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Advancing enhanced wood manufacturing industries in Laos and Australia

Luang Prabang Province Teak Inventory

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ບົດສະຫຼຸບຫຍໍ້

ອີງຕາມສະພາບໂດຍລວມແລ້ວ ປະເທດລາວ ຍັງຂາດຂໍ້ມູນທີ່ຊັດເຈນກ່ຽວກັບຄວາມເປັນຈິງຂອງການຂະຫຍາຍຕົວຂອງສວນປູກໄມ້ ເຊິ່ງເຮັດໃຫ້ການພັດທະນາວຽກງານສວນປູກມີຂໍ້ຈຳກັດ. ການພັດທະນາອົງຄວາມຮູ້ ແລະ ເງື່ອນໄຂສະພາບສວນປູກແມ່ນມີຄວາມຈຳເປັນໃນການສົ່ງເສີມການພັດທະນາດ້ານນະໂຍບາຍ ແລະ ຍຸດທະສາດທີ່ກ່ຽວຂ້ອງກັບວຽກງານດັ່ງກ່າວ ເພື່ອສະໜັບສະໜູນ ຂະບວນການຕັດສິນໃຈໃນຂົງເຂດອຸດສະຫະກຳ ແລະ ເປັນຂໍ້ມູນໃຫ້ແກ່ ລັດຖະບານ.

ສວນປູກໄມ້ຢູ່ ສປປ ລາວ ລວມມີຫຼາຍຊະນິດເຊັ່ນ: ໄມ້ອີກ, ໄມ້ກະຖິນ, ໄມ້ຢາງພາລາ, ໄມ້ສັກ ແລະ ຊະນິດໄມ້ທອງຖິ່ນອື່ນໆ. ແຕ່ພື້ນທີ່ສ່ວນໃຫຍ່ແມ່ນ ສວນໄມ້ຢາງພາລາ (*Hevea brasiliensis*), ໄມ້ຢາງພາລາຍັງບໍ່ທັນໄດ້ຮັບການນຳມາຜະລິດເປັນຜະລິດຕະພັນໄມ້ ເນື່ອງຈາກໄມ້ຍັງມີອາຍຸນ້ອຍ. ສຳລັບສ່ວນໄມ້ອີກ ແລະ ໄມ້ກະຖິນ ແມ່ນໄດ້ຮັບການລິເລີ່ມໂດຍຜ່ານໂຄງການທີ່ມີການຮ່ວມມືກັບຜູ້ລົງທຶນຕ່າງປະເທດ ຮ່ວມກັບລັດຖະບານ, ໂຄງການຮ່ວມ ຫຼື ຮ່ວມກັບເຈົ້າຂອງດິນທ້ອງຖິ່ນ (refer Smith et al. 2017) ແລະ ແຫຼ່ງທີ່ມາຂອງຂໍ້ມູນຈາກຜູ້ລົງທຶນ. ສຳລັບໄມ້ສັກ (*Tectona grandis*) ແມ່ນໄດ້ເລີ່ມປູກເປັນສວນຂະໜາດໜ້ອຍໂດຍປະຊາຊົນ ແລະ ທັງເປັນແຫຼ່ງສວນປູກໄມ້ເຊິ່ງໂຄງການນີ້ກຳລັງຊອກຫາວິທີແກ້ໄຂ ໂດຍລົ້ງໃສ່ກຸ່ມຜູ້ປູກຢູ່ແຂວງຫຼວງພະບາງ.

ສວນປູກໄມ້ສັກຢູ່ແຂວງຫຼວງພະບາງ ເຄີຍໄດ້ແຕ້ມອອກເປັນແຜນທີ່ ແລະ ຈຳແນກໂດຍ ໂຄງການ ACIAR, VALTIP2 (FST/2010/012); ລວມທັງໝົດມີຫຼາຍກ່ວາ 15,000 ເຮັກຕາ. ຈາກນັ້ນກໍໄດ້ມີການສືບຕໍ່ຕິດຕາມ ໃນປີ 2018 ເຫັນວ່າເນື້ອທີ່ໄດ້ເພີ່ມຂຶ້ນເປັນ 18,200 ເຮັກຕາ. ການສຳຫຼວດ ສ້າງແຜນທີສວນປູກໄມ້ສັກ ແມ່ນໄດ້ເລີ່ມແຕ່ ເດືອນ 11/2017-9/2018 ໄດ້ປະເມີນໃຫ້ເຫັນ ບໍລິມາດໄມ້ຢືນຕົ້ນທາງດ້ານຄວາມສູງການຄ້າ ໃນລະດັບແຂວງ. ບໍລິມາດໄມ້ທີ່ປະເມີນໄດ້ ສຳລັບແຂວງຫຼວງພະບາງແມ່ນ ມີຫຼາຍກວ່າ 570,000 ແມັດກ້ອນ. ແຕ່ບໍລິມາດໄມ້ສັກສ່ວນໃຫຍ່ແມ່ນເປັນໄມ້ຂະໜາດນ້ອຍ ທີ່ມີໜ້າຕ້ຽງຕ່ຳກວ່າ 10% ຂອງເນື້ອທີ່ໜ້າຕັດຂອງໄມ້ (30 ຊມ) ໃນລະດັບຄວາມສູງພຽງເອິກ. ແຕ່ຄຸນນະພາບຂອງໄມ້ແມ່ນມີລັກສະນະຄຸນນະພາບຕ່ຳ. ອີງຕາມຜົນຂອງການວິເຄາະ ສະແດງໃຫ້ເຫັນວ່າ ມີພຽງ 43% ຂອງບໍລິມາດໄມ້ເທົ່ານັ້ນ ທີ່ຖືກຈັດເຂົ້າໃນ ໄມ້ທ່ອນລະດັບເກດ A ຫຼື B ທີ່ມີຄຸນນະພາບດີ. ເຖິງວ່າ ຕົວເລກ 43% ຈະຄ້ອນຂ້າງຕ່ຳ ແຕ່ກໍເປັນທີເຂົ້າໃຈວ່າໄມ້ສ່ວນໃຫຍ່ແມ່ນມີຂະໜາດນ້ອຍ, ບໍ່ຮູ້ແຫຼ່ງທີ່ມາຂອງແກ່ນພັນ ແລະ ທັງໄດ້ຮັບການຈັດການຄຸ້ມຄອງຈາກຫຼາຍໆ ເຈົ້າຂອງທີ່ບໍ່ມີປະສົບການບຳລຸງຮັກສາສວນປູກ.

ການວິເຄາະພື້ນທີ່ໄດ້ດຳເນີນໄປ ເພື່ອຈຳແນກແຫຼ່ງສວນປູກໄມ້ສັກໃນພື້ນທີ່ ແລະ ປະເມີນຜົນກະທົບຕໍ່ກັບສວນປູກ ທີ່ເກີດຈາກ ການພັດທະນາໂຄງລ່າງພື້ນຖານຕົ້ນຕໍ.
ສ່ວນໃຫຍ່ແລ້ວຜົນກະທົບຈາກໂຄງການກໍ່ສ້າງໂຄງລ່າງພື້ນຖານແມ່ນມີພຽງເລັກນ້ອຍ
ແຕ່ສ່ວນໃຫຍ່ແມ່ນມາຈາກການກໍ່ສ້າງເຂື່ອນໄຟຟ້ານ້ຳ ຕົກທີ່ກຳລັງຈະຖືກສ້າງ.
ນອກຈາກນັ້ນກໍ່ແມ່ນການຂະຫຍາຍຕົວເມືອງຂອງເມືອງຫຼວງພະບາງ, ການຂະຫຍາຍຕາງໜ່າງເສັ້ນທາງ, ແລະ ສາຍສົ່ງ ແລະ ການນຳໃຊ້ທີ່ດິນທີ່ຖືກກົດດັນຈາກ ການພັດທະນາປະເທດຊາດຢ່າງວ່ອງໄວ. ແຕ່ເຖິງຢ່າງໃດກໍຕາມ ເນື້ອທີ່ສວນປູກຂອງໄມ້ສັກແມ່ນມີທ່າອ່ຽງເພີ່ມຂຶ້ນ, ສັງເກດເຫັນໄດ້ວ່າ ໄມ້ສັກຍັງເປັນໄມ້ທີ່ປະຊາຊົນ ແລະ ເຈົ້າຂອງທີ່ດິນ ໃຫ້ຄວາມສຳຄັນຕໍ່ກັບການນຳໃຊ້ທີ່ດິນ.

SUMMARY

The lack of precise information about the extent and nature of the plantation resource in Lao PDR is viewed as a constraint in development of the plantation sector as a whole. Improved knowledge of the extent and condition of plantations is needed to support the development of strategies and policies for the sector and to assist in government and industry decision making processes.

Plantations in Lao PDR include Eucalyptus, Acacia, Rubber, Teak and other indigenous species. While the main tree plantation species by area is rubber (*Hevea brasiliensis*), most rubber plantations do not have wood production as their primary use and are currently immature from the perspective of wood supply. Most Eucalyptus and Acacia plantations have been established through projects involving foreign investors in partnership with the government, as joint ventures, or with local landowners (refer Smith et al. 2017) and resource information is held by those investors. Teak (*Tectona grandis*) is grown in small plantations established by famers and it is this component of the plantation resource that this activity addresses, with a focus on Luang Prabang Province.

Plantation teak in Luang Prabang Province of Lao PDR was mapped and classified in ACIAR project VALTIP2 (FST/2010/012); over 15,000 ha were mapped. This study updated that mapping in 2018; finding over 18,200 ha. A field inventory of the mapped teak plantations was conducted from November 2017 to Sep 2018, to estimate a 'snapshot' of standing merchantable volumes at provincial level. Total merchantable volume of teak in Luang Prabang Province was estimated at over 570,000 m^3. However, the teak plantation resource is dominated by smaller size trees and less than 10% of the basal area is in trees over 30cm DBHob. Tree quality was found to be generally poor. Analysis of log mix shows only 43% of tree volume of as either A or B quality logs which are 'good quality' merchantable logs; 43% is low but not surprising given the resource is made up of a mostly small plantations, sourced from unknown seedstock, managed by many owners with little silvicultural experience.

Spatial analyses were performed to characterise the teak resource in the landscape and to estimate the impact of recent major infrastructure developments on the plantations. Impact on teak plantations of infrastructure project construction has been relatively minor and most of the direct impact will be from dams still to be constructed. More negative impact on teak plantations is likely to be caused by the current and ongoing expansion of Luang Prabang city, networks of roads and powerlines, and general land use pressures resulting from the rapid development of the nation as a whole. Nevertheless, the area of teak plantation is increasing, indicating that teak is still viewed as a beneficial land use by farmers and land holders.

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1. CONTEXT

This research originates from ACIAR project VALTIP3 *Advancing enhanced wood manufacturing industries in Laos and Australia* (VALTIP3), which is being undertaken jointly by Melbourne University, the National University of Laos Faculty of Forestry and Australian National University in collaboration with Lao partner organisations such as the Luang Prabang Teak Program, Department of Forestry and Ministry of Industry and Commerce.

Project research activity Objective 1 aims to identify the key elements of the policy, governance and administrative environment that constrain the development of plantation forests and plantation wood value chains in Lao PDR. It also aims to identify other constraints to improving plantation value chains, and to develop strategies for engaging with this environment. Activity 1.3 involves characterising the current plantation resource in Lao PDR, and assessment of options for modelling future wood supply. More specifically the activity aims to:

1. Expand the characterisation of teak plantation resources, building on the results of VALTIP2 project (FST/2010/012) through:
    a) GIS analysis of the area and geographical distribution of teak plantations in the landscape in Luang Prabang, and quantification of changes in the plantation area associated with major developments (see section
    b) Estimation of the standing volume of mapped teak plantations through field inventory and biometrics
    c) Evaluation of methods to quantify growth and yield of the teak resource using outputs from other sources
    d) Mapping the extent and structure of teak plantations, through training of PFS staff, in Xayaboury province using methods developed by FST/2010/012
    e) Testing the utility and reliability of other remote sensing imagery (some acquired under VALTIP2) for mapping teak in order to estimate temporal change and scale up into other provinces
2. Capture base information on corporate owned eucalypt plantations,
3. Researching methods for other significant plantation resources of potential benefit to future timber supply for domestic processing.

This report describes progress against the tasks 1.a) and 1. b).

2. METHODS

2.1. Objective

The objective of this research was to estimate the standing volume of merchantable log products of teak plantations in Luang Prabang Province with a precision ± 10% at 95% probability level.

2.2. Population

The area of teak plantations assessed in this study was the 15,000 hectares mapped by the VALTIP2 project (Map 1, see Boer and Seneanachack 2016), and updated for this project (refer Section 3.2).

The nine mapped size classes established in the VALTIP2 study were used as the initial stratification to plan the inventory in this activity (

Table 1). Reliably mapping the age class, which is typically done on the basis of tree size and crown size/features, was found to be difficult due to significant variation between plantations in their tree size at the same age. Size class was determined a more reliable and appropriate measure of the structure of plantations, and more relevant to industry, and as result this was used as the classification for the mapping.

Mapping classes were subsequently designed to:

- Cover the range of plantation size and structure.
- Be consistently identified and mapped.
- Provide for stratification for future volume inventory.

Dominant size class describes situations in which more than 50% of the basal area (BA) of the plantation has a diameter at breast height (dbh) range as specified. For classes 4, 5 and 6 this is not specified.

For partially stocked areas classes 1T, 2T, 3T describe stands where stocking is 60%-90% of a fully stocked plantation as a result of partial planting failure, competition with other growth or a result of partial harvests.

