for recording DBH and tree condition every six months. 1 person conducts data analysis.

EQUIPMENT:

- Transport to monitoring site every 2 weeks
- Diameter tape (to measure DBH)
- A compass and map
- GPS (record and map location of trees)
- Datasheets (data entry in field)
- Digital camera (document methods and tree condition)
- First aid kit
- Snake chaps (protect legs against snake bite)
- Computer with software (data entered in Excel, analysis using graphs and statistical tests)

Data analysis and dissemination

ANALYSIS:

- Field data entered into MS Excel spreadsheets.
- Simple descriptive statistics and graphs used to compare group means (e.g. average growth, indicators of condition and mortality rates) of each treatment and size class. Use MS Excel.
- Statistical tests to compare growth, indicators of condition and mortality rates of Tapped and Control trees in each size class. Tests include Mann-Whitney U test, Wilcoxon signed rank test, Pearson's test. Carry out analysis using XLSTAT statistical package.

DISSEMINATION PLAN:

- Technical report containing full details of methods and results, including maps (showing location of study site and trees), graphs, statistical tests, photographs.
- Meetings with tappers, other Forestry Department staff and other stakeholders to present findings, using PowerPoint presentation and photographs. Discuss ideas for solutions during meetings.
- Scientific paper submitted to a peer-reviewed journal to disseminate methods and findings to other scientists.

Note: This monitoring programme, conducted on Saint Lucia from 2010 to 2013, revealed that the customary or traditional methods of extracting resin are highly destructive, severely affecting tree growth and condition and killing over 6% of the trees annually. Moreover, the study obtained evidence that untapped trees are also more prone to decay in areas with heavily tapped trees, suggesting agents of disease can spread from the injured trees to non-tapped trees. Local tappers are now being taught alternative methods that do not appear to harm the trees and yet still produce very profitable quantities of lansan.

TOP TIPS

As you put your own plan into practice, it's worth remembering a few principles for a good monitoring programme.

1) **Be consistent.** Use exactly the same methods to collect data. Try to use the same equipment, same people, same locations, same times of year, etc.
2) **Keep it simple.** The less complicated and time-consuming the monitoring method, the more likely it will be continued accurately.
3) **Learn from others.** If you know other people are monitoring the same species or issues, try to apply the same methods. This will make your data and theirs easier to compare.
4) **Record methods thoroughly.** Write down enough details that would allow other people to repeat your methods perfectly.
5) **Be honest.** Never force the results to suit what you think they should be. If the results fluctuate or show the opposite of what you expected, record exactly that.
6) **Use your data.** Monitoring can help you learn about how your project is performing. Use your data to adapt and react to what it shows you.

Selected references and further guidance

References and further guidance on some of the methods described in this brief are provided below.

General guidance on monitoring

Bibby, C.J. and Alder, C. (eds) (2003) The Conservation Project Manual, Section 6: Monitoring and Evaluation. BP Conservation Programme, Cambridge, UK. Available at: **http://bit.ly/gtc_ref_3ai**

Guidance on monitoring techniques and sampling designs for forests and trees

Coe, R. (2008) Designing ecological and biodiversity sampling strategies. Working Paper no. 66, World Agroforestry Centre. Available at: **http://bit.ly/gtc_ref_3c**

Newton, A.C. (2007) Forest Ecology and Conservation: A Handbook of Techniques. Oxford University Press, UK. Available to order at **http://bit.ly/gtc_ref_3d**

Reimoser, F., Armstrong, H. and Suchant, E. (1999) Measuring forest damage of ungulates: what should be considered. Forest Ecology and Management: 20 (1-3), 47-58. Available at: **http://bit.ly/gtc_ref_3e**

Synott, T.J. (1979) A Manual of Permanent Plot Procedures for Tropical Rainforests. Tropical Forestry Paper No. 14, Commonwealth Forestry Institute, University of Oxford, Oxford, UK. 67 pp.

United States Department of Agriculture (USDA) Forest Service (2003) Multiparty Monitoring and Assessment Guidelines for Community-based Forest Restoration in Southwestern Ponderosa Pine Forests, Chapter 5: Ecological Monitoring Tools and Methods. Available at: **http://bit.ly/gtc_ref_3f**

Guidance on monitoring effectiveness of conservation actions

The Conservation Measures Partnership (2013) Open Standards for the Practice of Conservation Version 3.0. Available at: **http://bit.ly/gtc_ref_3g**

Introduction to SMART Conservation Software: **http://bit.ly/gtc_ref_3h**

Elliot, S., Blakesley, D. and Hardwick, K. (2013) Restoring Tropical Forests: A Practical Guide, Royal Botanic Gardens, Kew, UK. 344pp. Available at: **http://bit.ly/gtc_ref_3i**

Guidance on basic statistical analysis

Kindt, R. and Coe, R. (2005) Tree Diversity Analysis. A Manual and Software for Common Statistical Methods for Ecological and Biodiversity Studies. World Agroforestry Centre (ICRAF), Nairobi, Kenya. Available at: **http://bit.ly/gtc_ref_1h**

For more information, or to download the other briefs in this series, visit **www.globaltrees.org/resources/practical-guidance**

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