

# Afforestt

## Progress Update

# 1. RECAP

# Pre Project Preparation

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Prior to visit, a **species list** (Annex A) was developed based on recommended/available native species (51 sp.)

1. Site visit

- Plot demarcations made for 200 square meter forest

2. Determine soil texture

- Soil texture determined as 'sandy clay' through physical soil texture test
- Water retention and perforation capacity of soil increased with:

Water retention material: **Coco peat** (1400 kg)



Perforator: **Husk** (1400 kg)



# Pre Project Preparation

## 3. Visiting plant suppliers in Malaysia

- Check stock of species at nurseries
- Communicate key specifications to suppliers with respect to technical standards of saplings i.e. age and height
- Quality check on biomass (coco peat and husk)

## 4. Check suitability of mulching material

- Wood chips and dried leaves





# Project Execution





# Project Execution

## 3. Organising plants in respective layers and grouping



## 5. Mulching



## 4. Placing plants on the mound and layering



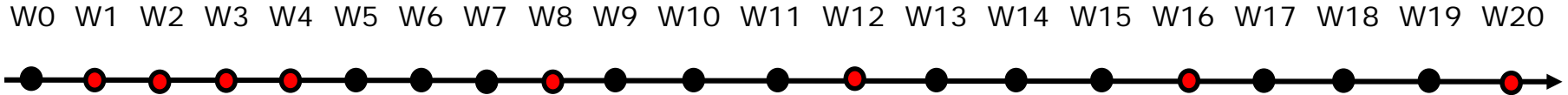
# Project Execution



6. Tree Planting

# Timeline

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- Sample size: 249 saplings
- Frequency: once per month, to not introduce too much measurement error as growth rate tapers

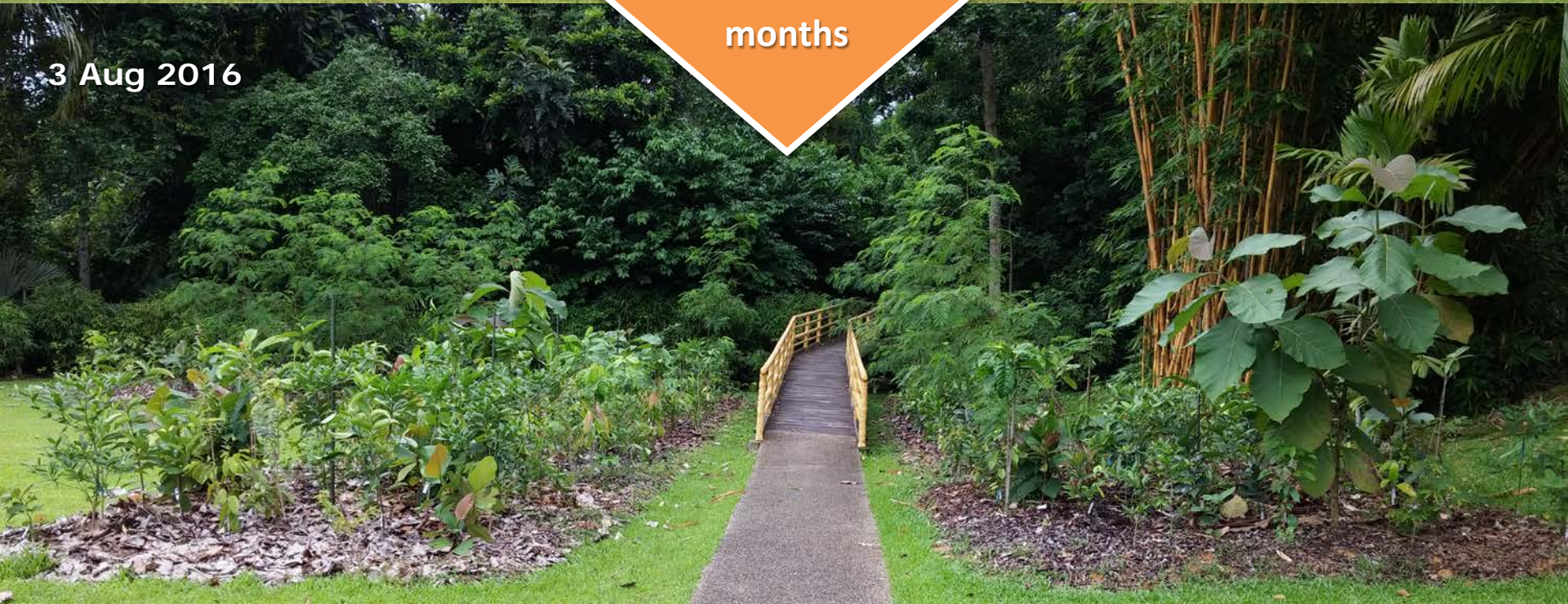


23 Mar 2016



~5  
months

3 Aug 2016





# Materials and Methods

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## Height measurement:

- Height of the sapling is taken as the top of the leaf litter to the top of the stem (i.e. not the vertical distance)
- Equipment used: measuring tape
- **Mid-point method** is used to estimate height of trees that were too tall for direct measurement:
  - 1) Estimate the mid-point of the tree
  - 2) Measure the height from the base of the tree stem to the mid-point
  - 3) Multiply the measured height by two to obtain the height of the entire tree