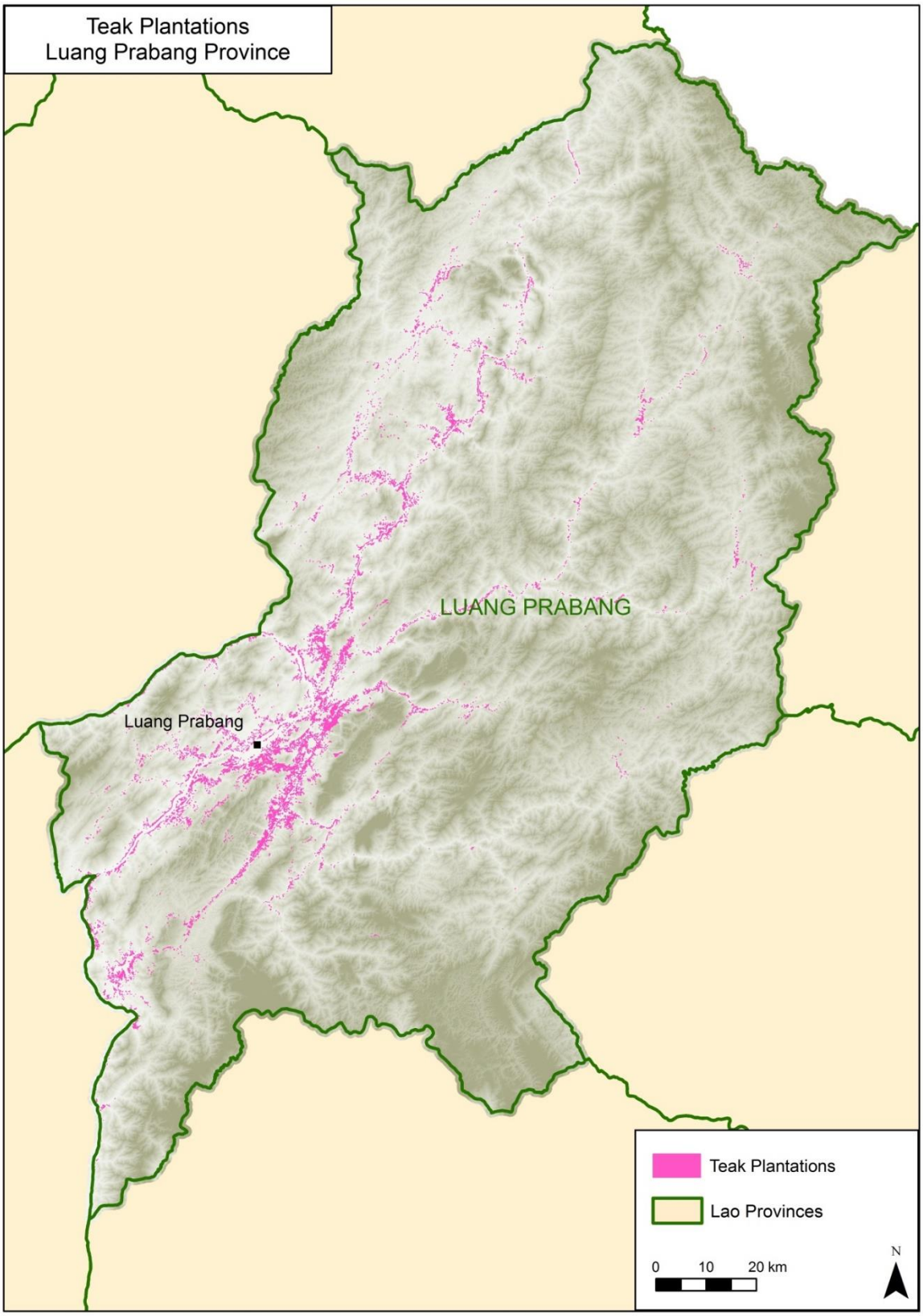
Class 4 describes areas where no dominant size class occurs and a mix of 2 or more size classes are found. This can be a result of adjacent small areas being planted at different times but more commonly by multiple partial harvests with subdominant trees and coppice growth occupying the gaps. This class can have variable stocking down to 60% of a fully stocked stand.

For partially stocked areas with 30%-60% of a fully stocked stand class 5 is used. Areas of <30% are not classed as plantation.

Table 1: Mapping Classification

Class	Dominant Size Class (dbh)	Class Description
1	< 15cm	Small, fully stocked
1T	< 15cm	Small, partially stocked
2	15-25cm	Intermediate, fully stocked
2T	15-25cm	Intermediate, partially stocked
3	> 25cm	Large, fully stocked
3T	> 25cm	Large, partially stocked
4	all	Mixed size
5	all	Partial plantation
6	all	Possible plantation

Map 1: Teak Plantations in Luang Prabang Province, mapped under VALTIP2



2.3. Sampling Design

A double sampling method was employed where all plots were measured in recording whole tree parameters and characteristics. A subsample of 20% were randomly selected in which additional estimates of log type and dimension within trees >20cm diameter at breast height over bark (DBHob) were included. The relationship between whole tree quality and log volumes was used to extrapolate log volume estimates across all plots.

The total number of plots was estimated from the desired precision, estimates of plot measurement productivity and constraints of budget and project limitations. Plots per stratum were proportional to stratum area with weighting for expected standing merchantable volume. Strata of smaller size class had lower weighting and strata of larger size classes had higher weighting so that more plots were in higher volume areas, increasing the precision of the estimate of standing merchantable volume. A total of 500 plots was estimated to be required and achievable. An extra 20% of plots were included to cater for inaccessibility, updating of the teak mapping and additional plots if time and resources permitted. 568 plots were measured and used in final dataset with 101 of those plots in the second stage subsample.

Initial testing of plot size found that 0.03 ha was a suitable size to capture between 15 – 40 trees/plot for most plots. Circular, fixed area 0.03 ha plot size was used for all plots.

Plot navigation used a GIS locality map and a GPS loaded with plot locations as waypoints. The locality map was used for navigation to within 1-2 km of a plot and then the GPS was used for final plot location.

For the plot measurement method see Appendix 1.

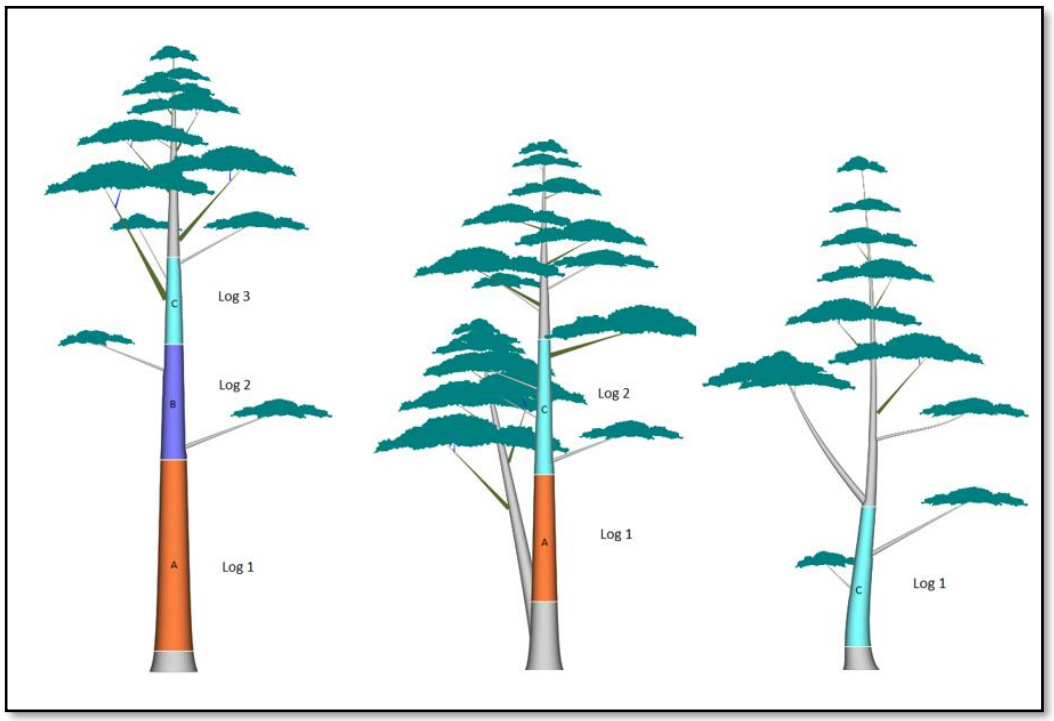
2.4. Training and teamwork

Luang Prabang Teak Program (LPTP) and Provincial Forest Section provided 4 staff for inventory measurement and coordination. Training in inventory techniques was conducted in November 2017 and included methods for plot location, tree measurement, tree quality assessment, GPS and Vertex hypsometer use. Training in log estimation and measurement for second stage plots was conducted in February 2018. The plot measurement program and team logistics was managed by the LPTP team. The measurement program concluded on time in May 2018, under budget and with 68 extra plots measured.

2.5. Tree quality and log volumation

All teak trees were assessed for whole tree quality and assigned one of three classes. From the 101 Stage 2 plots the tree quality codes and estimated log types and dimensions were used to estimate proportions of log types across all teak trees > 20cm DBHob. Log types were based on Luang Prabang Teak Program (LPTP) Production and Marketing SOP3 – Measuring and Grading Logs (Figure 1). Log types were estimated in the standing tree with start height and end height recorded.

Figure 1: Log type assessment in standing trees



2.6. Allometrics

Volume, taper and bark thickness equations were sourced from the most locally appropriate studies. The tree volume and bark thickness equation are derived from Luang Prabang plantations and are relatively simple (Dieters and McNamara 2010). The taper equation used was developed for teak plantations in northern Thailand (Warner et al 2016) and is a more complex, cubic polynomial function with hyperbolic and parabolic terms.

The Height - Diameter equation was calculated from the inventory data itself, using measured height trees in each plot. Best fit was Chapman Richards function with r = 0.7745.

$$Ht = 23.6155\ (1-\exp(-0.1324DBHob)^{3.0176}$$

Where *Ht* is predicted tree height in metres, *DBHob* is diameter at breast height over bark in centimetres.

Tree height was measured for 2-3 codominant teak trees per plot as well as all trees measured for log details. The equation was used to estimate tree height for all remaining teak trees based on their diameter and indexed by the plot predominant height by the ratio of actual : predicted predominant height.

Tree volume equation for plantation teak in Luang Prabang - equation 2 from Dieters and McNamara 2010.

$$Vol = 0.432\ \pi\ (DBHob/200)^2\ Ht$$

where *Vol* is tree volume in cubic metres, *DBHob* is diameter at breast height over bark in centimetres, *Ht* is tree height in metres.

Bark thickness equation was from from Dieters and McNamara 2010.

$$Bt = 0.0266\ DBHob + 0.2399$$

Where *Bt* is single bark thickness in centimetres and *DBHob* is diameter at breast height over bark in centimetres.

Taper equation from northern Thailand plantation teak (Warner et al, 2016). Equation 'FIO – teak1'

$$dob = (Ht-h)\ [0.59256\ Ht\ 0.40079(1.3-h) / (1.823004\ (1+0.63308\ h)\ (1+0.63308Ht)) + (0.77715/Ht + 0.012398(DbHob/10) - 0.0027653(DBHob/10)^2(h-1.3) + DBHob/(Ht-1.3)]$$

Where *dob* is diameter over bark in centimetres at height *h* in metres, *Ht* is tree height in metres and DBHob is diameter at breast height under bark in centimetres.

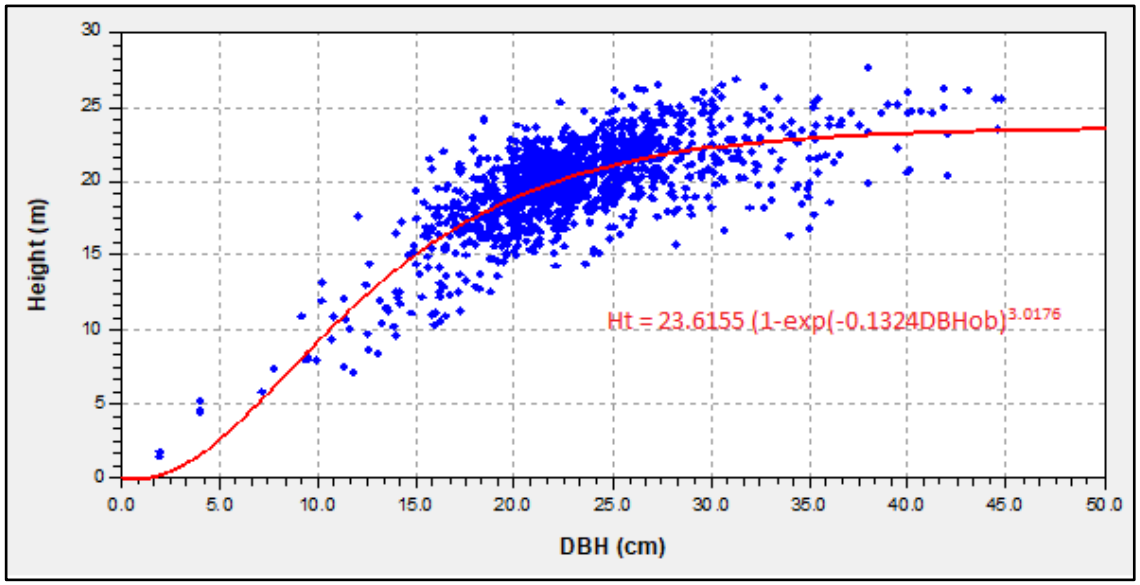
The taper equation was used to estimate diameter at intervals up trees assessed for log products in Stage 2 sample allowing log volumes to be estimated.

Log volume was calculated using Smalian's equation.

$$Lvol = ((LED + SED)/400)^2\ \pi\ Le$$

Where *Lvol* is log volume in cubic metres, *LED* is log large end diameter over bark in centimetres, *SED* is log small end diameter over bark in centimetres and *Le* is log length in metres.

Figure 2: Tree Height – Diameter



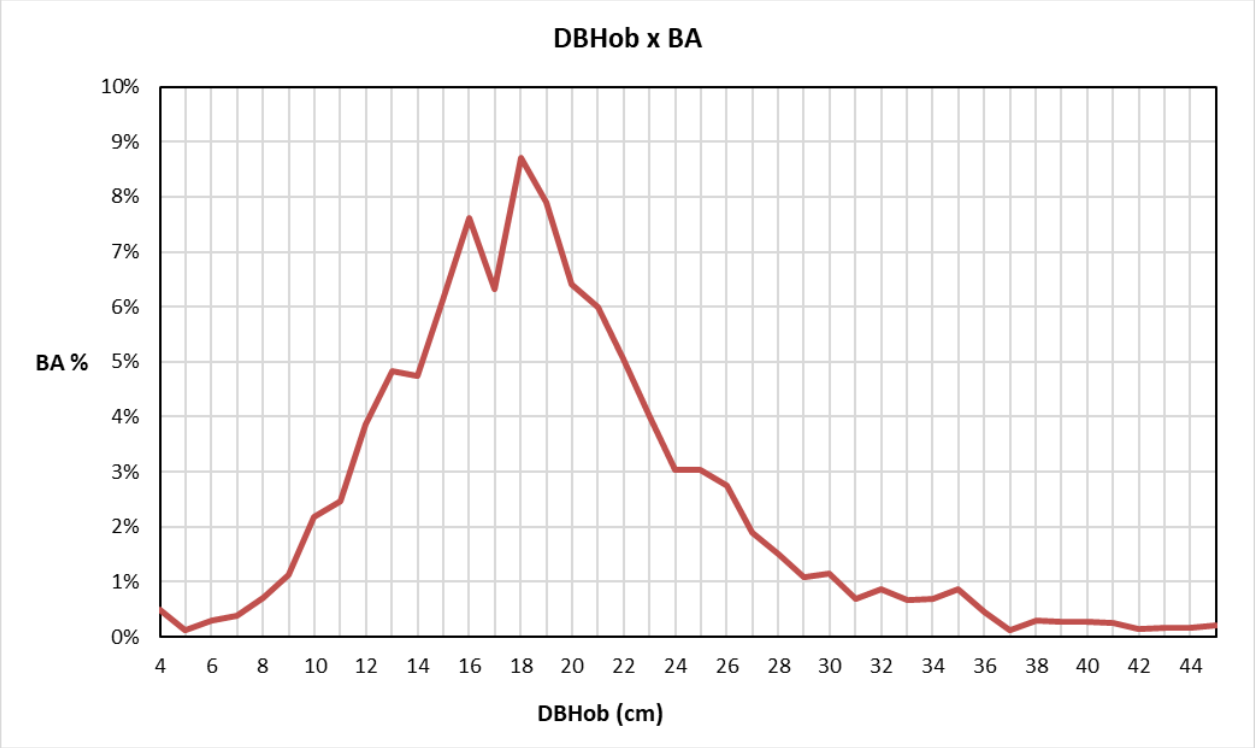
Whole tree volume was calculated using DBHob and height and the above tree volume equation.

