VERIFICATION OF TREE GROWTH MONITORING BY FUTURO FORESTAL S.A.

Project: La Reina

MSc. Sicco W. Stortelder
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1. Introduction

This report concerns the results of an independent verification of a tree plantation managed by Futuro Forestal S.A., called La Reina. The cooperative Waldmenschen eG contracted the author of this report for realizing an independent verification of the measurements of trees in this project.

The periodic measurement of trees within a permanent growth plot of an established plantation is generally considered as being part of good management practices, to determine the forest health, status, growth, and performance and also to be able to calculate figures such as the Mean Annual Increment and compare such figures with growth tables from literature or other sites. This allows both the management and investors to closely monitor the development of the site, and take information-based decisions regarding management techniques to be applied, but also to make projection of future growth.

The author visited the site, located in the province of Darien, Panama, on the 26th and 27th of October 2017, accompanied by staff of the Futuro Forestal.

The author would like to thank in particular Andreas Eke, Iliana Armien and Juan Gonzales for their pleasant cooperation and facilitation of my visit, but also to the rest of the field staff that helped making this verification possible.

About the author – MSc. Sicco W. Stortelder

An environmentally and socially inspired specialist in Sustainable Forestry Economics, with experience at the Dutch Ministry of Agriculture, Nature and Food Quality and the World Bank (IFC). Currently working as an independent forestry and economics consultant and counting with a BSc in computer science (University of Twente) and a Master's degree in Forest and Nature conservation at University of Wageningen. Specialties: - Economic/financial models for Forestry Businesses (NFM, private enterprises, NGO's) - Sustainable Forest Management.

2. Methodology

The objective of this study is:

- Revision of soundness of methodology and measurements by Futuro Forestal S.A. in established permanent growth plots in the project La Reina, Panama.

The author applied the following methodology to realize this study:

- Revision of Futuro Forestal's methodology for establishment and monitoring of permanent growth plots, set out in the document '*Guía para el Establecimiento, Monitoreo y Seguimiento de Parcelas Permanentes de Crecimiento, Futuro Forestal S.A., 2013*'.
- Revision of application of Futuro Forestal's methodology in practice[1].
- In-field measurements of a randomized selection of trees within the permanent growth plots.
- Analysis and comparison of data with previous measurements provided by Futuro Forestal S.A..

La Reina - Site characteristics

Site name	**La Reina**
Province, country	**Darien, Panama**
Establishment year (of first plantation)	**2013**
Total size of projects (ha.)	**25.3916**
.. of which plantation (ha.)	**20.70**
.. of which protected area (ha.)	**4.6916**
Species	**Teak, Mora, Spanish Cedar, Rosy Trumpet Tree, Rosewood**
Number of permanent growth plots	**6**
Number of permanent growth plots verified	**6**
Number of permanent growth compared with F.F. data	**5**

[1] insofar possible during the time of stay.

3. Analysis

Observations with respect to Futuro Forestal's methodology:

- The document *Guía para el Establecimiento, Monitoreo y Seguimiento de Parcelas Permanentes de Crecimiento, Futuro Forestal S.A., 2013,* provided by Futuro Forestal, can be considered a complete and practical guide for the establishment, monitoring and tracking of Permanent Growth plots. Among other aspects, it defines:
  - General and specific goals of the permanent growth plots
  - Shape, size, amount of permanent growth plots, including guidelines for their location and distribution
  - Practical guide for establishment, signaling, measurement and analysis
- Some observations could be made with respect to the guide and its practical implementation:
  - The document does not specify what is understood with Commercial height ('*Altura commercial*'). Although the concept is generally understandable, as it refers to the height of the tree that can be commercially used, it is not specified how this commercial height should be determined. Neither in literature there is an exact definition of this concept, as it depends on wood markets and (local) conventions. The author considers the commercial tree height to be the height of the tree up to the first damages or irregularities affecting wood quality. Also, in case of trees of considerable height and thickness, one can sometimes include several sections of the tree, e.g. the stem's height and another (or more) long straight, unaffected stems or branch(es), which are then summed up to calculate the total commercial tree height.
    During the field work, Futuro Forestal's supporting field staff mentioned they have also measured the height of the tree till the first branching, as the commercial height. Although this could be a good criterion, it was not clear whether this was a general standard applied. Such a determination should also be in line with what is considered 'commercial' in the local and/or international market centers, or with the criteria of the foreseen buyer of the timber (if any).
    The author recommends the company to determine what markets or potential buyers consider commercially usable wood (taking into account species, length, thickness, accepted level of distortions, branching), and based on that, include a definition of the commercial height in the respective guide, as well as trainings on this topic to the relevant staff.
  - The guide does not refer to required trainings to communicate the contents of the material to its (field) personal. The author recommends to include a short chapter about this, including aspects of training responsibility, frequency, scope and testing of knowledge of participants.