## 2. RESULTS OF MONITORING



# Qualitative Observations

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- **Healthy soil biota**

- Aid in decomposition, excretion provide nutrients for the plants



- **Fungi observed**

- Breakdown leaf litter and facilitate nutrient recycling



# Qualitative Observations

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- Fauna observations



# Growth Results

*By species*

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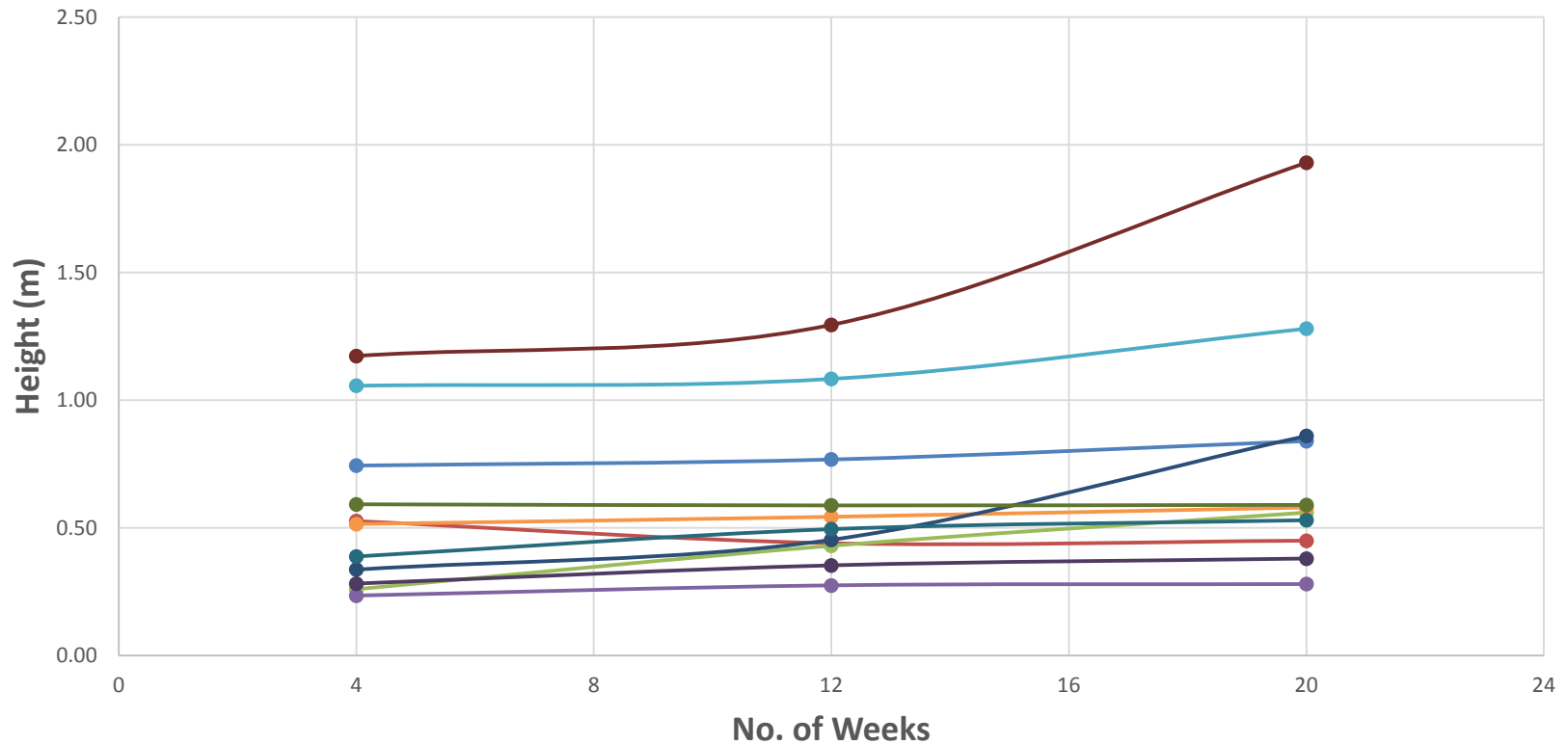
- Monitoring of growth of the species is done by plotting a **graph of height** (*averaged across individuals of a particular species*) **(m)** against **time (no. of weeks)**
  - Data points from Weeks 8 and 16 were observed to be anomalous, causing the heights to fluctuate and hence were excluded from the analysis
- **Species are plotted and categorized according to their layers** (canopy, trees, sub-trees and shrubs)
  - As there are **51 species**, plotting them together in one graph is not ideal
  - Representing the species by their layers also allow the growth of similar types of trees/shrubs to be compared, giving a **more meaningful graphical representation**
- In general, there is a **gradual increasing trend** for the height of saplings against time from **Week 4 to Week 20**.