For trees with log measurement details from Stage 2 plots the LED and SED were estimated using the taper equation and log start and end heights. Log volumes were calculated using Smalian's equation. Average log volumes were calculated for each tree quality. The proportions of log volumes in each tree quality were consistent across the diameter range.

3. RESULTS

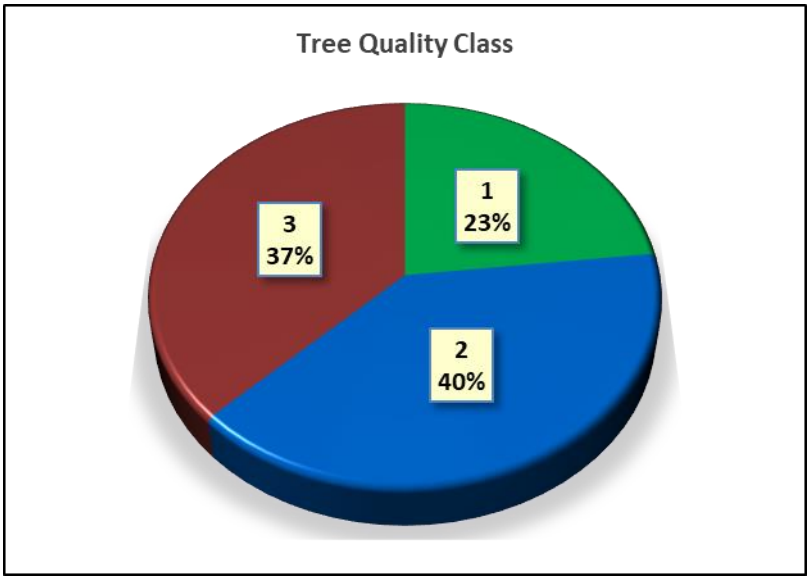
The teak plantation resource is dominated by smaller size trees with the median DBHob of 18cm. 50% of the tree basal area is between 14.5 and 21.5cm DBHob and less than 10% basal area is in trees over 30cm DBHob.

Figure 3: Diameter distribution for all plots



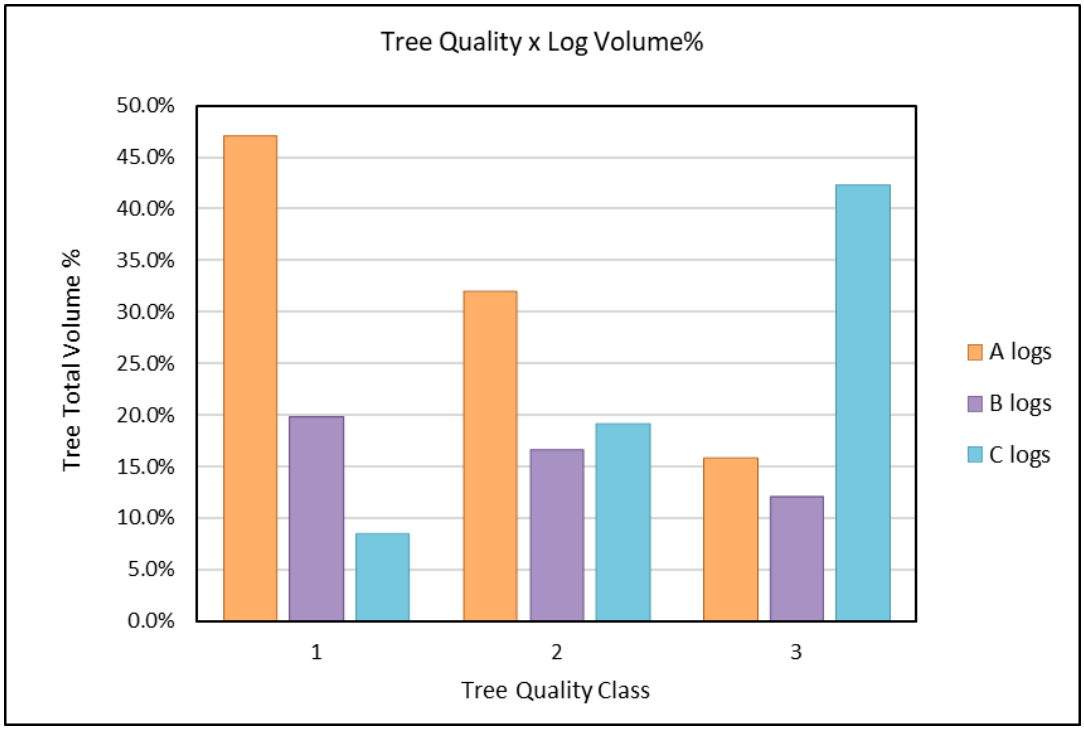
Tree quality was generally poor with 37% of tree volume in class 3 - trees with less than 25% of the bole straight and clear of defects and only 23% in class 1 - trees with > 50% of the bole straight and clear of defects.

Figure 4: Tree Quality class x Tree volume



Log volumation relied on the proportions of A, B and C class logs estimated in trees > 20cm DBHob in the 101 Stage 2 plots. Log volume proportions per tree quality were calculated by linear regression.

Figure 5: Tree Quality and Log Volume Proportions



Log volume proportions were calculated as ratios of tree total volume for each tree quality. These proportions were then used used to estimate log volumes for all trees > 20cm DBHob in Stage 1 plots.

3.1. Statistics for double sampling

Analysis of log mix for trees > 20cm DBHob shows 43% of tree volume of as either A or B quality. A and B logs are the desirable logs that will sell, whilst C logs are more optional and if able to be sold will go to lower value products. 43% of A and B log quality is low but not surprising given the resource is made up of a mostly small plantations, sourced from unknown seedstock, managed by many owners with little silvicultural experience.

Table 2: Log volume % for merchantable sized trees

Log Grade	% of Total Vol
A	28%
B	15%
C	28%
Total Tree	**100%**

Log sizes are generally small, as would be expected in standing volume assessment. Log 1, or butt log contains almost two thirds of the merchantable volume and almost all the A logs are to be found in these log.

Table 3: Log Mean Size and Lengths

Log No	Log Grade	Mean LED	Mean SED	Mean Length	% of Merch Vol
1	A	26.8	20.3	3.6	36.8%
1	B	25.7	20.1	3.1	8.2%
1	C	27.2	15.5	8.6	19.8%
1 Total		26.7	19.4	4.4	64.8%
2	A	22.6	20.0	3.4	2.1%
2	B	20.2	18.2	3.0	13.2%
2	C	19.5	17.0	3.6	11.9%
2 Total		20.1	17.8	3.3	27.2%
3	B	20.7	17.3	3.7	0.5%
3	C	18.2	15.8	2.9	7.5%
3 Total		18.3	15.8	2.9	8.0%
Grand Total		22.9	18.3	3.7	100.0%

3.2. Teak Mapping Update

At the time of inventory, the VALTIP2 mapping was based on imagery five years old. Google earth was investigated and found to have suitable, more recent imagery over most of the teak plantations in the province. The opportunity was taken to update the mapping however this was not possible prior to the inventory field measurement. The mapping was done concurrently with but independent of the plot measurement.

Table 4: Teak mapping update 2018

Google Earth Date	Area (ha.)	Area %
No Update	3,038	17%
2016	5,822	32%
2017	6,202	34%
2018	3,150	17%
Total	**18,211**	

The total area of teak mapped was 18,211 ha compared to 15, 340 ha mapped from the 2013 imagery. 83% of the area was updated from imagery from October 2016 or later. The mapping update resulted in 42 plots falling outside the teak plantation area which were not used in the inventory calculations.

3.3. Post Stratification

Stratification was revised after measurement and remapping of teak. Initial strata based on mapped teak class were tested to see if they were significantly different as to their plot merchantable volume using pairwise t tests as well as Mann-Whitney tests for non-parametric samples. Both tests showed non-significant differences for the same initial strata. Strata not significantly different were amalgamated. Initial strata 3 and 3T were further investigated. The statistical tests show them to be close to non-significance and combined their small

areal extent they have been combined for practical purposes. The difference in estimated volume is < 0.2% for the combined strata

Table 5: Stratification testing initial strata. Pairwise t test.

Mapped Teak Class	Mapped Teak Class	p-value	Mean	Significant
1	1T	0.0001	7.949843	yes
1	2	0.0000	31.70854	yes
1	2T	0.0000	32.21054	yes
1	3	0.0000	92.3052	yes
1	3T	0.0000	68.98671	yes
1	4	0.0000	24.6937	yes
1	5	0.1872	5.791065	no
1T	2	0.0000	39.65838	yes
1T	2T	0.0000	40.16038	yes
1T	3	0.0000	100.255	yes
1T	3T	0.0000	76.93655	yes
1T	4	0.0000	32.64354	yes
1T	5	0.0036	13.74091	yes
2	2T	0.9145	0.501998	no
2	3	0.0000	60.59667	yes
2	3T	0.0000	37.27817	yes
2	4	0.0711	7.01484	no
2	5	0.0000	25.91747	yes
2T	3	0.0000	60.09467	yes
2T	3T	0.0000	36.77617	yes
2T	4	0.1498	7.516838	no
2T	5	0.0000	26.41947	yes
3	3T	0.0310	23.3185	yes
3	4	0.0000	67.61151	yes
3	5	0.0000	86.51414	yes
3T	4	0.0000	44.29301	yes
3T	5	0.0000	63.19564	yes
4	5	0.0006	18.90263	yes

Almost half the area (46%) is in strata S3 whose mapped teak classes correlate well with the diameter profile as shown in Figure 3. More than 94% of the area is in strata 1, 2 and 3 highlighting the small size of most of the teak resource.

Table 6: Final stratification

Strata	Mapped Teak Class	Area (ha)	No. of Plots	Average Merch. Volume (m^3/ha)
S1	1T	2,407	33	4.8
S2	1, 5	6,447	140	14.0
S3	2, 2T, 4	8,332	315	45.5
S4	3, 3T	1,026	80	100.9
Totals		18,211	568	32.1

3.4. Standing Volume Estimates

Strata S4 is the most mature strata with more than half the basal area in trees > 25cm DBHob; it represents only 5.6% of the area but make up 17.6% of the merchantable volume with an average LED of logs of 26cm.

Stratum S3 is the largest stratum with 46% of the area and 65% of the standing merchantable volume. Most of the volume is in smaller logs with an average large end diameter of logs of 22cm. Strata S2 and S3 do contain some larger trees, reflecting the mixed sizes of trees found in of many of the plantation areas.

Table 7: Strata average volumes (m^3/ha)

Strata	A log	B log	C log	Merch. (A+B+C)	Total
S1	1.8	1.2	1.9	4.9	53.8
S2	5.8	2.9	5.1	13.8	94.3
S3	18.4	10.0	16.4	44.8	126.7
S4	39.5	20.6	37.2	97.3	169.4
All	**13.0**	**6.9**	**11.6**	**31.5**	**108.0**

Table 8: Strata Total Volumes (m^3)

Strata	Area (ha)	A log	B log	C log	Merch. (A+B+C)	Conf. Int. ±	Total	Conf. Int. ±
S1	2,407	4,385	2,883	4,565	11,832	7,133	129,430	38,518
S2	6,447	37,714	18,643	32,769	89,126	17,188	607,892	52,727
S3	8,332	153,652	83,036	136,262	372,951	28,770	1,055,305	55,752
S4	1,026	40,534	21,148	38,154	99,802	11,882	173,755	19,047
Totals	**18,211**	**236,285**	**125,711**	**211,750**	**573,711**	**35,313**	**1,966,380**	**85,555**

3.5. Errors and Precision

3.5.1. Non-Sampling Errors

Non sampling error sources were identified as location error, measurement error, measurement bias. Mitigation or minimisation of these errors was implemented through:

- Method development and testing. Keeping methods as simple and targeted as possible reduces opportunity for error
- Training and supervision of measurement crews
- Equipment testing and calibration
- Auditing, error checking and correction

Errors from direct measurement and equipment use can be minimised with training in correct techniques. Errors from measurement bias, particularly for assessments or estimates of tree characteristics not able to be directly measured (tree quality or log type in standing tree), are more difficult to minimise. Consistency amongst measurement crews can be achieved group training, discussion and checking.

3.5.2. Sampling Errors

Table 9: Regression of Tree quality to Log Volume

Tree Quality	A logs			B logs			C logs		
	Coeff.	R^2	C.I. (PLE)	Coeff.	R^2	C.I. (PLE)	Coeff.	R^2	C.I. (PLE)
1	0.471	0.899	12.5%	0.199	0.666	22.1%	0.086	0.388	26.2%
2	0.321	0.814	10.1%	0.166	0.609	13.1%	0.193	0.679	12.1%
3	0.159	0.397	18.3%	0.121	0.357	19.8%	0.424	0.589	13.6%

The coefficient values are the proportions of total tree volume.

