REGENERATION AND RESIDUAL STAND AFTER WOKABAUT SOMIL OPERATIONS IN SEASONALLY INUNDATED FOREST NEAR LAE, PAPUA NEW GUINEA.

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ABSTRACT

This study compares undisturbed seasonally inundated lowland rain forest with the same forest 6-8 months after completion of commercial wokabaut somil operations, and with similar forest 6-8 months after conventional logging took place. The results suggest that the commercial wokabaut somil operation reduces the basal area of the total standing stock, the number of trees in the lower diameter classes, and the number of species present in the area directly affected by the operations. The authors conclude that the operation will not be sustainable, unless better felling practices are adopted and TSI measures are implemented following harvesting. While the basal area of the residual stock was greater, and regeneration more abundant in the conventionally logged area than in the wokabaut somil area, the latter operation showed greater harvesting efficiency and less felling damage to the trees in lower diameter classes.

Keywords: *Workabaut somil, Residual stand, Regeneration.*

INTRODUCTION

The Wokabaut Somil (WS) is a small sawmill consisting of a beam along which moves an engine with two circular saws, mounted perpendicular to each other and sawing timber into planks of present sizes. The mill is usually dismantled and hand carried into the forest, where it is placed over the trees to be sawn. WS operations in Papua New Guinea (PNG) have expanded enormously over the past decades but very little is known about the effect of these operations on the immediate forest environment. Louman (1992) suggests that sustainability of a WS operation may be achieved, depending on the specific natural and socio-economic environment in which it takes place.

For tree harvesting to be sustainable, care has to be taken that the harvested trees are succeeded by healthy younger trees and seedlings. While these aspects have been studied in PNG in relation to conventional logging (CL) operations (Buenaflor (unpublished FAO report 1989), Johns (1987), Nir, (1992), Saulei (1984), Saulei and Lamb (1991), Sopu and Arentz (1990), and Vigus (in press)), "a dearth of validated information regarding the development of PNG forest following harvest" still exists (Cameron and Vigus, unpublished reports for the World Bank, 1993, pl Section 1).

In addition, none of the above mentioned studies investigates regeneration and residual stands following the type of operation related to the use of small portable sawmills.

This study, therefore, helps filling a gap in the existing knowledge on impact of tree harvesting systems on the PNG lowland rain forest. The present paper summarises the results of a study into the sustainability of the operations of a WS in a seasonally inundated forest, focussing on felling damage assessment and regeneration studies.

The project area

The study site of 90 hectares is located approximately 25 km West of Lae City on the banks of the Garagos Creek (see map 1). The altitude of the area is approximately 120 m.a.s.l. The climate is wet tropical with an annual rainfall approximately 3000 mm well distributed over the year. Temperatures range from 23° C to 32° C. The soil of the study site is little differentiated, with an alkaline, sandy loam A-horizon overlying a gleyic subsoil. The vegetation can be classified as seasonally inundated alluvial lowland rain forest. The canopy height of the forest is between 25 and 30 meters. Canopy species and