# Growth Results

*By species*

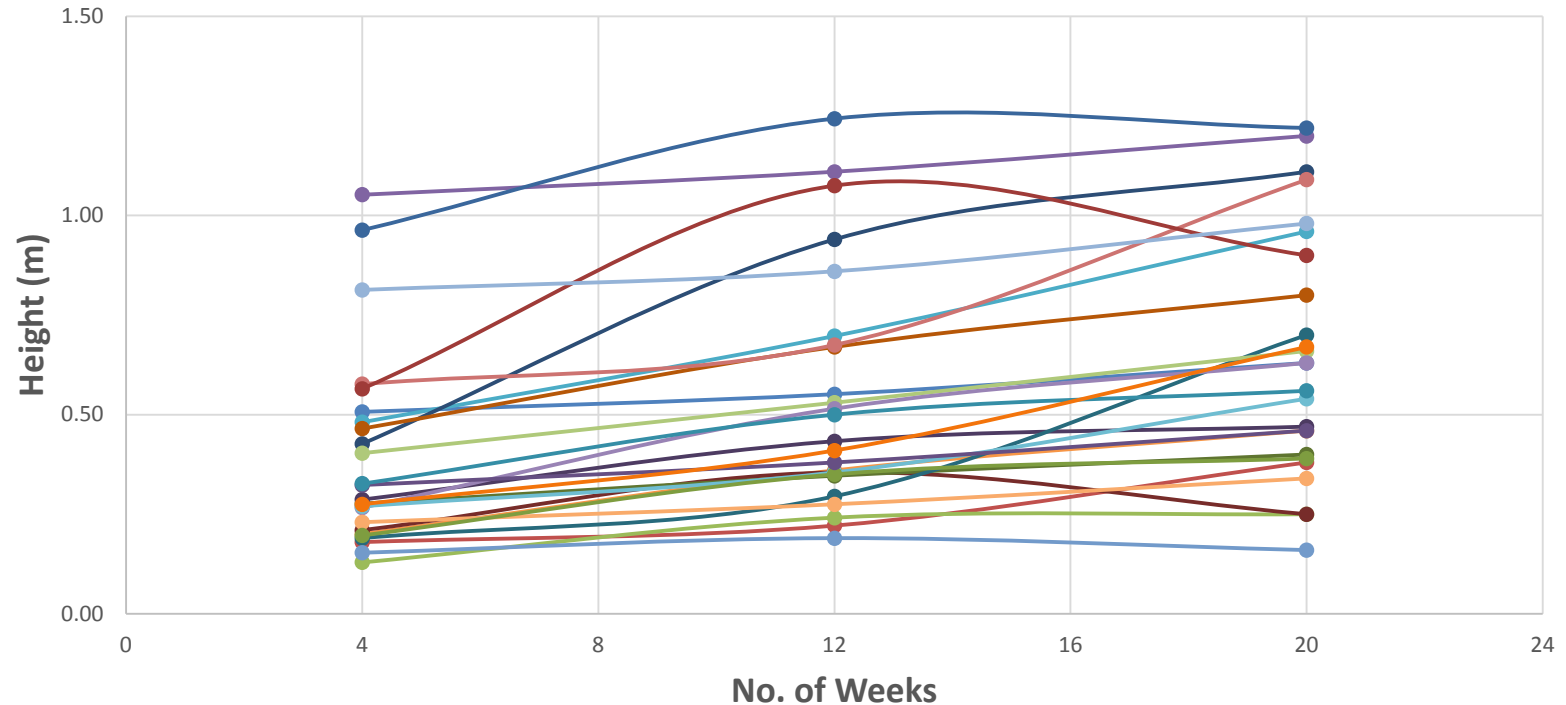
## Canopy



# Growth Results

*By species*

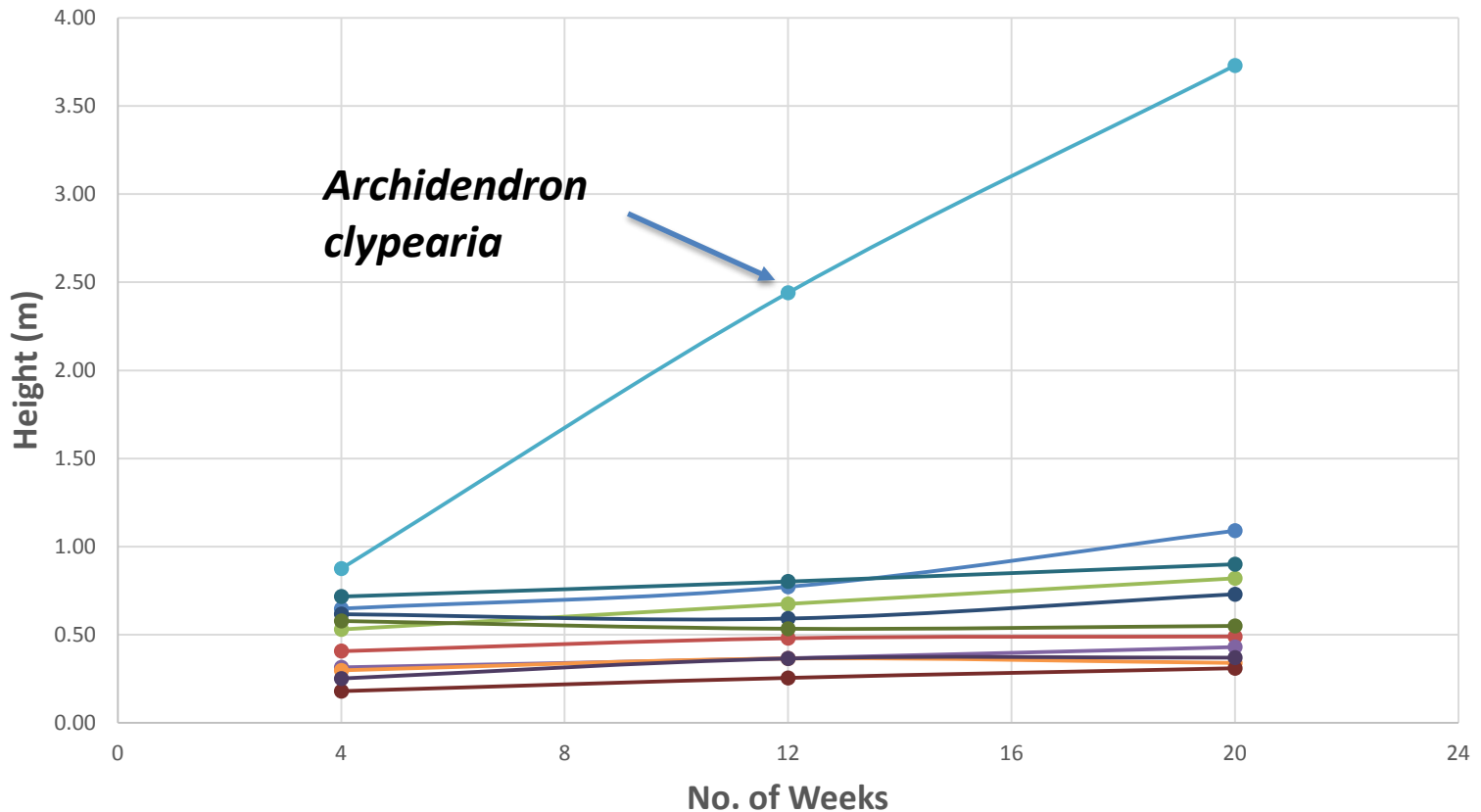
## Tree



# Growth Results

*By species*

## Sub-tree

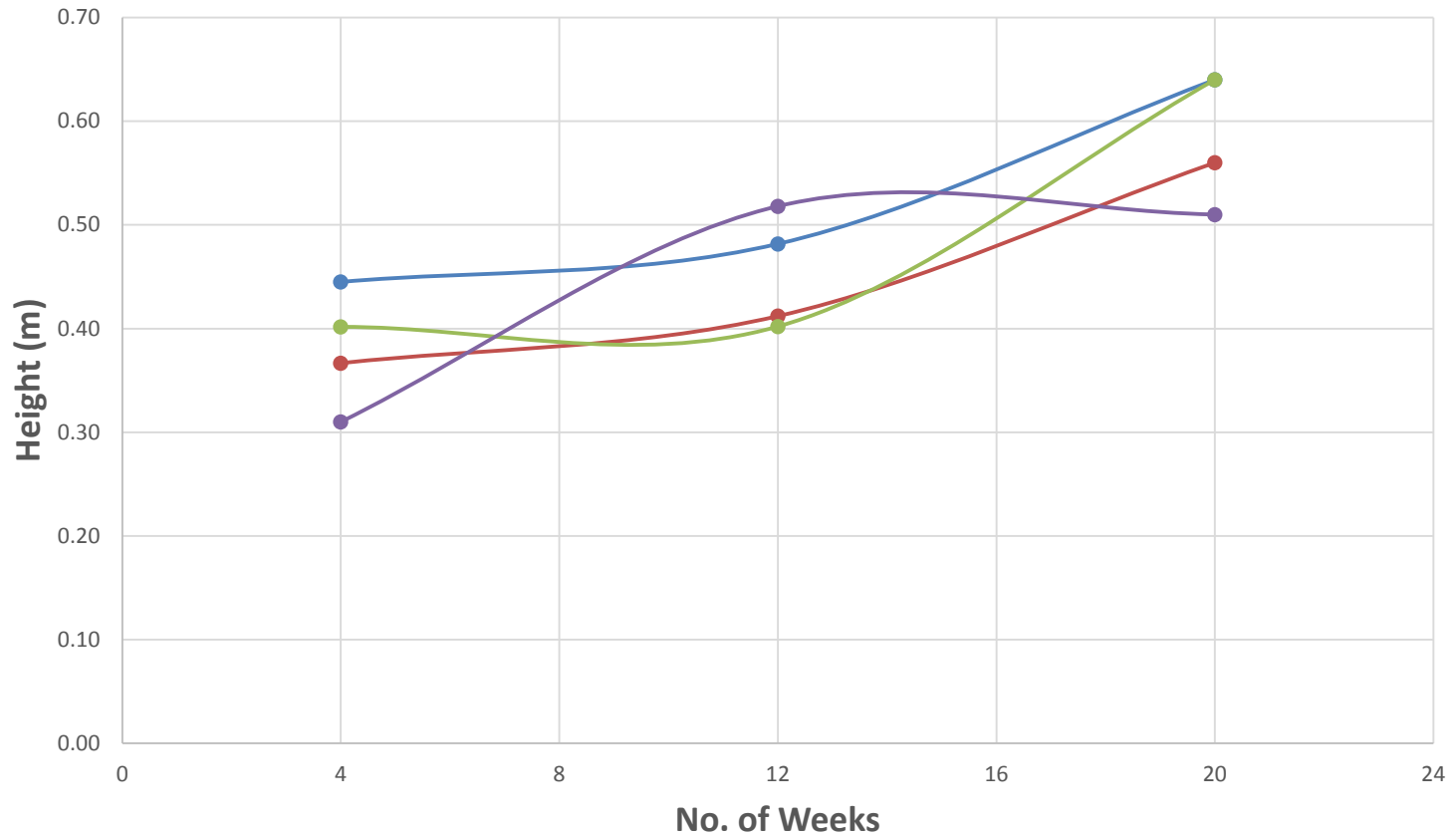




# Growth Results

*By species*

## Shrub



—●— *Suregada multiflora*    —●— *Ardisia elliptica*    —●— *Ardisia lanceolata*    —●— *Syzygium glaucum*

