Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.3, No.7, 2013

Residual Stand Damages after Decreasing on Selective Cutting Diameter Limit at Forest Concession of Pt Tri Tunggal Ebony Corporation Poso District Central Sulawesi Province

Pepi Saeful Jalal
School of Doctoral Programme of Forestry Science, Mulawarman University, Samarinda, Indonesia
Tel: 0541-749160 E-mail: pepisaeful.jalal@yahoo.com

Abstract
The objective of this research is to recognize the residual stand damages caused by timber harvesting after decreasing on selective cutting diameter limit on natural forest production management at forest concession of PT Tri Tunggal Ebony Corporation. The research shows that residual stand damages after decreasing on selective cutting diameter limit is 23,98%, bigger than before such as 21,06% and both of them included light damage class (< 25%). Based on damage tree population such as 1.988 pieces can be classified into heavy damage 72,30%, medium damage 12,10%, and light damage 15,60%. The results of research indicate that statistically there is no significant difference on residual stand damages caused by timber harvesting between after and before decreasing on selective cutting diameter limit.
Keywords : residual stand damages, decreasing on selective cutting diameter limit.

1. Introduction
1.1. Background
Based on Minister of Forestry decree No. 485/Kpts-II/1989 and Forest Utility Director General decree No. 564/Kpts/IV-BPHH/1989 and No. 151/Kpts/IV-BPHH/1993, silvicultural system applied on production natural forest management in Indonesia is Indonesian Selective Cutting and Planting (TPTI) system includes felling with diameter limit and forest regeneration. Than Minister of Forestry decree No. 309/Kpts-II/1999 regulates that cutting cycle on natural forest management with TPTI system is 35 years to harvest timber with minimum diameter cutting limit 50 cm at forest product (HP) and 60 cm at limited forest product (HPT).
According to Parthama (1999), nowadays those regulations are not suitable anylonger because natural forest management in outside Java island has been in the second rotation with most of forests which managed by forest concession (HPH) system are virgin forest nomore. Muhdin et al. (2008) state that now most of natural forests are logged over area or other degradated forest.
Realizing that most of forest concession areas are secondary forest and today regulations of cutting cycle and cutting diameter limit are not reasonable anymore, Minister of Forestry declared regulation No. P.11/Menhut-II/2009 dated February 9, 2009 about silvicultural system on Forest Concession at Production Forest.
Based on that regulation, cutting cycle is shorter to be 30 years and cutting diameter limit changes from 60 cm to 50 cm in limited production forest (HPT) and from 50 cm to 40 cm in production forest (HP) and convertion production forest (HPK).
Since it is applied on forest concession management, potency of residual stand damages tends to be bigger related with increasing on number of harvested timber.
1.2. Objective of Research
This research is aimed to know residual stand damages caused by timber harvesting after decreasing on selective cutting diameter limit on natural forest production management at forest concession of PT Tri Tunggal Ebony Corporation.

2. Research Method
2.1. Study Site and Research Time
This research is conducted at limited production forest working area forest concession of PT Tri Tunggal Ebony Corporation, Poso District Central Sulawesi Province (120°11'10,6"-120°11'30,7"E longitude and 01°34'45,4"- 01°35'31,6"N latitude, Figure 1) on October – Desember 2011.