Table 10: Stratum volume m^3/ha Confidence Intervals

Strata	A	C.I. ±	B	C.I. ±	C	C.I. ±	A+B	C.I. ±	Merch	C.I. ±	Total Vol	C.I. ±
S1	1.82	1.22	1.20	0.75	1.90	1.14	3.02	1.95	4.92	2.96	**53.78**	16.00
S2	5.85	1.23	2.89	0.59	5.08	1.14	8.74	1.76	13.82	2.67	**94.29**	8.18
S3	18.44	1.66	9.97	0.81	16.35	1.43	28.41	2.40	44.76	3.45	**126.66**	6.69
S4	39.51	5.73	20.61	2.62	37.19	5.50	60.13	8.19	97.28	11.58	**169.37**	18.57
All	12.97	0.92	6.90	0.45	11.63	0.82	19.88	1.33	31.50	1.94	**107.98**	4.70

Table 11: Error margins for total resource

	A	B	C	Merch	Total Vol
Volume	236,285	125,711	211,750	573,711	1,966,380
C.I. ±	16,797	8,188	14,908	35,313	85,555
PLE	7.1%	6.5%	7.0%	6.2%	4.4%

PLE is Probable Limit of Error, the confidence interval expressed as a percentage of the mean.

3.6. Teak in the Landscape

Spatial analyses were done to provide a picture of the location of teak and volumes in the landscape using the mapped teak plantation areas and the inventory strata volumes.

3.6.1. Haulage Indicators

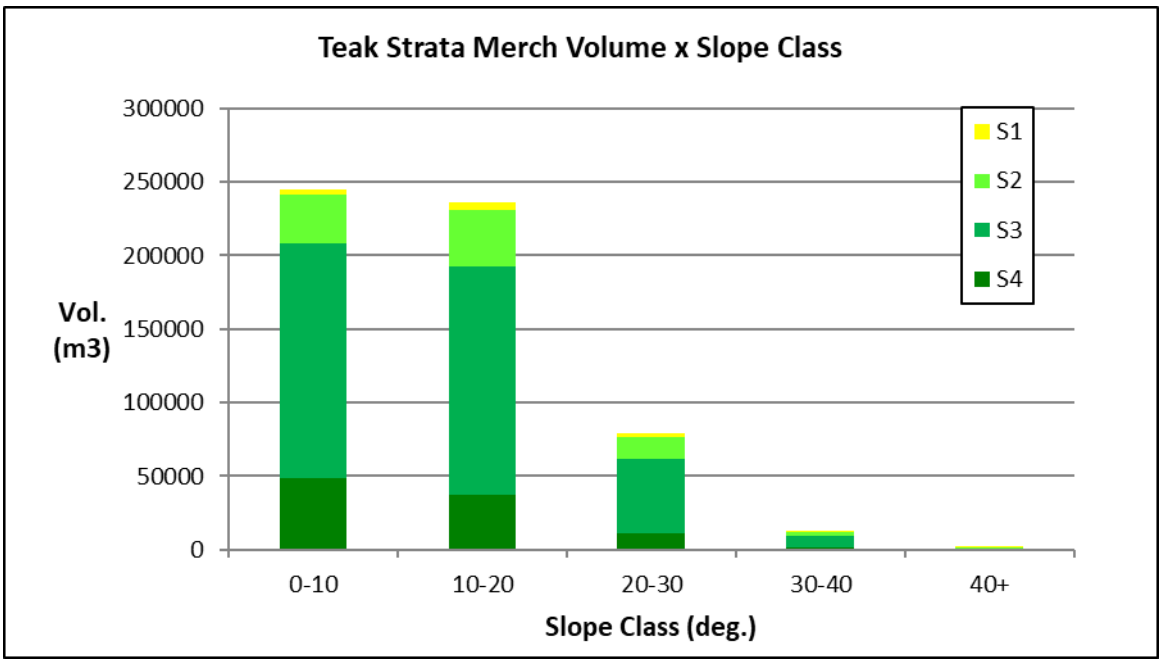
Roads mapping was updated to calculate proximity of teak plantations to roads trafficable by small haulage vehicles (Lot Sing) to give some indication of ease of access for timber harvesting. Direct line proximity to Luang Prabang centre was calculated.

Table 12: Plantation proximity

	Merch Vol.
Distance to roads < 200m	49%
Distance to roads < 1km	91%
Luang Prabang 25km radius	56%
Luang Prabang 50km radius	75%

Slope classes across the province were calculated from a 30m Digital Elevation Model (DEM) from the NASA Shuttle Radar Topographic Mission data made available worldwide in 2014. Intersected with the mapped teak plantation strata:

Figure 6: Merchantable volume x Slope Class

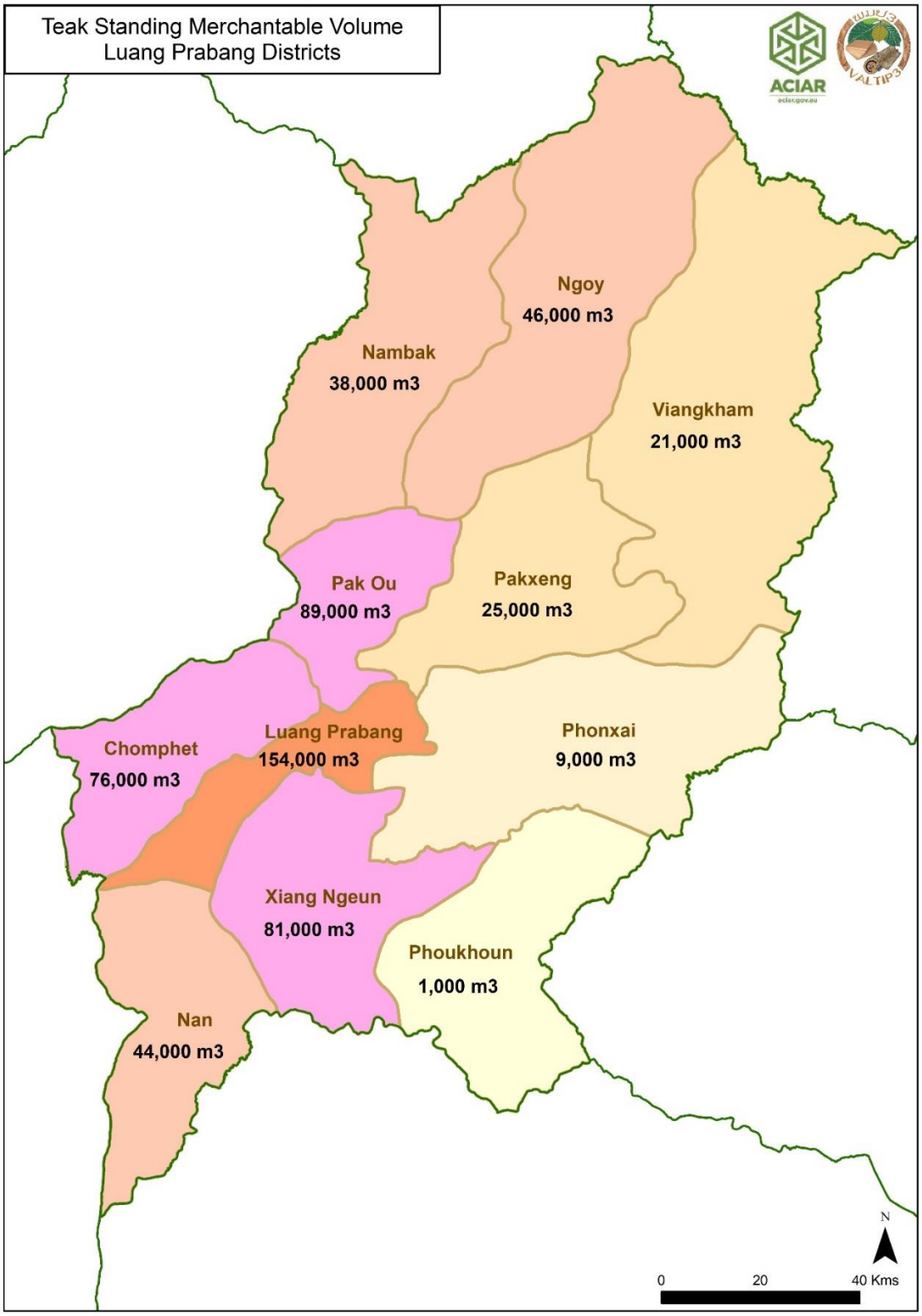


84% of the merchantable volume is on slope < 20^0. The $40+^0$ class is likely to be an error a result of the spatial resolution mismatch between the 30m pixelated DEM used for slope class and the vector mapping of the teak planation

3.7. District Breakdown

District subsets of teak area were used to estimate standing merchantable volume in each district.

Map 2: Teak Standing Volume in Districts

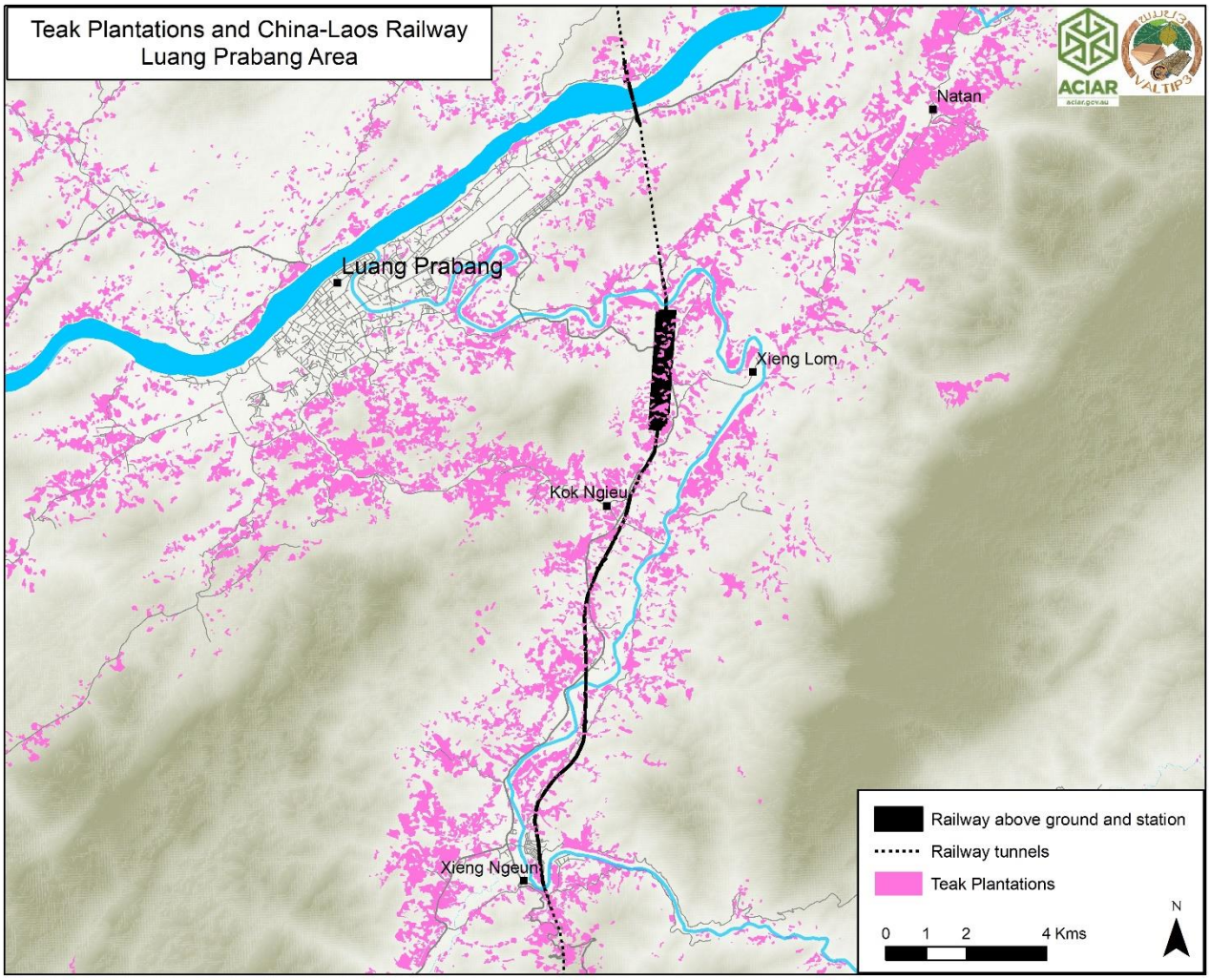


3.8. Impact of Infrastructure Development

Major infrastructure projects are in construction across the province. Hydropower and the Laos -China railway are two high profile projects that potentially impact teak plantations. To estimate their impact on plantations the existing and proposed hydropower dam reservoirs were mapped or modelled. A total of 11 dams were assessed with 7 either completed or under construction and 4 more planned as at July 2018. Direct mapping of reservoirs was possible for all or part of 4 of the dams Nam Khan 3, Nam Khan 2, Nam Ou 2 and Xayaboury. Modelling of dam reservoirs used the dam location and planned full supply level as made public by the Lao PDR Department of Mines and Energy with a Digital Elevation Model (DEM).

The China - Laos railway location and impact was estimated in a similar way. Existing construction of the line and station was mapped from Google Earth and the remaining corridor was estimated from the planned route. The majority of the railway line will run underground through the province with majority of the above ground impact being the Luang Prabang station and the line south to Xieng Nguen.