# Growth Results

*By species*

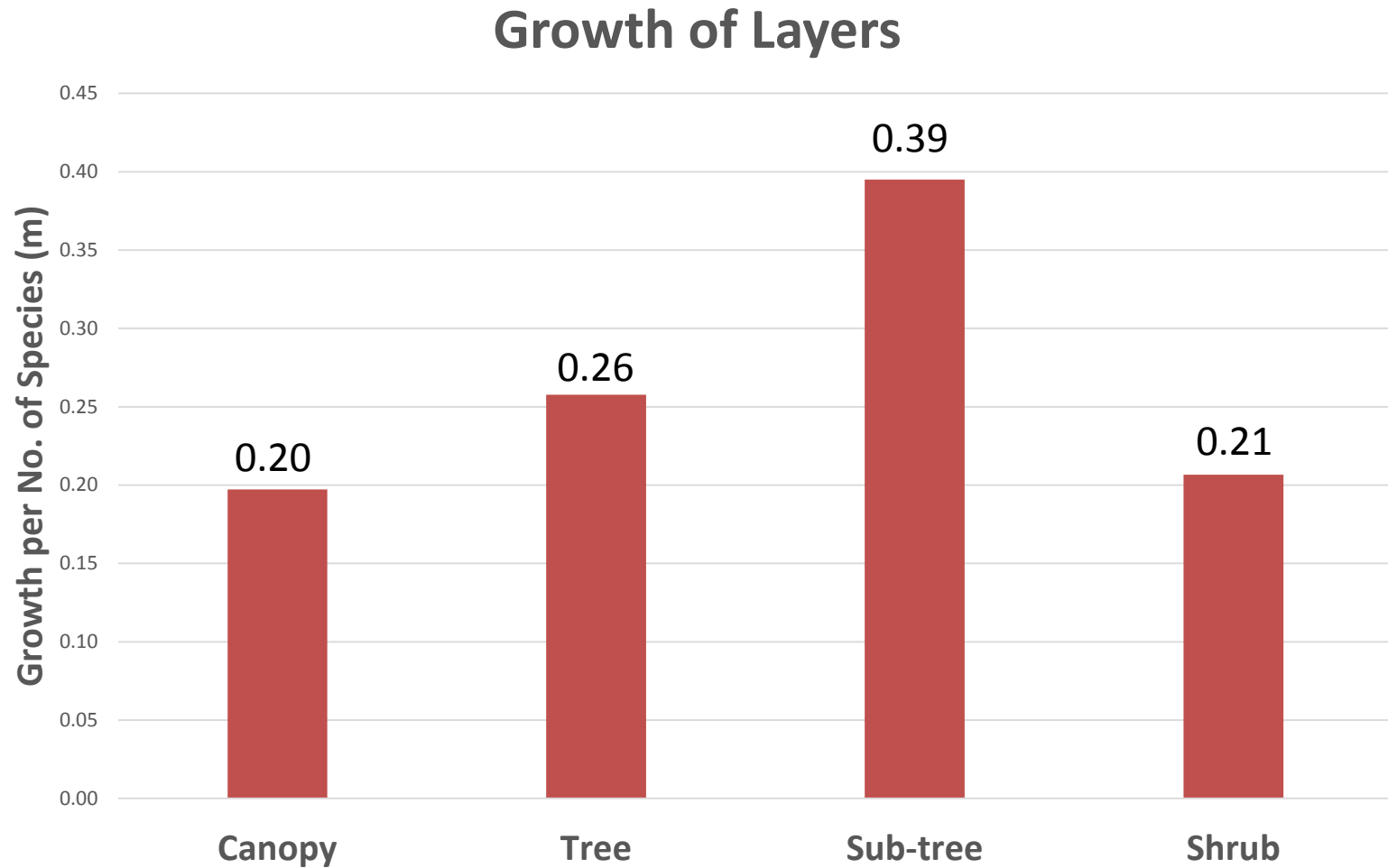
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Fall in height for some of the species could be due to the following reasons:

- 1) **Measurement of a taller individual** i.e. average height was taken, therefore the height shown on the graph could decrease when measurement of a taller was accidentally omitted during the monitoring session
- 2) **Human error in measurement**
  - Difficult to determine the stem height of some species
  - Communication of readings
- 3) **Dieback of plant**

# Growth Results

*By layer groups*





# Growth Results

*By layer groups*

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- Growth in terms of layer:  
**Sub-tree > Tree > Shrub > Canopy**
- **Growth per no. of species** was used to gauge the growth of the layers because each layer has a different number of species
- Expected for growth of canopy layer to be slow because the canopy species are generally late-successional species
- Expected for primary growth (i.e. height) of shrub species to be slow as well because shrub species tend to grow horizontally rather than vertically.



# 3. ANALYSIS AND RECOMMENDATIONS

# Recommendations

## Dipterocarps

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- What are Dipterocarps?
  - Giant trees with winged fruits that typically grow to 40m – 70m
  - Late-successional species
  - Slow-growing with long lifespan
- Why Dipterocarps?
  - Important element of primary forest
  - Contribute to emergent layer
  - Enhance structural complexity of the forest



Source:

<http://inspire.mongabay.com/news/2009/1216-dipterocarps.html>



# Recommendations

## Dipterocarps

- Some individuals of Dipterocarps are not doing well
  - Two individuals of *Shorea leprosula* do not seem to be growing poorly
  - One *Dipterocarpus grandiflorus* had failed several scratch tests and was considered to be dead (the only dead plant observed to date).
- Recommend growing 3 species of native dipterocarps listed below, which are the fastest growing dipterocarps tested by Shono *et al.* (2007)
  - *Dipterocarpus caudatus*
  - *Hopea nutans*
  - *Shorea acuminata*





# Recommendations

*Barringtonia racemosa*





# Recommendations

## *Barringtonia racemosa*

- Leaves of *Barringtonia racemosa* heavily damaged
- Food plant for the moth larvae of Atlas moth [*Gnathmoceroles tonsoria* & *Thosea andamanica*] (Wildsingapore, 2013), but no larvae observed on-site



# Recommendations

## *Barringtonia racemosa*

- *Barringtonia asiatica* also have leaves filled with holes
- Food plant for the moth larvae of *Dasychira* spp. & *Thyas honesta* (Wildsingapore, 2013), but no larvae observed on-site
- Problem may lie with genus of plant