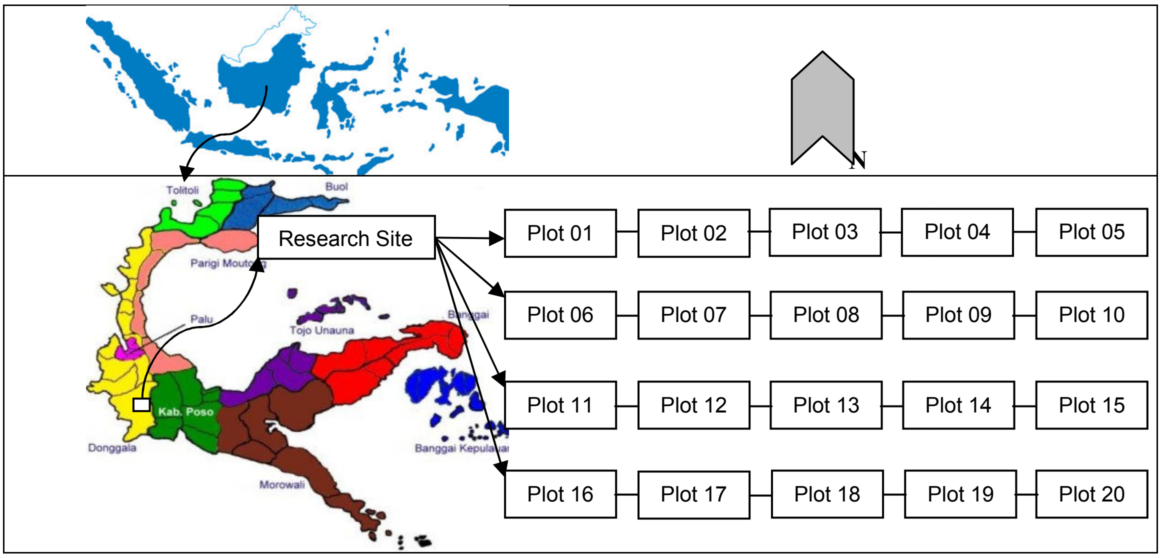

Figure 1. Map of Research Site.

2.2. *Object and Research Tools*

Object in the research is Residual stand on annual working plan (RKT) Year 2011. Tools are used in it : compass, clinometer, roll meter, tally sheet, and stationer.

2.3. *Plot Measurement*

Plots are designed with random in annual working plan (RKT) Year 2011. Data collecting held by making of plot as amount as 20 units with size 100 m x 100 m and on each plot carried out topography survey and stand inventory (pole and tree) with diameter ≥ 10 cm before and after timber harvesting.

2.4. *Measurement of Residual stand damages*

Measurement of residual stand damages conducted after timber harvesting (felling and skidding) with diameter ≥ 50 cm, includes : number of damage pole/tree and damage type.

2.5. *Data Processing And Analysis*

Based on number of damage pole and tree as impact from timber harvesting, then calculated residual stand damage with formula as follow :

$$K = \frac{R}{P - Q} \times 100 \qquad (1)$$

Where :
K = Residual stand damages caused by timber harvesting (%)
R = Number of damage pole and tree with diameter ≥ 10 cm in one plot (pcs/ha)
P = Number of pole and tree with diameter ≥ 10 cm before timber harvesting (pcs/ha)
Q = Number of tree harvested (pcs/ha)

In order to know about effect of stand density, harvesting intensity, and slope class to residual stand damages, all data analyzed by multilinear regression on excel programme 2007 with formula as follow :

$$Y = a + b_1SD_1 + b_2HI_2 + b_3SC_3 \qquad (2)$$

Where :
Y = residual stand damages (%)
a = constanta
b_1 = regression coefficient of stand density
b_2 = regression coefficient of harvesting intensity
b_3 = regression coefficient of slope class
SD = stand density (pcs/ha)
HI = harvesting intensity (pcs/ha)
SC = slope class (%)

In order to recognize mean difference between before and after decreasing on selective cutting diameter limit to residual stand damages tested by t-test on excel programme 2007.

3. Result And Discuss

3.1. Result of Topography Survey and Stand Inventory

Based on result of topography survey on all plots to know that topography condition is varied from 8 – 33% (flat – steep). Stand density on plot varies from 298 to 544 tree each hectar, with stand composision dominated by mixed wood group such as Bayur *(Pterospermum celebicum)*, Bintangur *(Calophyllum pulcherrimum)*, Dara-dara *(Myristica crassifolia)*, Jambu-jambu *(Eugenia sp.)*, dan Tapi-tapi *(Santiria celebicum)* so that in the future it is possible to increase utilization of mixed wood group.