Map 3: Teak Plantations and the Lao-China Railway



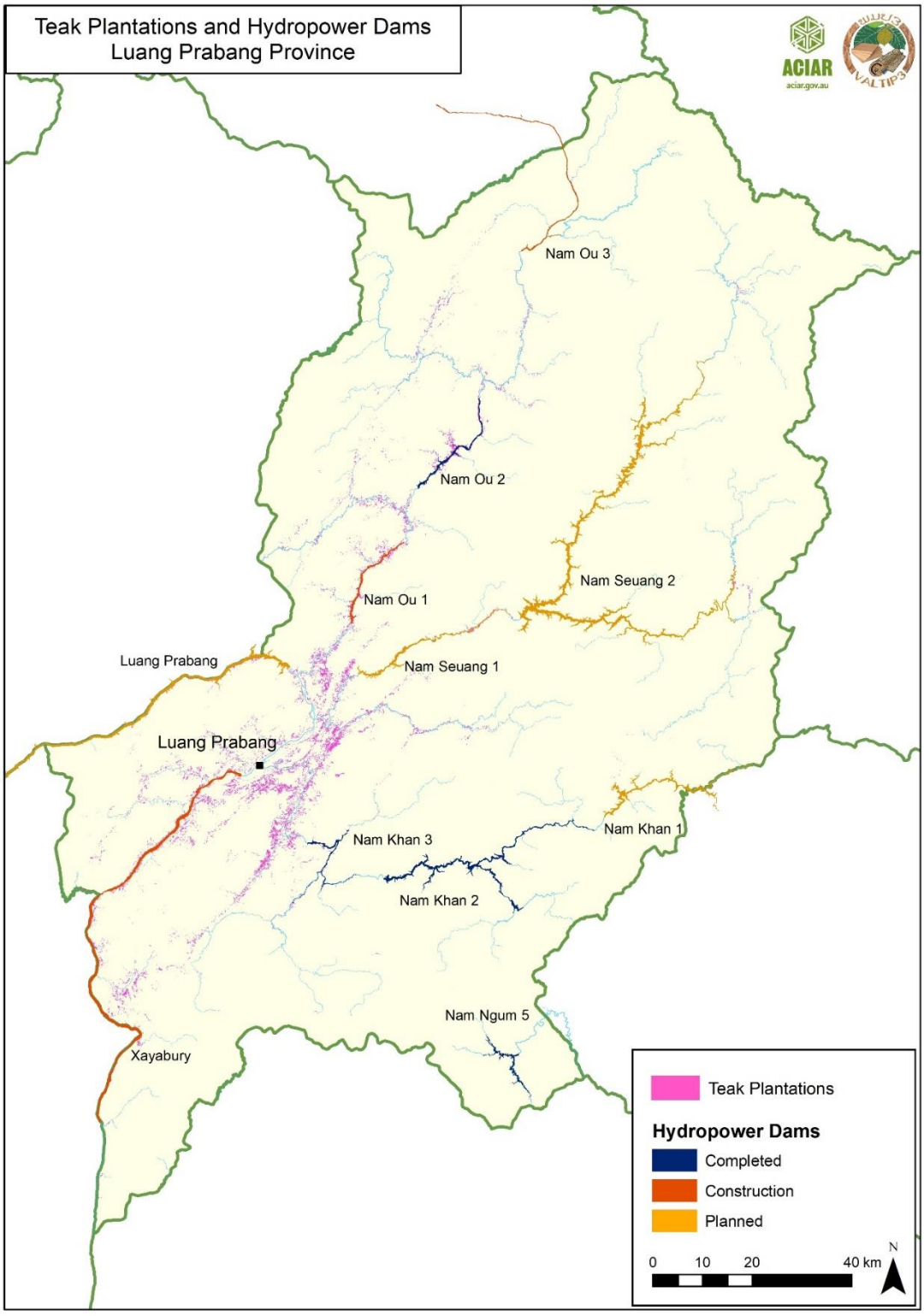
Impact on teak plantations of the infrastructure project construction has been minor. Most of the direct impact will be from dams still to be constructed.

Table 13: Infrastructure and Teak Plantations

Infrastructure	Teak Area (ha)	Merch Vol. (m^3)	Total Vol. (m^3)
Dams - completed	168	6,374	19,477
Dams - construction	71	3,450	11,631
Dams - planned	827	35,670	99,972
Railway	63	1,992	7,021
Totals	1,129	47,488	138,100
% of Total Teak	6%	8%	7%

More impact on teak plantations is likely to be caused by the current and ongoing expansion of Luang Prabang city, networks of roads and powerlines, and general land use pressures resulting from the rapid development of the nation as a whole.

Map 4: Teak Plantations and the impact of Hydro-power Dams



4. DISCUSSION

The teak plantation resource in Luang Prabang province is small in global terms but it is an important and valuable resource for both the many smallholders who grow teak and for the local economy. It is also expanding with the area under teak is still increasing and most of the existing plantations are sub-merchantable and yet to reach their full production potential. The standing volume estimates show a merchantable volume of 573,000 m^3 with good quality logs (A and B) comprising 361,000 m^3.

The older stands of the current resource are often quite mixed in tree sizes and quality reflecting the management practices of the owners where partial harvesting of saleable dominants and co-dominants seems to be common. The result is lower quality, mixed stands continuing on as plantations.

The inventory provides robust estimates with acceptable margins of error at a provincial level. Applying these estimates to subsets of the area will result in corresponding larger margins of error and should be applied with caution.

This inventory estimates standing volume of teak plantations in Luang Prabang province and thereby provides a snapshot picture of the whole teak resource itemised by log type volume. Other significant factors influencing availability of any or all of this volume over time:

- Increase or decrease in plantation area
- Growth and yield of plantations, incorporating site quality, genetic quality, stand condition and silviculture
- Market conditions and owner decision making

The common difficulty in quantifying these factors is the thousands of owners of plantation making their own decisions resulting in a complex mix of plantation states making estimates of teak timber availability difficult indeed.

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Zaoints C. Real Statistics Using EXCEL. http://www.real-statistics.com/

APPENDIX 1: VALTIP 3 TEAK INVENTORY METHOD

Description

Inventory of mapped teak plantations in Luang Prabang Province. Population is defined by the area of teak plantations mapped in VALTIP 2. Aim is to provide estimates of standing volume of teak in the province and the general location of the teak volume. It will not provide estimates of volume for small areas of the teak resource.

Low plot intensity randomly located across the teak plantation area. Stratified by mapped teak size class. Plots measured on the ground for basic tree parameters.

Double Sampling with 80% of plots to have trees assessed for whole tree quality and 20% of plots to have additional estimate of log type and dimensions for trees > 20cm DBH.

Measurement Method

Plots will be 0.03 hectare circular plots randomly located in mapped teak plantations. Radius is 9.77 metres.

Navigation

Use the map and/or GPS waypoint to locate plot centre:

- Use map to get to general location of plot
- Turn on GPS and wait for satellite connection
- Use map to get about 1 km from plot
- Use 'Find' button, then 'Waypoints', press 'Enter' button
- Scroll down to Plot number in the list, press 'Enter'
- Map screen shows with 'Go', press 'Enter'
- Map screen shows line to plot
- Use 'Find' to choose Road route or quit
- Use mapped roads to get close, then walk to waypoint as close as possible (<5m is OK).
- Mark plot centre with a stick and tape.

Permission

Contact DAFO to inform of inventory work in their district. If landholder asks what is happening, show official letter and explain briefly the purpose of the inventory.

Measurement

Plot details:

- Record Plot Number, Date, Team names
- **Slope** – measure downhill using hypsometer

Plot radius is **9.77** metres

Tree Details:

Identify start tree – select an easy to remember tree close to plot centre.

Move in a clockwise direction measuring each tree till you reach start tree again. Check carefully the distance to trees that are close to the plot radius to make sure they are in the plot. Use Hypsometer to measure the **horizontal** distance from plot centre to the middle of the tree.

Vertex Hypsometer

Turn on Transponder – Press DME button. Hold front speaker against Transponder speaker. Press and hold DME button until you hear 2 beeps.

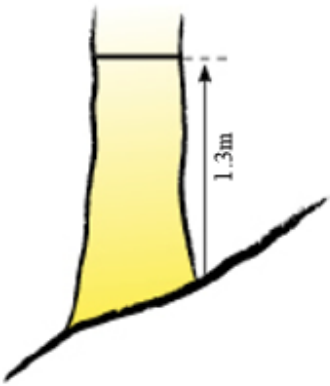
Turn off transponder – Repeat above until you hear 4 beeps

Horizontal distance measure

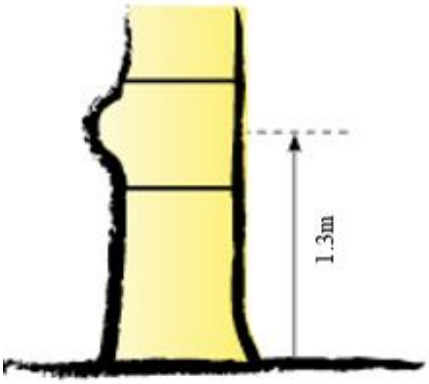
- Turn on transponder and hold on tree at 1.3m above ground
- Turn on Vertex with ON button. Use arrow keys to select '**Height**'
- Aim at the transponder and hold down the ON button until red cross goes out
- On screen will display **SD** – slope distance number, **HD** – horizontal distance number
- Record **HD** number

Measure all live trees for:

- **Diameter** at 1.3m (DBH) Use diameter tape.
    - Do not twist tape
    - Keep tape level
    - Measure 1.3m on the upslope side of the tree.
    - For Teak trees less than 5.0cm diameter, do not measure, record as '< 5'
    - For other species only measure if diameter > 15cm
    - For Bamboo group, do not measure diameter, but record Stem Origin as 'B'



    - If there is a bump, branch or defect at breast height that deforms the tree, measure diameter equal distance above and below 1.3m to avoid defect. Average diameter and record.



- Record in centimetres to nearest millimetre. Example: 17.3cm

- Tree quality class Estimate by eye

1 – tree bole is straight and clear of defects for more than 50% of bole height

2 – tree bole is straight and clear of defects for 25-50% of bole height

3 – tree bole is straight and clear of defects for less than 25% of bole height, Broken trees

Bole height is the bole from ground to first crown forming branch. Defects include open holes, scars, large branches, multiple branches. Defects must be large enough to affect wood quality.

- Stem Origin

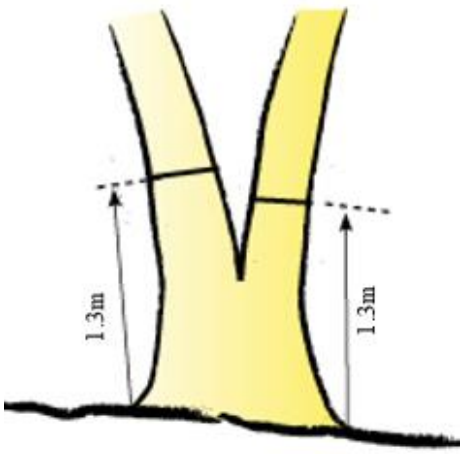
S – single stem. One main bole from ground to crown break. Not coppiced from stump of former tree. Any branches below crown break must be < 50% of bole diameter just above branch

M – multi-stem. Two or more stems above breast height (1.3m). Each stem must be >50% diameter of biggest stem. Tree is recorded as 1 tree

C – coppice. One or more stems below breast height growing from the stump of a former tree. Each stem to be recorded as a separate tree.

N – non teak species. **Only** for trees bigger than 15cm diameter

B – Bamboo group



STAGE 2 ONLY

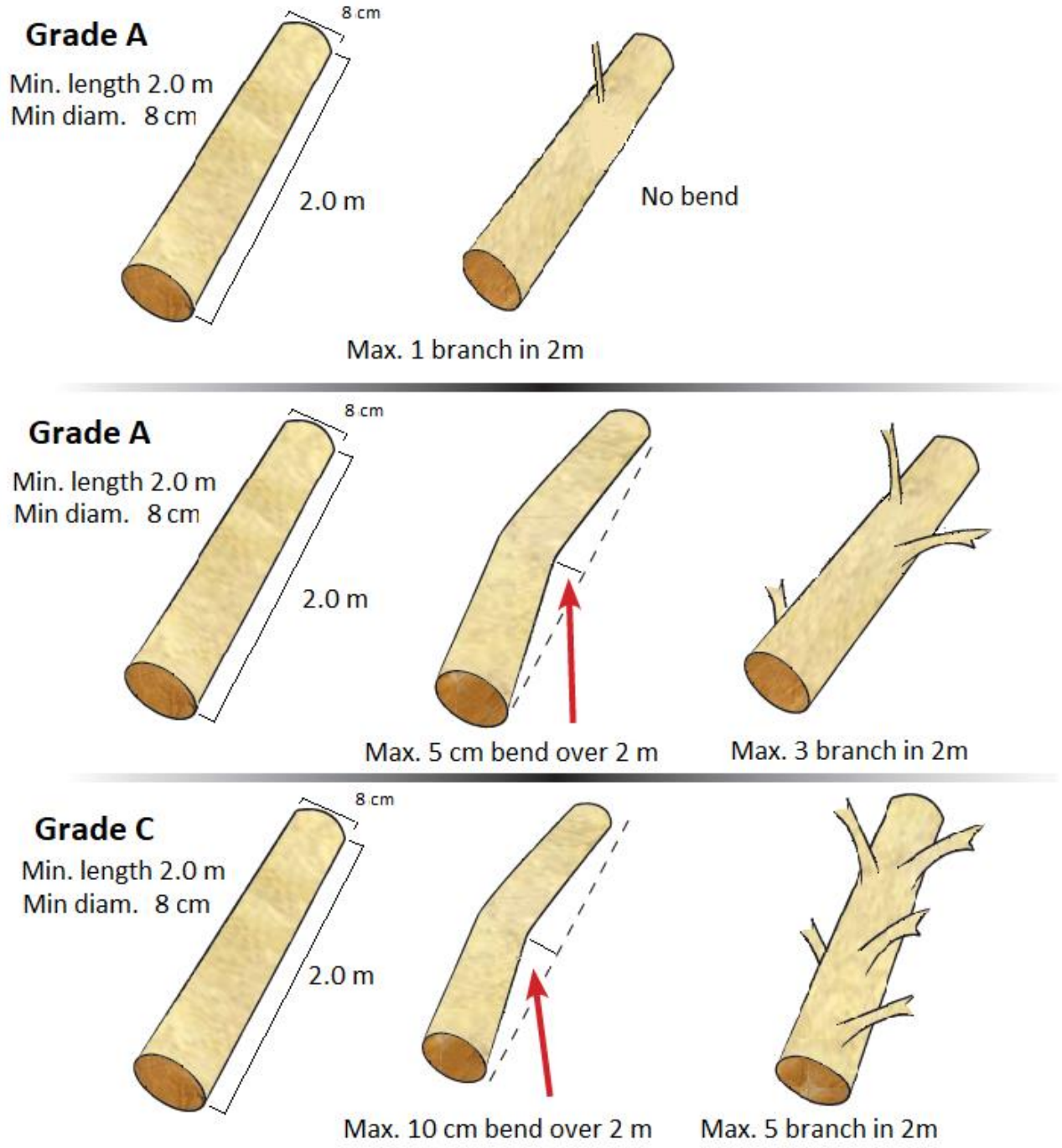
Log Measurement

FOR TREES > 20cm DBH

Logs - Identify A, B and C class logs in the tree

Inventory Log Grades

Fault	Grade A	Grade A/B	Grade C
Minimum length	2.0 m	2.0 m	2.0 m
Minimum small end diam.	10 cm	10 cm	10 cm
Branch	1 Maximum **< 3cm** diameter per 2m	3 Maximum **<5cm** diameter per 2 m	No limit
Closed knot	Small knots < **3cm** OK	3 Maximum **3-5cm** diameter per 2 m	No limit
Open or Rotten Knot	No	No	3 Maximum of <5cm diameter per 2 m
Insect Holes, scar or damage	No	No	Yes
Bend	Straight, no bend	Maximum 2.5% - 5cm per 2m	Maximum 5% -10cm per 2 m
Double Bend	No	No	No
Nails and other metal	No	No	No



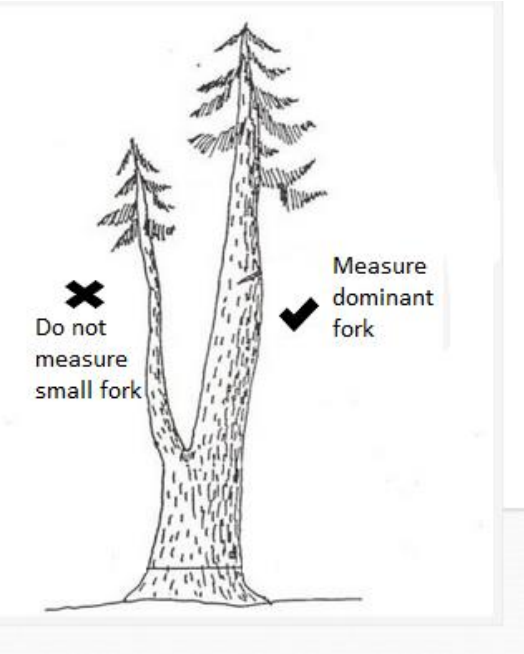
For each log in the tree measure the **start height** and **end height** using hypsometer. Record Grade, start ht. and end ht. in metres. Example:

					Log 1			Log2			Log3		
Tree	**Diam.**	**Quality**	**Stem**	**Height**	**Grade**	**Start**	**End**	**Grade**	**Start**	**End**	**Grade**	**Start**	**End**
1	25.6	1	S	22.1	A	0.3	4.1	C	4.1	8.6			
2	22.3	2	C	17.4	A	2.1	4.8	B	5.3	7.8			
3	27.3	1	S	23	A	1.5	5.5	B	5.5	9.0	C	9.0	13.2
4	23.3	1	S	21.4	A	1.5							

Example 2 has a gap between Log 1 and Log 2 from big branch or damage

For tree with single log type for whole tree only necessary to put start height – see Tree 4 in example

For forked trees measure only the largest fork. If the forks are same size measure the best fork.



