III-4 Design of the model skyline system

III-4-1 Specification of yarder

From the results of the survey on the artificial forest of Merkusii pine of the District Forest Office of West Pekalongan, nominated as the object place, we select #69 compartment as the average place for the model case of yarding by yarder, considering the topographical conditions and the aspects of forests.

The #69 compartment has the existing roads and is near to the base place Docktunger and is considered as the best fit place for the model place.

About the selection of yarder.

a) With the drum of great winding capacity, enabling the operation circle of 1,000 m radius.

b) Has the braking capacity enough for the falling operation in a great vertical distance.

c) Has a powerful engine with a wide range of speed change, enabling the high speed running and the strong tracting.

d) Light weight and best fit mechanism for the frequent moving in the mountainous forests.

e) The drum arrangement and the driving mechanism is best fit for the multi-purpose use, enabling the operations by the numerous skyline setting systems.

f) Easy operating system best fit for the complicated and delicate handlings.

Satisfying the above mentioned terms and considering the actual weight of the log per piece and the span of the cases of the #69 compartment, we adopted the Multi-purpose Y-32EA three drum yarder (two drums and one endless drum), which is now most widely used in Japan under these conditions.

About the specifications of this yarder, we have a following sheet.

Besides, about the skyline setting system, we adopted the Endless Tyler System which is most widely used in Japan and also is the most simple one, considering the features of each system and the conditions of the actual place.

Endless Tyler system has many variations according to the wirings of operating lines, but we take the fundamental type for easy understandings.

Specification of yarder

Model		Y-32 EA three drum yarder
No. of drums		3(two drums and one endless drum)
Engine	Type	ISUZU DA120P 4 cycle water-cooled, 6 cylinder diesel engine.
	Piston Displacement	6126 c.c.
	Max output/revol.	105 PS/2400 r.p.m.
Dimensions	Overall length	4315 mm
	" width	1650 mm
	" height	1350 mm
Gross weight		2500 kg. (about)
Drum size (1st & 2nd)	Diameter (SPOOL)	320mm
	width (SPOOL)	640mm
	Flange diameter	630mm
Drum size (Endless)	Diameter	443mm
	Width	158mm
Engine clutch		Dry, single plate hydraulically operated
Transmission		4 stages
Reversing mission		Sliding mesh type
Drum clutch	All drums	Expanding, mechanical
Drum brake	1st & 2nd	Band, cam actuated, manually operated.
	Endless	Post type, mechanical, manually operated.

Drum capacity (1st & 2nd alike)	Rope diam. (mm) Capacity (m)	10 1370		12 950		14 710		16 535	
Performance		Forward				Reverse			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th
Max. line pulls (kg) (Mean diam.)	1st drum	3370	1890	1000	520	2810	1570	830	430
	2nd drum	3370	1890	1000	520	2810	1570	830	430
	Endless drum	(3000)	2020	1070	560	(3000)	1690	890	470
Max. line speeds (m/min.) (Mean diam.)	1st drum	115	205	285	(500)	135	245	460	(500)
	2nd drum	115	205	285	(500)	135	245	460	(500)
	Endless drum	105	190	360	(500)	130	230	430	(500)
Fuel tank capacity		37 litres							

* (   ) value is the limited ones.

List of Accessories

Name	Type	Number	Unit Weight	Weight
Carriage	BCD 34	1	113 kg	
Loading block	BLS31B	1	30	
Loading hook	BLHA3D	1	11	
Saddle block	BD28A	2	46	
Heel block	BH28	2	35	
Skyline champ	BG28	1	61	
Guide block	BS7A	8	7	
" "	BS9	7	10	
" "	BS12PE	2	15	
Skyline support	BN28	1	82	
Wire clip	RC12	60	0.22	
" "	RC16	10	0.365	
" "	RC24	5	1.16	
Shackle	10mm	15	0.075	
"	22mm	2	1.2	
Special shackle	RP16	2	0.52	
Sling rope	R1220	2	1.45	
" "	R1230	2	2.055	
" "	R1240	2	2.695	
Choker hook	RHSI	6	0.88	
Eye socket	RSII	6	1.01	

Guaranteed breaking strength B and the weight W

Sort	Standard	Weight per meter	Guaranteed breaking strength B
Skyline	24ϕ ,6×7 C/L	2.140 kg	34.9 t
Endless line	12ϕ ,6×19 o/o	0.526	7.92
Lifting line	"	0.526	7.92

The necessary amount of wire rope is shown in a seperate sheet. (III-6)

III-4-2 Drawing of the designed skyline system

Plan view drawing of the skyline setting and the vertical sectional drawing of the main cable in the model area are as follows.

But the vertical sectional drawing of the main cable is the one using the artificial steel spar of 16 meters high.

Generally, we utilize the standing tree as a spar, but the trees in this area are used for taking out the pine resin and is anxious about to use as a spar that we used the artificial spars, instead.

Fig. III-52 Figure of the skyline system

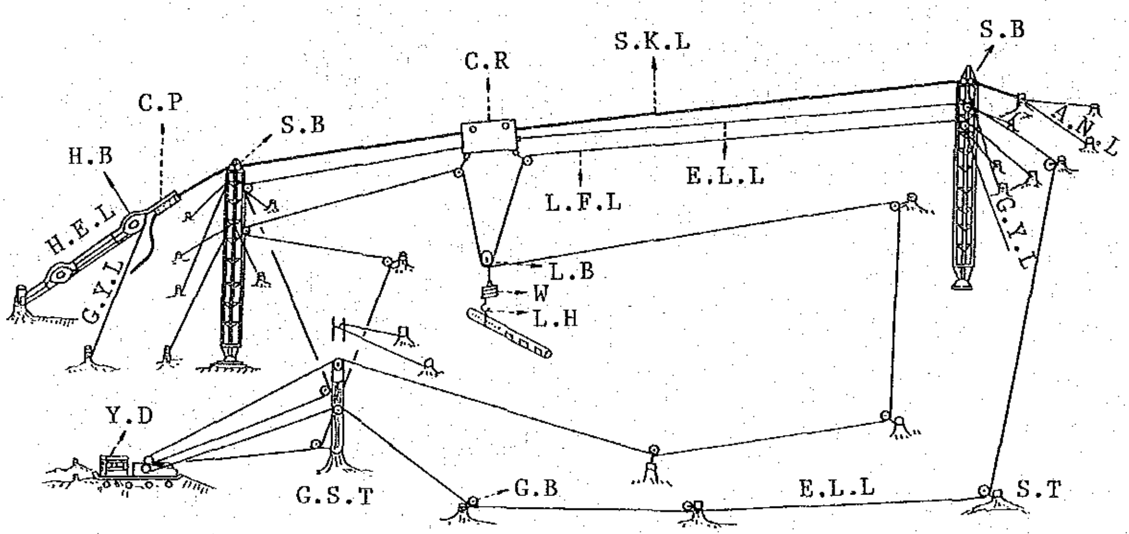
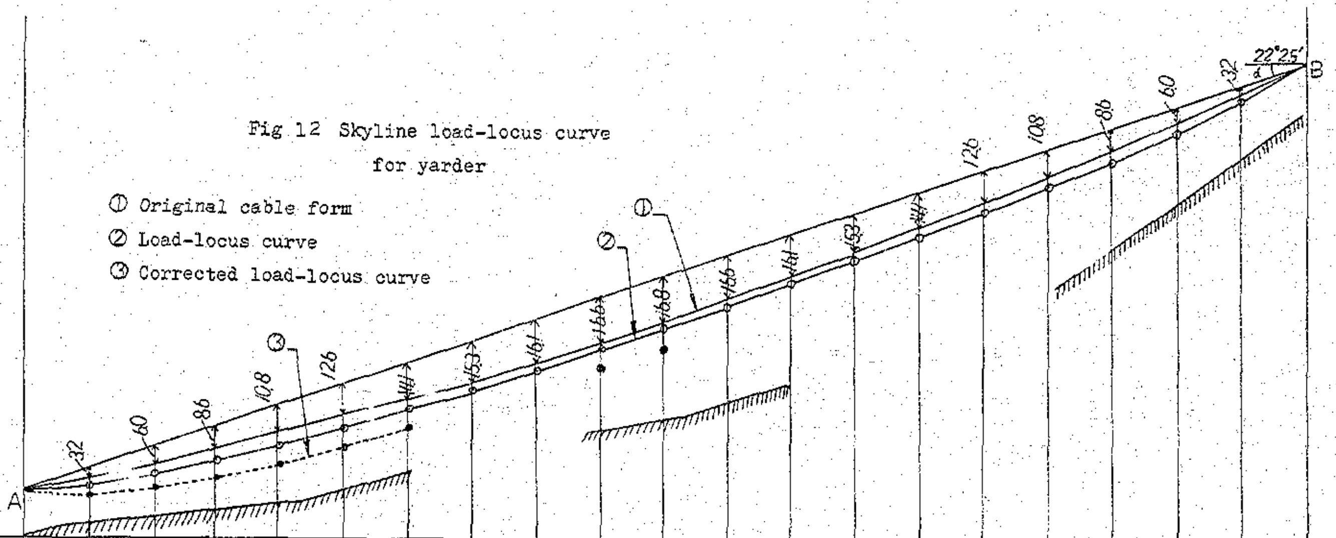


Fig. III-53 Skyline load-locus curve for yarder



Coefficient of Distance	k	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
Horizontal Distance	x	24	48	72	96	120	144	168	192	216	240	264	288	312	336	360	384	408	432	456	479.6
Coefficient determined by the horizontal distance from the lower end	m	0.19	0.36	0.51	0.64	0.75	0.84	0.91	0.96	0.99	1.00	0.99	0.96	0.91	0.84	0.75	0.64	0.51	0.36	0.19	
①	fx	3.2	6.0	8.6	10.8	12.6	14.1	15.3	16.1	16.6	16.8	16.6	16.1	15.3	14.1	12.6	10.8	8.6	6.0	3.2	
Coefficient of sag increasement	r	2.26	1.78	1.54	1.40	1.30	1.24	1.19	1.16	1.15	1.14	1.15	1.16	1.19	1.24	1.30	1.40	1.54	1.78	2.26	
②	fd	7.2	10.7	13.2	15.1	16.4	17.5	18.2	18.7	19.1	19.2	19.1	18.7	18.2	17.5	16.4	15.1	13.2	10.7	7.2	
Coefficient of Correction	E	1.56	1.56	1.56	1.56	1.56	1.56			1.56	1.56										
③	fd	11.2	16.7	20.6	23.6	25.6	27.3			29.8	30.0										
Span	l_0	l_0 = 479.6m , α = 22°25'																			

III-4-3 Example of calculation for the skyline system

About this model system we are going to calculate actually, by dint of the formerly mentioned calculating method.

For this design, we adopted the values as follows.

The oblique distance $\ell = 518.8$ m

Horizontal distance $\ell_0 = 479.6$ m

Vertical distance $h = 167.3$ m

Inclination angle of the span, $\cos\alpha \doteqdot \frac{\ell_0}{\ell}$

therefore $\alpha = 22°25'$

Sag span ratio of the original cable $S = 0.035$

From the formerly described table, we can get the weight of the wire rope used, as follows,

Skyline, 2.14 kg × 518.8 = 1,110 kg

(Strictly speaking, the length of the wire rope should be a little longer, but in general we use the oblique length ℓ for calculation.)

Lifting line, 0.526 kg × 518.8 m = 273 kg

Endless line, 0.526 kg × 518.8 m = 273 kg

Haul back line 0.364 kg × 518.8 m = 189 kg

(a) Original form of main cable

On the vertical sectional drawing of the main cable, we take the horizontal distance and divide it evenly in 20 parts, and fix the point every 24 m.

Central sag amount $f = s.\ell_0$

$= 0.035 \times 479.6\,m = 16.79\,m$

Therefore, the sag amount fx at any spot will be calculated by multiplying the value of m, the coefficient determined by the horizontal distance from the lower end, to 16.79 meters, and plot these points and tie them to get the curve of original form of main cable. This is the 1 curve in the vertical section drawing.

(b) Maximum tension of the skyline

*Weight of the empty carriage Pc = 294 kg

Carriage	113 kg
Guide block	20 "
Loading block	30 "
Loading hook	11 "
Sling rope	2,055 kg × 2 = 4.11 kg

Choker hook	0.88 kg × 2 = 1.76 kg
Eye socket	1.01 kg × 2 = 2.02 kg
Ballast	112 kg

Note: In order that the loading block may come down smoothly, the ballast is necessary and this weight may be at least 112 kg.

* Carriage load P (by design)

$$P = \{(Po + Pc) \times (1 + I)\} + W'$$

Assume the impact load coefficient I as 0.2 and as this is the endless Tyler system, the weight of the operating lines are 1/2 of each,

then

$$P = (780 + 294) \times 1.2 + (\frac{273}{2} + \frac{273 + 189}{2})$$

$$= 1657 \text{ kg}$$

Total load is, therefore

weight of main cable 1,110 kg

+ design load 1,657 kg

= 2,767 kg

* Coefficient of maximum tension Φ

load ratio $n = \frac{1,657}{1,110} = 1.5$

& $Z_1 = 0.714$

therefore, $s_1 = 0.714 \times 0.035 \fallingdotseq 0.0250$

and $\alpha = 22°25'$

$\therefore \Phi \fallingdotseq 5.5$

* Maximum tension T_1

Therefore, maximum tension T_1

$T_1 = (1,110 + 1,657) \times 5.5$

$= 15,219$ kg

* Safety coefficient N

$$N = \frac{34,900}{15,219} = 2.29$$

and this 2.29 is less than 2.7.

Therefore, it must be corrected.

(c) Load-locus curve

To draw in the vertical sectional drawing the load-locus curve when the carriage load is charged, we must at first calculate the value fd, which is the sag amount of original cable from fx multiplyed by the coefficient r of the sag increase relating to the situation of the carriage, and then plot this fd and draw the load-locus curve.

r is derived from the load-ratio n and the coefficient k of horizontal distance at any point measured from A. Curve 2 on the vertical sectional drawing is drawn by such process.

(d) Correction

* Correction for the displacement of the supporting point.

Assume the amount of this displacement as 40 cm, and

$$\Delta d = \frac{0.4\ \text{m}}{518.8} = 0.00077$$

The central sag span ratio $s = 0.035$

$\therefore Ed = 1.15$

* Correction for the change of Temperature is,

$Et = 1.06$ where the mean atmospheric temperature is 28°C

* Correction for the elastic elongation, Tension on no-load cable To

$To = W \times \Phi = 1,110 \times 5.5$

$= 6,105$ kg

Total load = 2,767 kg and from

$$\text{load-ratio} = \frac{1,657}{1,110} = 1.5, \text{ therefore}$$

$Z = 0.714$, and $s = 0.714 \times 0.035 = 0.025$

& $\Phi = 5.5$

Tension on the loaded cable Tmax

$Tmax = 2,767 \times 5.5 = 15,219$ kg

Difference of tension Td

$Td = Tmax - To = 15,219 - 6,105 = 9,114$ kg

$\lambda = 0.00042$ & $e = 0.00042 \times 9.11$

$= 0.0038$

$Ee = 1.28$

over-all correction

$E = 1.15 \times 1.06 \times 1.28 = 1.56$

As a result,

* Corrected sag-span ratio $S' = 0.035 \times 1.56$

$= 0.055$

* Corrected coefficient of the equivalency which is determined by the live-load ratio

$$s_2 = 0.714 \times 0.055$$
$$= 0.039$$

* Corrected maximum tension coefficient

Φ' will be 3.6

as $s_2 = 0.039$ & $\alpha = 22°25'$

* Corrected maximum tension T_2 max

T_2 max $= 2{,}767 \times 3.6 = 9{,}961$ kg

* Corrected coefficient for the tension

$$N = \frac{34{,}900}{9{,}961} = 3.5$$

Therefore, safety coefficient would be more than 2.7.

(e) Corrected load-locus curve

The value of fd on the load-locus curve 2 is corrected to f'd by multiplying the over-all correction coefficient 1.56, and we can get the corrected curve 3 on the vertical sectional drawing. By this curve we can check the obstacles on the ground surface.

(f) Tension on the lifting line

Load of the loading block is 941 kg.

Loading block	......	30 kg
Loading hook	......	11 "
Sling rope	......	8 "
Ballast	....	112 "
Log	....	780 "

The weight per unit length of the lifting line is 0.526 kg, and the maximum hoisting height is 50 m and the lifting line to the loading block is double, that, maximum tension will be 886 kg.

Therefore, the safety coefficient N

$$N = \frac{7{,}920}{886} = 8.9$$

and this value is greater than 6, that means it is safe.