# Recommendations

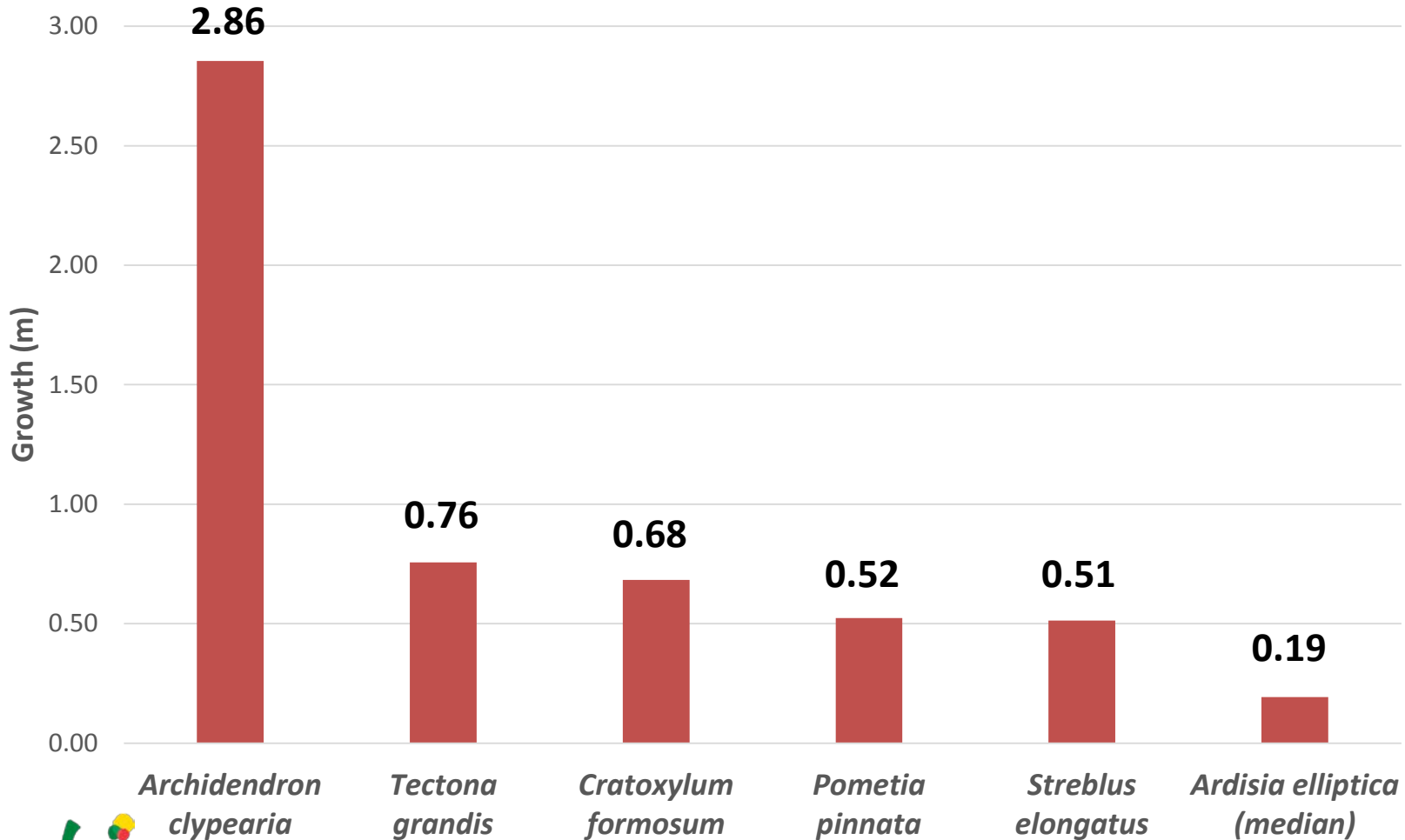
Genus *Barringtonia*

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- Suspected to be prone to infestation; requires further monitoring to determine if plant defense mechanism is able to withstand the insect attacks
- Coastal plant; better to plant trees that are found in the inland forests that can provide suitable food sources for the forest fauna instead
- To consider removal of plants from the genus *Barringtonia* for future planting

# Top 5 Fastest Growing Species

(Week 4 to Week 20)



# Top 5 Fastest Growing Species

## 1. *Archidendron clypearia*

- Small tree with alternate compound leaves.
- Small, white flowers produced in an inflorescence.
- Flat orange or red pods produced with black ellipsoidal seeds inside.
- Common in secondary forests and open country.



Source: <http://lkcnmh.nus.edu.sg/dna/organisms/details/351>



Source: <http://lkcnmh.nus.edu.sg/dna/organisms/details/351>

# Top 5 Fastest Growing Species

**1. *Archidendron clypearia*** (legume): the fastest growing species and also holds the record of the tallest individual in the plot at 4 meters





# Top 5 Fastest Growing Species

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## 2. *Tectona grandis*

- One of three species of teak.
- Large, deciduous tree.
- Valued for durability and water resistance.
- Can survive and grow in wide range of climatic conditions.
- Fed on by teak defoliators e.g. *Hyblaea puera* (pest species)



***Hyblaea puera*** (teak defoliator) – Dead individual observed on 3 Aug 2016, visible black and orange yellow underwings under brown forewings.

# Top 5 Fastest Growing Species

## 3. *Cratoxylum formosum*

- Species of flowering plant.
- Commercial name in timber is "mampat".
- Has pink flowers and can grow up to 20m.
- Found in open, disturbed and secondary forests, and forest gaps.



Source: <https://floraofsingapore.wordpress.com/2010/03/26/cratoxylum-formosum/>



Source: <https://floraofsingapore.wordpress.com/2010/03/26/cratoxylum-formosum/>

# Top 5 Fastest Growing Species

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## 4. *Pometia pinnata*

- Large tropical hardwood and fruit tree species.
- Grow up to tall canopy trees of 40m.
- Pinnate leaves and green, yellow or dark red edible fruits.



Source:  
[http://www.pngplants.org/PNGtrees/TreeDescriptions/Pometia\\_pinnata\\_J\\_R\\_Forster\\_&\\_G\\_Forster\\_0318.html](http://www.pngplants.org/PNGtrees/TreeDescriptions/Pometia_pinnata_J_R_Forster_&_G_Forster_0318.html)



Source: <https://www.pinterest.com/pin/375206212681016375/>



# Top 5 Fastest Growing Species

## 5. *Streblus elongatus*

- Big, busy evergreen tree that grows to about 12m but can reach 30m in the forest.
- Leaves are thin, leathery, drooping and yellowish green.
- Fruits are round and enclosed in the base of the flower.
- Has an ecological role: Ripe fruits are sweet and are eaten by squirrels, monkeys and birds. Long-tailed macaques are also known to feed on the leaves of this tree.



Source: <http://lknhm.nus.edu.sg/dna/organisms/details/338>



Source: <https://www.nparks.gov.sg/activities/family-time-with-nature/recommended-activities/roads-and-places-named-after-trees>



# Recommendations

## Legumes

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- Why Legumes?
  - **Framework species**; accelerate forest growth
  - **Fertilises the soil**; root nodules of many legumes have symbiotic nitrogen-fixing bacteria (legumes are used for crop-rotation for agriculture practices to enrich the soil)
  - Recommended to have legumes in the plot to supplement nutrient cycling because the **Afforestt method does not rely on regular fertilization** (i.e. only soil enhancement and mulching at the outset)

# Recommendations

## Legumes

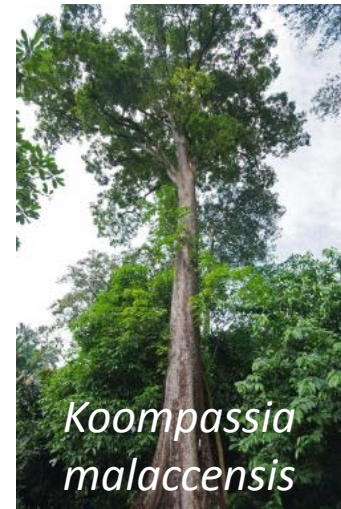
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Recommendations according to Shono *et al.* (2007)