Logs can be any length > 2.0m

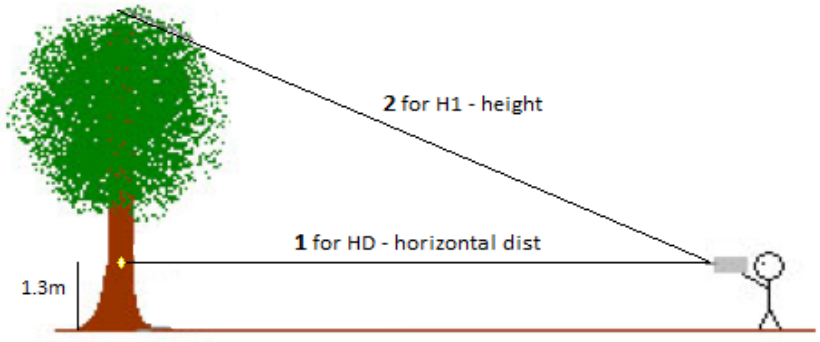
Height Measurement

STAGE 1 - Measure height of the 2 tallest trees in the plot

STAGE 2 - Measure tree height for all trees > 20cm diameter

Vertex Hypsometer Height measurement

- Turn on transponder and hold on tree at 1.3m
- Go away from tree with Vertex as far as possible to still see transponder and top of tree
- Turn on Vertex with ON button. Use arrow keys to select '**Height**'
- Aim at the transponder and hold down the ON button until red cross goes out
- Aim at the top of tree and hold down the ON button until red cross goes out
- H1 Height is shown on display



Record all details carefully on plot sheets to nearest 0.1m.

Troubleshooting

1. Plot is not in teak plantation.
    - Record on plot sheet
        - **Teak Plantation** – Cross 'No' box and put **Reason** – "Natural forest", "Other Plantation", "Cleared"
2. Plot is in teak plantation but no Teak trees in plot. Plot falls in a gap amongst teak trees
    - Record plot details
    - In **Comment** box put 'No Teak'
3. Recent logging. If plot area has been logged recently, put 'recent logging' in **Comment**
4. Cannot get to teak plantation. Roads and tracks do not get to within 1km of plot, rivers cannot be crossed safely, plantation is in a restricted area
    - Record plot details
    - In **Comment** box put 'No access"
5. Tree is dead
    - Do not measure or record

Australian Government
Australian Centre for International Agricultural Research

Australian Aid

VALTIP3 Teak Inventory Plot Sheet – Stage 1

Plot No ____ Date ____/____/____ Crew ____

Slope ____° Teak Plantation Yes ____ No ____ Reason ____

Comment ____

Tree	Diam.	Quality	Stem Origin	Height
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Tree	Diam.	Quality	Stem Origin	Height
31				
32				
33				
34				
35				
36				
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39				
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42				
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57				
58				
59				
60				

Australian Government
Australian Centre for International Agricultural Research

Australian Aid

VALTIP3 Teak Inventory Plot Sheet – Stage 2

Plot No | Date / / | Crew

Slope ° | Teak Plantation Yes | No | Reason

Comment

					Log 1			Log2			Log3		
Tree	Diam.	Quality	Stem	Height	Grade	Start	End	Grade	Start	End	Grade	Start	End
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
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22													
23													
24													
25													
26													
27													
28													
29													
30													

					Log 1			Log2			Log3		
Tree	Diam.	Quality	Stem	Height	Grade	Start	End	Grade	Start	Top	Grade	Start	End
31													
32													
33													
34													
35													
36													
37													
38													
39													
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VALTIP 3

ວິທີການສຳຫຼວດ ແລະ ເກັບກຳຂໍ້ມູນໄມ້ສັກແຂວງຫຼວງພະບາງ

ລາຍລະອຽດ

ການສຳຫຼວດເກັບກຳຂໍ້ມູນດ້ວຍແຜນທີ່ສວນໄມ້ສັກໃນແຂວງຫຼວງພະບາງ.
ຈຳນວນໄມ້ສັກແມ່ນກຳນົດຕາມພື້ນທີ່ສວນປູກໄມ້ສັກຕາມທີ່ໄດ້ເຮັດເປັນແຜນທີ່ໂດຍໂຄງການ VALTIP 2. ຈຸດປະສົງແມ່ນເພື່ອສະໜອງໃຫ້ແກ່ການປະເມີນບໍລິມາດໄມ້ສັກຢືນຕົ້ນພາຍໃນແຂວງ ແລະ ຈຳນວນບໍລິມາດໄມ້ທີ່ມີຢູ່ເຂດພື້ນທີ່ທົ່ວໄປ.
ການສຳຫຼວດເກັບກຳຂໍ້ມູນດ້ວຍແຜນທີ່ສວນໄມ້ສັກນີ້ຈະບໍ່ສາມາດຕອບສະໜອງໄດ້ສຳຫຼັບການປະເມີນບໍລິມາດໄມ້ໃນເຂດພື້ນທີ່ປູກໄມ້ສັກທີ່ມີເນື້ອທີ່ຂະໜາດນ້ອຍ.

ພື້ນທີ່ສວນປູກທີ່ມີຄວາມໜາແໜ້ນຂອງໄມ້ທີ່ປູກໃນພື້ນທີ່ຕ່ຳ(ໜ້ອຍ)ແມ່ນຈະຖືກສຳຫຼວດແບບເລືອກຊຸ່ມເອົາ ແລະທຳການວັດແທກແບບຂ້າງໆ.ຈັດປະເພດດ້ວຍການເຮັດແຜນທີ່ໝວດຂອງຂະໜາດໄມ້ສັກ. ສຳຫຼວດວັດແທກສວນໄມ້ສັກຢູ່ພື້ນທີ່ຕົວຈິງສຳຫຼັບຂໍ້ມູນພື້ນຖານລັກສະນະສະເພາະຂອງຕົ້ນໄມ້

ວິທີການວັດແທກ

ຕອນດິນສວນປູກຈະຖືກຄັດເລືອກໃນແຜນທີ່ສວນປູກໄມ້ສັກໂດຍວິທີການຄັດເລືອກແບບຊຸ່ມເອົາ ພື້ນທີ່ທີ່ຈະທຳການວັດແທກແມ່ນເປັນຮູບວົງກົມເຊິ່ງຈະມີເນື້ອທີ່ 0.03 ເຮັກຕ່າ. ເຊິ່ງມີຂະໜາດເສັ້ນລັດສະໝີ 9.77ແມັດ

ການນຳທາງໄປຫາຈຸດທີ່ຖືກເລືອກ

ການນຳທາງໄປຫາຈຸດທີ່ຈະວັດແທກແມ່ນນຳໃຊ້ແຜນທີ່ ຫຼື ເຄື່ອງລະບຸຈຸດພິກັດ waypoint ທີ່ຢູ່ໃນເຄື່ອງ GPS ເພື່ອນຳທາງໄປຫາຈຸດໃຈກາງຂອງດອນທີ່ຖືກເລືອກດັ່ງນີ້:

ນຳໃຊ້ GPS – ເພື່ອນຳໄປຫາດອນເກັບຂໍ້ມູນ

- ນຳໃຊ້ແຜນທີ່ເພື່ອໄປຫາຈຸດທີ່ຕັ້ງຂອງສວນ
- ເປີດ GPS ແລະ ລໍຖ້າໃຫ້ເຄື່ອງ ສາດມາດຮັບສັນຍານຫຼືຕິດຕໍ່ກັບດາວທຽມຢ່າງພຽງພໍ
- ນຳໃຊ້ແຜນທີ່ເພື່ອເຂົ້າໄປໃກ້ຈຸດທີ່ຕັ້ງຂອງດອນປະມານ 1 km
- ກົດປຸ່ມ ‘Find’, ຕໍ່ດ້ວຍ ‘Waypoints’, ແລ້ວກົດປຸ່ມ ‘Enter’
- ເລື່ອນລົງໄປຫາ ນ້ຳເບີດອນ/Plot number ໃນບັນຊີດອນເກັບຂໍ້ມູນ, ແລ້ວກົດ ‘Enter’
- ຈະປາກົດເຫັນ‘Go’ເທິງແຜນທີ່ ໜ້າຈໍຈີພີເອັດ, ກົດ ‘Enter’
- ຈະປາກົດເຫັນເສັ້ນເພື່ອນຳໄປຫາດອນເກັບຂໍ້ມູນເທິງແຜນທີ່ ໜ້າຈໍຈີພີເອັດ
- ນຳໃຊ້ ‘Find’ ເພື່ອເລືອກເສັ້ນທາງເດີນຫຼືທຳການຍົກເລີກ
- ນຳໃຊ້ແຜນທີ່ເສັ້ນທາງເພື່ອເພື່ອໃຫ້ເຂົ້າໄປໃກ້ດອນທີ່ຖືກເລືອກ, ແລ້ວຢ່າງເຂົ້າໄປຫາຈຸດ waypoint ໃຫ້ໃກ້ທີ່ສຸດເທົ່າທີ່ຈະໃກ້ໄດ້ (ໃຫ້ໃກ້ເຂົ້າໃກ້ຈຸດໃກ້/ນ່ຶກວ່າ 5 ແມັດແມ່ນຖືວ່າໃຊ້ໄດ້)
- ທຳການໝາຍຈຸດໃຈກາງຂອງດອນເກັບຂໍ້ມູນດ້ວນຫຼັກ ແລະ ເທບຢາງສີ

ການຂໍອານຸຍາດເຂົ້າພື້ນທີ່

ພ້ອມກັບຫ້ອງການກະສິກຳ ແລະ ປ່າໄມ້ເມືອງເພື່ອແຈ້ງໃຫ້ຮູ້ວ່າທີມງານຈົງມາຈັດຕັ້ງປະຕິບັດການສຳຫຼວດ ແລະ ເກັບກຳຂໍ້ມູນໄມ້ສັກຢູ່ຂອບເຂດເມືອງຂອງຂະເຈົ້າຫາກເຫັນວ່າມີຄວາມຈຳເປັນ. ໃນກໍລະນີທີ່ເຈົ້າຂອງສອບຖາມເລື່ອງການເຮັດວຽກ ກະລຸນານຳສະເໜີເອກະສານທາງການ ແລະ ອະທິບາຍຈຸດປະສົງໃນການຈົງເຮັດວຽກໃຫ້ຜູ້ກ່ຽວຮັບຊາບ

ການວັດແທກ

ຂໍ້ມູນຂອງດອນສຳຫຼວດ:

- ບັນທຶກເບີດອນ, ອັນເດືອນປີຈົງ, ຊື່ທີມງານຜູ້ວັດແທກເກັບກຳ
- **ຄວາມຄ້ອຍຊັນ** – ວັດແທກແຕ່ເທິງຈົງຕາມລວງຄ້ອຍຊັນໂດຍນຳໃຊ້ເຄື່ອງ **hypsometer**

ລັດສະໝີດອນແມ່ນ 9.77 ແມັດ

ລາຍລະອຽດຂອງຕົ້ນໄມ້:

ກຳນົດຕົ້ນທີ່ຈະເລີ້ມວັດແທກ-ໃຫ້ເລືອກຕົ້ນທີ່ງ່າຍໃນການຈົດຈຳທີ່ຢູ່ໃກ້ກັບຈຸດໃຈກາງຂອງດອນທີ່ສຸດ.

ຕ້ອງຮັບປະກັນໃຫ້ແຕ່ລະຕົ້ນໃນອົງກົມໄດ້ຖືກວັດແທກເກັບກຳໂດຍການຍ້າຍໃສ່ຕົ້ນທີ່ໃກ້ຕົ້ນທີ່ວັດແທກກ່ອນ ແລ້ວເຄື່ອນຍ້າຍໃສ່ຕົ້ນຕໍ່ໄປວັດແທກໝູນຕາມທິດເດີນຂອງເຂັ້ມໂມງ.ນຳໃຊ້ເຄື່ອງວັດແທກ Hypsometer ເພື່ອວັດແທກໄລຍະຫ່າງຂອງຕົ້ນໄມ້ຕາມແນວນອນຈາກຈຸດໃຈກາງຂອງດອນເກັບຂໍ້ມູນຫ່າງຈຸດເຄິ່ງກາງຂອງຕົ້ນໄມ້

ການນຳໃຊ້ເຄື່ອວັດແທກຄວາມສູງ **Vertex Hypsometer**

ເພື່ອເປີດເຄື່ອງຮັບສົ່ງສັນຍານ – ຈັບໂຕສະທ້ອນສັນຍານ (ສີເຫລືອງທີ່ຮັດຕິດກັບຫຼັກ) ມາຈ້ຳໃສ່ຊ່ອງຮັບສົ່ງສັນຍານຂອງເຄື່ອງວັດແທກ. ກົດປຸ່ມ DME ກົດຄ້າງໄວ້ຈົນໄດ້ຍິນສຽງຕອບຮັບສັນຍານຈາກລຳໂພງດັງປິບໆ 2 ຄັ້ງ.