(g) Tension on endless line

Fundamental sag ratio s'

$$s' = s \times 1.2 = 0.055 \times 1.2 = 0.066$$

oblique distance of the span is

518.8 m, and the coefficient of maximum tension

Φ is 2.2, therefore To' = 600 kg

Load tracting force when the carriage is not near the supporting points is,

$T_{p_1} = 1,657 \times 0.47 = 779$ kg

Load tracting force when the carriage is near the supporting point is,

$T_{p_1} = 1,657 \times 0.71 = 1,176$ kg

Therefore, the maximum tension when the carriage is not near the supporting point is,

$T_1 = To' + T_{p_1} = 1,379$ kg

$$N = \frac{7,920}{1,379} = 5.7$$

The maximum tension when the carriage is near the supporting point is,

$T_2 = To' + T_{p_2} = 1,776$ kg

$$N = \frac{7,920}{1,776} = 4.5$$

These values are both more than 4, and this means both are safe.

III-5 Operation process and its efficiency of skyline system

By the Rochmadi report, the effective working days in a year are 150 days, and we use this data straightly, and also consider about the actual volumes of works for a year by the yarder like this in Japan. This volume is 3,000 m^3 as for the average, and therefore,

$3,000 \div 150 = 20\ m^3/day$

that is, 20 m^3 per day must be dealt with.

Now we calculate the volume of days work for trial.

At first, we calculate the time for one cycle of the yarder yarding

$$T = \frac{2\ell}{V} + t$$

here, T: time for one cycle

ℓ: effective span. 400 m for this case

V: carriage speed when loaded, is 70 m/min and empty carriage speed is 145 m/min that the mean speed is 100 m/min.

t: spare time for operation, say 4 minutes.

Therefore, $T = \frac{2 \times 400}{100} + 4 = 12$ min.

One cycle takes 12 min, and therefore number of cycles per hour n is

$$n = \frac{60}{12} = 5$$

The mean volume A of tree length log is 0.65 m^3, and if we carry one log per one cycle, then the volume per hour is $A \times n = 0.65\ m^3 \times 5 = 3.25\ m^3$ and if the day's work is 6 hours, then the working volume for a day will be $3.25\ m^3 \times 6 = 19.5\ m^3$.

That is, about 20 m^3 per day is attainable.

III-6 Operation cost of skyline system

To calculate for trial the operation cost of the yarding by yarder, we must count the depreciation cost, the maintenance and repairing cost of machines and accessories, the cost of fuel and oil, and the labor cost.

1. Depreciation cost

In yarding by yarder, we must use many relating machines other than yarder, and therefore we must calculate the depreciation cost of these machines.

To calculate the depreciation cost of yarder proper, artificial spar and the telephone, we must subtract the remaining price of about 10% of the purchased price from the purchased price and divide this by the serviceable hours and can get the depréciation cost per hour.

But as for the blocks and the wire ropes, we had better settle the serviceable volumes from the stand point of handling volume.

The following tables will show you, the names of articles to be used and the serviceable volumes and hours of them.

By these, depreciation cost per one hour of the yarder proper will be

$$\frac{11{,}669{,}000^{RP} - 1{,}166{,}900^{RP}}{6{,}000 \text{ hours}} = 1{,}750^{RP}/\text{hour} \ldots\ldots \text{(A)}$$

About the artificial spars and the telephone, it is also calculated by the same way and these cost per one hour is

$$\frac{(3{,}134{,}000 + 1{,}024{,}000) - (313{,}400 - 102{,}400)}{6{,}000} = 624^{RP}/h \ldots\ldots \text{(B)}$$

Next, the blocks, wire clips, sling ropes, and the wire ropes like skyline will be calculated from the seperate sheet in which the unit price and its cost per m^3 of the serviceable volume are described, like as follows.

Per 1 m^3 ..... $167^{RP} + 16^{RP} + 22^{RP} + 889^{RP} = 1,094^{RP}$ ..... (C)

2. Maintenance and repairing cost

About the maintenance and repairing cost, we consider about it for three groups, namely the yarder proper, the less costly items like the artificial spars, telephones and etc, and the consumptive articles.

Name	Type	No.	Unit Price	Price	Deprecia-tion cost per 1 m^3	Serviceable volume m^3 or hours h
				RP	RP	
Yarder	Y-32E	1		11,660,000		6,000h
Carriage	BCD34	1		477,300	40	12,000m^3
Loading block	BLS31B	1		109,800	9	12,000m^3
Loading hook	BLHA3D	1		57,700	5	12,000m^3
Saddle block	BD28A	2	111,500	223,000	19	12,000m^3
Heel block	BH28	2	89,950	177,900	15	12,000m^3
Skyline clamp	BG28	1		220,900	18	12,000m^3
Guide block	BS7A	8	24,738	197,900	16	12,000m^3
"	BS9	7	30,371	212,600	18	12,000m^3
"	BS12PE	2	44,700	89,400	7	12,000m^3
Skyline support	BN28	1		243,500	20	12,000m^3
Sub-total				2,010,000	167	
Wire clip	RC12	60	847	50,800	8	6,000m^3
"	RC16	10	1,480	14,800	2	6,000m^3
"	RC24	5	3,380	16,900	3	6,000m^3
Shackle	10 m/m	15	433	6,500	1	6,000m^3
"	22 m/m	2	2,600	5,200	1	6,000m^3
Special shackle	RP16	2	2,400	4,800	1	6,000m^3
Sub-total				99,000	16	
Sling rope	R1220	2	6,950	13,900	2	7,000m^3
"	R1230	2	9,100	18,200	3	7,000m^3
"	R1240	2	11,250	22,500	3	7,000m^3
Choker hook	RHS1	6	6,583	39,500	7	6,000m^3
Eye-socket	RS11	6	7,150	42,900	7	6,000m^3
Sub-total				137,000	22	
Skyline	24 m/m 6×7 C/L	1,100m	2,473	2,720,000	151	18,000m^3
Endless line	12 m/m 6×19 %	2,400	764	1,832,400	262	7,000m^3
Lifting line	12 m/m 6×19 %	1,300	764	992,500	142	7,000m^3
Haul back line	10 m/m 6×19 %	2,400	586	1,405,600	201	7,000m^3
Heel line	12 m/m 6×19 %	600	764	458,000	65	7,000m^3
Guy line	12 m/m 6×19 %	500	764	381,800	55	7,000m^3
Support line	16 m/m 6×19 %	100	1,367	136,700	13	11,000m^3
Sub-total				7,927,000	889	
Telephone		1		275,900		6,000h
Tir-for		1		249,400		6,000h
Splicing tools		1		149,600		6,000h
Wire cutter (main cable)		1		260,200		6,000h
Wire cutter (Operating line)		1		89,900		6,000h
Sub-total				1,024,000		
Artificial spur	16 m	2	1,567,000	3,134,000		6,000h
Total				26,000,000		

About the yarder proper, the maintenance and repairing cost will be calculated like the other machines in general and also from the actual result of the past.

The cost per hour, will be calculated as follows,

$$\frac{\text{Purchased price of yarder} \times 0.45}{\text{Serviceable hours}}$$

$$= \frac{11,669,000 \times 0.45}{6,000} = 875 \ ^{RP}/h \ \ldots. \ (D)$$

Therefore, 875 ^{RP} per one hour.

About the artificial spars and the telephone

$$\frac{\text{Purchased price} \times 0.1}{\text{Serviceable hours}} = \frac{3,134,000 \times 0.1}{6,000} = 52 \ ^{RP}/h \ \ldots. \ (E)$$

That is, 52 ^{RP} per one hour.

About the wire ropes and etc, we do not consider about their maintenance and repairing costs.

3. Cost of fuel and oils

About the consumption of fuel and oils we decided as follows from the actual data of the past.

	Kerosine	Engine oil	Gear oil	Brake fluid	Grease
Consumption volume	3.5 ℓ/h	0.1 ℓ/h	0.01 ℓ/h	0.01 ℓ/h	0.01 kg/h
Unit price	$30^{RP}/ℓ$	$300^{RP}/ℓ$	$400^{RP}/ℓ$	$400^{RP}/ℓ$	$600^{RP}/kg$
Price	105RP	30^{RP}	4^{RP}	4^{RP}	66^{RP}

Therefore, the consumption per hour will be the sum of these, and is 149 RP per hour .... (F)

4. Labor cost

Necessary members to operate the yarding by yarder is as follows.

Driver	1	$1,000^{RP}$/man day
Loading man	2	600^{RP}/man day
Unloading man	1	300^{RP}/man day

four personnels in one team, and 6 working hours per day, then

$$\frac{1,000 + 600 \times 2 + 300}{6} = 417 \ ^{RP}/h \ \ldots. \ (G)$$

Therefore, the labor cost per hour is 417 ^{RP}

Now, we sum up these costs per hour (from (A) to (G) excluding (C)) and get the over-all cost per hour as 3,867 ^{RP}.

As we described in the former chapter about the working volume and efficiency, the working volume per hour is

$20\ m^3/6\ h = 3.334\ m^3/h$,

Therefore the cost per m^3 will be

$\frac{3,867}{3.334} = 1,159^{RP}$ .... (H)

5. Setting and removing cost

The necessary man-day to set and to remove the yarding system is considered to be 35 man-day in total, from our data of the past experiences.

Therefore, $300^{RP} \times 35$ man-day = 10,500 RP

The yielding volumes from the model area for yarder are considered as 754 m^3, the setting and removing cost per m^3 will be 14 RP .... (I)

6. Cost of construction of strip road

To work out the yarder yarding operation, we need at least 5 m per hectare of strip road. The strip road in this district will cost 5 million R.P per Km, and therefore it cost 5,000 RP per meter.

The area is 6.56 hectare, and the yield is 754 m^3, therefore

$\frac{5,000^{RP} \times 5\ ^{m} \times 6.56\ ^{ha}}{754\ m^3} = 218\ RP/m^3$ .... (J)

The cost per m^3 of the working volume of the yarding by yarder in this model area is, only the direct cost (H) + (C) + (I) + (J) = 2,485 RP.

But, in this area, the orthodoxical platform is not necessary, and therefore, the cost for the construction of platform is not considered specially, but is thought to be included in these costs.

III-7 Skidding by tractor

Formerly, in skidding operation, the animal power of horses or oxen are widely utilized, but lately the crawler type tractors are introduced in place of them.

In Japan, also the tractor have been used for a long time in the rather flat place, but the regular use of it began only of late.

In this area, about the flat place, we had better to utilize the tractor skidding.

III-7-1 Tractor

There are two types of tractors, crawler and wheel, but formerly in forestry operation, almost all the tractors were the crawler type.

These are all the tractors for the civil engineering use, or the wheel type ones for the agricultural use being utilized for the forestry operation.

But in nineteen-sixties, articulated frame steering, four wheel drive skidding tractors were developed, and this type is used for skidding in almost all the cases of it.

The features of this machine are the super low-pressure large diameter wheels and the whole wheel drive, using no-spin differential gears.

This mechanism is the one, when the wheel on one side will slip and rotate idle, the gear of this wheel will be disengaged automatically and the power will be transmitted to the remaining wheel, avoiding the loss of power from the idle running.

The body is made up with the articulated from construction, and the frame is seperated in two parts, front and rear, and are hinged together with a big vertical pin and can move around it, and also can be steered by swinging hydraulically the rear frame to left and right.

The front wheels are fixed on one beam and this beam can rocks like the seesaw, and the four wheels are always touching the ground, even in a rough terrain. This is called the front wheel rocking suspension, and these five points are the features of this machine.

Having these features, this tractor has the following functions and can display its prominent ability for tractor skidding.

1) Great resistance for slipping

The five features are all working for the prevention of slipping.

2) Great tracting force

The mechanical driving force is distributed to all four wheels and if one wheel may slip, the driving force can be concentrated on other three wheels.

3) Easy to roll over the obstacles.

As the wheel diameter is large, and the front wheels are power driven, that it can roll over the obstacle at its contact point with the wheel by the driving force of itself.

Also by the rocking suspension of the front wheels, one wheel roll over is easy.

4) Excellent manoeuvre ability in the muddy place.

As the wheel diameter is large, and the pressure is low, that the contact surface is great.

5) Stability in rough terrain

The stability of the vehicle depends on its length of wheel base, its grounding conditions, and the height of its center of gravity, and this machine is leading in those points from its constructions.

6) Turning radius is small.

Moving about in a narrow space in the forest, small turning radius is needed, but on the other hand the long wheel base is needed for its stability.

These two contradictory needs are smartly satisfied by the articulated frame construction.

7) Speed is faster

The lower speeds are almost the same as the crawler type one, but the higher speeds are three times as high and the speed range is wide. Therefore, the skidding distance may be longer.

By above mentioned features, skidding by tractor has come to be realized in the places, where it was considered impossible formerly.

Therefore, in this model area, we decided to use the tractor of these features.

Specification of Tractor

Type		T-50 Logging tractor	
	Gross weight	about 6000 kgs	
Speed		High-Speed	Low-Speed
	Forward & Reverse 1st Speed	4.2 km/h	2.2 km/h
	2nd	8.7	4.5
	3rd	15.0	7.7
	4th	27.0	14.0
Minimum turning radius		4.780^m (Tire center of rear wheel)	
Maximum climing ability		35°	
Dimen-sions	Over-all length	5390 mm	
	Over-all width	2290 mm	
	Over-all height	2450 mm	
	Wheel base	2720 mm	
	Tread	1840 mm	
	Ground clearance	490 mm	
Engine	Model	Hino "DM-100" diesel engine	
	Type	4 cycle, water cooled in line, precombustion chamber	
	Number of cylinders Bore × stroke	6 - 90 mm × 113 mm	
	Piston displacement	4313 c.c.	
	Perform-ance: Roted speed	2,400 r.p.m.	
	Perform-ance: Max.Out put/rev	73 PS/at about 2,370 r.p.m.	
	Perform-ance: Max.torque/rev	22.5 kg-m/at about 1,800 r.p.m.	
Power Train	Main clutch	Foot operated, spring actuated, dry, Single-disc-type	
	Transmission	4-Forward speeds, synchromesh	
	Transfer case	2-Speed, constant mesh	
	Reduction gear	1-stage spiral bevel gears	
	Differential	Straight bevel gears (front wheels) and "No-spin" differential gears (rear wheels)	
	Final Reduction gear	1 stage planetary gears	

Axles & wheels	Driving system	4 sheel drive
	Front axle	Rocking beam type (amount 560 mm)
	Rear axle	Frame-fixed type
	Tires	16.9 - 30, 10PLY "Logger special" with shredded wire.
Steering	Hydraulic power steering, articulated type.	
Brakes	Foot brake	Hydraulically operated, center braking type, disc brake.
	Hand brake	Center braking type, mechanical lock.
Fuel tank capacity		75 litres
Hydraulic unit	Hydraulic pump	Gear type, 73 litres/min, 140 kg/cm^2, 2400 r.p.m.
	Cylinders	Piston type, double action, 100 mm ⌀
	Control valve	3-row spool type
	Operating oil tank capacity	about 30 litres
Winch	Type	TW-9T, Singledrum (upward winding) Hydraulically controlled.
	Line pull/speed	9000 kg (bare drum) /30-300 m/min
	Rope capacity	120m, 12mm wire rope 90m, 14mm wire rope
	Clutch	Hydraulic power actuated, expanding type
	Brake	Hydraulic power actuated, band type
Fair-lead	Type	3 stage, height adjustable
	Height	Min.height 2,190 mm adjustable range 15 mm each
Blade (Dozer)	Type	Straight blade, with cutting edges
	Width × height	2290 mm × 720 mm

III-7-2 Operation process of tractor skidding

a. Road construction for the tractor operation

Of course, the tractor can move about freely in the forest, but to do the operation efficiently, the strip road of adequate ones becomes necessary.

(1) Nearer to the unloading yard the stronger strip road must be constructed.

The route of frequent passing must be made stronger, and this one would sometimes be reformed into truck road when the truck goes farther into the forest.

(2) At the loading and unloading yard, the route must be so arranged as the movement of tractor should become smooth.

To make it in the loop shape is important, lest the tractor should be driven in switch back motion, and as for the fundamental loops there are the u-shaped road, Loop road and L-shaped road.

(3) Width of the strip road and etc.

1) It should be more than 1.2 times of the tractor grounding width.

2) Route radius of the curve must be greater than a half of the log length, and the width of the road in this case is width

$$\fallingdotseq \frac{(\text{log length})^2}{\text{Route radius} \times 2} \text{ or } \frac{L^2}{R \times 2}$$

(4) The density of the tractor strip road should be rather high.

As for the preskidding distance by the winch rope of the tractor, 20m ∿ 30m is recommended, and over this length it will become less efficient.