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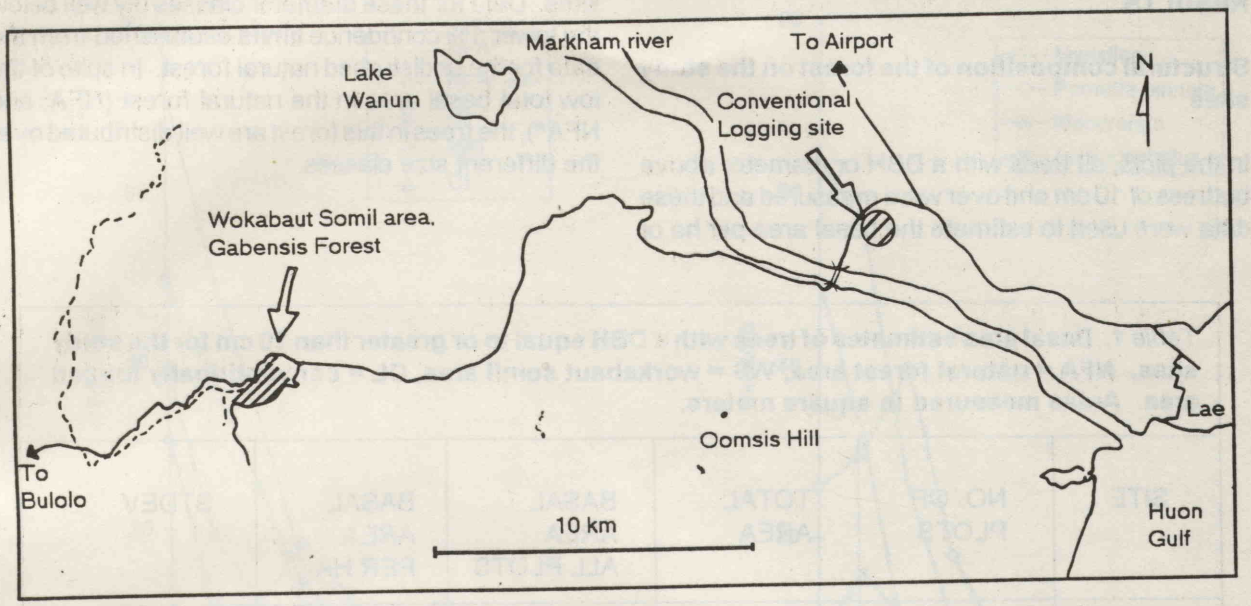

Map 1. **Location of the study sites: A = Gabensis area with wokabaut somil operations, B = Markham area with conventional logging operations.**

genera commonly found in the area are: *Anthocephalus chinensis* (Lamk) A. Rich. ex Walp., *Intsia bijuga* (Colebr.) O. Kuntze, *Macaranga* Thouars spp., *Myristica* Gronov. spp., *Nauclea* Merr. spp., *Octomeles sumatrana* Miq., *Pometia pinnata* J.R. Forster & J.G. Forster, *Pterocarpus indicus* Willd., *Sterculia* L. spp., and *Terminalia* L. spp Palms, rattans and woody lianas are abundant.

A WS has operated in the area for two years prior to the study. Harvest is market oriented, rather than based on silvicultural planning. The result is a mosaic of forest patches cut at different intensities: from heavily cut, locally clear felled areas to nearly untouched areas, the latter having few trees of commercial value. In general, trees are felled in a patch of forest. Then the WS is set-up alongside a felled tree. The other logs felled in that patch of forest are pulled toward the mill using a hand winch. This procedure usually creates more or less circular gaps in the canopy. Canopy cover increases slowly with increasing distance from the centrally located sawmill.

METHODOLOGY

Three circular plots with a 30 m radius were established in areas 6-8 months after the WS ceased operation in those sites. The plot had the original location of the mills as centre. They were used for sampling the vegetation density in terms of basal area of trees above 10 cm DBH. Within the same plots a circle with 20 m radius was marked, which was used for a complete regeneration count.

Similar plots were established in undisturbed forest (NFA), using mature commercial trees as the central point for each plot. Information obtained from these plots was compared to data collected during an inventory of 5.7 ha out of the total 90 ha of the study site. For statistical analysis of the inventory data, it was assumed that the trees in each size class were normally distributed over the area. Out of the 57 plots of 0.1 ha each, only those were used that had at least one potential harvestable tree in it (i.e DBH > 50 cm). A total of 35 plots met this criterion.

In all the sub-plots, regeneration was identified to genus level. Individual plants were counted, and it was established whether the plants were seedlings, or regenerated from stumps.

A comparative analysis was done using the same methodology in a conventionally logged over area (CL) in similar forest, approximately 12 km West of Lae. Trees had been harvested 6-8 months prior to the study.

RESULTS

Structural composition of the forest on the study sites

In the plots, all trees with a DBH or diameter above buttress of 10 cm and over were measured and these data were used to estimate the basal area per ha of sites. Data for these diameter classes lay well below the lower 1% confidence limits established from the data for the undisturbed natural forest. In spite of the low total basal area in the natural forest (NFA, and NFA*), the trees in this forest are well distributed over the different size classes.