3.2. Residual Stand Damages

Residual stand damages happen because of many factors. Table 1 shows data of residual stand damages after decreasing selective cutting diameter limit on variation of stand density, harvesting intensity, and slope class.

Table 1. Residual Stand Damages After Decreasing on Selective Cutting Diameter Limit (Ø ≥ 50 cm) on Variation of Stand Density, Harvesting Intensity, and Slope Class on Each Plot.

Plot	Stand Density	Harvesting Intensity	Slope Class	Number of damaged tree caused by				Residual stand Damages
				Felling		Skidding		
	(pcs/ha)	(pcs/ha)	(%)	Damaged Tree	(%)	Damaged Tree	(%)	(%)
01	449	10	23	58	13.21	60	13.67	26.88
02	486	19	33	68	14.56	102	21.84	36.40
03	460	16	19	55	12.39	75	16.89	29.28
04	382	9	15	14	3.75	31	8.31	12.06
05	505	19	15	69	14.20	45	9.26	23.46
06	334	20	12	33	10.51	38	12.10	22.61
07	544	16	19	92	17.42	68	12.88	30.30
08	467	15	14	59	13.05	65	14.38	27.43
09	332	9	11	11	3.41	21	6.50	9.91
10	485	10	8	35	7.37	36	7.58	14.95
11	390	11	20	27	7.12	64	16.89	24.01
12	332	7	15	19	5.85	10	3.08	8.92
13	458	14	15	58	13.06	84	18.92	31.98
14	308	21	11	23	8.01	44	15.33	23.34
15	298	13	13	16	5.61	62	21.75	27.37
16	480	16	18	38	8.19	70	15.09	23.28
17	425	13	25	79	19.17	40	9.71	28.88
18	305	19	20	22	7.69	51	17.83	25.52
19	395	5	23	25	6.41	43	11.03	17.44
20	525	17	11	101	19.88	80	15.75	35.63
Mean	418	14	17	45	10.54	54	13.44	23.98

Based on data on Table 1 can be known that residual stand damages caused by timber harvesting (felling and skidding) after decreasing selective cutting diameter limit (Ø ≥ 50 cm) is varied from 8,92 – 36,40%, depends on stand density, harvesting intensity, and slope class.

Besides that based on Table 1 can be recognized that every harvesting 1 (one) tree each hectar causes mean residual stand damages as amount as 7 (seven) trees each hectar or harvesting as amount as 14 tress each hectar causes mean residual stand damages as amount as 23,98%.

Mean residual stand damages after decreasing selective cutting diameter limit as mentioned above is bigger than before decreasing selective cutting diameter limit (Ø ≥ 60 cm) such as merely 21,06%, as shown on Figure 2. It is predicted as impact from increasing on number of tree harvested after decreasing selective cutting diameter limit.

According to Tang (1980) in Sianturi (1997), Sularso (1996), Elias (1997), Bertault and Sist (1998), and Muhdi (2001), residual stand damages are related to harvesting intensity. Incerasing on harvesting intensity means residual stand damages bigger.

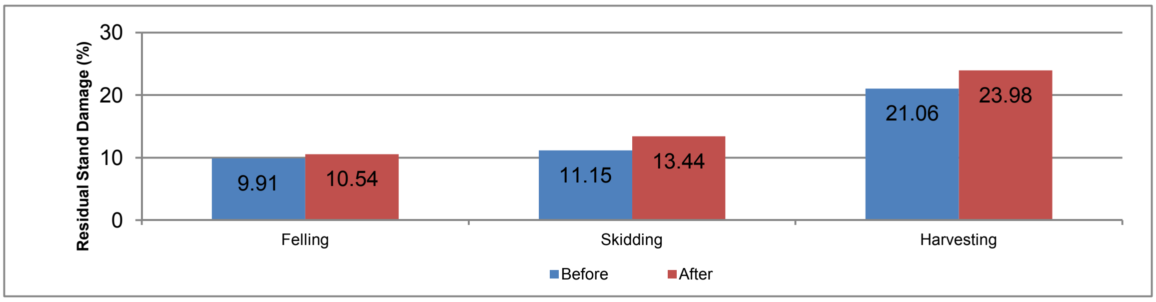

Figure 2. Mean Residual Stand Damages Before and After Decreasing on Selective Cutting Diameter Limit.