(5) Combination of the truck road and the tractor road

It is said that the tractor skidding is efficient for the distance of 350m ∿ 400m. Therefore, the combination with the truck road should be considered.

b. Felling and bucking operations

There is no new way of felling & bucking especially for the tractor skidding. But to do it more efficiently.

(1) You had better fell the trees so as the bottom ends face the skidding line and the felling direction should be making 30 ~ 45 degrees to the skidding line.

(2) Fell the trees so as the top ends are collected in one direction.

To preskid from the bottom end or from the top end has each merits and demerits, but in this area the preskidding from the top end is more profitable.

(3) The stamps should be as low as possible. The high stamps in the pass of the tractor would do more harm than we think of.

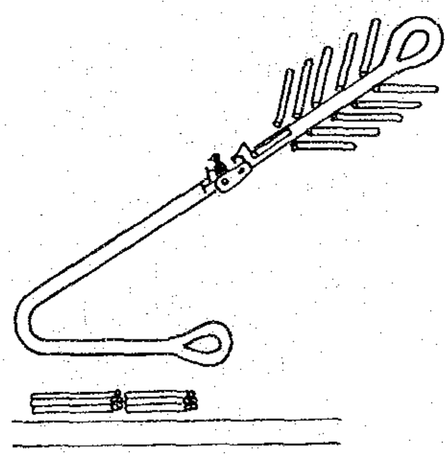
(4) To skid as near a tree length log as possible.

As in skidding the tree length log, if the branches are not removed the number of logs would become smaller. Therefore, you had better cut off the branches before skidding.

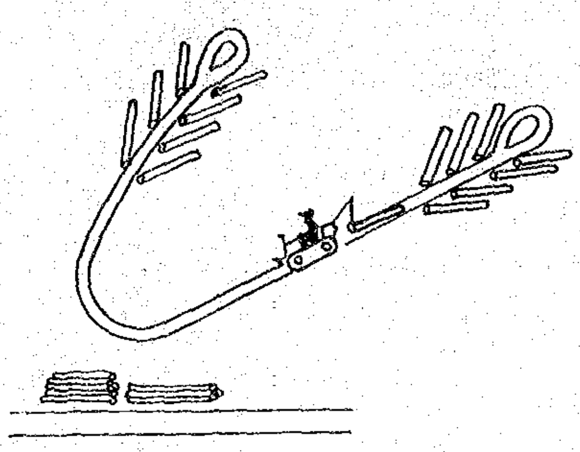
c. Skidding operation

(1) To utilize the gravity as possible and operates in downward slope. If there is an upward slope or a swamp on the way, release the winch line and put the load before them and go on forward unwinding the line and when it reaches to a good conditioned place, then draw up the load by rewinding the winch.

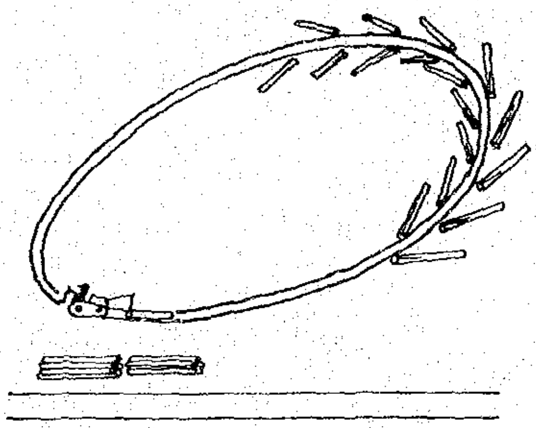
(2) In climbing or descending the slope, do it along with the maximum slope, and to go athwart the slope with the load is very dangerous and should be avoided.



L - shaped road



U - shaped road



Loop road

III-8 *Operating efficiency of tractor skidding*

To calculate as trial the working volume per day in case of skidding in the model tractor logging area, using the wheel type tractor of the specifications of the seperate sheet.

At first, calculate the tracting volume,

$W_L = W_T \times \mu$

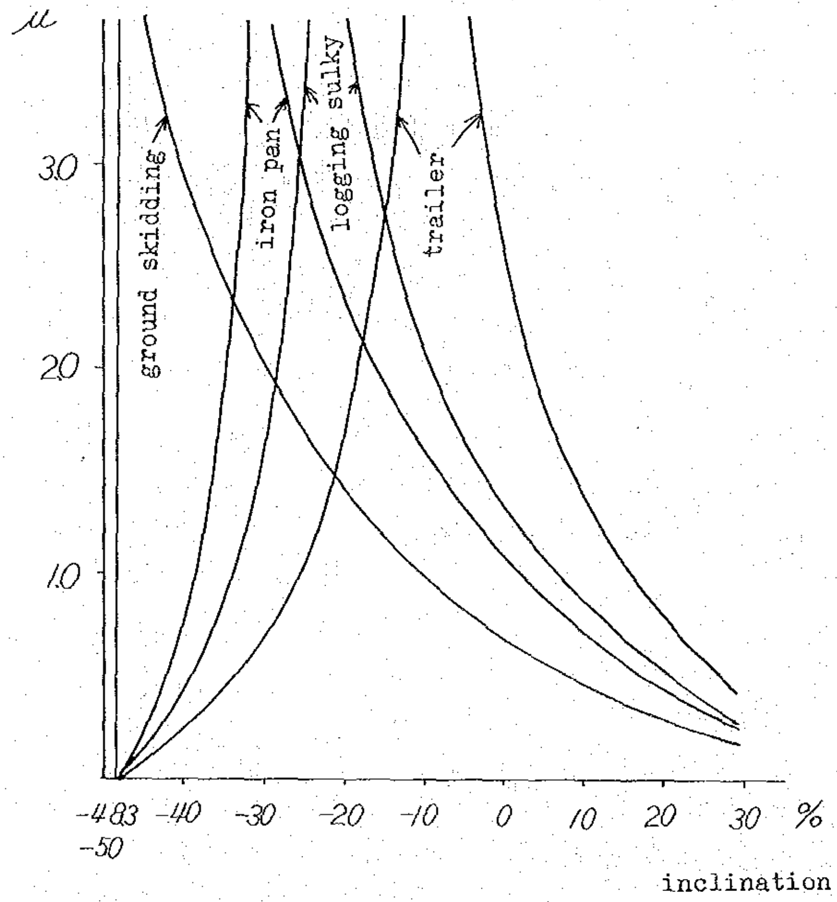
W_T: self weight of tractor, 6,000 kg

μ : coefficient (as from the following graph)

therefore, W_L = 6,000 kg × 1.2 = 7,200 kg

That is, this tractor is capable of tracting 7,200 kg at a time.

The weight of one tree length log in this area is 780 kg, and 780 kg × 9 = 7,020 kg, that is this tractor can tract 9 logs at a time, but we take it as 6 logs.



This graph show the relations between the coefficient and the gradient of slope.

It shows seperately, refering to the operation mediums as trailer, logging sulky, iron pan and the ground skidding, and also refering to the running conditions of tracting and braking, the relations between the gradient of slopes and the value μ.

From this graph we take the value of μ corresponding to the slope.

The wheel type tractor, which we are going to use in this case, resembles to the sulky and we used the curve of sulky.

The last slope of the tracting road is 0° and the tracting in this case is $\mu = 1.2$, and therefore the tracting weight is 7,200 kgs.

Next, we calculate the time for one cycle of tractor operation.

$$T = \frac{2\ X}{V} + \frac{2nx}{v} + C + I$$

Here, T: Time for one cycle

X: Average skidding distance (250m)

V: Operation velocity (mean value of loaded and empty time. 75 m/min.)

n: Number of logs per cycle

x: Average preskidding distance (50m)

C: Time to fix the load. (10 minutes)

I: Spare time per cycle (3 minutes)

v: Winding velocity of winch ... 30m/min (Equal to walking speed)

$$\text{Therefore,} \quad T = \frac{2 \times 250}{75} + \frac{2 \times 6 \times 50}{30} + 10 + 3$$

$$= 40 \text{ minutes.}$$

Take the working hours for a day as 6 hours, and the average stem volume as 0.65 m^3, then 0.65 m^3 × 6 logs = 3.9 m^3/cycle and the working volume per day S is

$$S = \frac{360 \times 3.9\ m^3}{40} = 36\ m^3$$

III-9 Cost of tractor skidding

To calculate the cost of tractor skidding as a trial, we must calculate the depreciation cost, maintenance and repairing cost, fuel and oils cost, and labor cost, for one hour.

a. Depreciation cost

To calculate this cost we subtract the remaining price after its serviceable hours, and this we fix as the 10% of purchased price, from the purchased price, and divide this by serviceable hours. Thus we get the depreciation cost per hour.

Now, the purchased price as 22,000,000 RP and the serviceable hours as 5,000 hours, somewhat shorter than yarder, and we get,

$$\frac{22,000,000 - 2,200,000}{5,000} = 3,960 \text{ PR/hour}$$

b. Maintenance and repairing cost

This cost varies according to the machine, working place and working ways, but we calculate as follows,

$$\frac{\text{Purchased price} \times 0.8 \times 0.6}{\text{serviceable hours}} = \frac{22,000,000 \times 0.48}{5,000}$$

= 2,112 RP/hour

Therefore it is 2,112 RP per hour.

c. Cost of fuel and oils

This cost also varies by the working ways and conditions, but we set, considering the actual data of the past, as follows,

Consumption volumes	Kerosine 5.0 ℓ/h	Engine Oil 0.1 ℓ/h	Gear Oil 0.1 ℓ/h	Turbine Oil 0.05 ℓ/h	Grease 0.05 kgs/h
Unit price	30^{RP}/ℓ	300^{RP}/ℓ	400^{RP}/ℓ	100^{RP}/ℓ	600^{RP}/kg
Price	150^{RP}	30^{RP}	40^{RP}	5^{RP}	30^{RP}

Therefore, the cost of fuel and oils becomes 255 RP per hour.

d. Labor cost

The members of the team of tractor yarding, are,

Driver .... 1 1,000 RP (day's wage)
Loading man .... 1 300 RP (day's wage)
Unloading man ...... 1 300 RP (day's wage)
Three personnels in one team

Therefore, the labor cost will be

(1,000 + 300 + 300)/6 = 267 RP per hour

From these above mentioned costs we get the over-all sum of costs per hour as 6,594 RP.

And as the working volumes per hour is,

$36 \text{ m}^3/6 \text{ h} = 6 \text{ m}^3/\text{hour}$

Therefore, cost per m^3 is

$$\frac{6,594\ RP}{6\ m^3} = 1,099\ RP/m^3$$

e. Strip road construction cost

To promote the tractor yarding efficiently, we decided to construct the strip roads of 10 m per hectare, and this costs as follows. From the data of the forest road construction in that area, the simple forest road costs 5,000 RP per meter.

Therefore, it will be

$$5,000^{RP} \times 10^{m} = 50,000^{RP} \text{ per ha.}$$

On the other hand, the nominated area for tractor skidding is 3 ha, and its yield to be 393 m^3. Therefore, the cost per m^3 will be

$$\frac{50,000^{RP} \times 3^{ha}}{393\ m^3} = 382\ RP/m^3$$

Therefore, the total cost for tractor skidding will be

$$1,099^{RP} + 382^{RP} = 1,481^{RP} \text{ per } m^3$$

III-10 Constructing platform

It is necessary to construct the platform at the terminal pile of skidding both in the case of tractor skidding and the yarder yarding. Especially, in case of tree length log yarding, the bucking and limbing operations can be done efficiently on the platform, and also the loading operation to the truck can be done so efficiently that in some case the loading machine is not necessary.

As for the material of this platform the produced logs are used, and after the work is finished the logs can be sold as the products, the value of which are somewhat diminished.

As for the size of the platform, too large one is uneconomical and too small one is inefficient, and so the adequate space is necessary.

To decide the dimensions of the platform, we must consider that the space is adequate to secure the accumulation of logs, at least the minimum volume of it, to promote smoothly the transportation of them by truck, and also the length of it must be more than the tree length log to be bucked on it.

In this model logging area the average height of tree is 20 m, and so the length of the platform is set as 22 m, 2 meters is added to the full-length, and the breadth of it would be at least the 1/10 of the length, namely

2.2 meters.

Therefore, the space of it should be as follows,

$$22\,\text{m} \times 2.2\,\text{m} \fallingdotseq 48\,\text{m}^2$$

As a rule, the platform is set when the yarder is set, and is removed when the yarder is removed, and the man-day, required in setting it regularly will be derived from the formula,

$$Z = 0.066\,x + 2{,}120\,Y + 10.27$$

where the area of platform (m^2) is x, the height (m) is Y, and the total man-day needed in setting is Z.

This value is derived from the experiment in Japan, but if we apply the values of the case in model area, that is $x = 48\ m^2$, $Y = 1.5\,m$, then $Z \fallingdotseq 17$, and it is fixed that the removing takes 30% of setting, therefore it is 5 personnels.

Totally, the setting and removing of the platform will take 22 man-days, but the working conditions in this logging area to construct the platform is very favourable and the very simple one only to arrange the logs side by side will do, that the man-day will be enough by 1/2 of the regular case.

Next, the volume of logs needed for the construction of platform will be calculated from the following formula,

$$y = 0.029 + 0.0111\,x$$

where x: the top end diameter of the log to be used in cm.

y: the log volume in m^3 needed for the platform per one m^2.

Therefore, the mean diameter at its top end of the logs to be used here is 20 cm, and so $y = 0.251\ m^3$, and the area of the platform is 48 m^2, that the volume of logs needed will be

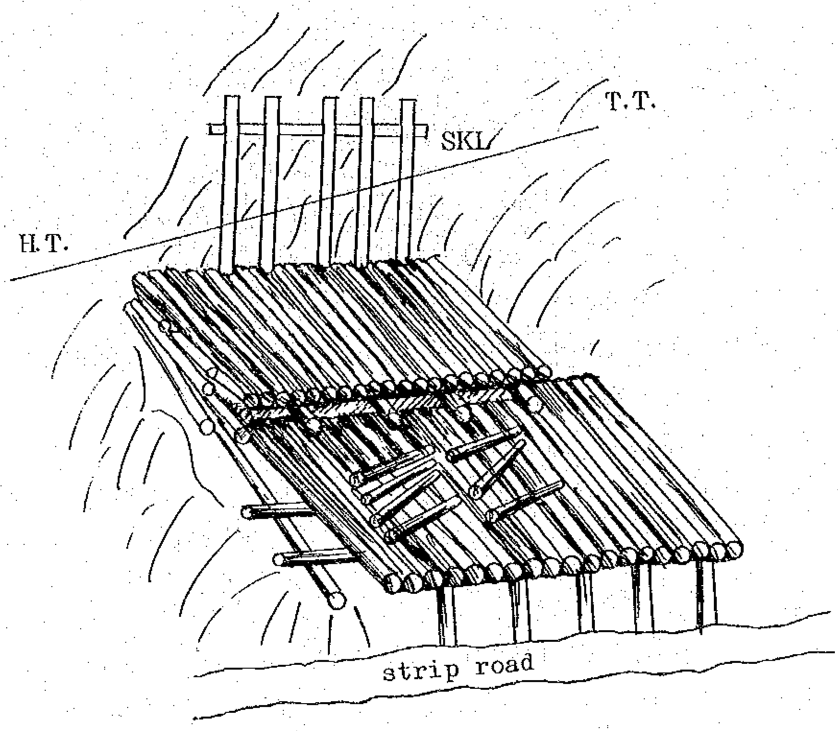
$$0.251\ m^3 \times 48 = 12\ m^3$$

As a rule, when the height of the platform would be more than 1.5 meters, we must attach the facility to step up and down safely, and if it is more than 2 meters, we must set the rails and guards for the safety of operation lest the personnel should drop off.

If the platform is just beneath the main cable, the logs carried by the yarder would give damage to the personnels that we prepare the "skip" as shown in the following figure, and the logs carried by the yarder strike this "skip" at first and be changed its direction and then fall down on the platform.

In constructing the platform we need not design it. We construct it by the way as mentioned formerly.

Fig. III-54 Platform



IV. Management of Machines

IV-1 Introducing machines

Operation by machines when compared with manual one, requires a greater investment to purchase the machines, and this increases the fixed cost like its depreciation cost and the interests for it, and for this reason, some size of operation scale is necessary.

As the fundamental theory for the standard to judge the scale to introduce the machines, there is the Equivalent point theory.

Now we set the total cost of operation by using the machine as C, fixed cost F, and variable cost V and by manual operation, the total cost C', fixed cost F' and the variable cost V' and the yielding volumes N,

then, $C = F + NV$

$C' = F' + NV'$

and equal value means $C = C'$

Therefore, $N = \dfrac{F' - F}{V - V'}$

This is the fundamental equation of equivalent point theory and from this we can understand that the economical merit will not appear as long as the yielding increases more than N.