- ***Parkia speciosa*** (tree layer)
  - has the fastest growing width and height out of the 45 species of plant tested in this study
- ***Koompassia malaccensis*** (canopy layer)
  - a common reforested species in CCNR and Bukit Batok Nature Park, also shows promise with steady annual growth rate



Source:  
<https://www.flickr.com/photos/7493476@N04/2572755241>



Source:  
<https://www.pinterest.com/pin/320037117244827521/>

# Recommendations

## Figs

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- **Framework species;** accelerate forest growth
- **Important food source for birds**
- The convolutions of the trunk and the complexity of the aerial roots forms a **'mini-ecosystem'**
- Roots of fig tree capable of breaking apart compacted soils **allowing water and oxygen to penetrate into subsoil**
- The framework species method suggests that **about 20% of planted seedlings should be fig species** (Elliott *et al.* 1998)



***Ficus benjamina***

Source:

<http://www.besgroup.org/2014/02/21/trees-for-birds-1-ficus-benjamina-weeping-fig/>



## 4. NEXT STEPS



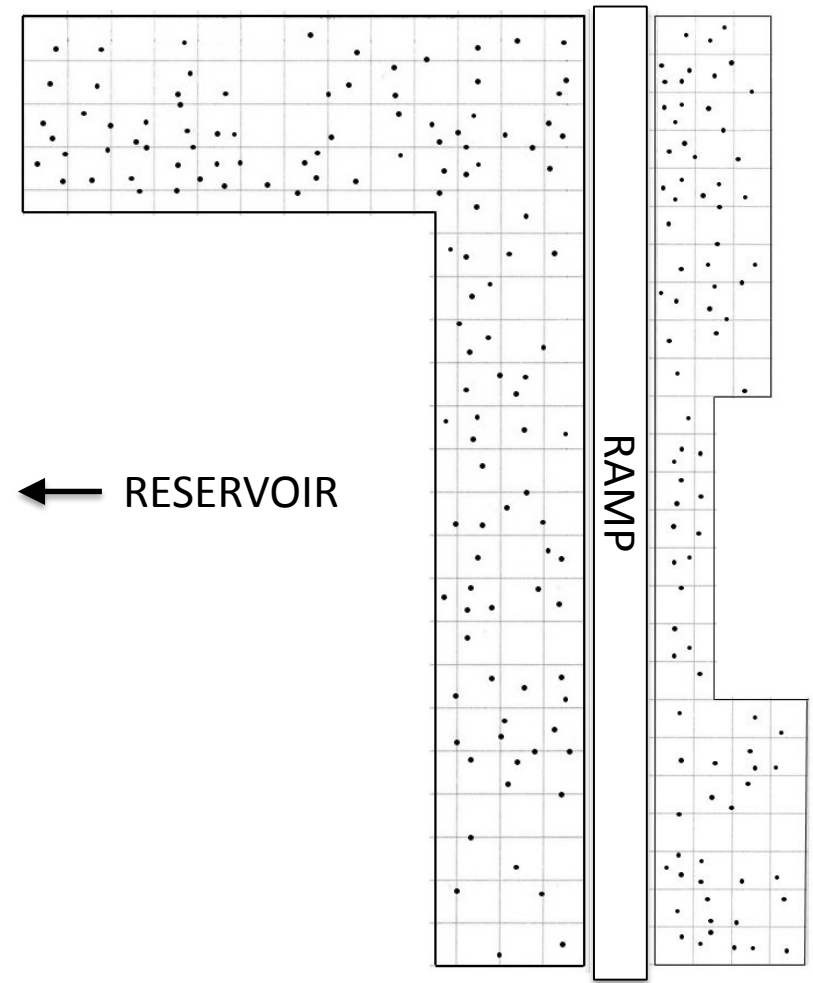
# Next Steps

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- Monitoring to continue once per month
- **Standardize monitoring method** across our team and WRS
  - **To measure height of fast-growing species**  
i.e. mid-point method

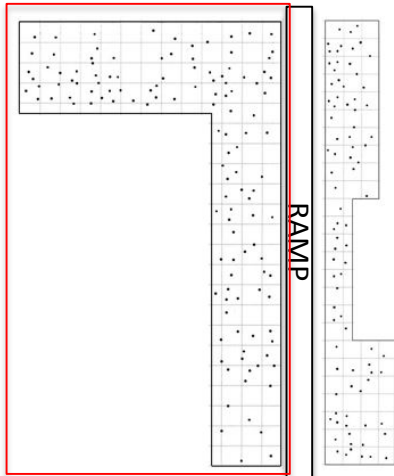
# Next Steps

- Potential analysis through **visual representation** of saplings on map to identify any localized external factors that may affect growth rate, e.g. amount of sunlight
- For example to investigate the reasons for the dipterocarps to be doing poorly
  - Is it due to the amount of exposure to sunlight?