In order to know more detail about residual stand damages, on Table 2 and Table 3 shown residual stand damages based on damage type and classification.

Table 2. Residual Stand Damages After Decreasing Selective Cutting Diameter Limit (Ø ≥ 50 cm) Based on Damage Type Caused by Felling and Skidding on Each Plot.

Plot	Damage Type Caused by Felling (tree)								Damage Type Caused by Skidding (tree)								Total
	Rn	Ln	Sbr	Sdm	Sij	Cdm	Bdm	∑	Rn	Ln	Sbr	Sdm	Sij	Cdm	Bdm	∑	
01	5	2	29	3	0	19	0	58	44	0	1	0	9	5	1	60	118
02	8	2	36	5	3	48	0	102	50	9	2	1	2	4	0	68	170
03	6	1	28	0	1	19	0	55	55	8	0	0	3	7	2	75	130
04	4	0	6	0	0	4	0	14	26	3	0	0	2	0	0	31	45
05	8	3	17	4	1	35	1	69	28	8	3	0	5	1	0	45	114
06	3	0	12	0	2	16	0	33	23	3	1	0	7	4	0	38	71
07	4	0	43	2	4	39	0	92	54	4	1	0	6	3	0	68	160
08	4	0	15	0	2	38	0	59	44	5	2	0	9	4	1	65	124
09	2	0	6	0	0	3	0	11	12	6	0	0	2	1	0	21	32
10	2	1	13	1	0	17	1	35	27	0	6	0	1	2	0	36	71
11	2	0	13	0	2	10	0	27	48	5	2	0	4	5	0	64	91
12	1	0	11	0	0	7	0	19	4	2	2	0	1	0	1	10	29
13	3	0	19	4	0	32	0	58	52	9	3	1	8	6	2	81	139
14	7	1	5	3	0	7	0	23	35	4	1	0	2	2	0	44	67
15	3	0	7	1	0	5	0	16	48	3	2	0	3	5	1	62	78
16	5	0	8	0	0	24	1	38	52	5	1	0	4	7	1	70	108
17	3	1	28	2	0	45	0	79	25	6	3	0	4	2	0	40	119
18	4	0	10	1	0	7	0	22	42	5	0	0	1	2	1	51	73
19	1	0	14	0	0	10	0	25	27	6	2	0	4	4	0	43	68
20	2	0	43	6	0	50	0	101	51	12	2	1	10	4	0	80	181
Mean	4	1	17	1	1	20	0	43	35	5	2	0	3	3	0	47	90

Remark :
Rn = Ruin; Ln = Lean; Sbr = Stem broken; Sdm = Stem damage; Thr = Stem injure; Cdm= Crown damage; Bdm = Buttressroot damage

Table 3. Residual Stand Damages After Decreasing Selective Cutting Diameter Limit (Ø ≥ 50 cm) Based on Damage Type Caused by Felling, Skidding, and Harvesting.