When the merit of operation by machine is proved, then the next great point is how to control the machines.

To sort roughly the main points of controlling the machines we can do it in three parts, that is, the maintenance, repairing and renewal.

IV-2 Maintenance control

As for the maintenance, we must by special attentions for the forestry machines, because they are almost all used in outdoors, and therefore we must make the rule for the control of forestry machines which prescribe to fix the man responsible for the control of machines, and to prepare the career sheets of machines in which the record about the way of maintenance, daily maintenance check, the actual running conditions, repairing points and etc. are written, and to keep the machines always ready to use.

Especially, in the forest operations, the actual operation fields are apt to be far from the repair-shop, that the trifle trouble would cause to stop the whole line and would make a great loss, and therefore we must pay great attention to the maintenance and check.

In some case, even the spare machines would be needed.

Simple daily repairing can be done at the operation field, but the big repairing will need the special repairing factory.

We must establish a repairing factory for the machines of several operation fields in the future.

This factory must have a certain numbers of machine tools and the techniques.

The scale of the factory may be fixed by the numbers of machines to be handled.

Next, the important point in introducing the machines is the problem of the spare parts. About the amount of spare parts, it is the greater the better, but it needs some amount of funds and this would be the demerits economically, and therefore, in the ordinary case, prepare about 15 - 20% of the purchasing price of machine, mainly of the consumptive parts, and if necessary replenish them.

What parts are necessary as the spare parts would be decided by the maker from their actual data of the past, but this selection is the very difficult one, and the case of unexpected trouble would happen when the spare parts for it is not prepared.

Therefore, we must prepare the spare Machine in the repairing factory.

IV-3 Renewal of machines

As for the renewal of machine, the machine in general will gradually decrease its performance, trouble will happen frequently, the output goes down, and the fuel and oil consumption increases. Equal to these or more than these, becoming old fashioned of the machine must be counted for. As the time passes, more efficient machine would appear and to use the old fashioned one would be come unprofitable.

If you always use the up-to-date machine, then you can avoid the depression of performance and the increasing of costs by using the old fashioned one.

But it needs a certain amount of expense to buy a machine. Therefore, it is a very important point to control the machine when to renew it most profitably, after using it for sometime.

The machine, in general, have many sorts and types, and even if the sort and type are the same, the servicing conditions, maintenance and repairing conditions are different.

Therefore, the performance of machine at one moment varies to each other and the time for renewal also varies to each other. To decide this, we must at first recognize the right performance of the machine at present.

It is also a very important matters, to check the operation costs till to-day and find the present price of the machine and decide the most profitable renewal.

Considering all these we decided to take the time, for yarder as 6,000 hours and for wheel type tractor as 5,000 hours.

IV-4 Safety control of yarding operation by skyline system

As the forestry operations are done mostly in the had surroundings in forest, the labour accidents occur more frequently than other operations. Among these frequent accidents of forestry operations, those of the yarding operations by skyline system are extremely frequent.

These accidents are often caused by the breakage of skyline, hauling line, setting rope, and by the falling down of supporting spars, the breakage of the structural parts of yarding machine system, or by going into the dangerous area, or by the falling down materials or the repulsions of working materials.

Therefore, to avoid these accidents, we must pay necessary considerations from the view-point of safety in designing and setting of the machine yarding system, and always be on the alert for the safety operations in yarding during the actual working, not to speak of the practicing of the periodical checkings.

About the yarding machine proper and the accessories like wire rope, carriage and other blocks, the safety considerations are paid in the production stage, but in using other materials than the above mentioned, be careful not to cause the serious accidents, as those materials may cause them.

Also in setting the skyline, the design, calculation and wiring process must be kept to the standard rules of safety operations. The materials and the items about the safety control in setting skyline are mentioned in each articles and therefore we refer here after to the items to be kept about the yarding operations.

I. Correspondence

Yarding operations are consisted of the setting of machine, operation of machine, loading and unloading of loads, etc., and these operations are done in most cases at the separated places at a time and each of them situa situated far apart, and especially the loading operation, in most cases, are done normally in the farthest place from the unloading or the machine operated spot. Therefore, the yarding operations must always be done under a certain fixed relations to make them flow, smoothly, or the troubles and accidents may be induced from them.

As for this communication, telephone, flags and buzzer signals are adopted and each steps of operation must be proceeded after they affirmed the signals.

II. The Costume of operator

The dress of operator must be the one free from the danger of being drawn into the machine, and the shoes sufficient for the operations and also the safe-guard-helmet must be worn.

III. Cautions in operation

Operator must be careful about the following items.

1. Practice the necessary checks prior to the operation.
2. In the rainy or the damp weather, the brake would sometimes slip by the wet brake drum, and so evaporate the wetness by actuating the brake at the beginning of winding.
3. Don't load more than designed, except the special case.
4. Don't leave the driver's seat under the loaded state or the engine running.
5. Don't operate go or brake action suddenly.
6. Be careful about the indexing of meters.
7. In winding the wire rope, be careful not to become the irregular windings, and always look for the damaged conditions.
8. Don't wind up the wire rope when derailed from the sheave.
9. Don't wind up the lifting line as in the entangled state.
10. Beware that in case of downward yarding in steep slope, the brake drum would sometimes be overheated by friction.
11. Don't wipe clean or lubricate the machines and others, while running.
12. Pay attentions to the head-tree, guide-tree and tail-tree while running, and if you find something unusual, stop running at once.
13. If any unusual noise is heard, stop running at once and check it.

IV. Travelling speed of carriage

The travelling speed of carriage in loaded state must always be kept to the safety speed, considering the length of skyline, its inclination, sort of wire ropes, construction of carriage (the diameter and number of sheaves), the loaded conditions, braking capacity of drum, sort of operating lines, and etc., but it should be kept under 500m/min as possible.

V. Prevent over winding of operating lines

Following phenomena would appear by over winding or unwinding of operating lines.

1. By over winding the haul line, the loading block would hit the carriage.
2. In case of gravity cable logging, if endless line is not availed as the haul back line, its over unwinding causes the collision of carriage to the head-tree.
   To avoid these phenomena, set the marks on the proper position of operating lines, and brake the line when these marks approach to the drum.

VI. Dangerous area

1. Appoint the following places as the dangerous area.
   a) Beneath the skyline.
   b) Within the surrounded place by creating lines and its vicinity.
   c) Around the pole under work.
   d) Other places appointed from necessity.
2. Those who need to go into there dangerous areas, except the one directly engaging to the yarding by yarder, must correspond to the driver, the signal man and the operator, and get their directions.

VII. Loading & unloading

Sling

1. Wire rope used as the sling must have the breaking strength more than 6 times of the load charged on each slings, in accordance with the conditions of the load.
2. The number of logs hanged by the sling must be less than three, at a time because more than three some of them would easily drop off and is dangerous.

Loading

As the loading operation is to be done where the logs are piled up or scattered unstably and is extremely dangerous that the following items must be considered.

1. Unstable logs must be arranged stable prior to the operation.
2. Prepare the foot outfit perfectly, and care for tumbling using the anti-slipping devices.
3. Operate under close contact with the driver and the signal man.
4. Use the slings in order and prepare the following, successive load while the carriage is being wound up.
5. When hooking the load to loading hook and start hanging up, be careful about the choker hook to release or the logs slipping down.
6. When finished the loading operation, shelter to the safe spot and correspond to the driver or the signal man surely.
7. If it is necessary to hold in hand the operating line for adjusting the position or the direction of the block, you had better grip it at least 2 meters apart from the block, lest your hand should be wound in together and be hurt.

Unloading

Unloading operation is the highly dangerous one which is done on the narrow platform and is often at the same time the loading operation to the truck, and so the following items must be kept in mind.

1. While the load is descending, shelter to the safe spot, and as long as the load is still suspended swinging, the operation beneath it is strictly forbidden.
2. Prepare the foot outfit perfectly, and care for the tumbling, availing the anti-slipping devices.
3. Releasing of the load must be done after the load landed surely on the ground or on platform and send the signal to the driver.
4. When finished the unloading operation, send the signal to the driver and turn to next operations like loading etc., caring for the loading block and slings.
5. Be careful not to be hit by the slings in returning the carriage, and for this send the signal to the driver sheltering to the safe spot.
6. When unloading to the spot where can not be seen, from the driver's seat, proceed the operation by contacting closely to the intermittent communicator, and after affirming to each other the signals.

V. Arrangement of Forest Road and Strip Road

V-1 Fundamental considerations

As for the road to transport the logs to the paper-mill, the public road would be maintained by the district government, and only for the forest road Perum Perhutani is responsible.

About the planning of forest road, the Rochmadi Report already mentioned about the results of survey refering to the network of roads and therefore we take it as a base for the plan shown in the separate sheet.

From the results of the actual survey about the public road and forest road of the whole Central Java, the slopes, the bridges, the curves, and the width of the road would not permit the traffics of the large size truck and now they are using the small-size trucks of about 5 ton capacity.

To transport the enormous amount of pulp logs, it is necessary to carry out the transportation by the large size truck efficiently and intentionally, but to do this, the total reconstruction of the public road would be necessary.

About the designing of the forest road, we must also consider about the connection to the public road, and therefore we decided to use the small size trucks for the time being, and the width is one lane and in the future if the road would become the main forest road then it would be reconstructed into two lanes, according to the reconstruction progress of the public road.

When using the smaller size trucks, we must increase the frequency of transportation to carry an enormous amount of logs, and for this we must prepare a lot of turnouts.

At the designing of forest road, we decided to use the crest line road fundamentally, in order to minimize the amount of earth cutting. And in the rainy district like this, we must construct the structures for the water, side ditches and the traversing ditches of the road and also plan the afforestation of the slopes both on the hill side and the valley side.

V-2 Consideration upon designing forest road

In Japan the Rules for forest road construction is fixed and also its standards are set, and as the nominated place here resembles to the forest of Japan, we refer to the Japanese standard of forest road about the radius of curves and the slopes in designing the forest road.

From this, the radius of curves are 40 - 60m, when the speed of truck is 40 km/h, 20 - 30m, when the truck's speed is 30 km/h, and more than 12 - 15m when the truck's speed is 20 km/h.

In designing the road structures, also at the curve we must set the one way grade (cant) of adequate amount, less than 8% and enlarge the width by 0.25m - 2.25m at the spot. As for the slope, 7 - 10% when the truck's speed is 40 km/h, 8 - 12% when 30 km/h and less than 9 - 14% when 20 km/h. At the spot of the change in slope we must set the curve and the radius in this case is 450 m when the truck speed is 40 km/h, 250 m when 30 km/h and less than 100 m when 20 km/h, and the length of the curve will be 40 m when 40 km/h, 30 m when 30 km/h and more than 20 m when 20 km/h.

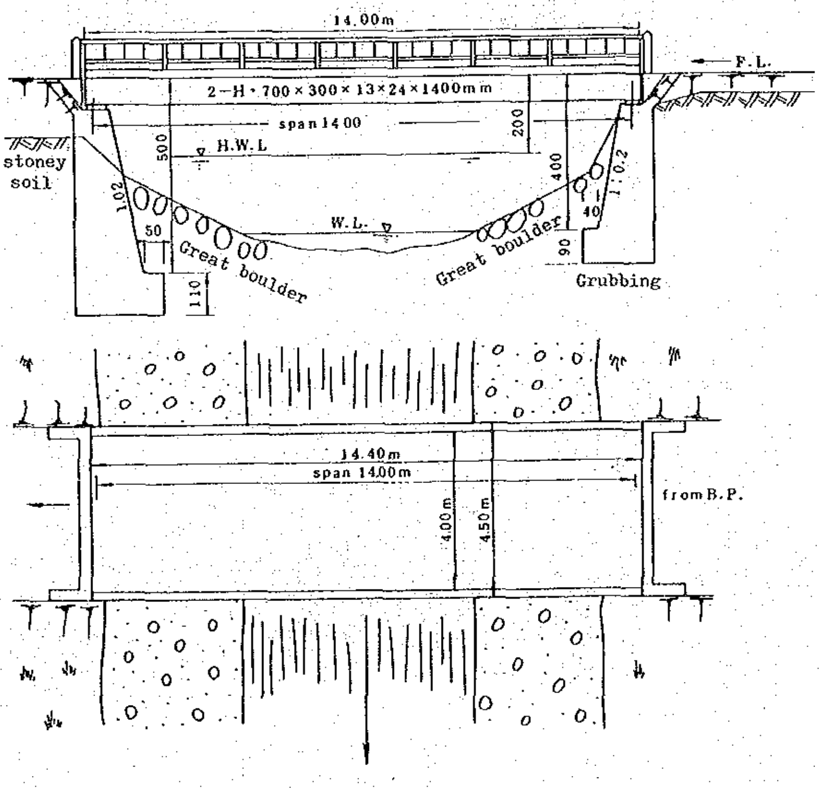
As for the bridge, they are almost all made of wood, but it is easy to rot and the serviceable years are short.

Therefore, it is better to utilize the simple beam bridge made of steel H-beam which is easy to set in the actual field. The span of the beams are set in 6 sizes, 10, 12, 14, 16, 18, 20 m, and combining these units, build up the desir-d length of bridge.

As for the bridge less than 10 m long, the culvert made of corrugated tube may be considered.

These simple beam bridges cost ¥29,000 (41,429 RP) per meter, and is cheaper than the conventional iron bridge which costs ¥33,000 (47,143 RP), and also the labor man-hour decrease by 40%.

Fig. V-1 Example of the skelton design of simple H-beam steel bridge



V-3 Strip road

The strip road is shunted from the forest road and is designed to go along with the contour line, somewhat swaying left and right from it in wave shape.

At constructing, we don't survey or design. To mark the center points of strip road along with the contour line, and directly open the road by bulldozer, aiming at these marked points.

As for the cut or banked slopes, pay attention lest the collapsion or the erosion should occur, and plant the seeds gathered from the weeds of the spot to cover ti with plants and set the covering net on the sloped surface to stabilize it.

VI. Yielding Plan and its Cost for Successive Calender Years

Concerning yielding plan of successive calender years, firstly divided the nominated area into 21 BLOCKS I-XXI from west to east in general as shown Fig. VI-2 based on Fig. VI-I, and secondarily categorized all the blocks as so-called "training unit" and so-called "5 business units" A-E covering all the remaining blocks to be operated by graduates of the training later on.

And planned yielding target as shown in Table VI-I and then conceived and calculated yearly yielding plan and its cost, as shown in Table VI-5, considering their topography, forest stand, volume growth, scale of operation and hauling system respectively in order to be able accomplish the target mentioned above.

VI-1 Yielding volume of successive calender years

In the yielding plan of successive calender years, divided the nominated area into I-XXI blocks from west to east generally a block covered by plenty of young forests was named BLOCK XX.

Obtained respective bare log volume for felling, adding an estimated volume growth to present standing volume, measured in 1977, of each compartment/subcompartment calculated basing on data of forest stand analysis thru air photographs respectively.

The volume growth was obtained from the growth-curve, shown in Fig. VI-3 basing on standing volume per ha by age prepared thru data of land -cruising, a part of the air survey basing on 88 plots system. And basing on the above data of growth curve, further prepared growth-ratio table as shown in Table VI-3 to make it easier to obtain needed felling volume in a respective year.

VI-2 Yearly costs for logging operation

Yearly allocation of the operation was scheduled as follows considering training site for trainees in initial period, and for the years starting with 1983 scale of business operation in which graduates from the training will be utilized as well as its hauling routes necessary for business operation capable to supply the above pulp logs.

a. BLOCK I, II, III, IV & VI ________ UNIT A
b. " VIII, IX, X, XI, & XII ________ " B
c. " XIII, XIV & XVII ________ " C

d. BLOCK XV, XVI, XVIII, XIX __________ " D

e. " V, VII, XX & XXI _____________ " E

f. " (supplementary area) ______ others

The training site shall be established in UNIT C which is equipped with the Model Skyline System.

As most of the above units can be operated with skyline system, cost calculation for the operation was based on the skyline system only.

Needed equipments/machinery, manpower and direct cost for each unit is as specified in Table VI-5 respectively.

For the calculation the date specified in "III Yielding System" were utilized, meantime only for cost calculation of yarder training the following formula was adopted because its equipments/machinery were no-value on grant basis and the some time its operational efficiency is regarded as lower than a normal business basis operation.