ເພື່ອປິດເຄື່ອງຮັບສົ່ງສັນຍານ – ປະຕິບັດລື້ມຄືນຂັ້ນຕອນຂ້າງເທິງ ຈົນກວ່າຈະໄດ້ຍິນສຽງສັນຍານຈາກລຳໂພງດັງປິບໆ 4 ຄັ້ງ.

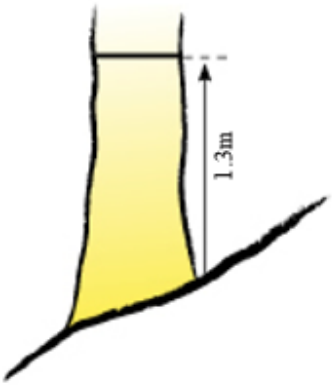
ການວັດແທກໄລຍະຫ່າງຕາມແນວນອນ

- ເປີດເຄື່ອງສະທ້ອນສັນຍານ ແລະ ຕັ້ງໄວ້ທີ່ຈຸດຫ່າງຈາກພື້ນດິນ 1.3 ແມັດແປະຂ້າງທີ່ເປັນຈຸດເຄິ່ງກາງຂອງຕົ້ນໄມ້
- ເປີດເຄື່ອງVertex ດ້ວຍການກົດປຸ່ມ ON. ໃຊ້ເຄື່ອງໝາຍລູກສອນເພື່ອເລືອກວັດແທກ '**Height**'
- ແນເປົ້າໝາຍໄປໃສ່ເຄື່ອງສະທ້ອນສັນຍານ ແລະ ກົດປຸ່ມ ON ຄ້າງໄວ້ຈົນການະບາດສີແດງຈະຫາຍໄປ
- ຢູ່ເທິງຈໍຂອງເຄື່ອງວັດແທກຈະໂຊ **SD** – ຕົວເລກໄລຍະຫ່າງຕາມຄ້ອຍ **HD** – ຕົວເລກໄລຍະຫ່າງຕາມທາງນອນ
- ທຳການບັນທຶກຕົວເລກ **HD**

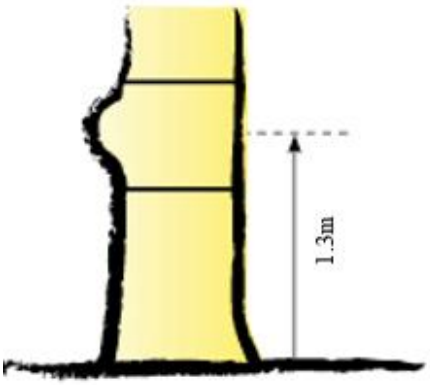
ວັດແທກໄມ້ທີ່ຍັງມີຊີວິດທັງໝົດເພື່ອເກັບກຳ:

- ໜ້າຕ້າງຢູ່ຈຸດ 1.3 ແມັດ (ໜ້າຕ້າງພຽງເອິກ) ໂດຍການນຳໃຊ້ເຊືອກແມັດແທກໜ້າຕ້າງ.

- ລະວັງບໍ່ໃຫ້ເລືອກແມັດລື້ອຫຼືພັບງໍ
- ດຶງເລືອກແມັດໃຫ້ຊື່ແລະໄດ້ລະດັບ
- ວັດແທກຈຸດ 1.3m ໂດຍຢືນທາງເບື້ອງເທິງຄ້ອຍຂອງຕົ້ນໄມ້
- ສຳຫຼັບໄມ້ສັນທີ່ມີໜ້າຕ້ານ້ອຍກວ່າ 5.0 ຊມ ແມ່ນບໍ່ວັດແທກ , ແຕ່ໃຫ້ບັນທຶກເປັນ "<5 " ວົງໃນຟອມ
- ສຳລັບດອນທີ່ບໍ່ມີໄມ້ສັກແມ່ນໃຫ້ວັດແທກໄມ້ທຳມະຊາດອື່ນທີ່ມີໜ້າຕ້າງໃຫຍ່ກວ່າ 15 ຊັ້ງຕີແມັດຂຶ້ນໄປ ທີ່ພົບໃນດອນເກັບຂໍ້ມູນ
- ສຳຫຼັບໄມ້ສຸມໄມ້ໃຜ່ຫຼືໄມ້ປ່ອງ ແມ່ນບໍ່ວັດແທກໜ້າຕ້າງ, ແຕ່ໃຫ້ທຳການບັນທຶກໃສ່ຫ້ອງຕົ້ນກຳເນີດ ເປັນ **" B "**



- ຖ້າກໍລະນີໄມ້ມີປູດ, ຫງ່າ ຫຼືຕຳນິໃນບໍລິເວນຈຸດສູງພຽງເອິກ ທີ່ເຮັດໃຫ້ຕົ້ນໄມ້ມີຮູບຮ່າງຜິດຜ່ຽນ, ໃຫ້ວັດແທກເອົາຈຸດທຽບເທົ່າຢູ່ເທິງ ແລະ ຢູ່ລຸ່ມ ຈຸດ 1.3 ແມັດເພື່ອຫຼີກລ້ຽງຄວາມຜິດພາດ. ທຳການຄິດໄລ່ເອົາຄ່າສະເລ່ຍ ແລະ ບັນທຶກ



- ການຂົດບັນທຶກແມ່ນເປັນຊັ້ງຕແມັດ
  ລວມທັ້ງຄ່າຈາກຊັ້ງຕີແມັດໄປອີກຕົວເລກນຶ່ງເຊັ່ນຕົວຢ່າງ: 17.3cm

- ຊັ້ນຄຸນະພາບຂອງຕົ້ນໄມ້ ແມ່ນທຳການປະເມີນດ້ວຍສາຍຕາ

1 – ລຳຕົ້ນຂອງໄມ້ ມີຄວາມຊື່ຕົ້ງ ແລະ ມີຈຸດຕຳນິຂອງລຳຕົ້ນທີ່ຊັດເຈນຫລາຍກວ່າ 50% ຂອງລວງສູງລຳຕົ້ນ

2 – ລຳຕົ້ນຂອງໄມ້ ມີຄວາມຊື່ຕົ້ງ ແລະ ມີຈຸດຕຳນິຂອງລຳຕົ້ນທີ່ຊັດເຈນໃນລະຫວ່າງ 25-50% ຂອງລວງສູງລຳຕົ້ນ

3 – ລຳຕົ້ນຂອງໄມ້ ມີຄວາມຊື່ຕົງ ແລະ ມີຈຸດຕຳນິຂອງລຳຕົ້ນທີ່ຊັດເຈນໜ້ອຍກວ່າ25%, ຕົ້ນໄມ້ຫັກປາຍ

ລວງສູງຂອງລຳຕົ້ນ ແມ່ນລຳຕົ້ນທີ່ເລີ້ມຈາກພື້ນດິນຫາຫງ່າເຄ້ົ. ຕຳນິຂອງລວມທັງຮູເປີດ, ບາດແຜຈີກ, ຫງ່າໃຫຍ່, ຫງ່າເປັນກຸ່ມ. ຕຳນິຄວນຈະໃຫຍ່ແລະກ່ໃຫ້ເກີດເປັນຜົນກະທົບຕ່ຄຸນນະພາບຂອງໄມ້ໄດ້.

- ຕົ້ນເຫງ້ົາ(ກຳເນີດ)

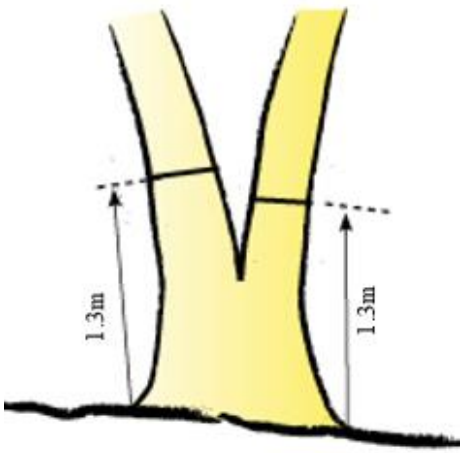
S – ຕົ້ນທີ່ມີເຫງ້ົາດຽວ. ເປັນລຳຕົ້ນດຽວຈາກພື້ນດິນຫາຫງ່າທີ່ແຕກເປັນເຮືອນຍອດ. ບ່ແມ່ນລຳຕົ້ນທີ່ແຫນງເກີດຈາກເຫງ້ົາໄມ້ເຕ້ົາເກ່ົາ. ຫງ່າເກີດຂຶ້ນຈາກລຸ່ມຫງ່າທີ່ແຕກເປັນເຮືອນຍອດ ຄວນມີນ້ອຍກວ່າ < 50% ໜ້າຕ້ົາງວັດແທກແມ່ນຈຸດສູງກວ່າຫງ່າ

M – ຕົ້ນທີ່ມີຫຼາຍເຫງ້ົາ. ຕົ້ນທີ່ມີສອງຫຼືຫລາຍລຳເກີດຂຶ້ນເທິງຈຸດສຸງພຽງເອີກ(1.3m) ນັ້ນທຸກລຳຕ້ອງມີໜ້າຕ້ົາງໃຫຍ່ກວ່າ >50% ຂອງໜ້າຕ້ົາງຕົ້ນເຄ້ົ. ບັນທຶກເປັນຕົ້ນ

C – ລຳຕົ້ນທີ່ເກີດຈາກແຫນງ. ນຶ່ງຫຼືຫລາຍລຳຕົ້ນທີ່ເກີດຢູ່ລຸ່ມຈຸດສູງພຽງເອີກທີ່ເກີດຈາກແຫນງຂອງຕໍ່ໄມ້ເກ່ົາ ແມ່ນຈະໄດ້ບັນທຶກແຍກເປັນແຕ່ລະຕົ້ນ.

N – ກໍລະນີມີແຕ່ຊະນິດໄມ້ພັນອື່ນທີ່ບ່ແມ່ນໄມ້ສັກ.

B – ສຸມໄມ້ໄຜ່ຫຼືໄມ້ປ່ອງ.



Stage 2

ການວັດແທກ ໄມ້ທ່ອນ ແລະ ລວງສູງ

ສຳລັບຕົ້ນໄມ້ທີ່ມີໜ້າຕ້ົາງ ຈຸດ 1,30 ໃຫ່ຍກວ່າ 20 cm (> 20cm)

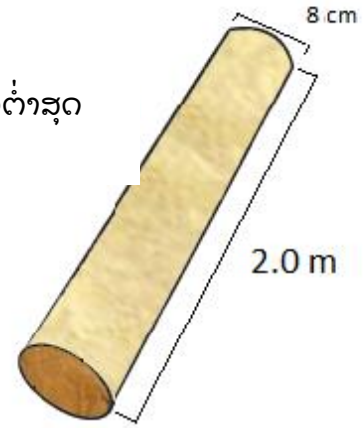
ໄມ້ທ່ອນ- ການຈັດແບ່ງ ປະເພດ ໄມ້ທ່ອນ A, B ແລະ C ຂອງຕໄມ້ຍືນຕົ້ນ (ຕົ້ນໄມ້)

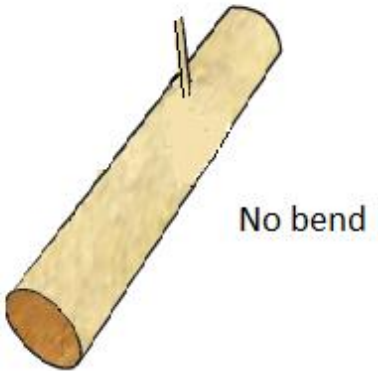
ການຂຶ້ນບັນຊີ ປະເພດໄມ້ທ່ອນ

ຕຳນິຫຼືຈຸດບົກຜ່ອງ	ປະເພດ A	ປະເພດ B	ປະເພດ C
ລວງຍາວຕ່ຳສຸດ	2.0 m	2.0 m	2.0 m
ໜ້າຕ້ຽງໜ້ອຍສຸດ	10 cm	10 cm	10 cm
ງ່ຳ	ສຸງສຸດ 1ງ່ຳ ໜ້າຕ້ຽງ ນ້ອຍກວ່ຳ 3 cm ຕໍ່ ລວງ ຍາວ 2 m	ສຸງສຸດ 3 ງ່ຳ ໜ້າຕ້ຽງ ນ້ອຍກວ່ຳ 5 cm ຕໍ່ລວງ ຍາວ 2 m	ບໍ່ຈຳກັດ
ຕາປິດ(ຕາຫຸ້ມ)	ຕ່ຳນ້ອຍ, ນ້ອຍກວ່ຳ 3 cm ອະນຸຍາດ	ສຸງສຸດ 3 ຕ ໜ້າຕ້ຽງ 3-5 cm ຕໍ່ລວງ ຍາວ 2 m	ບໍ່ຈຳກັດ
ຕາເປັນຮູ ຫຼື ເນົ່ຳ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ສຸງສຸດ 3 ຕ່ຳທີ່ເປັນຮູ ໜ້າຕ້ຽງນ້ອຍກວ່ຳ 5 cm ຕໍ່ລວງ ຍາວ 2 m
ຮູແມງໄມ້,ເປັນບາດແຜຫຼື ມີ ຄວາມເສຍຫາຍ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ອະນຸຍາດ
ຄົດ	ຊື, ບໍ່ຄົດ	ສຸງສຸດ 2,5 %, 5 cm ຕໍ່ ລວງ ຍາວ 2 m	ສຸງສຸດ 5 %, 10 cm ຕໍ່ ລວງ ຍາວ 2 m
ຄົດ ສອງ ເທື່ອ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ບໍ່ອະນຸຍາດໃຫ້ມີ
ມີຕະປູ ແລະ ໂລຫະອື່ນໆ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ບໍ່ອະນຸຍາດໃຫ້ມີ	ບໍ່ອະນຸຍາດໃຫ້ມີ

