



“ Sound nursery practice is the foundation of any successful planting programme ” Munjuga et al. (2013)

### Introduction

A good nursery will protect young trees and provide them with the best possible conditions for survival and growth. Designed in the right way, even a very basic nursery can provide you with the space and facilities needed to grow your target number, size and quality of trees. In this brief we provide guidance on (a) how to design and set-up a basic nursery and (b) how to plan and manage nursery operations (from watering and weeding plants, to keeping records of their survival and growth).

### Who is this guidance for?

This brief is for individuals with limited horticultural experience but who nonetheless are tasked with growing tree species for conservation purposes.



This guidance sheet was written by Gail Stott<sup>1</sup> and David Gill<sup>2</sup>



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## Before you start

A common mistake when constructing a nursery is to build a structure that does not fit the needs of the project. If your resources (money, time, personnel) are limited, or if you have never built a nursery before, **start with something small and simple** and learn how to run it effectively. You might choose to expand the nursery at a later date, so think about making your nursery space as flexible as possible.

To ensure that your nursery meets the needs of your project we recommend that, before you start, you (1) identify a suitable location, (2) get to know basic nursery features and (3) select the optimum size and layout for your nursery.

### STEP 1: Identify a suitable location

A good nursery location will (a) provide the best possible conditions for seedling growth and (b) ensure that the nursery is accessible, safe and comfortable for workers. Consider the following factors when selecting a nursery site:

#### Water Supply



A reliable source of water is essential. This is especially true for nurseries located in areas with a distinct dry season.

Ideally, position your nursery close to a nearby spring, stream, pond, borehole or well. This will minimise the time workers will have to spend collecting water.

Alternatively you may be able to access and pay for piped water. If this is your best option, make sure you have enough funds to cover water bills.

Ask yourself whether water sources may be prone to drying up during periods when there is little rain. Consider installing water tanks to store water as a back-up for water shortages during dry periods.

#### Topography and Aspect



Your nursery should be located somewhere flat, sheltered and well-drained.

Avoid placing your nursery in areas that are prone to flooding (e.g. at the bottom of a valley or in riverine areas), strong winds (e.g. at the top or a hill or in the middle of an exposed valley) or soil erosion (e.g. on a steep hill).

Aspect (the direction your nursery faces) is also important. In summer months, strong afternoon sun (south facing in the northern hemisphere and north facing in the southern hemisphere) may damage seedlings. Therefore it is generally best to position your nursery so that the seedlings face the morning sun (always rising from the east). The exact direction your nursery faces should be defined by the light requirements of the species you grow.

#### Soil



Ideally, suitable soil should be available near the nursery.

A light and free-draining medium is essential for growing trees in containers. This can be achieved by including sandy soil, river gravel or bark chippings in the growing medium, reducing the chance of the medium becoming water-logged.

Some species require certain fungi to be present in the soil – and so you may need to collect some soil from a nearby forest.

If there is no suitable soil nearby, assess the cost of transporting or buying it from other sites.

#### Access and Ownership



Your nursery must be safe and accessible at all times for nursery workers.

Ideally it should be located close to a road to (a) help transport materials to the nursery and (b) take seedlings from the nursery to your planting sites.

Make sure that ownership of the land is clear before any construction begins. This may include consulting people on traditional use and ownership of the land in question and holding meetings with local landowners and land users that could be affected by its construction