Efficiency of yarder practice by trainees is regarded as 10 m^3 per day, and as costs of depreciation as well as maintenance of equipments/machinery may be neglect, and direct costs of the practice is calculated as RP 511 per 1 m^3 log.

$$\frac{\text{Fuel \& oils RP149/hour + Wages RP 317/hour}}{\left(\frac{10\ m^3}{6\ \text{hours}}\right)} = \frac{\text{RP466}}{1.67m^3} = \text{RP279}/m^3 \qquad (1)$$

Removal of wire/line	= RP 14/m^3	(2)
Operational road construction	= RP218/m^3	(3)
Direct cost for training	TOTAL = RP511/m^3	

Fig. VI-2 Sectional map of the unit blocks of the nominated area for yielding

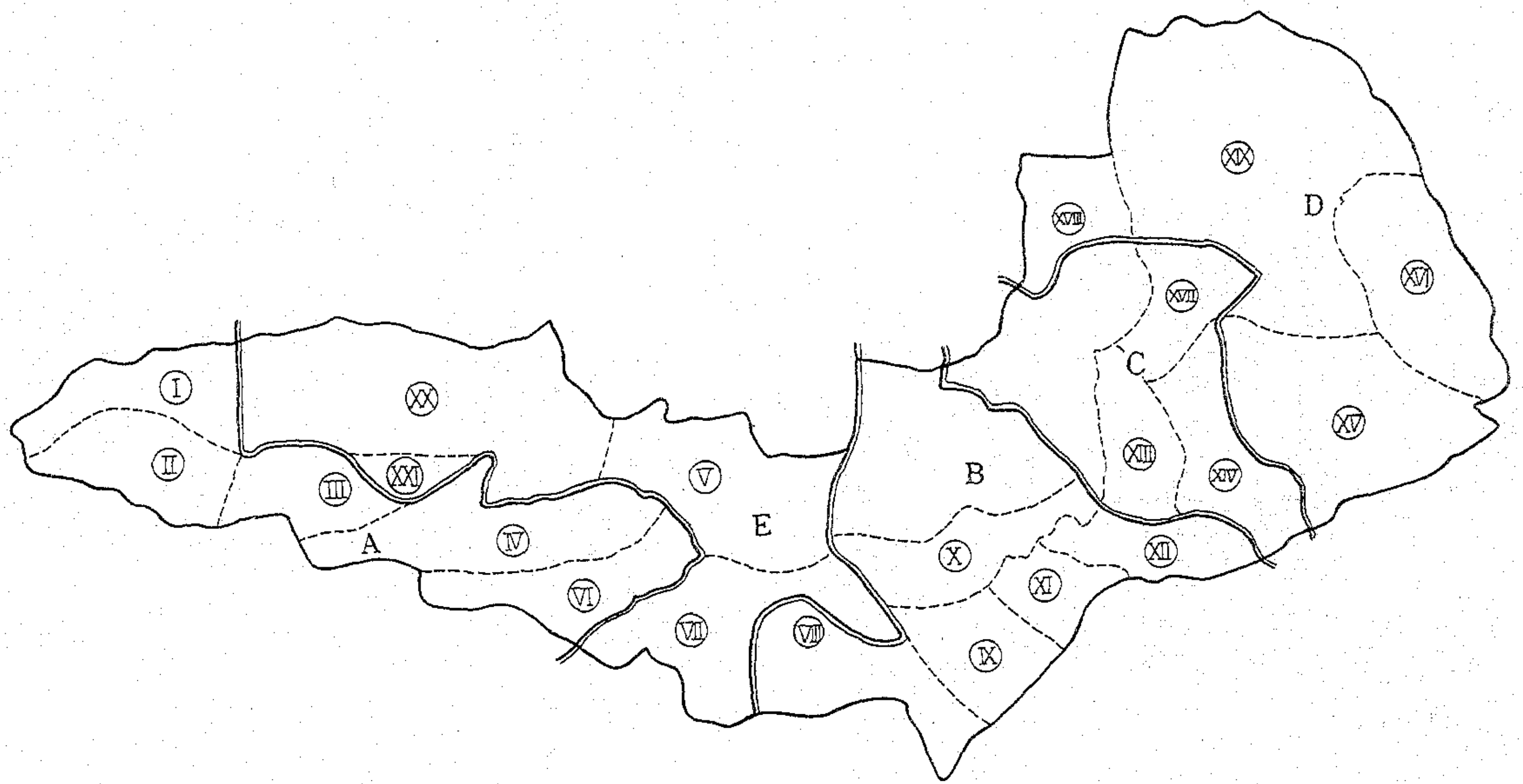


Table VI-1 10 years (1979 ∿ 1988) yielding target by unit

Year	Training yield by trainees			Business Yield											
				A			B			C			D		
	Yarder	Trainee	Volume	Yarder	Trainee	Volume	Yarder	Trainee	Volume	Yarder	Trainee	Volume	Yarder	Trainee	Volume
	unit	person	m³	unit	person	m³	unit	person	m³	unit	person	m³	unit	person	m³
1979	3	12	3,000												
1980	6	24	6,000							6	12	18,000			
1981	8	32	8,000				8	16	24,000	10	20	30,000			
1982	8	32	8,000	4	8	12,000	10	20	30,000	10	20	30,000	10	20	30,000
1983				10	20	30,000	10	20	30,000	10	20	30,000	10	20	30,000
1984				10	20	30,000	10	20	30,000	10	20	30,000	10	20	30,000
1985				10	20	30,000	10	20	30,000	10	20	30,000	10	20	30,000
1986				10	20	30,000	10	20	30,000	10	20	30,000	10	20	30,000
1987				10	20	30,000	10	20	30,000	10	20	30,000	10	20	30,000
1988				10	20	30,000	10	20	30,000	10	20	30,000	10	20	30,000
Total			25,000			192,000			234,000			258,000			210,000

Note: 1) For training yielding, 4 trainees will be stationed per 1 yarder of which efficient 10 m³ per day and 100 days working per year.

2) For business yielding, 2 graduates, as trainers, from the training and 2 of common workers total 4 will be stationed per 1 yarder, efficient 20 m³ per day and 150 days working.

E			Total			Yield total volume
Yarder	Trainee	Volume	Yarder	Trainee	Volume	
unit	person	m³	unit	person	m³	m³
						3,000
			6	12	18,000	24,000
			18	36	54,000	62,000
			34	68	102,000	110,000
10	20	30,000	50	100	150,000	150,000
10	20	30,000	50	100	150,000	150,000
10	20	30,000	50	100	150,000	150,000
10	20	30,000	50	100	150,000	150,000
10	20	30,000	50	100	150,000	150,000
10	20	30,000	50	100	150,000	150,000
		180,000			1,074,000	1,099,000

Fig. VI-3 Volume-Growth curve per year by Forest age in 1977

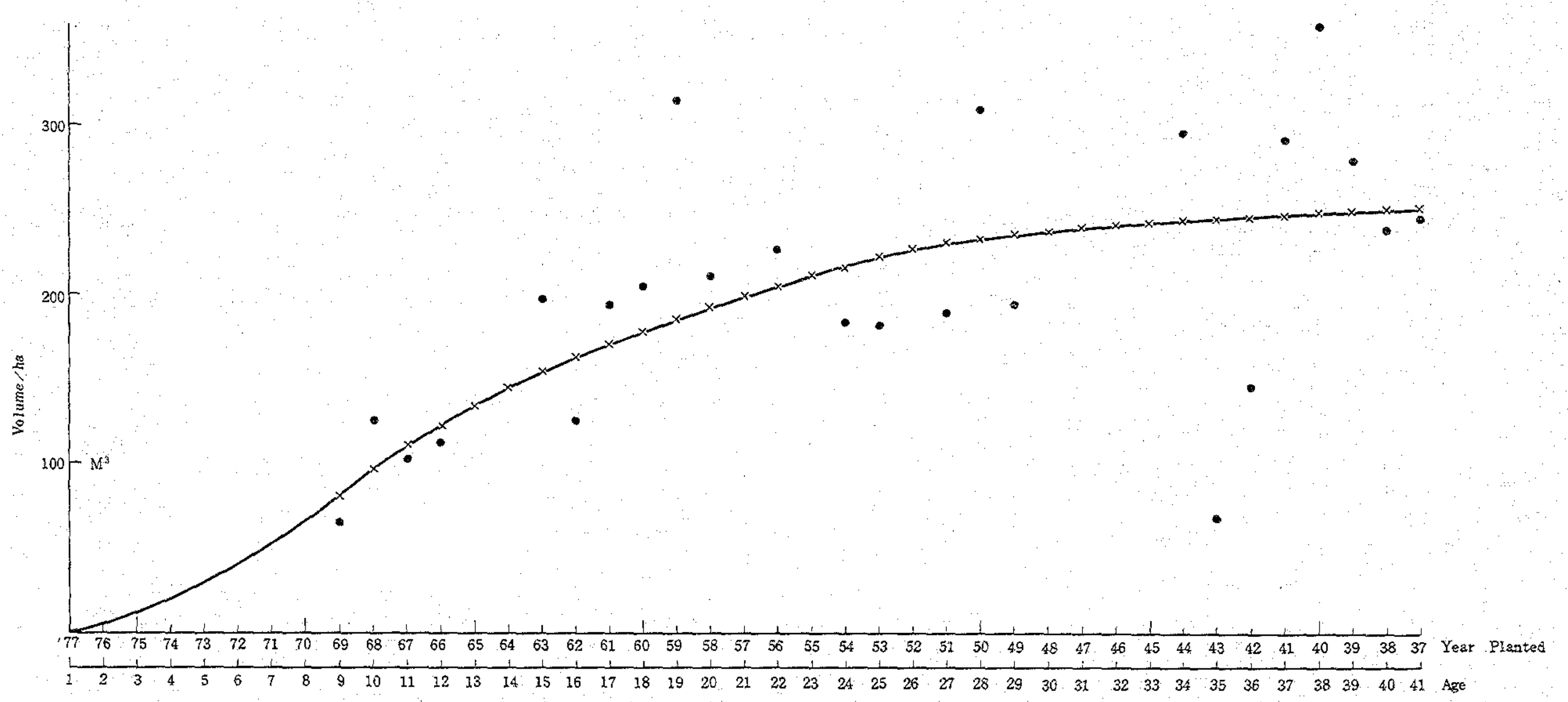


Table VI-2 Volume increment by forest age

Planted in	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959	1958	1957	1956	1955	1954	1953
Age	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Volume/ha m^3	80	96	110	122	134	144	154	162	170	178	186	192	198	204	210	216	222
Yearly growth m^3		16	14	12	12	10	10	8	8	8	8	6	6	6	6	6	6
Planted in	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938	1937	
Age	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	
Volume/ha m^3	226	230	232	234	236	238	240	242	244	245	246	247	248	249	250	250	
Yearly growth m^3	4	4	2	2	2	2	2	2	2	1	1	1	1	1	1	0	

Table VI-3 Growth-ratio by Age

	Age	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Age	Planted in	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959	1958	1957	1956	1955	1954	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938
9	1969	1.00	1.20	1.38	1.52	1.68	1.80	1.93	2.03	2.13	2.23	2.33	2.40	2.48	2.55	2.63	2.70	2.78	2.83	2.88	2.90	2.93	2.95	2.98	3.00	3.03	3.05	3.06	3.08	3.09	3.10	3.11	3.13
10	1968		1.00	1.15	1.27	1.40	1.50	1.60	1.69	1.77	1.85	1.94	2.00	2.06	2.13	2.19	2.25	2.31	2.35	2.40	2.42	2.44	2.46	2.48	2.50	2.52	2.54	2.55	2.56	2.57	2.58	2.59	2.60
11	1967			1.00	1.11	1.22	1.31	1.40	1.47	1.55	1.62	1.69	1.75	1.80	1.85	1.91	1.96	2.02	2.05	2.09	2.11	2.13	2.15	2.16	2.18	2.20	2.22	2.23	2.24	2.25	2.25	2.26	2.27
12	1966				1.00	1.10	1.18	1.26	1.33	1.39	1.46	1.52	1.57	1.62	1.67	1.72	1.77	1.82	1.85	1.89	1.90	1.92	1.93	1.95	1.97	1.98	2.00	2.01	2.02	2.02	2.03	2.04	2.05
13	1965					1.00	1.07	1.15	1.21	1.27	1.33	1.39	1.43	1.48	1.52	1.57	1.61	1.66	1.69	1.72	1.73	1.75	1.76	1.78	1.79	1.81	1.82	1.83	1.84	1.84	1.85	1.86	1.87
14	1964						1.00	1.07	1.13	1.18	1.24	1.29	1.33	1.38	1.42	1.46	1.50	1.54	1.57	1.60	1.61	1.63	1.64	1.65	1.67	1.68	1.69	1.70	1.71	1.72	1.72	1.73	1.74
15	1963							1.00	1.05	1.10	1.16	1.21	1.25	1.29	1.32	1.36	1.40	1.44	1.47	1.49	1.51	1.52	1.53	1.55	1.56	1.57	1.58	1.59	1.60	1.60	1.61	1.62	1.62
16	1962								1.00	1.05	1.10	1.15	1.19	1.22	1.26	1.30	1.33	1.37	1.40	1.42	1.43	1.44	1.46	1.47	1.48	1.49	1.51	1.51	1.52	1.52	1.53	1.54	1.54
17	1961									1.00	1.05	1.09	1.13	1.16	1.20	1.24	1.27	1.31	1.33	1.35	1.36	1.38	1.39	1.40	1.41	1.42	1.44	1.44	1.45	1.45	1.46	1.46	1.47
18	1960										1.00	1.04	1.09	1.11	1.15	1.18	1.21	1.25	1.27	1.29	1.30	1.31	1.33	1.34	1.35	1.36	1.37	1.38	1.38	1.39	1.39	1.40	1.40
19	1959											1.00	1.03	1.06	1.10	1.13	1.16	1.19	1.22	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.32	1.33	1.33	1.34	1.34
20	1958												1.00	1.03	1.06	1.09	1.13	1.16	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.28	1.29	1.29	1.30	1.30
21	1957													1.00	1.03	1.06	1.09	1.12	1.14	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.24	1.25	1.25	1.26	1.26
22	1956														1.00	1.03	1.06	1.09	1.11	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.20	1.21	1.21	1.22	1.22	1.23
23	1955															1.00	1.03	1.06	1.08	1.10	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.17	1.18	1.18	1.19	1.19
24	1954																1.00	1.03	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.13	1.14	1.14	1.15	1.15	1.16
25	1953																	1.00	1.02	1.04	1.05	1.05	1.06	1.07	1.08	1.09	1.10	1.10	1.11	1.11	1.12	1.12	1.13
26	1952																		1.00	1.02	1.03	1.04	1.04	1.05	1.06	1.07	1.08	1.08	1.09	1.09	1.10	1.10	1.11
27	1951																			1.00	1.01	1.02	1.03	1.03	1.04	1.05	1.06	1.07	1.07	1.07	1.08	1.08	1.09
28	1950																				1.00	1.01	1.02	1.03	1.03	1.04	1.05	1.06	1.06	1.06	1.07	1.07	1.08
29	1949																					1.00	1.01	1.02	1.03	1.03	1.04	1.05	1.05	1.06	1.06	1.06	1.07
30	1948																						1.00	1.01	1.02	1.03	1.03	1.04	1.04	1.05	1.05	1.06	1.06
31	1947																							1.00	1.01	1.02	1.03	1.03	1.03	1.04	1.04	1.05	1.05
32	1946																								1.00	1.01	1.02	1.02	1.03	1.03	1.03	1.04	1.04
33	1945																									1.00	1.01	1.01	1.02	1.02	1.02	1.03	1.03
34	1944																										1.00	1.00	1.01	1.01	1.02	1.02	1.02
35	1943																											1.00	1.00	1.01	1.01	1.02	1.02
36	1942																												1.00	1.00	1.01	1.01	1.02
37	1941																													1.00	1.00	1.01	1.01
38	1940																														1.00	1.00	1.01
39	1939																															1.00	1.00
40	1938																																1.00

Note: 1) This table of growth-ratio is prepared for the coming 10 *years yielding*, *therefore* the ratio for pine forests presently younger than 9 years old which will not yet reach the minimum age for yielding, 20 years, within this plan is omitted.