Table 1. **Basal area estimates of trees with a DBH equal to or greater than 10 cm for the study sites. NFA = natural forest area, WS = workabaut somil area, CL = conventionally logged area. Areas measured in square meters.**

SITE	NO. OF PLOTS	TOTAL AREA	BASAL AREA ALL PLOTS	BASAL AREA PER HA	STDEV
NFA	3	8482.3	9.55	11.3	1.522
WS	3	8482.3	4.06	4.8**	0.227
CL	3	8482.3	6.97	8.2**	0.253
NFA*	35	35000		19.4**	0.810

* based on data from 6.3% inventory of study area.
** significantly different at 1% level.

the different sites. Table 1 shows the basal area estimates for each site. The basal area, in particular of the undisturbed forest, is very low (11.3 m²/ha). The high standard deviation of the undisturbed forest figures indicate a low level of reliability of the data. For that reason the inventory data of the same forest are included, showing a higher basal area (19.4 m²/ha) and a lower standard deviation (0.81). Unfortunately no undisturbed patch of forest of sufficient size was left in the conventionally logged area to be able to compare basal areas. The data for the WS site and CL site (4.8 and 8.2 m²/ha respectively) indicate that the WS operation studied extracts significantly more trees per ha than the conventional operation at a 1% significance level. Both basal area estimates differ significantly from the data obtained in the inventory of the undisturbed forest.

Figure 1 summarises data on diameter distribution of the trees in the circular plots of 30 m radius for each study site. The Figure shows the lack of trees in the 10-40 cm diameter classes relative to the frequencies in the other diameter classes for both the logged over

Floristic composition of the forest on the study sites

Table 2 indicates the occurrence of 11 major tree genera and species in the different study areas. Appendix A indicates the occurrence of all species in each site. These data confirm the higher harvesting intensity in the WS area. Six to eight months after harvesting only an average of 6 (range 5-9) species were present per circular plot, compared to an average of 10 (9-11) species in the circular plots in the CL area, and of 18 (15-20) species in the NFA.

REGENERATION

Table 3 shows the main results of the regeneration counts in the different size. Regeneration from seedlings was most abundant in the NFA with an average of 481 seedlings of 31 species per plot, followed by the CL area with 315 seedlings of 20 species. While the WS area only had an average of 170 seedlings and 12 species per plot. These figures

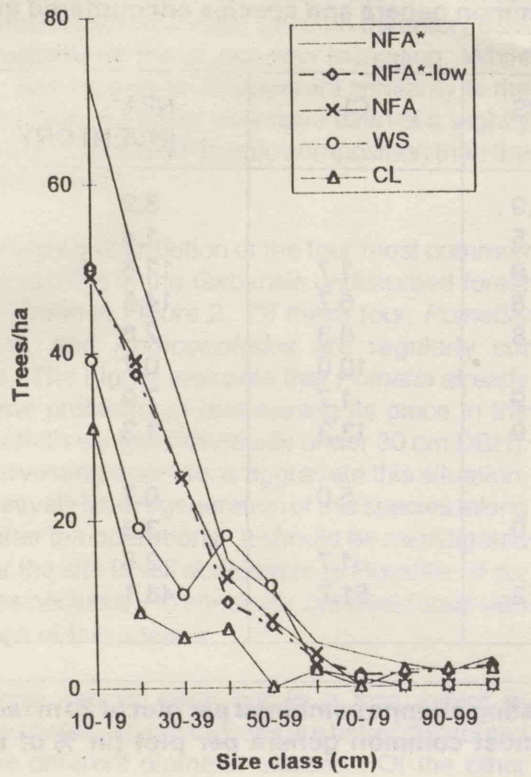

Figure 1: **Frequency distribution of all species combined for each site studied. (*) based on data from Appendix B, NFA*-low indicates the 1% lower limits of the NFA* data**