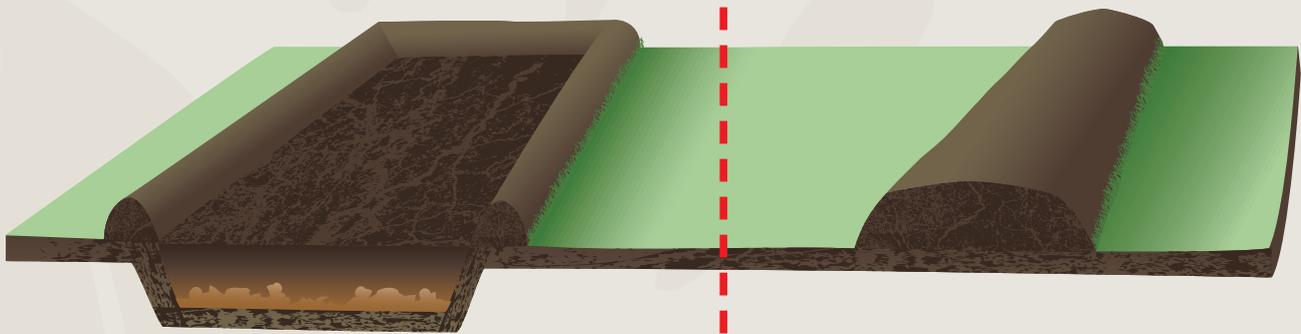
## STEP 2: Get to know basic nursery features

Below we provide a checklist of features that most basic nurseries will contain:

- **Potting medium:** a mixture of sandy soil and organic materials (e.g. compost).
- **Germination medium:** a slightly finer mix for the germination of smaller seeds.
- **Seed germination areas** are the parts of your nursery where you will sow seeds. They include seedbeds and seed trays.
- **Seedbeds** are typically around 1m wide and 5-10m long. They require a shade cover (e.g. palm leaves, bamboo, wire mesh) to protect them from harsh sun. Seedbeds tend to take one of two forms:

A) **Dug beds** are created by digging a bed to around 10cm deep, adding a thin layer of gravel (to aid drainage) and filling the bed with soil.

B) **Raised beds** are created by forming a mound of soil on a well-drained area of the nursery floor around 10cm high.



Examples (a) of a seedbed dug into the ground and (b) a raised seed bed.

- **Seed trays** are small plastic containers placed on benches or in special propagation trays (that function like a miniature greenhouse). Like seedbeds, seed trays should be kept in a shaded area.
- **Potbeds** are where pots or bags containing seedlings are placed. They should be located in an area that receives sunlight in the morning and should be well-ventilated to minimise disease problems in the nursery. Each bed is typically 1m wide and 5-10m long – with a 60cm path kept between beds to allow workers and wheelbarrows space to move between them.



Installing a potbed may involve placing individual pots directly on the ground or they may be raised on top of a mound of soil. Raised beds are advised for areas that receive high levels of rainfall. In these areas, draining ditches should be dug on either side of the bed, to help carry water away from the seedlings.

Individual pots are kept upright with a frame that extends around the perimeter of each bed (made from rope, sawn timber, stones, bamboo or mounds of soil).

- **Shading** – including netting, wire mesh or locally sourced materials such as bamboo, palm leaves or grass – should be placed over potbeds (especially when seeds are young and delicate). Good shading allows around half the light to pass through and should be easy to remove (especially if seedlings need to be exposed to higher levels of sunlight before they are planted out).

An example potbed with removable shading. In this case, a mound of soil has been formed around the perimeter to help keep pots upright.



- **Fencing** may be required to keep out stray animals. Live fencing – including the planting of small shrubs – can also function as a windbreak. However, some ventilation is needed to minimise spread of fungal pathogens in the nursery.
- A store or a pit for **compost, potting medium or germination medium**. Do not place this area immediately next to your seedlings. If the area becomes contaminated by fungal pathogens, a short distance between them will help you to reduce risk of spread to the seedlings growing in the nursery beds.
- A **sheltered work area** for workers to fill pots, sow seeds and transplant seedlings from seed trays to pots.
- **Access roads** for any vehicles coming into the nursery.
- A **water supply**. This may involve creating a small channel from a nearby stream to the project nursery or allocating space for a water tank to capture rain water. If you expect shortages in water supply throughout the year, water storage is absolutely essential.
- A **lockable tool shed** may be required to keep equipment safe overnight or when no-one is on site.
- **Shelter and toilet** for workers and visitors.