Observations regarding application of Futuro Forestal's methodology in practice:

- The other confirms size and shape of the permanent growth plot is according to its guide.
- The methodology mentions that the plots are annually measured in the dry period (April-May). Measurement data for years before 2017 was not provided. Also, the 2017

measurement was realized in January and February of that year. Although this is a difference of just a few months, for data consistency it is recommended to realize measurements each year at the same time.

- In some cases, the trees' painted numbers were not always legible, recommended is to carefully check this and repaint them, as well as the DBH height. In several plots, the plot (or parcel) number was not painted on the trees – recommended is to include this number at a number of trees of each plot, to avoid any confusion.
- Although the company's guide, in Chapter 9.1, mentions how measured data should be processed and systemized, the author did not receive e.g. analysis, comparisons and graphs of multiple years of a single plot in excel or statistical programs. The author suggests to improve the general systemization and analysis of this data.

Analysis and comparison of field data

Trees were measured by the author in all present plots, with a sample of 15 trees per plot. The exact data of these measurements can be reviewed in Annex I. The following Table (1) provides a short statistical summary.

PLOT	1,2,3,4,5,6
SPECIES	Teak (Tectona Grandis)
ESTABL. YEAR	2013

PLOT #	GIRTH (CM)	DBH (CM)	COM. HEIGHT (M)	TOTAL HEIGHT (M)
AVERAGE	51,1	16,3	6,5	11,1
MINIMUM	33,5	10,7	2,5	8,0
MAXIMUM	77,0	24,5	10,0	14,0
MEDIAN	49,5	15,8	6,5	11,0
STD. DEV.	9,5	3,0	1,3	1,2

Table 1 –Statistical summary measurement PGPs

All plots concern the species Teak (*Tectona Grandis*). Although some plots did contain some (natural regeneration of) Native species, they were not part of the trees monitored and could therefore not be analyzed.

The following table shows a summary of the comparison with data provided by Futuro Forestal. Please refer to Annex II for all detailed tables with per-tree comparisons.

	DBH (CM)	DBH (CM)	DIFF.	COM. HEIGHT (M)	COM. HEIGHT (M)	DIFF.	TOTAL HEIGHT (M)	TOTAL HEIGHT (M)	DIFF.
	AUTHOR	F.F.		AUTHOR	F.F.		AUTHOR	F.F.	
AVERAGE	16,4	13,7	2,7	6,4	4,0	2,4	11,0	10,8	0,3
MINIMUM	10,7	8,6	1,0	2,5	2,0	-0,2	8,0	8,3	-5,1
MAXIMUM	24,5	22,5	13,0	10,0	5,4	5,7	14,0	18,8	3,7
MEDIAN	15,8	13,0	2,6	6,5	4,0	2,6	11,0	10,1	0,3
STD. DEV.	3,2	3,1	1,4	1,4	0,6	1,4	1,2	2,0	1,4

Table 2 - Measurement data comparison (summary)

Comparative analysis:

- All measured DBH values by the author are above those measured by Futuro Forestal in January and February 2017. The average difference is 2.7 cm, which can be explained by the growth in the period January/February 2017 – October 2017.
- The differences in Commercial height is on average 2.4 m; almost all values measured by the author are significantly higher than those measured by the company. This can be explained by the growth during the approx. 9-10 months between the measurements, though part it of can also be a result of the different criteria used for the estimation of the commercial height (see comments on previous page). In 3 cases the measured commercial height was lower than the measured value, yet this difference was very small (0.1 to 0.2 m) and can be attributed to the fact the author rounded off numbers to 0.5 m precision while F.F. measured trees up to 0.1 m precision.
- The differences in Total tree height are relatively small, especially when considering the total size, with an average difference of 0.3 m. This is a relatively small, considering that in about 10 months one would expect a somewhat higher average growth. In general, this can be explained by the difficulty and relative uncertainty of measuring the tree's total height. Because of this uncertainty, the author preferred to round off the total meters of a tree to 0.5 m precision, whereas height measured by the company was measured up to 0.1 m precision. This is probably one of the reason of the differences and the reason why measured values by the author show little differences. In two cases, Futuro Forestal measured a height around 5 meters higher than the one measured by the author. Possibly this is due to a mismeasurement or wrong annotation, and it would be advisable to double-check these trees in the next scheduled monitoring.

Commercial volume comparison:

In the following table, the author compared commercial volume and Mean Annual Increment (MAI) in further detail.

	DBH (cm)	DBH (cm)	M3	M3	DIFF M3	DIFF M3	DIFF M3	MAI	MAI
	AUTHOR	F.F.	AUTHOR	F.F.	(TOTAL)	(% DUE TO DBH DIFF.)	(% DUE TO COM. HEIGHT DIFF.)	AUTHOR	F.F.
AVERAGE	16,43	13,33	0,064	0,028	0,037	47%	53%	7,721	4,451
MINIMUM	10,66	0,00	0,021	0,000	0,004	15%	-16%	1,968	0,000
MAXIMUM	24,51	22,50	0,191	0,081	0,120	116%	85%	25,319	14,224
MEDIAN	15,76	12,70	0,059	0,023	0,031	42%	58%	6,971	3,864
STD. DEV.	3,21	3,73	0,034	0,016	0,023	24%	24%	4,387	2,767

Table 3 - Commercial volume and MAI comparison

There is an average increase of 0.037 M3 per tree between the data of the author and F.F. The MAI calculated by the author is 7.72 M3/ha, while F.F. measured 4.45 M3/ha[2] earlier in 2017[3]. This difference is caused by both the measured wider diameter, and the higher commercial tree height. Calculating the contribution of each factors, the higher estimated commercial tree height contributes on average 47% to this increase, while the increased DBH contributes 53% to the increased, estimated commercial volume.

[2] Calculation done by the author.

[3] The MAI was calculated on a per-tree basis, based on the density (amount of trees/ha) of the plots, the commercial volume per tree and the moment of measurement. For Futuro Forestal's measurement in January/February 2017, the author assumed an age of 3 years (2013-2016), while the age of the stand when measured in October 2017 was considered 4 years.

The basal area per plot was also calculated, as shown in the following table.

PLOT	# TREES	# TREES /HA	EST. STAND BASAL AREA (M2/HA)
1	53	530	13,40
2	37	370	8,58
3	41	410	9,40
5	62	620	13,95
6	47	470	10,47
AVERAGE	**48**	**480**	**11,16**

Table 4 – Tree density in PGPs and estimated standing basal area (m2/ha)

Noteworthy are the significant differences in density, and estimated standing basal area[4]. During future thinnings, the number of trees/ha will likely be equalized, and it would be interesting to analyze the optimal tree density for growth for all age ranges.

The data on individual tree level can be found in Annex III.

[4] The differences in density may be due to the presence of not-monitored Native tree species in the permanent growth plots.