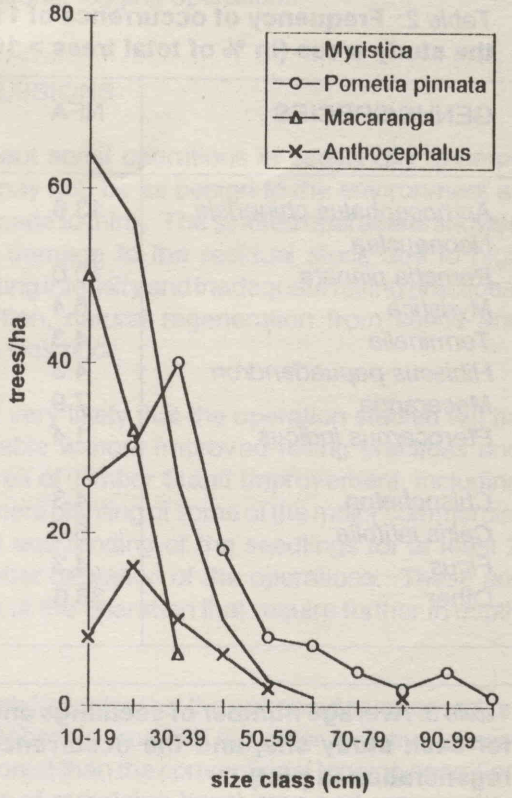

Figure 2: **Frequency distribution of four most common species in the natural forest of the Gabensis study site (data from Appendix B).**

amount to 3828, 2507, and 1353 seedlings per ha. respectively.

Regeneration from stumps averaged nil, 31, and 48 plants per plot for the respective sites. Including this generation from stumps, regeneration in the WS area was significantly less than in both the NFA and CL areas (at 10% level).
Noteworthy is the abundance of *P. pinnata* in the undisturbed forest and it's relative lack (less than 7.5% of seedlings) in the other sites. *Myristica* occurs throughout the plots, while *Neonauclea* Merr. is abundant in the WS site but hardly occurs at all in the other sites. Regeneration of *Elaeocarpus* L. is also abundant in the WS sites, both for stumps and seedlings.

DISCUSSION

Wokabaut somil operations as studied in the seasonally swampy forest near Gabensis in the Morobe Province resulted in great reduction in basal area of standing trees in all diameter classes, but in particular in the smaller diameter classes. This indicates severe felling damage to the potential residual stand or systematic cutting of undersized species.

Conventional logging also resulted in reduced basal areas, but to a lesser extent than that occurred in the studied wokabaut somil operations. Figure 1 data indicate more severe damage to the residual stand than in the wokabaut somil site, while more trees of the larger size classes have been left standing, explaining the higher basal area.

Table 2: **Frequency of occurrence of 11 most common genera and species encountered in the study areas (in % of total trees > 10cm DBH).**

GENUS/SPECIES	NFA	WS	CL	NFA* INVENTORY
Anthocephalus chinensis	13.6	4.9		3.9
Neonauclea		25.5		1.4
Pometia pinnata	10.0	3.9	1.7	12.6
Myristica	6.4	7.8	6.7	14.5
Terminalia	4.3	9.8	8.3	2.8
Hibiscus papuadendron	4.3		10.0	0.7
Macaranga	7.9	3.9	1.7	7.9
Pterocarpus indicus	1.4	4.9	13.3	1.3
Chisocheton	4.3		5.0	0.7
Celtis latifolia	5.0	1.0		3.3
Ficus	4.3		1.7	2.8
Other	38.6	38.2	51.7	48.1

Table 3: **Average number of seedlings and regenerating stumps combined per plot of 20 m radius for each study site, and the occurrence of the most common genera per plot (in % of total regeneration in plot).**

PLOT	NFA	WS6-8	CL
1	783	196	271
2	300	233	264
3	360	226	503
MEAN	481	218	346
STDEV	263.25	19.66	136.01
LOW 10%	286.22	203.79	245.37
HIGH 10%	675.78	232.88	446.64

Note:
At 10% significance level
NFA and WS are different
CL and WS are different
NFA and CL are NOT different

Plot	Most common genera	% of regeneration per plot	Plot	Most common genera	% of regeneration per plot
NFA			CL		
plot 1	*Pometia*	14.3	plot 1	*Dysoxylum*	11.4
	Chisocheton	10.5		*Semecarpus*	8.1
plot 2	*Medusanthera*	9.3		*Nauclea*	8.1
	Myristica	8.7	plot 2	*Vitex*	16.4
	Pometia	7.7		*Hibiscus*	10.4
plot 3	*Pometia*	13.1		*Syzygium*	8.4
	Ficus	10.6	plot 3	*Macaranga*	11.5
	Manilto	9.2		*Barrintonia*	10.3
WS(6-8)				*Polyalthia*	9.5
plot 1	mixed			*Syzygium*	8.5
plot 2	*Myristica*	12.8		*Hibiscus*	8.5
	Elaeocarpus	12.0			
	Terminalia	11.2			
plot 3	*Elaeocarpus*	14.1			
	Neonauclea	14.1			
	Myristica	9.7			

Some caution should be taken, though, in the interpretation of these data, since no inventory data were available for the CL site prior to logging. While the site was chosen for its apparent similarity to the Gabensis site, the forest may have been of a slightly different structural and floristic composition than the Gabensis forest.