ເກດ A

ລວງຍາວຕ່ຳສຸດ
2.0 m

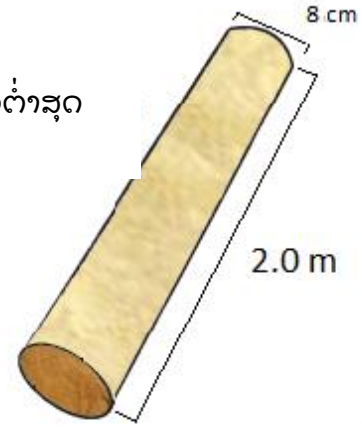


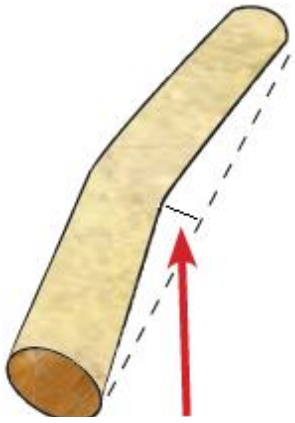

No bend

ສຽງສຸດ 1ງ່າ ຕໍ່ລວງ ຍາວ 2 m

ເກດ A

ລວງຍາວຕ່ຳສຸດ
2.0 m



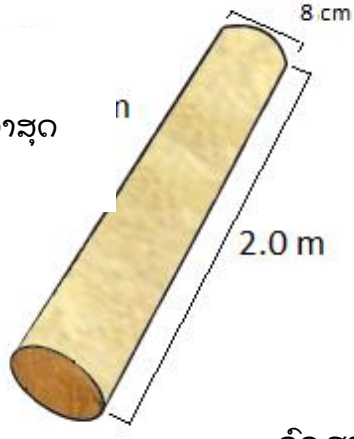


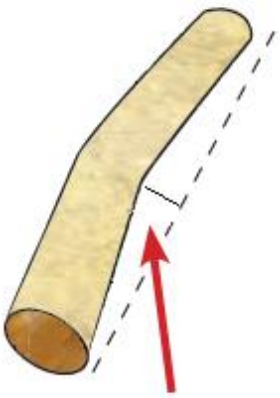
ຄົດ ສຽງສຸດ 5 cm ຕໍ່ລວງ ຍາວ 2

ສຽງສຸດ 3 ງ່າ ຕໍ່ລວງ ຍາວ 2

ເກດ C

ລວງຍາວຕ່ຳສຸດ
2.0 m





ຄົດ ສຽງສຸດ 10 cm ຕໍ່ລວງ ຍາວ 2

ສຽງສຸດ 7 ງ່າ ຕໍ່ລວງ ຍາວ 2

ທຳການວັດແທກໄມ້ທ່ອນ ທຸກທ່ອນ ໃນໄມ້ ຕົ້ນໜຶ່ງ ໂດຍວັດແທກ ລວງສຽງເລີ້ມຕົ້ນ ແລະ ລວງສຽງສຸດທ້າຍ ໂດຍ ການນຳ ໃຊ້ເຄື່ອງວັດແທກ (Hypsometer), ທຳການ ບັນທຶກ ປະເພດ(ເກດ)ໄມ້ທ່ອນ ທີ່ຈັດ ແລະ ລວງສຽງເລີ້ມຕົ້ນ ແລະ ລວງສຽງສຸດທ້າຍ ເປັນແມັດ . ເຊັ່ນ:

ຕົວຢ່າງ

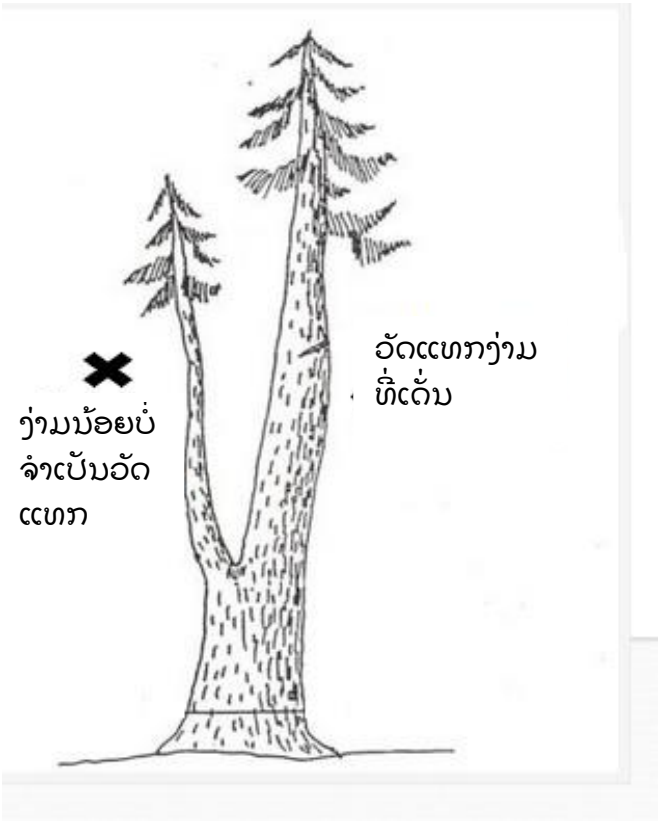
					ທ່ອນທີ 1			ທ່ອນທີ 2			ທ່ອນທີ 3		
ຕົ້ນທີ່	ໜ້າ ຕ້ຽ	ຄຸນ ນະພາ ບ	ຕົ້ນ ກຳ ເນີນ	ລວງ ສູງ	ປະເພດ (ເກດ)	ຈຸດ ເລີ້ມ ຕົ້ນ	ຈຸດ ສຸດ ທ້າຍ	ປະເພດ (ເກດ)	ຈຸດ ເລີ້ມ ຕົ້ນ	ຈຸດ ສຸດ ທ້າຍ	ປະ ເພດ (ເກດ)	ຈຸດ ເລີ້ມ ຕົ້ນ	ຈຸດ ສຸດ ທ້າຍ
1	25.6	1	S	22.1	A	0.3	4.1	C	4.1	8.6			
2	22.3	2	C	17.4	A	2.1	4.8	B	5.3	7.8			
3	27.3	1	S	23	A	1.5	5.5	B	5.5	9.0	C	9.0	13.2
4	23.3	1	S	21.4	A	1.5							

ຕົວຢ່າງ :

ຕົ້ນທີ່ 2 ມີ ງ່າໃຫ່ຍ ຫຼື ເກີດຄວາມເສຍຫາຍ ໃນລະຫວ່າງ ທ່ອນທີ່ 1 ແລະ ທ່ອນທີ່ 2

ສຳລັບຕົ້ນໄມ້ ທີ່ທ່ອນດຽວ ຂອງຕົ້ນໄມ້ທັງໝົດຕົ້ນ ຈຳເປັນຕ້ອງກຳນົດລວງສູງເລີ້ມຕົ້ນຢ່າງດຽວ-ສັງເກດເບິ່ງ ຕົ້ນທີ່ 4 ຢູ່ໃນຕົວຢ່າງ

ສຳລັບຕົ້ໄມ້ທີ່ ເປັນງ່າມ ທຳການວັດແທກ ງ່າມທີ່ໃຫ່ຍທີ່ສຸດ ເທົ່ານັ້ນ, ຖ້າຫາກງ່າມມີຂະໜາດທົ່ຽກັນ ໃຫ້ວັດ ແທກງ່າມທີ່ ເດັ່ນກວ່າ

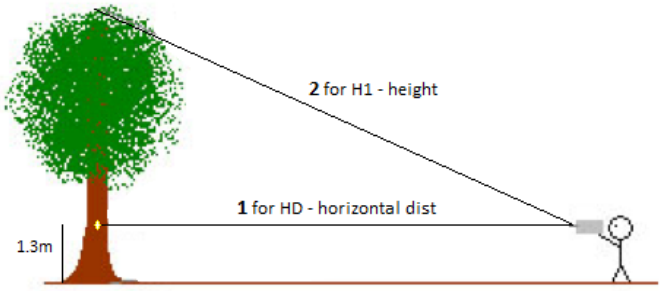


- ລວງຍາວຂອງໄມ້ທ່ອນສາມາດກຳນົດ ຫຼາຍຂະໜາດແຕກຕ່າງກັນ ອາດຈະ ຍາວກວ່າ 2.0 m (> 2.0m)

ຈຸດສູງສຸດ

Stage 1 ແທກຄວາມສູງຂອງຕົ້ນທີ່ສູງສຸດຈຳນວນ 2 ຕົ້ນໃນວົງກົມວັດແທກ Measure height of the 2 tallest trees in the plot

Stage 2 ວັດແທກລວງສູງຂອງຕົ້ນໄມ້ທຸກໆຕົ້ນ ທີ່ມີ ໜ້າຕ້ານ ໃຫ່ຍກວ່າ 20 cm (> 20cm)



VERTEX ການວັດແທກລວງສູງ

- ເປີດເຄື່ອງສະທ້ອນສັນຍານ ແລະ ຕັ້ງໄວ້ທີ່ຈຸດຫ່າງຈາກພື້ນດິນ 1.3 ແມັດແປະຂ້າງຕົ້ນໄມ້
- ນຳເຄື່ອງວັດແທກ Vertex ເດີນອອກຫ່າງຕົ້ນໄມ້ເທົ່າທີ່ຈະເບັ່ນໄປໄດ້ແຕ່ຕ້ອງຮັບປະກັນໃຫ້ແນມເຫັນເຄື່ອງເຄື່ອງສະທ້ອນສັນຍານ ແລະ ເຮືອນຍອດທີ່ສູງສຸດຂອງຕົ້ນໄມ້
- ເປີດເຄື່ອງວັດແທກ Vertex ດ້ວຍການກົດປຸ່ມ ON. ໃຊ້ເຄື່ອງໝາຍລູກສອນເພື່ອເລືອກໄປທີ່ '**Height**'
- ແນເປົ້າໝາຍເຄື່ອງວັດແທກ Vertex ໄປໃສ່ເຄື່ອງສະທ້ອນສັນຍານ ແລະ ກົດປຸ່ມ ON ຄ້າງໄວ້ຈົນການກະບາດສີແດງຫາຍໄປ
- ແນເປົ້າໝາຍເຄື່ອງວັດແທກ Vertex ໄປໃສ່ເຮືອນຍອດທີ່ສູງສຸດຂອງຕົ້ນໄມ້ ແລະ ກົດປຸ່ມ ON ຄ້າງໄວ້ຈົນການກະບາດສີແດງຫາຍໄປ
- ຄວາມສູງຂອງຕົ້ນໄມ້ຈະປາກົດໃຫ້ເຫັນເທິງໜ້າຈໍຂອງເຄື່ອງ Vertex (ລວມທັງ ຂໍ້ມູນອື່ນ)

ທ່ານການບັນທຶກທຸກລາຍລະອຽດຢ່າງລະມັດລະວັງ ລົງໃນ**ຮ່າງ ສຳຫຼວດ ແລະ ເກັບກຳຂໍ້ມູນ ຂອງດອນສອນໄປສັກ**

ການແກ້ໄຂບັນຫາທີ່ພົບ

1. ຕອນຫຼືດອນ ບໍ່ແມ່ນຢູ່ໃນສອນປູກໄມ້ສັກ.
    - ບັນທຶກລົງໃນຮ່າງ ສຳຫຼວດ ແລະ ເກັບກຳຂໍ້ມູນ ຂອງດອນສອນໄມ້
        - **ສອນໄມ້ ສັກ** – ຂີດ X ໃສ່ຊ່ອງທີ່ບໍ່ແມ່ນ ແລະ ໃສ່ເຫດຜົນເຊັ່ນ " ປ່າທຳມະຊາດ", "ສອນປະເພດອື່ນ", "ຕັດອອກກ້ຽງ"
2. ກໍລະນີທີ່ດອນທີ່ຢູ່ໃນສອນປູກໄມ້ສັກແຕ່ວ່າບໍ່ມີຕົ້ນໄມ້ສັກໃນດອນເກັບຂໍ້ມູນ.
   ດອນຕົກຖືກຫວ່າງທີ່ບໍ່ມີໄມ້ສັກ
    - ບັນທຶກລາຍລະອຽດຂອງດອນ

- ໃນຊ່ອງທີ່ຄຳຄິດເຫັນໃຫ້ຂຽນໃສ່ວ່າບໍ່ມີຕົ້ນໄມ້ສັກໃສ່

3. ກໍລະນີທີ່ບໍ່ສາມາດເຂົ້າໄປຫາສອນໄມ້ສັກໄດ້. ສະຖານທີ່ມີຂໍ້ຈຳກັດ ບໍ່ມີລົດ ແລະ ທາງເຂົ້າເຖິງສອນດັ່ງກ່າວ ໃນລະຍະ 1 ກິໂລແມັດ , ບໍ່ສາມາດຂ້າມແມ່ນ້ຳໄປຫາສອນໄດ້ຢ່າງປອດໄພ
   - ບັນທຶກລາຍລະອຽດຂອງດອນ
   - ໃນຊ່ອງທີ່ຄຳຄິດເຫັນໃຫ້ຂຽນໃສ່ວ່າ"ບໍ່ສາມາດເຂົ້າເຖິງພື້ນທີ່ໄດ້"
4. ຕົ້ນໄມ້ທີ່ຕາຍ
   - ບໍ່ໃຫ້ທຳການວັດແທກ ແລະ ບັນທຶກ
5. ກໍລະນີທີ່ປະຈຸບັນມີການຂຸດຄົ້ນໄມ້ໃຫ້ຂຽນໃສ່ຊ່ອງຄຳຄິດເຫັນວ່າ " ມີການຂຸດຄົ້ນໄມ້ "

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VALTIP3

ຊັ່ງ ລຳຫູອດ ແລະ ເກັບກຳຂໍ້ມູນ ຂອງດອນວອນໄປລັກ

ເວລາໝາຍດອນ ______ ວັນທີ ___ / ___ / ___ ຊື່ຜູ້ເກັບຂໍ້ມູນ ______

ຄວາມຕ້ອຍຊຸ້ນ ______ = ຂອນໄມ້ສັກ, ແມ່ນ [ ] ບໍ່ແມ່ນ [ ] ສາເຫດ ______

ຄຳຄິດເຫັນ ______

ເບີທີ	ໜັກເດີ່ງ	ຄຸນນະພາບ	ເບີນ່ກເບີດ	ວອງວອງ
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ເບີທີ	ໜັກເດີ່ງ	ຄຸນນະພາບ	ເບີນ່ກເບີດ	ວອງວອງ
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VALTIP3 - ຮ່າງ ສໍາຫຼວດ ແລະ ເກັບກໍາຂໍ້ມູນ ຂອງດອນສວນໄມ້ສັກ

ເລກໝາຍດອນ ______ ວັນທີ ____ / ____ / ____ ຊື່ຜູ້ເກັບຂໍ້ມູນ ______

ຄວາມຄ້ອຍຊັນ ______ ສວນໄມ້ສັກ, ແມ່ນ ☐ ບໍ່ແມ່ນ ☐ ສາເຫດ ______

ຄໍາຄິດເຫັນ ______

					Log 1			Log2			Log3		
ຕົ້ນທີ	ໜ້າວັດ	ຮູບພາບ	ຕົ້ນກໍາເນີດ	ວອງວຽງ	Grade	Start	End	Grade	Start	End	Grade	Start	End
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30													

					Log 1			Log2			Log3		
Tree	Diam.	Quality	Stem	Height	Grade	Start	End	Grade	Start	Top	Grade	Start	End
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