4. Conclusion and recommendations:

Futuro Forestal S.A. counts with a well-described methodology for the establishment and monitoring of permanent growth plots. In general, the company adheres to its own guide regarding shape, size and distribution of plots, though the company did not provide annual measurements for each year in the same month of the year and data systemization can be improved. Also, the methodology lacks a specific definition of commercial tree height, which complicated analysis of the author's data with data from Futuro Forestal.

With respect to the verification of measurements of the plots, the author confirms that DBH measurements and total height measurements by Futuro Forestal are accurate, with increases in diameter due to growth in the Jan/Feb. 2017 -> Oct 2017 period and average increase in commercial height and total height as well.

The average MAI calculated by the author was 7.72 M3/ha, with a standing basal area of 11.16 m2/ha and an average DBH of 16.3 cm.

Some further recommendations, particular to the La Reina project:

- Include special monitoring plots for the Native species, and include and number Native trees present within the Permanent growth plot for the annual monitoring.
- Determine the optimal tree densities for each age and take this into account with thinnings. The permanent growth plots measured show a density variation of 370 to 620 trees per hectare – a significant difference for equally aged stands. Compared to reference growth tables, usual densities after the first thinning (as in the case of Reina) for Teak are close to 680 trees/ha[5], so the actual density in all plots was lower. Possibly, the difference is due the presence of non-monitored Native species, another reason to include these trees in the monitoring data.

[5] Data from Futuro Forestal.

Annex I - Measured data from PGPs

PLOT #	GIRTH (CM)	DBH (CM)	COM. HEIGHT (M)	TOTAL HEIGHT (M)
P1	75	23,9	7,5	12
P1	61	19,4	5	12
P1	60,5	19,3	6,5	13
P1	49,5	15,8	8	12
P1	67,5	21,5	4,5	13
P1	52,5	16,7	6,5	13
P1	63	20,1	10	14
P1	46,5	14,8	4,5	11
P1	75,5	24,0	6	13
P1	73	23,2	8	12
P1	62	19,7	6	13
P1	43	13,7	5,5	10
P1	40,5	12,9	7,5	11
P1	77	24,5	9	13
P1	56	17,8	5	14
P2	40,5	12,9	5	9
P2	58,5	18,6	7	10,5
P2	55	17,5	7	11
P2	44,5	14,2	3	10,5
P2	64	20,4	6,5	12
P2	45	14,3	5,5	11
P2	43	13,7	6,5	11
P2	49,5	15,8	7,5	11
P2	45	14,3	7,5	11
P2	59,5	18,9	8	12
P2	38,5	12,3	7,5	10
P2	49	15,6	7	10
P2	41	13,1	6,5	10
P2	46,5	14,8	7	10,5
P2	39	12,4	7,5	11
P3	58,5	18,6	7	12
P3	46	14,6	7	11
P3	48	15,3	7,5	11
P3	47	15,0	4,5	10
P3	63	20,1	6,5	12
P3	40,5	12,9	6,5	12
P3	73	23,2	8,5	12
P3	57	18,1	6	12
P3	54,5	17,3	7	11
P3	58	18,5	5	12
P3	54	17,2	7,5	12
P3	44	14,0	6,5	12
P3	51	16,2	7	12
P3	42	13,4	4	10

PLOT #	GIRTH (CM)	DBH (CM)	COM. HEIGHT (M)	TOTAL HEIGHT (M)
P4	49,5	15,8	8	12
P4	53	16,9	6	12
P4	47	15,0	6,5	12
P4	42	13,4	5	12
P4	50,5	16,1	6,5	12
P4	50	15,9	5,5	12
P4	57,5	18,3	7,5	12
P4	46	14,6	6,5	11
P4	55,5	17,7	7	12
P4	44,5	14,2	6	11
P4	48,5	15,4	6,5	12
P4	40	12,7	7	12
P4	40,5	12,9	7,5	11
P4	51	16,2	8	12
P4	56	17,8	9	12
P5	57	18,1	3,5	10
P5	59,5	18,9	6,5	11
P5	42	13,4	7	8
P5	49,5	15,8	6	11
P5	48,5	15,4	2,5	10
P5	40	12,7	4	9
P5	47,5	15,1	5	11
P5	56	17,8	8	12
P5	33,5	10,7	6,5	10
P5	41	13,1	7	11
P5	42,5	13,5	6,5	11
P5	45,5	14,5	8	11
P5	49	15,6	8	11
P5	47	15,0	6	10,5
P5	45	14,3	6,5	11
P6	60	19,1	6,5	11
P6	33,5	10,7	7	10
P6	55,5	17,7	6,5	10
P6	64	20,4	5	11
P6	47	15,0	7,5	10
P6	52,5	16,7	6,5	10
P6	41	13,1	6,5	9
P6	50,5	16,1	6,5	10
P6	57	18,1	7,5	10
P6	66	21,0	6,5	9
P6	51,5	16,4	5	11
P6	47	15,0	6,5	10
P6	43,5	13,8	4,5	9
P6	60	19,1	5	9
P6	43	13,7	7	11