Table VI-4 Sum up table of the yielding plans for the successive years
(West Pekalongan District Forest Office)

Unit	BLOCK	1979		1980		1981		1982		1983		1984		1985		1986		1987		1988		Total	
		ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
Trainee	XIV	(30.09)	3,000	(36.21)	6,000	(29.00)	6,376															(95.30)	15,376
Trainee	XIII					(8.87)	1,624	(58.58)	7,971													(67.45)	9,595
	Total	(30.09)	3,000	(36.21)	6,000	(37.87)	8,000	(58.58)	7,971													(162.75)	24,971
A	I							(17.71)	1,725			(8.93)	1,847			(33.37)	4,331	(111.15)	15,514			(171,16)	23,417
	II							(70.65)	6,232							(36.23)	3,849			(140.18)	11,160	(264.16)	23,137
	III							(39.95)	4,180	(206.23)	30,000	(38.28)	7,817	(73.73)	8,662							(358.19)	50,659
	IV													(42.46)	6,612			(134.55)	11,193	(10.80)	2,653	(187.81)	20,458
	VI																			(173.93)	14,298	(173.93)	14,298
	Total							(128.31)	12,137	(206.23)	30,000	(47.21)	9,664	(116.19)	15,274	(69.6)	8,18C	(262.80)	28,603	(324.91)	28,111	(1,155.25)	131,969
B	VIII																	(14.18)	513			(14.18)	513
	IX					(74.49)	5,876			(8.63)	379							(9.90)	533	(81.00)	954	(174.02)	7,742
	X					(112.52)	18,379	(223.93)	18,561	(14.63)	386							(84.38)	11,641	(249.37)	20,321	(684.83)	69.288
	XI							(216.49)	11,348									(13.50)	727			(229.99)	12,075
	XII									(164.14)	13,181							(39.60)	202			(203.74)	13,383
	Total					(187.01)	24,255	(440.42)	29,909	(187.40)	13,946							(161.56)	13,616	(330.37)	21,275	(1,306.76)	103,001
C	XIII			(140.48)	18,000	(185.57)	29,727	(214.90)	30,274	(154.98)	21,844											(695.93)	99,845
	XIV									(41.73)	4,845											(41.73)	4,845
	XVII									(28.00)	3,293	(56.27)	5,453									(84.27)	8,746
	Total			(140.48)	18,000	(185.57)	29,727	(214.90)	30,274	(224.71)	29,982	(56.27)	5,453									(821.93)	113,436
D	XV							(319.08)	30,467	(60.99)	5,277	(68.86)	2,974									(448.93)	38,718
	XVI									(129.83)	24,721	(137.52)	27,142	(146.86)	30,071	(70.97)	10,324	(78.54)	12,600	(17.40)	3,217	(581.12)	108,075
	XVIII															(217.82)	19,477	(114.53)	17,252			(332.35)	36,729
	XIX																			(136.98)	16,510	(136.98)	16,510
	Total							(319.08)	30,467	(190.82)	29,998	(206.38)	30,116	(146.86)	30,071	(288.79)	29,801	(193.07)	29,852	(154.38)	19,727	(1,499.38)	200,032
E	XX									(4.28)	454	(64.36)	4,967					(70.21)	3,611			(138.85)	9,032
	VII																	(90.06)	4,508			(90.06)	4,508
	XXI									(165.48)	29,608											(165.48)	29,608
	Total									(169.76)	30,062	(64.36)	4,967					(160.27)	8,119			(394.39)	43,148
Total		(30.09)	3,000	(176.21)	24,000	(410.45)	61,982	(1,161.29)	110.758	(978.92)	133,988	(374.22)	50,200	(263.05)	45,345	(358.39)	37,981	(777.70)	80,190	(809.66)	69,113	(5,340.46)	616,557

Table VI-5 Cost for successive years (of whole area)

But the direct cost of felling, logging, and yarding, (including the construction of strip road.)

Unit		Sort \ Calender year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total
Trainee		Yielding volume (m^3)	3,000	6,000	8,000	7,971							24,971
		Necessary machines (unit)	3	6	8	8							—
	Personnels	Felling & bucking (man)	900	1,800	2,400	2,391							7,491
		Yarding (man)	1,200	2,400	3,200	3,188							9,988
		Total (man)	2,100	4,200	5,600	5,579							17,479
	Cost	Felling & bucking (1,000 RP)	450	900	1,200	1,196							3,746
		Yarding (1,000 RP)	1,533	3,066	4,088	4,073							12,760
		Total (1,000 RP)	1,983	3,966	5,288	5,269							16,506
A		Yielding volume (m^3)				12,137	30,000	9,664	15,274	8,180	28,603	28,111	131,969
		Necessary machines (unit)				4	10	3	5	3	10	10	—
	Personnels	Felling & bucking (man)				3,641	9,000	2,899	4,582	2,454	8,581	8,433	39,590
		Yarding (man)				2,427	6,000	1,933	3,055	1,636	5,721	5,622	26,394
		Total (man)				6,068	15,000	4,832	7,637	4,090	14,302	14,055	65,984
	Cost	Felling & bucking (1,000 RP)				1,821	4,500	1,450	2,291	1,227	4,291	4,217	19,797
		Yarding (1,000 RP)				30,160	74,550	24,015	37,956	20,327	71,078	69,856	327,942
		Total (1,000 RP)				31,981	79,050	25,465	40,247	21,554	75,369	74,073	347,739

Unit		Sort \ Calender year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total
B		Yielding volume (m^3)			24,255	29,909	13,946				13,616	21,275	103,001
		Necessary machines (unit)			8	10	5				5	7	—
	Personnels	Felling & bucking (man)			7,277	8,973	4,184				4,085	6,383	30,902
		Yarding (man)			4,851	5,982	2,789				2,723	4,255	20,600
		Total (man)			12,128	14,955	6,973				6,808	10,638	51,502
	Cost	Felling & bucking (1,000 RP)			3,638	4,486	2,092				2,042	3,191	15,449
		Yarding (1,000 RP)			60,274	74,324	34,656				33,836	52,868	255,958
		Total (1,000 RP)			63,912	78,810	36,748				35,878	56,059	271,407
C		Yielding volume (m^3)		18,000	29,727	30,274	29,982	5,453					113,436
		Necessary machines (unit)		6	10	10	10	2					—
	Personnels	Felling & bucking (man)		5,400	8,918	9,082	8,995	1,636					34,031
		Yarding (man)		3,600	5,945	6,055	5,996	1,091					22,687
		Total (man)		9,000	14,863	15,137	14,991	2,727					56,718
	Cost	Felling & bucking (1,000 RP)		2,700	4,459	4,541	4,497	818					17,015
		Yarding (1,000 RP)		44,730	73,872	75,231	74,505	13,551					281,889
		Total (1,000 RP)		47,430	78,331	79,772	79,002	14,369					298,904
D		Yielding volume (m^3)				30,467	29,998	30,116	30,071	29,801	29,852	19,727	200,032
		Necessary machines (unit)				10	10	10	10	10	10	7	—
	Personnels	Felling & bucking (man)				9,140	8,999	9,035	9,021	8,940	8,956	5,918	60,009
		Yarding (man)				6,093	6,000	6,023	6,014	5,960	5,970	3,945	40,005
		Total (man)				15,233	14,999	15,058	15,035	14,900	14,926	9,863	100,014
	Cost	Felling & bucking (1,000 RP)				4,570	4,500	4,517	4,511	4,470	4,478	2,959	30,005
		Yarding (1,000 RP)				75,710	74,545	74,838	74,726	74,055	74,182	49,022	497,078
		Total (1,000 RP)				80,280	79,045	79,355	79,237	78,525	78,660	51,981	527,083

Unit	Sort / Calender year		1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total
E	Yielding volume (m^3)						30,062	4,967			8,119		43,148
	Necessary machines (unit)						10	2			3		—
	Personnels	Felling & bucking (man)					9,019	1,490			2,436		12,945
		Yarding (man)					6,012	993			1,624		8,629
		Total (man)					15,031	2,483			4,060		21,574
	Cost	Felling & bucking (1,000 RP)					4,509	745			1,218		6,472
		Yarding (1,000 RP)					74,704	12,343			20,176		107,223
		Total (1,000 RP)					79,213	13,088			21,394		113,695
Total	Yielding volume (m^3)		3,000	24,000	61,982	110,758	133,988	50,200	45,345	37,981	80,190	69,113	616,557
	Necessary machines (unit)		3	12	26	42	45	17	15	13	28	24	—
	Personnels	Felling & bucking (man)	900	7,200	18,595	33,227	40,197	15,060	13,603	11,394	24,058	20,734	184,968
		Yarding (man)	1,200	6,000	13,996	23,745	26,797	10,040	9,069	7,596	16,038	13,822	128,303
		Total (man)	2,100	13,200	32,591	56,972	66,994	25,100	22,672	18,990	40,096	34,556	313,271
	Cost	Felling & bucking (1,000 RP)	450	3,600	9,297	16,614	20,098	7,530	6,802	5,697	12,029	10,367	92,484
		Yarding (1,000 RP)	1,533	47,796	138,234	259,498	332,960	124,747	112,682	94,382	199,272	171,746	1,482,850
		Total (1,000 RP)	1,983	51,396	147,531	276,112	353,058	132,277	119,484	100,079	211,301	182,113	1,575,334
Other area	Yielding volume (m^3)						16,012	99,800	104,655	112,019	69,810	80,887	483,183
	Necessary machines (unit)						5	33	35	37	22	26	—
	Personnels	Felling & bucking (man)					4,804	29,940	31,397	33,606	20,942	24,266	144,955
		Yarding (man)					3,202	19,960	20,931	22,404	13,962	16,178	96,637
		Total (man)					8,006	49,900	52,328	56,010	34,904	40,444	241,592
	Cost	Felling & bucking (1,000 RP)					2,402	14,970	15,698	16,803	10,477	12,133	72,477
		Yarding (1,000 RP)					39,790	248,003	260,068	278,367	173,478	201,004	1,200,710
		Total (1,000 RP)					42,192	262,973	275,766	295,170	183,949	213,137	1,273,187

Unit	Sort \ Calender year		1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	Total
Grand total	Yielding volume (m^3)		3,000	24,000	61,982	110,758	150,000	150,000	150,000	150,000	150,000	150,000	1,099,740
	Necessary machines (unit)		3	12	26	42	50	50	50	50	50	50	—
	Personnels	Felling & bucking (man)	900	7,200	18,595	33,227	45,000	45,000	45,000	45,000	45,000	45,000	329,923
		Yarding (man)	1,200	6,000	13,996	23,745	30,000	30,000	30,000	30,000	30,000	30,000	224,940
		Total (man)	2,100	13,200	32,591	56,972	75,000	75,000	75,000	75,000	75,000	75,000	554,863
	Cost	Felling & bucking (1,000 RP)	450	3,600	9,297	16,614	22,500	22,500	22,500	22,500	22,500	22,500	164,961
		Yarding (1,000 RP)	1,533	47,796	138,234	259,498	372,750	372,750	372,750	372,750	372,750	372,750	2,683,560
		Total (1,000 RP)	1,983	51,396	147,531	276,112	395,250	395,250	395,250	395,250	395,250	395,250	2,848,521

TABLE OF FELLING PLAN

BLOCK	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XIV	69 a	16.25	1950	30°	30%	VI	2,466	740	592	4.88	604		
	b	12.00	1944	"	"	VIII	1,838	551	441	3.60	445		
	c	5.50	1944	"	"	"	526	158	126	1.65	127		
	d	24.25	1940	"	"	"	2,363	708	566	7.28	572		
	e	7.25	1943	"	"	"	993	298	238	2.18	240		
	f	10.75	1959	"	"	V	1,310	393	314	3.23	333		
	g	4.25	1942	"	"	VIII	546	164	131	1.28	132		
	h	33.25	1943	"	"	VI	3,792	138	910	5.99	547	3.99	372
	67 a	21.25	1948	"	"	VII	3,650	1,095	876			6.38	902
	b	23.75	1958	"	"	VI	3,358	1,007	806			7.13	879
	c	24.75	1949	"	"	VII	2,144	1,715	1,372			7.43	1,413
	d	134.25	1958	"	"	V	32,726	9,818	7,854			11.28	2,434
			Total							30.09	3,000	36.21	6,000
XIII	68 b	34.00	1949	30°	30%	VII	7,767	2,330	1,864				
	c	13.75	1958	"	"	V	2,385	716	572				
	d	31.00	1949	"	"	VII	6,134	1,840	1,472				
	h	12.00	1952	"	"	VI	1,757	527	422				
	i	13.00	1956	"	"	"	1,805	542	433				
	j	25.25	1952	"	"	"	4,031	1,209	967				
	k,m,o	48.75	1956	"	"	V	5,481	1,644	1,315				
	n	7.00	1952	"	"	VI	1,117	335	268				
	66 e	32.25	1956	"	"	V	5,385	1,616	1,292				
	i	7.75	1958	"	"	VII	1,087	326	261				
			Total										

1981		1982		1983		1984		1985		1986		1987		1988	
ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
29.00	6,376														
29.00	6,376														
8.87	1,624	1.33	299												
		4.13	664												
		9.30	1,531												
		3.60	443												
		3.90	489												
		7.58	1,015												
		14.63	1,486												
		2.10	281												
		9.68	1,460												
		2.33	303												
8.87	1,624	58.58	7,971												

BLOCK	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
I	6	4.25	1966	>30°	30%	III	583	175	140				
		11.75	1956	"	"	V	2,198	659	528				
	9 b	16.00	1966	"	"	III	944	283	227				
		3.75	1960	"	"	IV	292	88	70				
	10 b,c	108.00	1967	<30°	90%	III	11,784	10,606	8,484				
		3.50	1956	"	"	V	247	222	178				
	11	14.50	1966	"	"	III	1,148	1,033	827				
		4.00	1961	"	"	IV	585	527	422				
		7.00	1956	"	"	V	414	373	298				
	13 b	5.25	1964	>30°	30%	IV	1,267	380	304				
	14 b	24.50	1964	"	"	IV	4,308	1,292	1,034				
	15 a	47.45	1966	"	"	III	6,164	1,849	1,479				
	16 a	46.50	1967	"	"	III	563	169	135				
			Total										
II	44	25.00	1968	<30°	90%	III	927	834	667				
	45 a	100.25	1968	"	"	III	4,604	4,144	3,315				
	46 b	6.50	1968	"	"	III	105	95	76				
	c	4.50	1960	"	"	IV	349	314	251				
	47 a	24.00	1968	"	"	III	1,887	1,698	1,359				
	b	68.50	1960	"	"	IV	6,494	5,845	4,676				
	49 b	40.25	1966	"	"	III	3,300	2,970	2,376				
	51 b	11.50	1967	"	"	III	1,023	921	737				
		5.50	1956	"	"	V	514	463	370				
	54 b	7.50	1967	"	"	III	439	395	316				
			Total										

1981		1982		1983		1984		1985		1986		1987		1988	
ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
										1.28	227				
		3.53	597												
										4.80	368				
		1.13	83												
												97.20	15,271		
		3.15	202												
										13.05	1,340				
		3.60	506												
		6.30	337												
						1.58	420								
						7.35	1,427								
										14.24	2,396				
												13.95	243		
		17.71	1,725			8.93	1,847			33.37	4,331	111.15	15,514		
														22.50	1,374
														90.23	6,829
														5.85	157
		4.05	296												
														21.60	2,800
		61.65	5,518												
										36.23	3,849				
												10.35	1,327		
		4.95	418												
												6.75	569		
		70.65	6,232							36.23	3,849	17.10	1,896	140.18	11,160

BLOCK	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
III	38 a,b,c	137.75	1956	<30°	100%	V	15,686	15,686	12,549				
	d	3.00	1965	"	"	III	92	92	74				
	39 a	20.25	1965	"	90%	III	882	794	635				
	40	8.50	1965	"	100%	III	794	794	635				
	41 a	44.00	1965	"	"	III	5,639	5,639	4,511				
	b	38.25	1956	"	"	V	7,853	7,853	6,282				
	42 a,b	41.75	1956	"	90%	V	7,195	6,476	5,180				
	43 a,b	78.75	1958	"	"	V	16,588	14,929	11,943				
			Total										
IV	55 a	64.50	1961	>30°	30%	IV	10,300	3,090	2,472				
	b	6.75	1958	"	"	V	1,607	482	386				
	56 a	7.50	1961	"	"	IV	1,053	316	253				
	b	22.75	1958	"	"	V	4,230	1,269	1,015				
	94 b	36.00	1968	"	"	III	5,366	1,610	1,288				
	95 a,b	54.00	1967	<30°	100%	III	2,020	2,020	1,616				
	96 b,c	89.50	1967	"	90%	III	6,391	5,752	4,602				
	105 a	16.00	1958	>30	30%	V	1,321	396	317				
	106 a	24.00	1958	"	"	V	3,319	996	797				
			Total										
VI	90 a,b	127.00	1967	<30°	90%	III	9,760	8,784	7,027				
	93 a	33.25	1967	"	"	III	1,034	931	744				
	100 a	33.00	1967	"	"	III	239	215	172				
			Total										