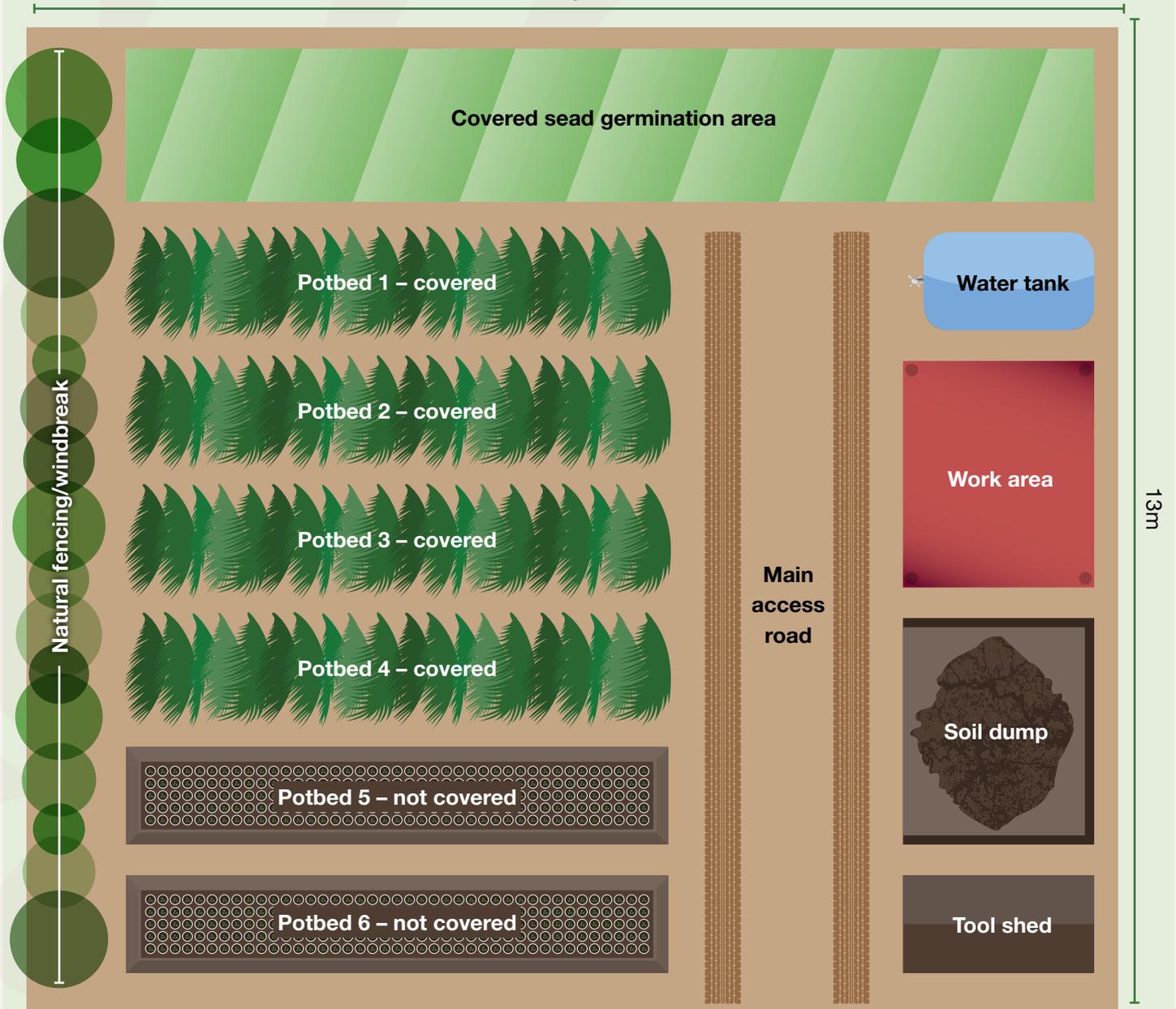
### STEP 3: Select and optimum size and layout

The size, standard, and permanence of your nursery structure, as well as the layout and features of your nursery, will depend on the objectives of your project, your available budget and the local conditions at your chosen site.