Annex II – Data comparison

	DBH (CM)	DBH (CM)	DIFF.	COM. HEIGHT (M)	COM. HEIGHT (M)	DIFF.	TOTAL HEIGHT (M)	TOTAL HEIGHT (M)	DIFF.
	AUTHOR	F.F.		AUTHOR	F.F.		AUTHOR	F.F.	
P1	23,9	22,5	1,4	7,5	4,5	3	12	13	-1
P1	19,4	17,7	1,7	5	4,1	0,9	12	12,3	-0,3
P1	19,3	17,4	1,9	6,5	4,8	1,7	13	13,7	-0,7
P1	15,8	14	1,8	8	4,1	3,9	12	13,4	-1,4
P1	21,5	18,3	3,2	4,5	4,4	0,1	13	13,5	-0,5
P1	16,7	14,7	2,0	6,5	4,5	2	13	13,7	-0,7
P1	20,1	17,5	2,6	10	4,3	5,7	14	13,9	0,1
P1	14,8	13,3	1,5	4,5	4,4	0,1	11	10,1	0,9
P1	24,0	11	13,0	6	5,4	0,6	13	12,5	0,5
P1	23,2	21,1	2,1	8	4,5	3,5	12	13,4	-1,4
P1	19,7	17,3	2,4	6	4	2	13	12,7	0,3
P1	13,7	11	2,7	5,5	3,9	1,6	10	8,7	1,3
P1	12,9	10,5	2,4	7,5	4,6	2,9	11	10,1	0,9
P1	24,5	21,4	3,1	9	4,4	4,6	13	14,8	-1,8
P1	17,8	16,8	1,0	5	4,6	0,4	14	18,8	-4,8
P2	12,9	10,8	2,1	5	2,7	2,3	9	9,6	-0,6
P2	18,6	15,7	2,9	7	3,5	3,5	10,5	10,6	-0,1
P2	17,5	14,5	3,0	7	4,2	2,8	11	11,6	-0,6
P2	14,2	12,4	1,8	3	3,1	-0,1	10,5	9,1	1,4
P2	20,4	16,6	3,8	6,5	3,9	2,6	12	10	2
P2	14,3	11	3,3	5,5	3,2	2,3	11	8,5	2,5
P2	13,7	10,8	2,9	6,5	3,6	2,9	11	8,9	2,1
P2	15,8	12,7	3,1	7,5	3,5	4	11	10,1	0,9
P2	14,3	12,3	2,0	7,5	3,7	3,8	11	10,6	0,4
P2	18,9	15,5	3,4	8	4,1	3,9	12	12,8	-0,8
P2	12,3	9,6	2,7	7,5	4,3	3,2	10	10,9	-0,9
P2	15,6	12,3	3,3	7	2,6	4,4	10	10,2	-0,2
P2	13,1	11	2,1	6,5	3,6	2,9	10	11	-1
P2	14,8	12,7	2,1	7	3,8	3,2	10,5	11	-0,5
P2	12,4	11	1,4	7,5	3,7	3,8	11	10,5	0,5
P3	18,6	17	1,6	7	3,9	3,1	12	12,2	-0,2
P3	14,6	11	3,6	7	3,9	3,1	11	8,9	2,1
P3	15,3	12,3	3,0	7,5	4,1	3,4	11	9,7	1,3
P3	15,0	11,2	3,8	4,5	3,2	1,3	10	10,1	-0,1
P3	20,1	18,3	1,8	6,5	5,3	1,2	12	12,7	-0,7
P3	12,9	10,9	2,0	6,5	3,91	2,59	12	11,6	0,4
P3	23,2	20,3	2,9	8,5	4,1	4,4	12	13,4	-1,4
P3	18,1	16	2,1	6	4,3	1,7	12	11,7	0,3
P3	17,3	15	2,3	7	4	3	11	12,6	-1,6
P3	18,5	15,5	3,0	5	3,8	1,2	12	12,7	-0,7
P3	17,2	14,8	2,4	7,5	4	3,5	12	12,8	-0,8
P3	14,0	12,3	1,7	6,5	3,8	2,7	12	11,7	0,3
P3	16,2	14	2,2	7	4,1	2,9	12	10,5	1,5
P3	13,4	11,2	2,2	4	4,2	-0,2	10	10,4	-0,4
P3	12,1	10,8	1,3	4,5	3,8	0,7	10	10	0