The frequency distribution of the four most common species existing in the Gabensis undisturbed forest area is shown in Figure 2. Of these four, *Pometia, Myristica,* and *Anthocephalus* are regularly cut species. The Figure indicates that *Pometia* already has some problems in maintaining its place in the forest (relatively few individuals under 30 cm DBH). Tree harvesting operations aggravate this situation, with relatively little regeneration of this species taking place after the operations. It should be investigated whether the site is still acceptable to *Pometia*. If so, it may be necessary to enrich the cut-over forest with seedlings of this species.

The same can be said, but to a less extent of *Anthocephalus*. *Myristica* trees are better distributed over the different diameter classes. Of the other commercial species present in the undisturbed forest. *Dracontomelon dao* (Blanco) Merr. & Rolfe *Intsia bijuga, Octomeles sumatrana, Planchonella* Pierre sp., and *Pterocarpus indicus* seemed to have a lack of trees in the lower diameter classes, resulting in very flat to climbing frequency distribution curves (compare data in Appendix B). Regeneration of these species may need to be encouraged, if their presence in the future harvestable stock is desired. This may be of greater necessity in the WS area than in the CL site, due to poorer regeneration in the former site.

In general, regeneration is low in the sites studied. In forests in New Britain average regeneration counts of 30,000 seedlings per ha. have been obtained (Vigus, in press), while Saulei (1984) found up to 40,000 seedlings per ha. after clear felling. The seasonal swampiness of the areas studied is probably the main cause for the lack of generation. This aspect would need further investigations to see whether any type of tree harvesting operation should be carried out in such an area.

The site selected by the sawmill owner appears to be barely suitable for this type of operations. Unfortunately, wokabaut somil owners will often have to resort to these second or third rate sites, since these are the sites normally left untouched by previous, conventional logging operations.

CONCLUSIONS

Wokabaut somil operations in seasonally swampy areas may not be as benign to the environment as one is made to think. The studied operations showed severe damage to the residual stock due to high harvesting intensity and inadequate felling practices. In addition, natural regeneration from seeds and stumps was poor.

It is not very likely that the operation studied will be sustainable without improved felling practices and measures of Timber Stand Improvement, including enrichment planting of some of the major commercial species and tending of the seedlings for at least 2 years after cessation of the operations. These are aspects of the operation that require further in depth study.

This study indicates that the wokabaut somil operation in the Gabensis area had a greater negative impact on the forest than the conventional logging operation in terms of remaining basal area and regeneration from seedlings and stumps, both in species composition and number. On the other hand, the residual stand had a relative greater number of young trees (diameter classes 10-40 cm) in the WS area than in the CL area, indicating that harvesting had been more efficient, that less felling damage occurred per felled tree, and that therefore the potential for timber production from the residual stock is greater in the wokabaut somil area. Thus wokabaul sawmilling in Gabensis has good prospects for the next crop in 25-30 years time, but what happens thereafter will completely depend on the ability of the sawmill owners to improve regeneration in the area.

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Map 1; Location of the study sites: A = Gabensis area with wokabaut

APPENDIX A

Frequency of occurrence (% of all trees above 10 cm DBH) of all genera in all study sites. NFA = natural forest area, WS = wokabaut somil area, CL = conventional logging area.