In this brief we use an example of a nursery that aims to grow 5,000 seedlings for a planting project. Because a percentage of seedlings will die over the year, the nursery will need to have some reserve capacity (e.g. if you aim to grow 5,000 seedlings, then allocate sufficient space to grow 6,000 seedlings). Below we estimate nursery size based on the space required for (a) potbeds, (b) seedbeds and (c) paths, roads, fencing and work areas needed for growing 6,000 seedlings.

Feature	Explanation		Total area
Potbeds	Each m <sup>2</sup> can hold 100 pots	6,000 pots required	60 m <sup>2</sup>
Seedbeds	Seedbed area is typically 25% of area required for potbeds		15 m <sup>2</sup>
Access paths	Each path is 6 m <sup>2</sup>	11 paths required	66 m <sup>2</sup>
Small road	11m x 3 m		33 m <sup>2</sup>
Sheltered area/potting shed	4m x 2m		8 m <sup>2</sup>
Soil dump	3m x 2m		6 m <sup>2</sup>
Tool shed	2m x 2m		4 m <sup>2</sup>
Water tank	2m x 1m		2 m <sup>2</sup>
<b>Total area</b>			<b>194 m<sup>2</sup></b>

15m



Not to scale

## Nursery operations

After building your nursery there are a number of jobs to do to promote ideal conditions for seedling growth. Over the next two pages we provide guidance on (1) what these jobs are, (2) what equipment you will need and (3) who you will need in your nursery team.

### 1 Nursery Jobs

#### Obtain and prepare seed

- **Obtaining seed** from threatened trees may involve acquiring seed from a seedbank or a local botanic garden or collecting seed from wild trees. For guidance on how to collect seed from trees without harming wild populations see [GTC Brief 5](#).
- In your sheltered work area, collected seed may need to be **extracted** from the fruit, **cleaned** and tested to see if it is **viable** before it can be sown in the nursery seedbeds or seed trays. After seed is extracted you may also be able to store a proportion of it for longer-term use (only for 'orthodox' species with high storage capacity). For more information on these procedures see [GTC Brief 6](#).
- Many tree species will have seed that undergoes a period of dormancy. For these species, you may need to **apply various treatments to help overcome dormancy**. For more information see [guidance provided by the Food and Agricultural Organisation of the United Nations](#).

#### Prepare germination and potting medium

- **Prepare germination and potting medium** in your sheltered work area by mixing sandy soil with organic materials such as compost or humus-rich top soil found under trees. Sieve the medium to remove large stones, weeds and roots and leave the mix in a sheltered soil dump. Very small stones or river gravel should be retained or added, to help keep the mix open. You may want to prepare a slightly finer mix for the germination medium, especially if you aim to sow trees with very small seeds.
- **Prepare seedbeds in advance**. As mentioned on Page 3, this may involve (a) digging a hole in the ground before filling the hole with a layer of gravel and then covering with a layer of germination medium or (b) forming a mound of germination medium on top of a well-drained area of the nursery.
- **Prepare seed trays in advance**. If you use seed trays, fill each one with 6-8cm of germination medium and place it on a bench in a sheltered area.
- **Prepare planting bags / pots in advance by filling them with potting medium**. Potting medium should be gently pressed into the bottom third of each pot (to stop loose soil spilling out) and loosely in the top two thirds to allow roots to develop easily. For trees, planting bags and pots need to be relatively deep (more than 20cm) to support root development and to minimise the effects of water-logging on seedling health.

#### Sow seeds in beds, trays or directly into pots

- **For small seeds or seeds with low germination rates:**
  - Sow seeds into seedbeds or in the seed trays.
  - Label beds or trays (with information on species name and date planted).
  - Make sure seedbeds and seed trays are covered.
  - Ensure medium is evenly moist. Do not over-water or allow medium to dry out.
  - When seedlings germinate, transplant them into pots or planting bags and move them to the potbeds.

- **For larger seeds or seeds with high germination rates:**
  - Sow seeds directly into planting bags/pots and move them to the potbeds.
  - Label plants (with information on species name and date planted).
  - Ensure medium is evenly moist. Do not over-water or allow medium to dry out.

TOP  
TIP

Some species will have very specific requirements for germination, including particular temperatures, moisture levels, substrate types or application of different treatments to overcome seed dormancy. To help evaluate optimal germination conditions carry out your own germination experiments (for guidance see [GTC Brief 8](#)).