	DBH (CM)	DBH (CM)	DIFF.	COM. HEIGHT (M)	COM. HEIGHT (M)	DIFF.	TOTAL HEIGHT (M)	TOTAL HEIGHT (M)	DIFF.
	AUTHOR	F.F.		AUTHOR	F.F.		AUTHOR	F.F.	
P5	18,1	14,1	4,0	3,5	3,5	0	10	9,6	0,4
P5	18,9	14,1	4,8	6,5	3,8	2,7	11	9,4	1,6
P5	13,4	11	2,4	7	3	4	8	9,4	-1,4
P5	15,8	13	2,8	6	4	2	11	8,4	2,6
P5	15,4	12,5	2,9	2,5	2,7	-0,2	10	9,4	0,6
P5	12,7	10,3	2,4	4	4	0	9	9,4	-0,4
P5	15,1	13,3	1,8	5	3,4	1,6	11	8,6	2,4
P5	17,8	14,7	3,1	8	3,2	4,8	12	8,3	3,7
P5	10,7	8,6	2,1	6,5	3,6	2,9	10	9,2	0,8
P5	13,1	10	3,1	7	3,8	3,2	11	16,1	-5,1
P5	13,5	11,4	2,1	6,5	4	2,5	11	8,4	2,6
P5	14,5	11,2	3,3	8	4	4	11	9,6	1,4
P5	15,6	12,2	3,4	8	4,6	3,4	11	8,8	2,2
P5	15,0	11,6	3,4	6	3,3	2,7	10,5	9,3	1,2
P5	14,3	11,5	2,8	6,5	4	2,5	11	9,1	1,9
P6	19,1	16,7	2,4	6,5	5	1,5	11	10,6	0,4
P6	10,7	8,9	1,8	7	2	5	10	8,4	1,6
P6	17,7	14	3,7	6,5	4,8	1,7	10	9,8	0,2
P6	20,4	0	-	5	0	-	11	0	-
P6	15,0	0	-	7,5	0	-	10	0	-
P6	16,7	14	2,7	6,5	4	2,5	10	9,4	0,6
P6	13,1	10,4	2,7	6,5	4,6	1,9	9	8,7	0,3
P6	16,1	13,3	2,8	6,5	5	1,5	10	8,9	1,1
P6	18,1	14,7	3,4	7,5	4,6	2,9	10	8,6	1,4
P6	21,0	18,3	2,7	6,5	4,6	1,9	9	9,5	-0,5
P6	16,4	15,3	1,1	5	4	1	11	10,1	0,9
P6	15,0	11,8	3,2	6,5	4	2,5	10	9,6	0,4
P6	13,8	11,4	2,4	4,5	3,8	0,7	9	8,3	0,7
P6	19,1	15,5	3,6	5	4,6	0,4	9	9,1	-0,1
P6	13,7	11,7	2,0	7	4,6	2,4	11	10,1	0,9