GENUS/SPECIES	NFA	WS	CL
Alstonia	0.7	2.6	3.3
Anthocephalus chinensis	13.6	2.6	
Antiaris	0.7		
Artocarpus incisus			1.7
Campnosperma sp.		5.1	
C. brevipetiolatum		5.1	
Cananga odorata	2.1		
Chisocheton	4.3		5.0
Celtis latifolia	5.0		
Cerbera floribunda	0.7		6.7
Denrocnide peltata	2.9		
Diospyros	0.7	10.3	
Duabanga moluccana		2.6	
Dysoxylum			3.3
Elaeocarpus	0.7	2.6	
Endospermum medullos	1.2		
Evodia elleryana	0.7		
Ficus	4.3		1.7
Firminiana	0.7		
Gmelina	1.4		
Gnetum gnemon	1.4		5.0
Hernandia origera	2.1		
Hibiscus papuadendron	4.3		10.0
Homalium foetidum	0.7		
Intsia bijuga	0.7	2.6	3.3
Macaranga	7.9		1.7
Maniltoa	2.1		
Medusanthera	3.6		
Myristica	6.4	2.6	6.7
Nauclea	0.7		5.0
Neonauclea		46.2	
Octomeles sumatrana	2.9		
Palaquium	0.7		
Pimeleodendron amboinicum			8.3
Pisonia	2.9	2.6	
Pittosporum	0.7		
Polyalthia oblongifolia			1.7
Pometia pinnata	10.0		1.7
Pterocarpus indicus	1.4	5.1	13.3
Pterocymbium	0.7		
Rhus titensis	1.4		
Semecarpus			3.3
Sloanea	0.7		
Sterculia			1.7
Syzygium	0.7	2.6	
Terminalia	4.3	5.1	8.3
Tristiropsis	3.6		
Vitex cofassus	0.7		
Vitex quinnata			5.0
Other	1.0	5.1	11.7

APPENDIX B

Inventory data Gabensis, 1994. 5.7 ha of seasonally inundated alluvial rain forest. Frequent distribution by size class.

	DBH-CLASSES (cm)										
SPECIES	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	TOTAL
Aglaia	8	8	4								20
Aleurites			2								2
Alstonia chinensis	2		8	1							11
Anthocephalus	8	16	10	6	2			1			43
Artocarpus	10	2	10	1	2		1				26
Bischofia				1						1	2
Buchanania	6			1	1						8
Calophyllum	4	2									6
Campnosperma	4	2	4	3		1		1			15
Cananga	8	8	8	4							28
Canarium	10	4	4	3	2	1	1				25
Celtis	12	10	8	4	3						37
Cerbera		2	2	1							5
Chisocheton	2	2	2		2						8
Chrysophyllum		2									2
Cryptocarya		6				1					7
Dendrocnide	10		2								12
Diospyros		2									2
Dracontomelon			2	1	3	1	1	1	2	1	12
Dysoxylum	8	2		1	1						12
Elaeocarpus	2		4								6
Endospermum	4	6									10
Euphorbiaceae		2									2
Evodia	2	2									4
Ficus	26	2		1			1	1			31
Garcinia	6	4		1							11
Gardenia	2										2
Glochidion	2	2	2								6
Gnetum gnemon	4	4									8
Gordonia	2										2
Hernandia	4										4
Hibiscus	2	2	4								8
Homalium	2						1				3
Horsfieldia	12		4								16
Intsia bijuga		2	2	2	1	2	1				10
Kingiodendron	2	4									6
Litsea	8	12	4	1							25
Macaranga	50	32	6								88
Maniltoa	4		2	1							7
Maranthis		2									2
Medusanthera	8										8
Miscellaneous	14	6		1	1						22
Myristica	64	56	26	10	3	1				1	161
Nauclea	6	2	2	3	2	1					16
Neonauclea					2		1				3
Octomeles sumatrensis	2	4			2					3	11
Palagquium				1							1
Pimeleodendron	18	14	12	1							45
Planchonia		2									2
Planchonella	2	4		1			1				8
Polyalthia			4	2	4			1			11
Pometia pinnata	26	30	40	18	8	7	4	2	4	1	140
Protium	4					1					5

Appendix B continued

SPECIES	DBH-CLASSES (cm) 10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	>100	TOTAL
Pterocarpus	2			3	2	2		4	1		14
Rubiaceae			2								2
Semecarpus	4										4
Sloanea	6	6	2		1	1	2		1		19
Sterculia	14	8	8	2	2						34
Syzygium	4	2		1	1						8
Terminalia	8	8	2	6	3	1		2		1	31
Thespesia	22										22
Vitex		2		1	1	2	1			3	10
TOTAL	430	286	194	83	49	22	15	13	8	11	1111