### Care for young seedlings in the nursery (covered in greater detail in [GTC Brief 7](#))

- After germination, young seedlings will require **watering** (again, avoid over-watering but never allow the growing medium to dry out).
- Seedlings will require **regular weeding** and some species may require **occasional root-pruning** (to encourage root development).
- You will need to **monitor the health and condition of seedlings / saplings**. Keep small and weak seedlings to one side. If some plants show signs of pest or disease, you will need to act quickly to prevent transmission to other plants.
- If plants show symptoms of nutrient deficiency, consider adding fertilizer to the soil. Be careful not to add too much as this may cause root burn.
- Before saplings are ready for planting they will need to be **hardened-off** (a process that typically involves a gradual removal of shade and watering). This helps saplings to develop a woody stem and prepares them for the physiological stress involved with transport to, and establishment within, the wild planting site.

### Carry out general maintenance

- Drainage ditches should be cleared regularly to avoid waterlogging in the nursery.
- Fencing and shading materials should be inspected regularly and repaired and replaced as necessary. As mentioned above, you may need to remove shade from seedlings that need to be hardened-off.

## 2 Equipment checklist

- **Spade or shovels** for working the soil.
- **A trowel** for filling planting bags or pots with soil.
- **Large wooden-frame sieve** for preparing potting soil.
- **Seed trays** for germination of very small seeds.
- **Plastic planting bags or pots** for germination of larger seeds and growth of seedlings.
- **Shade cover** to replace shading damaged or lost during operations.
- **Hosepipe** with spray nozzle (you may need a fine mist for delicate seedlings); or a **watering can** for watering plants.
- For more sophisticated nurseries, a mist or drip **irrigation system** can be used to water plants, although this may be very expensive to install.
- **Spray bottles** for misting very small, delicate seedlings.
- **Secateurs or scissors** for pruning seedlings.
- **Wheelbarrow or trolley** for transporting materials within the nursery.
- **Planting labels**.
- **Notebooks** for record keeping.
- **Pens and Pencils**.

### 3 People required

The size and capacity of your nursery will dictate how many people are needed to staff it. You may want to hire a combination of temporary and permanent workers. This will provide you with extra labour during busy periods throughout the year.



Credit: David Gill/FFI

As a minimum you will need at least one member of staff to carry out day-to-day tasks including care of plants in the nursery (e.g. planting seeds, watering, removal of weeds) and maintenance of the nursery itself (e.g. repairs to the structure, cleaning). For difficult to grow species, your nursery may require somebody with experience in horticulture.

Ideally, at least one person will also be responsible for taking notes on the condition and performance of nursery plants. This may be the same person responsible for day-to-day tasks.

Most nurseries will need one person with overall responsibility for coordinating all nursery activities – a nursery manager. This person should have some experience with record keeping and with uploading and analysing data on a computer (e.g. using MS Excel).

## Organisation and record keeping

To help schedule nursery activities for different species, we recommend developing a production calendar and hanging this up in the nursery to keep track of key duties.

A production calendar highlights key milestones for each species (from seed collection right through to planting). Ultimately all activities are geared towards ensuring seedlings will be the right size for planting by a set planting date (e.g. in the seasonal tropics, seedlings need to be planted at the start of the wet season).

For some fast growing species, this may mean keeping the seeds in storage for a short while so that they do not outgrow their pots before planting out at the start of the rainy season (e.g. see Species B below).

To perfect this production schedule you will need to keep records on the time of fruit production, time to seed germination and seedling growth rate.