Annex III – Tree volumes and MAI comparison

PLOT #	DBH (cm)	DBH (cm)	M3	M3	DIFF M3	DIFF M3	DIFF M3	MAI (4y)	MAI (3y)
	AUTHOR	F.F.	AUTHOR	F.F.	(TOTAL)	(% DUE TO DBH DIFF.)	(% DUE TO COM. HEIGHT DIFF.)	AUTHOR	F.F.
P1	23,87	22,50	0,151	0,081	0,071	16%	84%	20,02	14,22
P1	19,42	17,70	0,067	0,045	0,021	48%	52%	8,83	8,02
P1	19,26	17,40	0,085	0,051	0,034	39%	61%	11,29	9,07
P1	15,76	14,00	0,070	0,028	0,042	22%	78%	9,30	5,02
P1	21,49	18,30	0,073	0,052	0,021	94%	6%	9,73	9,20
P1	16,71	14,70	0,064	0,034	0,030	40%	60%	8,50	6,07
P1	20,05	17,50	0,142	0,047	0,096	19%	81%	18,83	8,22
P1	14,80	13,30	0,035	0,028	0,007	91%	9%	4,62	4,86
P1	24,03	11,00	0,122	0,023	0,099	97%	3%	16,23	4,08
P1	23,24	21,10	0,153	0,071	0,082	21%	79%	20,23	12,51
P1	19,74	17,30	0,083	0,042	0,040	38%	62%	10,94	7,47
P1	13,69	11,00	0,036	0,017	0,020	57%	43%	4,83	2,95
P1	12,89	10,50	0,044	0,018	0,026	45%	55%	5,84	3,17
P1	24,51	21,40	0,191	0,071	0,120	23%	77%	25,32	12,58
P1	17,83	16,80	0,056	0,046	0,010	59%	41%	7,44	8,11
P2	12,89	10,80	0,029	0,011	0,018	33%	67%	2,72	1,37
P2	18,62	15,70	0,086	0,030	0,055	29%	71%	7,94	3,76
P2	17,51	14,50	0,076	0,031	0,045	41%	59%	7,01	3,85
P2	14,16	12,40	0,021	0,017	0,004	112%	-12%	1,97	2,08
P2	20,37	16,60	0,095	0,038	0,057	43%	57%	8,82	4,68
P2	14,32	11,00	0,040	0,014	0,026	49%	51%	3,69	1,69
P2	13,69	10,80	0,043	0,015	0,028	43%	57%	3,98	1,83
P2	15,76	12,70	0,066	0,020	0,046	32%	68%	6,09	2,46
P2	14,32	12,30	0,054	0,020	0,035	26%	74%	5,03	2,44
P2	18,94	15,50	0,101	0,035	0,067	34%	66%	9,38	4,29
P2	12,25	9,60	0,040	0,014	0,026	46%	54%	3,68	1,73
P2	15,60	12,30	0,060	0,014	0,046	26%	74%	5,57	1,71
P2	13,05	11,00	0,039	0,015	0,024	34%	66%	3,62	1,90
P2	14,80	12,70	0,054	0,022	0,033	30%	70%	5,01	2,67
P2	12,41	11,00	0,041	0,016	0,025	21%	79%	3,78	1,95
P3	18,62	17,00	0,086	0,040	0,046	20%	80%	8,79	5,44
P3	14,64	11,00	0,053	0,017	0,036	49%	51%	5,44	2,28
P3	15,28	12,30	0,062	0,022	0,040	40%	60%	6,34	3,00
P3	14,96	11,20	0,036	0,014	0,021	66%	34%	3,65	1,94
P3	20,05	18,30	0,092	0,063	0,030	47%	53%	9,47	8,57
P3	12,89	10,90	0,038	0,016	0,022	38%	62%	3,91	2,24
P3	23,24	20,30	0,162	0,060	0,102	22%	78%	16,63	8,16
P3	18,14	16,00	0,070	0,039	0,031	42%	58%	7,16	5,32
P3	17,35	15,00	0,074	0,032	0,043	31%	69%	7,63	4,35
P3	18,46	15,50	0,060	0,032	0,028	57%	43%	6,17	4,41
P3	17,19	14,80	0,078	0,031	0,047	29%	71%	8,03	4,23
P3	14,01	12,30	0,045	0,020	0,025	29%	71%	4,62	2,78
P3	16,23	14,00	0,065	0,028	0,037	33%	67%	6,68	3,88
P3	13,37	11,20	0,025	0,019	0,007	113%	-13%	2,59	2,54
P3	12,10	10,80	0,023	0,016	0,008	58%	42%	2,39	2,14