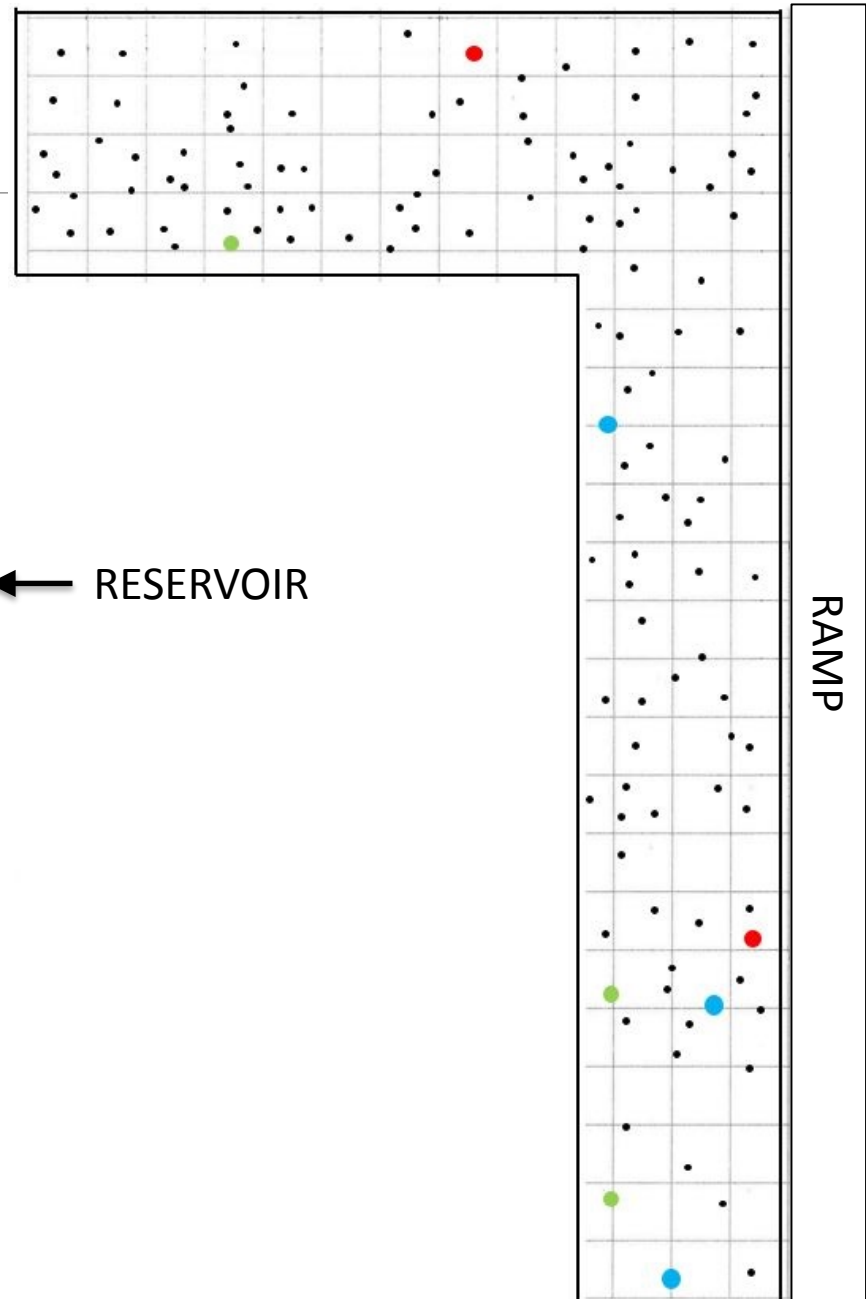


# Plot Map

## Dipterocarps



← RESERVOIR



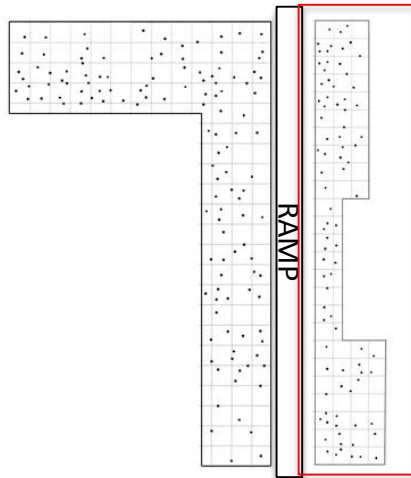
### Dipterocarps:

- - *Shorea leprosula*
- - *Neobalanocarpus heimii*
- - *Dipterocarpus grandiflorus*



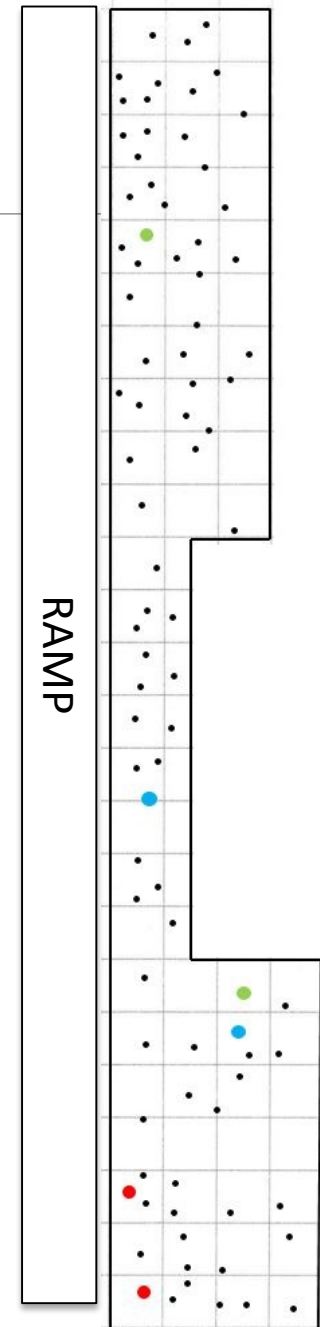
# Plot Map

## Dipterocarps



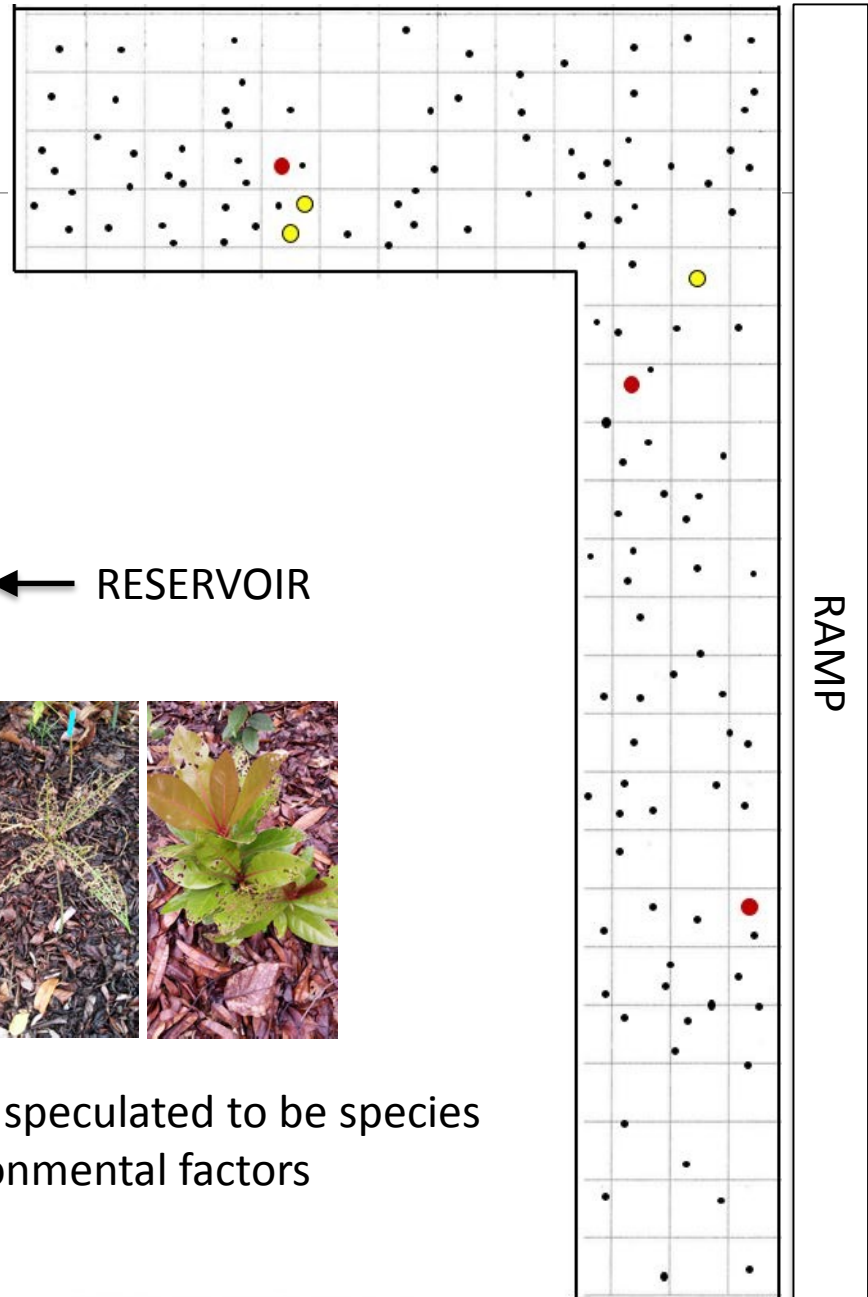
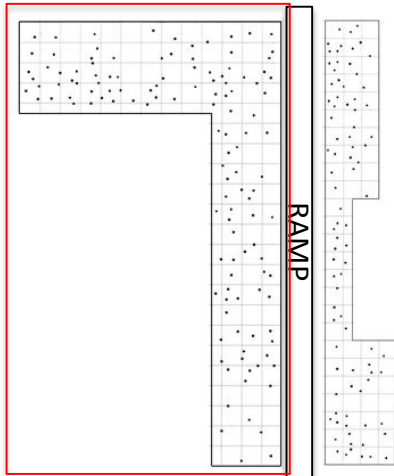
### Dipterocarps:

- - *Shorea leprosula*
- - *Neobalanocarpus heimii*
- - *Dipterocarpus grandiflorus*



# Plot Map

*Barringtonia* spp.