## Nursery Production calendar

Rare Tree Nursery			Year 1 (Planting season = November-December)											
Species	Notes	Saplings required Year 1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Species A	Requires temporary storage to ensure seedlings don't outgrow pots before planting season	400	Seed collection, viability testing and pre-treatments	Seed collection, viability testing and pre-treatments	Time in storage / dormancy	Time in storage / dormancy	Sowing date / germination time	Sowing date / germination time	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Harden off seedlings	Planting
Species B	Long dormancy period	500		Seed collection, viability testing and pre-treatments	Time in storage / dormancy	Time in storage / dormancy	Sowing date / germination time	Sowing date / germination time	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Harden off seedlings	Planting
Species C	Recalcitrant species: sow seed immediately after collection	250				Seed collection, viability testing and pre-treatments	Sowing date / germination time	Sowing date / germination time	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Harden off seedlings	Planting
Species D	Recalcitrant species: sow seed immediately after collection	300	Seed collection, viability testing and pre-treatments	Sowing date / germination time	Sowing date / germination time	Sowing date / germination time	Sowing date / germination time	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Harden off seedlings	Planting
Species E	Slow-growing species – to be planted in Year 2	-		Seed collection, viability testing and pre-treatments	Sowing date / germination time	Sowing date / germination time	Sowing date / germination time	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Seedling growth	Seedling growth

**Key:**

- Seed collection, viability testing and pre-treatments
- Seedling growth
- Time in storage / dormancy
- Harden off seedlings
- Sowing date / germination time
- Planting

## Record keeping

The long-term success of your nursery depends on reliable information about how to efficiently grow your target species to a high standard. Obtaining this information requires regular record keeping that documents both failures and successes. Over time, these records can help to create a clear picture of best practice for the species of concern within your own nursery.

Specifically, record keeping in the nursery can also help you to:

- Estimate how much seed is required to grow a given number of plants for each species.
- Estimate how long each seedling takes to grow to planting size.
- Develop and improve protocols for nursery workers to follow.
- Measure the performance of the nursery as a whole.

In this brief we provide examples three types of records you may choose to keep in your nursery.

- 1) **Plant Development Records** document how **each species** is performing within your nursery. Typically this involves having one separate datasheet for each batch of seed that comes into the nursery for each species, and recording data on seed source, germination, growth and planting. They are particularly useful for developing new protocols for each species in the nursery.

## Plant Development Record

<b>Species</b>	Species A	<b>Batch no.</b>	00023
<b>Seed source</b>			
<b>Date of collection</b>	10/02/2015	<b>Number collected</b>	750
<b>Place of Collection</b>	Rare Tree Nature Reserve	<b>Estimate altitude</b>	1000-1200 m
<b>Mother tree ID</b>	SA009	<b>Collected by</b>	James Diaz
<b>Germination</b>			
<b>Date sown</b>	01/05/2015	<b>Number Sown</b>	600
<b>Pre-sowing treatment</b>	Yes - Scarified	<b>Seedbeds or Seed trays</b>	Seed trays
<b>Germination medium</b>	Coir-Sand medium 50:50 ratio		
<b>1st Germination Date</b>	20/05/2015	<b>% Germinated</b>	75%
<b>Nursery Care</b>			
<b>Date seeds transplanted into larger pots</b>	01/06/2015 – 08/06/2015	<b>Number of seeds transplanted to larger pots</b>	450
<b>Potting medium</b>	Sandy soil mixed with compost	<b>Shading</b>	Yes
<b>Fertilizer applied?</b>	Yes	<b>Dates fertilizer applied?</b>	11/07/2015
<b>Pest / disease control</b>	No	<b>Dates applied</b>	NA
<b>Other notes</b>			
<b>Hardening off and Dispatch</b>			
<b>Hardening date started</b>	October 1st	<b>Number survived before hardening off</b>	412
<b>Dispatches</b>			
<b>Dispatch 1</b>	02/11/2015	200	Rare Tree Nature Reserve buffer zone
<b>Dispatch 2</b>	03/12/2015	212	Rare Tree Nature Reserve
<b>Dispatch 3</b>	-	-	-

**2) A nursery inventory** can describe the performance of the **whole nursery** at one point in time. Typically this involves counting the number seedlings for each species in your nursery and their stage of development. Inventories should be completed at least every two months.