1981		1982		1983		1984		1985		1986		1987		1988	
ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
		39.95	4,180	97.80	10,227										
								3.00	106						
								18.23	940						
								8.50	940						
								44.00	6,676						
				38.25	7,224										
				37.58	5,957										
				32.60	6,592	38.28	7,817								
		39.95	4,180	206.23	30,000	38.28	7,817	73.73	8,662						
								19.35	3,238						
								2.03	467						
								2.25	331						
								6.83	1,228						
														10.80	2,653
												54.00	2,909		
												80.55	8,284		
								4.80	384						
								7.20	964						
								42.46	6,612			134.55	11,193	10.80	2,653
														114.30	12,649
														29.93	1,339
														29.70	310
														173.93	14,298

BLOCK	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
VIII	5	47.25	1967	>30°	30%	III	1,188	356	285				
			Total										
IX	8 c	42.25	1961	<30°	90%	IV	5,218	4,696	3,757				
	10 b	42.50	1968	"	"	IV	413	372	297				
	d	47.50	1968	"	"	III	231	208	166				
	12 a	28.75	1963	>30°	30%	IV	1,223	367	294				
	13 a	11.00	1967	<30°	90%	III	411	370	296				
	b	25.75	1959	"	"	V	1,106	995	796				
	e	6.50	1956	"	"	V	283	255	204				
	f	8.25	1956	"	"	V	492	443	354				
			Total										

BLOCK	Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
		ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
VIII	5													14.18	513		
	Total													14.18	513		
IX	8 c	38.03	4,358														
	10 b													38.25	612		
	d													42.75	342		
	12 a					8.63	379										
	13 a											9.90	533				
	b	23.18	899														
	e	5.85	226														
	f	7.43	393														
	Total	74.49	5,876			8.63	379					9.90	533	81.00	954		

BLOCK	Compartment Sub compartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
X	14 b,c	185.75	1968	<30°	90%	III	3,763	3,362	2,690				
	15 b	17.00	1958	"	"	V	1,870	1,683	1,346				
	16 c	11.75	1957	"	"	V	563	507	405				
	e	6.25	1957	"	"	V	514	463	370				
	g	25.25	1968	"	"	III	930	837	670				
	17 a	6.50	1956	"	"	V	1,629	1,466	1,173				
	b	12.75	1968	"	"	III	1,745	1,571	1,256				
	c	6.00	1958	"	"	V	493	444	355				
	e	16.25	1963	"	"	IV	415	374	299				
	18 a	46.00	1956	"	"	V	11,529	10,376	8,301				
	b	53.25	1968	"	"	III	7,290	6,561	5,249				
	c	5.75	1956	"	"	V	725	653	522				
	19 a	25.75	1958	"	"	V	3,141	2,827	2,262				
	c	55.75	1967	"	"	III	6,569	5,912	4,730				
	20 b	25.75	1956	"	"	V	5,623	5,061	4,049				
	21 a	16.75	1958	"	"	V	1,621	1,459	1,167				
	d	5.75	1951	"	"	VI	212	191	153				
	22 c	6.25	1956	"	"	V	300	270	216				
	23 b	8.25	1956	"	"	V	682	614	491				
	d	30.25	1956	"	"	V	2,827	2,544	2,035				
	g	22.50	1956	"	"	V	2,432	2,189	1,751				
	24 a	11.25	1956	"	"	V	930	837	670				
	b	12.50	1952	"	"	VI	1,234	1,111	888				
	d	49.50	1956	"	"	V	4,092	3,683	2,946				
	25 a	38.00	1967	"	"	III	2,412	2,171	1,737				
	d	11.50	1962	"	"	IV	898	808	647				
	26 b	23.50	1956	"	"	V	2,961	2,665	2,132				
	27 c	8.00	1951	"	"	VI	494	445	356				
	e	5.00	1950	"	"	VI	13	12	9				
	f	11.75	1961	"	"	IV	870	783	626				
			Total										

Compartment Sub compartment	1981		1982		1983		1984		1985		1986		1987		1988	
	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
14 b,c															167.18	5,541
15 b	15.30	1,521														
16 c	10.58	454														
e	5.63	414														
g															22.78	1,380
17 a	5.85	1,302														
b															11.48	2,587
c	5.40	401														
e					14.63	386										
18 a	41.40	9,214														
b															47.93	10,813
c	5.18	579														
19 a			23.18	2,624												
c													50.18	8,514		
20 b	23.18	4,494														
21 a			15.08	1,354												
d			5.18	159												
22 c			5.83	244												
23 b			7.43	555												
d			27.23	2,300												
g			20.29	1,979												
24 a			10.13	757												
b			11.25	932												
d			44.55	3,329												
25 a													34.20	3,127		
d			10.35	789												
26 b			21.15	2,409												
27 c			7.20	370												
e			4.50	9												
f			10.58	751												
Total	112.52	18,379	223.93	18,561	14.63	386							84.38	11,641	249.37	20,321

BLOCK	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m^3)	(m^3)	(m^3)				
XI	34 b	11.50	1956	<30°	90%	V	256	230	184				
	d	18.25	1956	"	"	V	850	765	612				
	e	17.25	1956	"	"	V	516	464	372				
	35 a	11.00	1956	"	"	V	824	742	593				
	d	5.25	1956	"	"	V	125	113	90				
	36 d	15.00	1967	"	"	III	561	505	404				
	g	9.25	1961	"	"	IV	1,377	1,239	991				
	37 c	23.25	1961	"	"	IV	3,461	3,115	2,492				
	g	10.75	1956	"	"	V	1,088	979	783				
	39 b	34.50	1960	"	"	IV	462	416	333				
	f	29.25	1961	"	"	IV	3,281	2,953	2,362				
	40 b	10.25	1962	"	"	IV	214	193	154				
	c	27.25	1956	"	"	V	307	276	221				
	41 d	37.00	1958	"	"	V	630	567	454				
			Total										
XII	28 a	19.25	1959	<30°	90%	V	2,211	1,990	1,592				
	29 c	33.75	1956	>30°	30%	V	1,935	581	464				
	30 a	38.25	1956	<30°	90%	V	3,450	3,105	2,484				
	b	8.25	1956	"	"	V	744	670	536				
	31 c	9.75	1939	"	"	VIII	999	899	719				
	d	27.00	1956	"	"	V	1,983	1,785	1,428				
	e	14.25	1961	"	"	IV	504	454	363				
	32 b	9.50	1940	"	"	VIII	971	874	699				
	c	36.50	1954	"	"	VI	3,067	2,760	2,208				
	d	44.00	1967	"	"	III	155	140	112				
	33 a	9.25	1951	>30°	30%	VI	986	296	237				
	e	13.50	1956	"	"	V	851	255	204				
	f	4.75	1958	"	"	V	292	88	70				
	g	37.25	1956	"	"	V	3,072	922	737				
			Total										

Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
XI 34 b			10.35	208												
d			16.43	692												
e			15.53	420												
35 a			9.90	670												
d			4.73	102												
36 d													13.50	727		
g			8.33	1,189												
37 c			20.93	2,990												
g			9.68	885												
39 b			31.05	393												
f			22.50	2,834												
40 b			9.23	188												
c			24.53	250												
41 d			33.30	527												
Total			216.49	11,348									13.50	727		
XII 28 a					17.33	1,894										
29 c					10.13	529										
30 a					22.50	2,832										
b					7.43	611										
31 c					8.78	719										
d					24.30	1,628										
e					12.83	450										
32 b					8.55	706										
c					32.85	2,407										
d													39.60	202		
33 a					2.78	249										
e					4.05	233										
f					1.43	83										
g					11.18	840										
Total					164.14	13,181							39.60	202		

BLOCK	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XIII	66 f	13.50	1949	>30°	30%	VII	1,894	568	455			4.05	469
	g	23.25	1956	"	"	V	3,075	923	738			6.98	804
	h	5.75	1950	"	"	VI	807	242	194			1.73	200
	j	49.00	1958	"	"	V	4,967	1,490	1,192			14.70	1,299
	42 a	18.25	1950	20°	90%	VI	3,224	2,902	2,321			16.43	2,391
	b	17.00	1956	"	"	V	2,649	2,384	1,907			15.30	2,079
	d	14.00	1961	"	"	IV	2,634	2,371	1,896				
	e	54.50	1952	"	"	VI	8,108	7,297	5,838			49.05	6,072
	j	6.50	1940	"	"	VIII	1,089	980	784			5.85	792
	g,h,j	57.50	1942	"	"	VIII	10,460	9,414	7,532			26.39	3,894
	j	20.50	1959	"	"	V	3,859	3,473	2,778				
	k	46.00	1956	"	"	V	6,553	5,898	4,718				
	43 a	13.25	1946	"	"	VII	2,563	2,307	1,845				
	b,d	84.25	1950	"	"	VI	18,207	16,386	13,109				
	c	15.50	1956	"	"	V	2,208	1,987	2,484				
	f	20.50	1946	"	"	VII	4,052	3,647	2,917				
	g	14.50	1941	"	"	VIII	3,297	2,698	2,374				
	h,i	2.75	1958	"	"	V	392	353	282				
	44 a	2.00	1948	<30°	90%	VII	328	295	236				
	b	8.50	1940	"	"	VIII	1,092	986	789				
	d,g	23.75	1940	"	"	VIII	4,495	4,046	3,236				
	e	5.00	1958	"	"	V	289	260	208				
	f	3.50	1954	"	"	VI	844	760	608				
	h	4.00	1956	"	"	V	729	656	525				
	i	27.50	1950	"	"	VI	4,450	4,005	3,204				
	j	14.75	1949	"	"	VII	2,594	2,335	1,868				

BLOCK	Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
		ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
XIII	66 f																
	g																
	h																
	j																
	42 a																
	b																
	d	12.60	2,199														
	e																
	j																
	g,h,j	25.36	3,750														
	j	18.45	3,139														
	k	41.40	5,237														
	43 a	11.93	1,900														
	b,d	75.83	13,502														
	c			13.95	2,807												
	f			18.45	3,005												
	g			13.05	2,398												
	h,i			2.48	327												
	44 a			1.80	245												
	b			7.65	797												
	d,g			21.38	3,268												
	e			4.50	241												
	f			3.15	657												
	h			3.60	593												
	i			24.75	3,332												
	j			13.28	1,943												

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XIII	45 b	17.00	1939	<30°	90%	IX	2,830	2,457	2,038				
	c	14.75	1950	"	"	VI	1,805	1,625	1,300				
	f	48.75	1941	"	"	VIII	7,488	6,739	5,391				
	g	4.50	1950	"	"	VI	226	203	163				
	h,i	12.50	1950	"	"	VI	1,064	958	766				
	j	16.00	1950	"	"	VI	2,439	2,195	1,756				
	k	6.25	1950	"	"	VI	594	535	428				
	l	11.50	1942	"	"	VIII	2,890	2,601	2,081				
	o	29.75	1936	"	"	IX	7,034	6,331	5,064				
	46 a	8.25	1935	<30°	90%	IX	1,397	1,257	1,006				
	c	8.25	1937	"	"	IX	1,536	1,382	1,106				
	d	6.00	1936	"	"	IX	1,689	1,520	1,216				
	e,f	17.50	1938	"	"	IX	2,621	2,359	1,887				
	g	20.50	1950	"	"	VI	3,111	2,800	2,240				
	j	10.00	1940	"	"	VIII	1,464	1,318	1,054				
	l	4.50	1940	"	"	VIII	361	325	260				
	65 a	17.75	1950	>30°	30%	VI	2,514	754	603				
	b	19.75	1956	"	"	V	3,102	931	745				
	c	60.50	1958	"	"	V	10,204	3,061	2,449				
			Total									140.48	18,000

Block	Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
		ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
XIII	45 b			15.30	2,038												
	c			13.28	1,352												
	f			43.88	5,445												
	g					4.05	170										
	h,i					11.25	797										
	j			14.40	1,826												
	k					5.63	445										
	l					10.35	2,123										
	o					26.78	5,064										
	46 a					7.43	1,006										
	c					7.43	1,106										
	d					5.40	1,216										
	e,f					15.75	1,887										
	g					18.45	2,330										
	j					9.00	1,065										
	l					4.05	263										
	65 a					5.33	633										
	b					5.93	849										
	c					18.15	2,890										
	Total	185.57	29,727	214.90	30,274	154.98	21,844										

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m^3	ha	m^3
		(ha)			(%)		(m^3)	(m^3)	(m^3)				
XIV	70 a	6.00	1940	30°	>30%	VII	1,618	485	388				
	c	18.75	1950	"	"	VI	2,571	771	617				
	63 b	3.75	1940	30°	>30%	VIII	406	122	97				
	c	6.50	1942	"	"	VIII	701	210	168				
	g	7.00	1938	"	"	VIII	322	97	77				
	59 a	0.50	1940	30°	>30%	VIII	78	23	19				
	c	4.00	1944	"	"	VIII	619	186	149				
	g	7.25	1940	"	"	VIII	852	256	204				
	60 b	13.75	1941	30°	>30%	VIII	2,070	621	497				
	d	32.00	1958	"	"	V	4,206	1,262	1,009				
	f	1.25	1950	"	"	VI	164	49	39				
	g	1.50	1943	"	"	VIII	210	63	50				
	h	6.25	1961	"	"	IV	763	229	183				
	61 a	10.25	1958	30°	>30%	V	1,347	404	323				
	d	28.50	1956	"	"	V	3,746	1,124	899				
	g	4.00	1956	"	"	V	526	156	126				
			Total										

1981		1982		1983		1984		1985		1986		1987		1988	
ha	m^3	ha	m^3	ha	m^3	ha	m^3	ha	m^3	ha	m^3	ha	m^3	ha	m^3
				1.80	392										
				1.95	171										
				1.13	98										
				1.95	171										
				2.10	77										
				0.15	19										
				1.20	152										
				2.18	204										
				4.13	501										
				9.60	1,191										
				0.38	41										
				0.45	51										
				1.88	227										
				3.08	381										
				8.55	1,025										
				1.20	144										
				41.73	4,845										

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis: Age class	1977 basis: Standing volume	1977 basis: Standing volume for felling	1977 basis: Log volume felled	1979 ha	1979 m³	1980 ha	1980 m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XVII	55 e	4.00	1954	>30°	30%	VI	508	152	122				
	g,h	10.75	1954	< "	"	VI	1,508	452	362				
	56 a	6.25	1954	"	"	VI	913	274	219				
	c	3.50	1956	"	"	V	253	76	61				
	57 d	21.75	1950	>30°	90%	VI	2,991	2,692	2,154				
	58 c	3.50	1964	<30°	30%	IV	608	182	146				
	71 a	2.00	1942	30°	90%	VIII	277	249	199				
	b	4.25	1942	"	"	VIII	567	510	408				
	e,f,h	10.00	1944	"	"	VIII	1,306	1,175	940				
	72 a	18.75	1955	"	"	V	2,215	1,994	1,595				
	c	3.75	1963	"	"	IV	250	225	180				
	e	7.50	1945	"	"	VII	847	762	610				
	i	16.25	1950	"	"	VI	1,603	1,443	1,154				
			Total										

Block	Compartment Subcompartment	1981 ha	1981 m³	1982 ha	1982 m³	1983 ha	1983 m³	1984 ha	1984 m³	1985 ha	1985 m³	1986 ha	1986 m³	1987 ha	1987 m³	1988 ha	1988 m³
XVII	55 e					1.20	133										
	g,h					3.23	395										
	56 a					1.89	239										
	c					1.05	70										
	57 d					19.58	2,262										
	58 c					1.05	194										
	71 a							1.80	203								
	b							3.83	416								
	e,f,h							9.00	959								
	72 a							16.88	1,786								
	c							3.38	238								
	e							6.75	628								
	i							14.63	1,223								
	Total					28.00	3,293	56.27	5,453								

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XV	96 a	9.75	1941	<30°	90%	VIII	1,121	1,009	807				
	b	13.50	1946	"	"	VII	1,297	1,167	934				
	c	33.75	1957	"	"	V	3,566	3,209	2,568				
	d	42.00	1957	"	"	V	2,171	1,954	1,563				
	e	38.25	1951	"	"	VI	4,356	3,920	3,136				
	f	25.75	1953	"	"	VII	2,589	2,330	1,864				
	h	11.50	1957	"	"	V	648	583	467				
	97 a,b,c	35.75	1941	"	"	VIII	2,134	1,921	1,536				
	d	21.50	1951	"	"	VI	1,199	1,079	863				
	e	33.50	1950	"	"	VI	4,426	3,983	3,187				
	f	20.25	1946	"	"	VII	3,172	2,855	2,284				
	g,h	69.00	1943	"	"	VIII	13,747	12,372	9,897				
	i	28.00	1951	"	"	VI	3,624	3,262	2,609				
	j	10.75	1951	"	"	VI	588	529	423				
	k	11.25	1959	"	"	V	689	620	496				
	98 a,b	38.75	1951	"	"	VI	2,554	2,299	1,839				
	e,f	15.50	1957	"	"	V	822	740	592				
	i	22.25	1951	"	"	VI	435	392	313				
	100 b	8.75	1954	"	"	VI	1,158	1,042	834				
	f	9.00	1951	"	"	VI	794	715	572				
			Total										