## Species with eaten leaves:

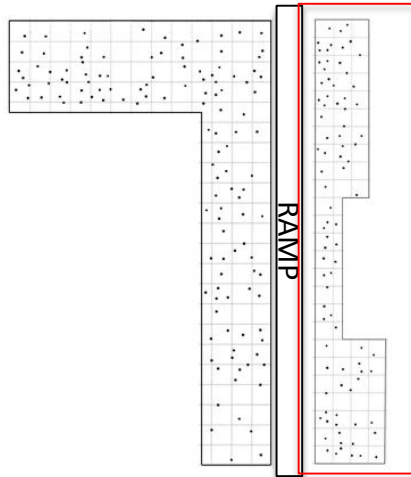
- - *Barringtonia racemosa*
- - *Barringtonia asiatica*



- Effects on species not localized – speculated to be species specific rather than due to environmental factors

# Plot Map

*Barringtonia* spp.



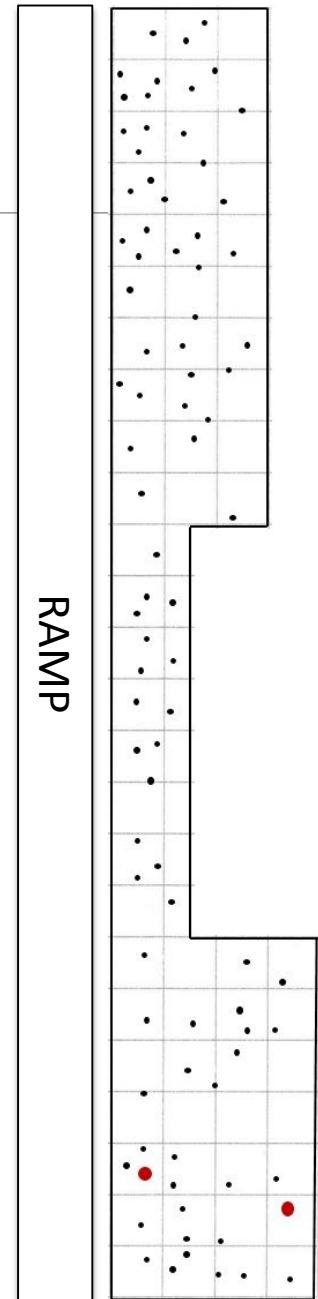
## Species with eaten leaves:

● - *Barringtonia racemosa*

● - *Barringtonia asiatica*



- Effects on species not localized – speculated to be species specific rather than due to environmental factors.
- In the long run, relationships between sapling growth and environmental factors may be more evident and conclusions can be drawn from these observations.





# Annex A: Species List

No.	Scientific Name	No.	Scientific Name
1	<i>Adinandra dumosa</i>	15	<i>Pouteria obovata</i>
2	<i>Alstonia angustiloba</i>	16	<i>Sandoricum koetjape</i>
3	<i>Aquilaria malaccensis</i>	17	<i>Alstonia angustifolia</i>
4	<i>Cratoxylum cochinchinense</i>	18	<i>Melaleuca cajuputti</i>
5	<i>Cratoxylum formosum</i>	19	<i>Diospyrus buxifolia</i>
6	<i>Dillenia indica</i>	20	<i>Shorea leprosula</i>
7	<i>Dillenia reticulata</i>	21	<i>Garcinia parvifolia</i>
8	<i>Dillenia suffruticosa</i>	22	<i>Sindora wallichii</i>
9	<i>Elaeocarpus mastersii</i>	23	<i>Barringtonia racemosa</i>
10	<i>Elateriospermum tapos</i>	24	<i>Sterculia parvifolia</i>
11	<i>Fagraea fragrans</i>	25	<i>Streblus elongatus</i>
12	<i>Koompasia excelsa</i>	26	<i>Suregada multiflora</i>
13	<i>Artocarpus elasticus</i>	27	<i>Syzygium grande</i>
14	<i>Pometia pinnata</i>	28	<i>Syzygium polyanthum</i>

# Annex A: Species List

No.	Scientific Name	No.	Scientific Name
29	<i>Syzygium zeylanicum</i>	43	<i>Eurycoma longifolia</i>
30	<i>Tectona grandis</i>	44	<i>Cratoxylum maingayi</i>
31	<i>Syzygium lineatum</i>	45	<i>Barringtonia asiatica</i>
32	<i>Calophyllum soulattri</i>	46	<i>Gnetum gnemon</i>
33	<i>Archidendron clypearia</i>	47	<i>Cynometra ramiflora</i>
34	<i>Archidendron jiringa</i>	48	<i>Morinda citrifolia</i>
35	<i>Ardisia elliptica</i>	49	<i>Nephelium lappaceum</i>
36	<i>Ardisia lanceolata</i>	50	<i>Calophyllum inophyllum</i>
37	<i>Millettia pinnata</i>	51	<i>Ficus microcarpa</i>
38	<i>Baccaurea parviflora</i>		
39	<i>Syzygium glaucum</i>		
40	<i>Cinnamomum iners</i>		
41	<i>Dipterocarpus grandiflorus</i>		
42	<i>Neobalanocarpus heimii</i>		

# Annex B: References

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- Elliott, S., Anusarnsunthorn, V. & Blakesley, D. (1998). Forests for the Future: Growing and Planting Native Trees for Restoring Forest Ecosystems. Within Design Co. Ltd, Chiang Mai.
- Shono, K., Cadaweng, E., & Durst, P. (2007). Application of Assisted Natural Regeneration to Restore Degraded Tropical Forestlands. *Restoration Ecology*, 15(4), 620-626.  
<http://dx.doi.org/10.1111/j.1526-100x.2007.00274.x>



# Annex B: References

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- *Putat laut or Sea poison (Barringtonia asiatica) on the Shores of Singapore.* (2016). Wildsingapore.com. Retrieved 5 August 2016, from <http://www.wildsingapore.com/wildfacts/plants/coastal/barringtonia/asiatica.htm>
- *Putat sungei (Barringtonia racemosa) on the Shores of Singapore.* (2016). Wildsingapore.com. Retrieved 5 August 2016, from <http://www.wildsingapore.com/wildfacts/plants/coastal/barringtonia/racemosa.htm>



**Thank you**