Nursery Inventory Form				
Nursery	Rare tree nursery		Location	Rare Tree Nature Reserve
Manager	Luis Pinto		Number of workers	2
Species	Date 30/4/2015	Date 30/6/2015	Date 31/8/2015	Date 31/10/2015
	Number	Number	Number	Number
<b>Species A</b>				
Seed sown	600	0	0	
Seed germinated	0	299	0	
Saplings in pots	0	151	440	
Hardening-off	0	0		412
<b>Species B</b>				
Seed sown	0	490		
Seed germinated	0	210	0	
Saplings in pots	0	0	544	99
Hardening-off	0	0	0	412
<b>Species C</b>				
Seed sown	250	92		
Seed germinated	0	158		
Saplings in pots	0	0	211	100
Hardening-off	0	0		76

**3) Plant supply records** help to record the number and quality of plants supplied to different planting sites. They also contain information on dates of delivery, who received the saplings and which site they were sent to. These records will be vital if you want to follow-up and monitor survival of saplings in the wild.

Plant Supply Records				
Nursery	Rare tree nursery		Location	Rare Tree Nature Reserve
Manager	Luis Pinto		Season	Wet season (November-January)
Species	Number	Number	Number	Number
Species A	200	02/11/2015	Rare Tree Nature Reserve buffer zone	2 communities (Mountain creek and River Valley)
Species A	212	03/12/2015	Rare Tree Nature Reserve	Nature Reserve Management
Species B	480	03/12/2015	Rare Tree Nature Reserve	Nature Reserve Management
<b>Total</b>	<b>892</b>	-	-	-

### What next?

For more guidance on where and how to plant the trees you grow in your nursery, see [GTC Brief 9 – How to Plant and Establish Rare and Threatened Trees in the Wild](#).

## Selected references and further guidance

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

### Guidance on planning and managing a nursery

DANIDA-CTSP, GTZ-CGFP, DFW, JICA, PRASAC. (2003). Farmers' Tree Planting Manual. Chapter 3.2, Seedling Nursery. Available at: [http://bit.ly/gtc\\_ref\\_4b](http://bit.ly/gtc_ref_4b)

Longman, K. A. (1998). Tropical Trees: Propagation and Planting Manuals. Volume 3 – Growing Good Tropical Trees for Planting. Commonwealth Science Council. Available at: [http://bit.ly/gtc\\_ref\\_4a](http://bit.ly/gtc_ref_4a)

Munjuga MR, Gachuri AN, Ofori DA, Mpanda MM, Muriuki JK, Jamnadass RH, Mowo JG. 2013. Nursery management, tree propagation and marketing: A training manual for smallholder farmers and nursery operators. Nairobi: World Agroforestry Centre Nursery. Available at: [http://bit.ly/gtc\\_ref\\_4c](http://bit.ly/gtc_ref_4c)

United Nations Development Programme, Special Public Works Programme (1989). Tree Nurseries: An Illustrated Technical Guide and Training Manual, Booklet Number 6. International Labour Organisation. Available to order from: [http://bit.ly/gtc\\_ref\\_7d](http://bit.ly/gtc_ref_7d)

### Guidance on germination and care of seedlings within a tree nursery

Elliot, S., Blakesley, D. and Hardwick, K. (2013). Restoring Tropical Forests: a practical guide, Royal Botanic Gardens Kew; 344pp. Available at: [http://bit.ly/gtc\\_ref\\_3i](http://bit.ly/gtc_ref_3i)

Gosling, P. Raising trees and shrubs from seed. Forestry Commission Practice Guide. Forestry Commission, Edinburgh. Available at: [http://bit.ly/gtc\\_ref\\_7e](http://bit.ly/gtc_ref_7e)

Hoffmann, P.M and Velazco, S.J.E (2014). How to Germinate Seed and Grow Tree Seedlings, Global Trees Campaign, Fauna & Flora International. Available at [http://bit.ly/gtc\\_brief7](http://bit.ly/gtc_brief7)

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Willan R.L. (1987). A Guide to Forest Seed Handling, with Special Reference to the Tropics. Rome, Food and Agriculture Organization of the United Nations. Available at: [http://bit.ly/gtc\\_ref\\_4d](http://bit.ly/gtc_ref_4d)

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