1981		1982		1983		1984		1985		1986		1987		1988	
ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
		8.78	815												
		12.15	962												
		30.38	2,928												
		37.80	1,782												
		34.43	3,261												
		23.18	1,976												
		10.35	532												
		32.18	1,551												
		19.35	898												
		30.15	3,314												
		18.23	2,353												
		62.10	10,095												
				25.20	2,733										
				9.68	444										
				10.13	590										
						34.88	1,949								
						13.95	693								
						20.03	332								
				7.88	909										
				8.10	601										
		319.08	30,467	60.99	5,277	68.86	2,974								

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XVI	85	19.25	1953	<30°	90%	V	176	158	127				
	86	125.00	1951	"	"	VI	32,520	29,268	23,414				
	87 a	20.75	1954	>30°	30%	V	2,490	747	598				
	b	30.00	1967	"	"	V	3,722	1,117	893				
	c	15.50	1957	"	"	V	2,345	704	563				
	d	28.00	1967	"	"	III	3,524	1,057	846				
	f	16.75	1959	"	"	V	2,438	731	585				
	g	7.75	1954	<30°	90%	VI	1,423	1,281	1,025				
	h	10.25	1967	"	"	III	609	548	438				
	i,j	40.25	1962	"	"	IV	7,242	6,518	5,214				
	k	67.50	1966	>30°	30%	VI	17,047	5,114	4,091				
	l	10.25	1957	"	"	V	2,498	749	600				
	m	13.25	1954	"	"	VI	1,924	577	462				
	88 a	4.25	1954	<30°	90%	VI	780	702	562				
	j.k	41.75	1967	"	"	III	2,805	2,525	2,020				
	89 a	19.00	1958	"	"	V	4,415	3,974	3,179				
	b	12.75	1968	"	"	III	933	840	672				
	c	40.75	1951	"	"	VI	11,609	10,448	8,358				
	90 e	10.25	1959	>30°	30%	V	1,028	308	247				
	91 a	63.00	1951	<30°	90%	VI	19,645	17,681	14,144				
	b	15.25	1961	"	"	VI	2,955	2,660	2,128				
	c	61.50	1951	"	"	IV	13,413	12,072	9,657				
	92 a	14.75	1959	>30°	30%	V	1,479	444	355				
	f	35.25	1954	"	"	VI	7,268	2,180	1,744				
	i	10.00	1957	"	"	V	2,225	668	534				
	93 a	22.00	1958	<30°	90%	V	2,557	2,301	1,841				
	c	3.50	1957	"	"	V	395	356	284				
	d	6.25	1957	"	"	V	1,260	1,134	907				
	94 a	5.00	1957	"	"	V	605	545	436				
	c	61.75	1957	30°	>30%	V	6,530	1,959	1,567				
	f	38.50	1954	"	"	VI	5,992	1,798	1,438				
	g	8.00	1959	"	"	V	802	241	192				

Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
85					17.33	136										
86					112.50	24,585										
87 a							6.23	658								
b															9.00	1,652
c							4.65	659								
d															8.40	1,565
f							5.03	714								
g							6.98	1,128								
h													9.23	788		
i,j							36.23	6,778								
k													20.25	6,832		
l							3.08	702								
m							3.98	508								
88 a							3.83	618								
j.k													37.58	3,636		
89 a							17.10	3,815								
b													11.48	1,344		
c							36.68	8,859								
90 e																
91 a									56.70	15,134						
b							13.73	2,703								
c									55.35	10,333						
92 a									4.43	440						
f									10.58	1,936						
i											3.00	635				
93 a									19.80	2,228						
c											3.15	338				
d											5.63	1,079				
94 a											4.50	519				
c											18.53	1,865				
f											11.55	1,611				
g											2.40	240				

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XVI	95 b	17.00	1959	>30°	30%	V	2,973	892	714				
	c	22.00	1959	"	"	V	4,336	1,301	1,041				
	d	5.25	1956	"	"	V	975	293	234				
	e	5.00	1959	"	"	V	708	212	170				
	f	24.75	1959	"	"	V	4,519	1,356	1,085				
			Total										
XVIII	48 a	13.50	1959	<30°	90%	V	1,226	1,103	883				
	b	10.25	1959	"	"	V	763	687	549				
	c	31.75	1967	"	"	IV	1,862	1,676	1,341				
	d	16.00	1959	"	"	V	1,211	1,090	872				
	49 a	29.50	1963	"	"	IV	4,145	3,731	2,984				
	b	15.00	1958	"	"	V	347	312	250				
	50 a	52.00	1958	"	"	V	3,586	3,227	2,582				
	b,c,e	60.75	1967	"	"	III	4,592	4,133	3,306				
	g,h	40.00	1963	"	"	IV	8,646	7,781	6,225				
	i	13.25	1958	"	"	V	945	851	681				
	51 a,c	87.25	1967	"	"	III	6,578	5,920	4,736				
			Total										

Block	Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
		ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
XVI	95 b											5.10	893				
	c											6.60	1,301				
	d											1.58	274				
	e											1.50	213				
	f											7.43	1,356				
	Total					129.83	24,721	137.52	27,142	146.86	30,071	70.97	10,324	78.54	12,600	17.40	3,217
XVIII	48 a											12.15	1,104				
	b											9.23	686				
	c											28.58	2,347				
	d											14.40	1,090				
	49 a											26.55	4,178				
	b											13.50	305				
	50 a											46.80	3,150				
	b,c,e											54.68	5,786				
	g,h													36.00	8,964		
	i											11.93	831				
	51 a,c													78.53	8,288		
	Total											217.82	19,477	114.53	17,252		

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XIX	52 a,d	23.-0	1960	>30°	30%	IV	4,001	1,200	960				
	e	3.00	1960	"	"	IV	238	71	57				
	53 b,d	23.50	1958	"	"	V	1,112	334	267				
	f	16.75	1958	"	"	V	1,764	529	423				
	54 d	38.25	1958	"	"	V	4,271	1,281	1,025				
	73 a	14.00	1957	"	"	V	1,706	512	409				
	b	29.50	1957	"	"	V	3,644	1,093	875				
	d	3.00	1957	"	"	V	113	34	10				
	74	88.50	1953	"	"	VI	19,505	5,852	4,681				
	75 b	22.25	1957	"	"	V	3,699	1,110	888				
	c	11.00	1953	"	"	VI	1,488	446	357				
	76 a,b,c	97.50	1957	"	"	V	9,331	2,799	2,239				
	78 b	96.00	1968	"	"	III	3,733	1,120	896				
	84 d	6.25	1957	"	"	V	910	273	218				
			Total										

1981		1982		1983		1984		1985		1986		1987		1988	
ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
														6.90	1,258
														0.09	75
														7.05	331
														5.03	525
														7.50	1,271
														4.20	495
														8.85	1,059
														0.90	12
														26.55	5,195
														6.68	1,074
														3.30	396
														29.25	2,709
														28.80	1,846
														1.88	264
														136,98	16,510

Block	Compartment Subcompartment	Area	Year planted	Dip	Felling ratio	1977 basis				1979		1980	
						Age class	Standing volume	Standing volume for felling	Log volume felled	ha	m³	ha	m³
		(ha)			(%)		(m³)	(m³)	(m³)				
XXI	34 b	43.00	1958	<30°	90%	V	6,976	6,278	5,022				
	35 b	34.75	1958	"	"	V	7,573	6,816	5,453				
	37 a	95.50	1956	"	100%	V	18,911	18,911	15,129				
			Total										
XX	30 b	38.50	1961	<30°	90%	IV	2,611	2,350	1,880				
	32	14.25	1966	"	"	III	770	693	554				
	33	4.75	1958	"	"	V	535	482	385				
	58 a	63.75	1967	"	"	III	2,095	1,886	1,508				
	62 b	25.25	1958	"	"	V	2,418	2,176	1,741				
	63 b	7.75	1958	"	"	V	685	617	493				
			Total										
VII	79 a	19.25	1967	<30°	100%	III	590	590	472				
	80 a	48.75	1967	"	"	III	1,808	1,808	1,445				
	81 c	6.75	1968	"	"	III	177	177	142				
	82 b	18.75	1967	>30°	30%	III	593	178	142				
	89 a	10.75	1967	<30°	90%	III	391	352	282				
			Total										

Block	Compartment Subcompartment	1981		1982		1983		1984		1985		1986		1987		1988	
		ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³	ha	m³
XXI	34 b					38.70	5,926										
	35 b					31.28	6,435										
	37 a					95.50	17,247										
	Total					165.48	29,608										
XX	30 b							34.65	2,331								
	32													12.83	897		
	33					4.28	454										
	58 a													57.38	2,714		
	62 b							22.73	2,054								
	63 b							6.98	582								
	Total					4.28	454	64.36	4,967					70.21	3,611		
VII	79 a													19.25	850		
	80 a													48.75	2,601		
	81 c													6.75	293		
	82 b													5.63	256		
	89 a													9.68	508		
	Total													90.06	4,508		

VII. Aerial-Photo Interpretation and Mapping of Pinus Merkusii Forest

VII-1 Material

The basis material of the interpretation and mapping mainly consist of:

a. Vertical aerial photographs with specification:

Scale, approximately	1 : 20,000
Focal length	154 mm
Size	23 × 23 cm
Total number	291 sheets
Overlap	60% - 80%
Sidelap	40% - 50%

b. Field data of 79 plots of 50 m × 50 m, namely:

1. Average tree height
2. Number of trees per hectare
3. Volume (m^3) per hectare, that was computed based on tariff or volume/ diameter table.
4. Slope

In this context, volume is the total stem volume with diameter bigger than 7 cm.

c. Photo volume table, $V_I = F(H_I, N_I)$ and the regression equation.

V_I = stand volume (m^3) hectare.

H_I = stand height measured on aerial photographs.

N_I = average number of trees per hectare, calculated on aerialphotographs.

The regression equation is:

$V_I = 13.1619\ H_I + 0.2121\ N_I - 116.3809$, multiple correlation coefficient (= r) = 0.90

d. Stereogram, scale 1 : 20,000

e. Topographic map, with the scale of 1 : 10,000, and the altitude interval between contour lines 10 meter.

f. Forest cover type map with the description includes:

- Compartment and subcompartment boundary.
- Age classes of Pinus forests.

The scale of this map is 1 : 25,000.

g. Dot grid for area determination. The density of the dot grid is 0.25 cm^2/dot.

VII-2 Interpretation of forested area

The interpretation of Forest area based on the analysis of aerial-photographs. Especially to the grey density, texture, structure, shape, size and pattern of details.

The forest cover type map and topographic map were very useful as guidance to the location of forested area. From the aerial photo interpretation could be quantified that:

a. Some forests mentioned on forest cover type map had been cut.
b. Has been found some forests those were not mentioned on forest cover type map.
c. All Pinus forests those are visible on aerial photographs, including Pinus forest with age class less than III would be mentioned on photo-interpretation map. The age class of each of these forests was defined by comparing it to other forest which its age class was known.

VII-3 Staratification

Stratification of forested area was provided due to age class and crown coverage density. Age classes those are available in this forest complex ranging from I to IX. And the class limits of crown density classes are:

1 -	1 - 10 %
2 -	11 - 40 %
3 -	41 - 70 %
4 -	71 - 100 %

The measurements and estimation of stand height, number of trees per hectare and stand volume have been undertaken for each forest sub-complex, compartment and sub-compartment. Where:

Sub-complex	Bagian Kesatuan Pemangkuan Hutan
Compartment	Petak
Sub-compartment	Anak Petak or Age Class
Forest type	Density class & tree height class

VII-4 Mapping

Mapping was provided by inserting details from aerialphotographs to topographic map scale 1 : 10,000 with Liesegang - antiskop. The minimum size of detail, in this context is forested area, was 2.5 mm × 2.5 mm.

The description includes: number of compartment, number of sub-compartment, age class, density and average tree height.

The average tree height is in classes of:

a. 1 - 10 m

b. 11 - 15 m

c. 16 - 20 m

d. 21 - 25 m

e. 26 - 30 m

f. 31 m & up

The negative of maps was made on permatrace and the negative of legenda was on film. All maps printed on ocalide paper and coloured. Each set of map consist of 24 sheets of 100 cm × 70 cm.

VII-5 Stand height estimation

The steps tree height estimation namely:

a. To measure the average tree height of each ground plot on aerial-photographs. The formula:

$$H_I = \frac{\Delta p}{B + \Delta p} \cdot (H_o - h)$$

H_I = tree height

H_o = altitude of photograph

h = elevation of the spot

B = photo base-line length

Δp = parallax difference

b. To define the regression equation of actual average tree height on H_I by mean of least squared technique. The equation is:

$$H_E = 1.826 + 0.94 H_I$$

correlation coefficient (= r) = 0.95

c. To measure the average tree height (= H_I) of each subcompartment in the whole forest complex with age class of III - IX.

The measurement was provided on sample plots in each subcompartment.

d. To calculate the estimate average tree height of each subcompartment with regression equation. Each H_E was in real value with a unit of 1 meter.

H_I was ranging from 8 m to 31 m and the number of plots is 79.

VII-6 Number of trees per hectare estimation

The steps of the estimation of the average number of trees per hectare of forested area:

a. To calculate the number of trees per hectare (= N_I) of each ground plot on aerial photographs. The calculation was provided in stereoscopic vision.

b. To find out the regression equation of N_I on the actual number of trees per hectare of ground plots (= N_A) which least squared technique. The regression equation is:

$$N_E = 21.43 + 1.11\ N_I$$

correlation coefficient (= r) = 0.92

The value of N_I was ranging from 63 to 806.

c. To calculate the number of trees per hectare (N_I) of each sub-compartment on aerial photographs.

In this calculation, plot of 0.1 ha was used. Correction the number of trees per hectare (= N_I) due to the slope of the field was provided with the following formula:

$$N_I = N_I \cdot \sec\alpha$$

α = slope

The slope of terrain was measured and calculated for each plot.

d. To compute the estimate average number of trees per hectare (= N_E) of each subcompartment:

$$N_E = 21.43 + 1.11\ N_I$$

VII-7 Volume estimation

The estimate of average volume per hectare and the total volume of each subcompartment, compartment and sub-forest complex were computed with the following procedure:

a. To calculate the volume of each ground plot with substitution of N_I and H_I to the regression equation:

$$V_I = 13.1619\ H_I + 0.2121\ N_I - 116.3809$$

b. To develop regression equation of the actual volume (= V_A) on V_I with least squared technique:

$$V_E = - 46{,}99 + 1.036.\ V_I$$

r = 0.81.

V_I was ranging from 88 m^3 to 320 m^3/ha.

The correlation coefficient is significant different from zero. So the regression equation is considered effective for estimating the volume of the forest stand.

The calculation of all above regression equations is attached in appendix 1.

c. From the results of measurements and calculation No. 5 and No. 6, to calculate V_I of each subcompartment with formula:

$$V_I = 13.1619\ H_I + 0.2121\ N_I - 116.3809.$$

d. To substitute the V_I from c above to the formula:

$$V_E = -46.99 + 1.036 .\ V_I.$$

V_E is the estimate average volume per hectare of the each concerned sub-compartment.

e. To determine the area of each sub-compartment on forest map (scale 1 : 10.000) with dot grid.

f. To calculate the total volume stand of each sub-compartment.

$$V_I\ T = V_I \cdot A$$

$$V_E\ T = V_E \cdot A$$

A = area (hectare)

g. To calculate the total volume stand of each compartment.

h. To calculate the total volume stand of each sub-complex and of the whole complex.

From the calculations above some conclusions could drawn briefly as follows:

1. Subcomplex (= B.K.P.H.) Bumi Jawa.
   The total area of Pinus merkusii forest = 6,526.00 ha
   With the total stand volume (= V_E)
   = 780,650.89 m^3

2. Subcomplex Bantar Kawung
   The total area of Pinus merkusii plantation forest = 2,094.50 ha
   With the total stand volume (V_E)
   = 239,259.68 m^3

3. Forest complex Pekalongan Barat
   - The total area Pinus merkusii plantation forest = 8,620.50 ha
   - Total stand volume = 1,019,910.57 m^3

VII-8 Forest inventory book

The results of No. 3, No. 5, No. 6 and No. 7 of the above were summarized and the forest inventory book were prepared.

Descriptions included as follows:

- Compartment No.
- Sub-compartment No.
- Forest type No.
- Area
- Planted year and Age class
- Tree height
- Crown density
- Number of trees per Ha
- Volume per Ha
- Total volume