PLOT #	DBH (cm)	DBH (cm)	M3	M3	DIFF M3	DIFF M3	DIFF M3	MAI (4y)	MAI (3y)
	AUTHOR	F.F.	AUTHOR	F.F.	(TOTAL)	(% DUE TO DBH DIFF.)	(% DUE TO COM. HEIGHT DIFF.)	AUTHOR	F.F.
P5	18,14	14,10	0,041	0,025	0,016	100%	0%	6,31	5,08
P5	18,94	14,10	0,082	0,027	0,056	53%	47%	12,77	5,52
P5	13,37	11,00	0,044	0,013	0,031	26%	74%	6,85	2,65
P5	15,76	13,00	0,053	0,024	0,029	48%	52%	8,16	4,94
P5	15,44	12,50	0,021	0,015	0,006	116%	-16%	3,26	3,08
P5	12,73	10,30	0,023	0,015	0,008	100%	0%	3,55	3,10
P5	15,12	13,30	0,040	0,021	0,019	38%	62%	6,26	4,39
P5	17,83	14,70	0,090	0,024	0,065	24%	76%	13,93	5,05
P5	10,66	8,60	0,026	0,009	0,017	40%	60%	4,05	1,94
P5	13,05	10,00	0,042	0,013	0,029	46%	54%	6,53	2,78
P5	13,53	11,40	0,042	0,018	0,024	40%	60%	6,52	3,80
P5	14,48	11,20	0,059	0,018	0,042	40%	60%	9,19	3,66
P5	15,60	12,20	0,069	0,024	0,045	46%	54%	10,66	5,00
P5	14,96	11,60	0,047	0,016	0,032	45%	55%	7,36	3,24
P5	14,32	11,50	0,047	0,019	0,028	47%	53%	7,31	3,86
P6	19,10	16,70	0,084	0,049	0,035	51%	49%	9,85	7,72
P6	10,66	8,90	0,028	0,006	0,023	15%	85%	3,31	0,88
P6	17,67	14,00	0,072	0,033	0,038	63%	37%	8,42	5,21
P6	20,37	0,00	0,073	0,000	0,073			8,62	0,00
P6	14,96	0,00	0,059	0,000	0,059			6,97	0,00
P6	16,71	14,00	0,064	0,028	0,036	40%	60%	7,54	4,34
P6	13,05	10,40	0,039	0,018	0,022	58%	42%	4,60	2,75
P6	16,07	13,30	0,059	0,031	0,028	61%	39%	6,97	4,90
P6	18,14	14,70	0,087	0,035	0,052	45%	55%	10,25	5,50
P6	21,01	18,30	0,101	0,054	0,047	43%	57%	11,91	8,53
P6	16,39	15,30	0,047	0,033	0,014	37%	63%	5,58	5,18
P6	14,96	11,80	0,051	0,020	0,032	49%	51%	6,04	3,08
P6	13,85	11,40	0,030	0,017	0,013	72%	28%	3,58	2,73
P6	19,10	15,50	0,064	0,039	0,025	86%	14%	7,57	6,12
P6	13,69	11,70	0,046	0,022	0,024	41%	59%	5,45	3,49