No	Damage Classification	Damage Type	Felling		Skidding		Harvesting	
			DamageTree (pieces)	Percentage (%)	DamageTree (pieces)	Percentage (%)	DamageTree (pieces)	Percentage (%)
1	Heavy	Ruin	77	8.23	747	71.01	824	41.45
		Lean	3	0.29	77	7.34	80	4.02
		Stem broken	363	38.78	34	3.23	397	19.97
		Stem damage	32	3.42	3	0.29	35	1.76
		Stem injure	3	0.31	7	0.62	9	0.48
		Crown damage	92	9.81	0	0.00	92	4.62
	Sum		569	60.84	868	82.49	1437	72.30
2	Medium	Lean	8	0.88	26	2.45	34	1.71
		Stem injure	4	0.43	13	1.24	17	0.86
		Crown damage	188	20.04	0	0.00	188	9.44
		Buttressroot damage	0	0.00	2	0.19	2	0.10
	Sum		200	21.35	41	3.88	241	12.10
3	Light	Stem injure	8	0.86	67	6.41	75	3.80
		Crown damage	156	16.63	68	6.46	224	11.25
		Buttressroot damage	3	0.32	8	0.76	11	0.55
	Sum		167	17.81	143	13.63	310	15.60
	Total		936	100.00	1052	100.00	1988	100.00

Based on data on Table 2 dan Table 3 can be known residual stand damages type caused by felling dominated by crown damage (46,47%), stem broken (38,78%), ruin (8,23%), and the rest stem injure, lean, and buttressroot damage (6,52%). Whereas residual stand damages type caused by skidding dominated by ruin (71,01%), lean (9,79%), stem injure (8,27%), and the rest crown damage, stem broken, stem damage, and buttressroot damage (10,93%), as shown on the Figure 3.

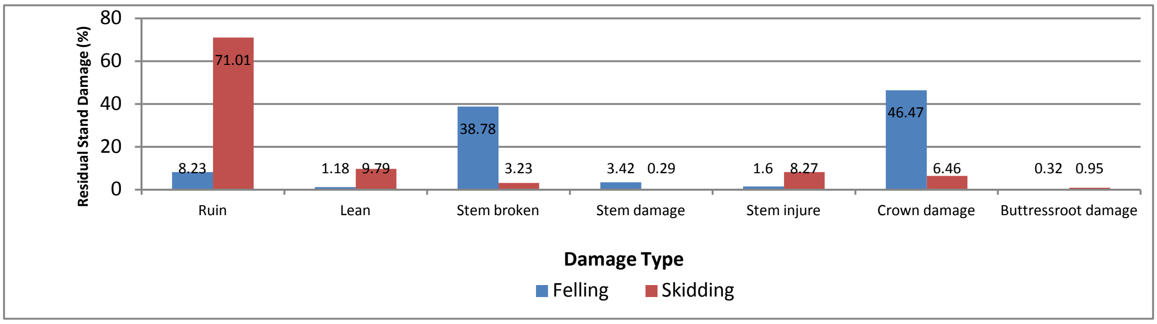

Figure 3. Mean Residual Stand Damages Based on Damage Type After and Before Decreasing Selective Cutting Diameter Limit.

Based on result of field observation, residual stand damages caused by felling such as crown damage happens because tree crown felt down by either stem or branch. In general, felt trees are dominance trees with bigger diameters, heights more than average, and their crown wider. When felt trees through big trees, they damages crown. While felt trees are smaller, they cause stem broken and ruin.

Sukanda (1996), Kuswandi (2001[a]), Elias (2002), Muhdi et al.(2007), Indriyati (2010), and Rohidayanti (2012) say that residual stand damages caused by felling dominated by crown damage and stem broken.

Difference to residual stand damages caused by felling, source of residual stand damages caused by skidding are damage trees when construction of skidding road and felt tree skidding by bulldozer.

Based on field observation, residual stand damages caused by skidding such as ruin, lean, and stem injure happen because standing stock pushed down by bulldozer, pulled by skidded tree, and scratched by bulldozer blade.

According to Ruchanda (1993), Sukanda (1996), Kuswandi (2001[b]), and Muhdi et al. (2007), type of residual stand damages caused by skidding dominated by ruin.

In relation to residual stand damages classification caused by felling and skidding, based on data on Table 1 can be recognized that from mean residual stand damages amount 23,98%, most of (72,30%) residual stand damages happened on plots can be classified as heavy damage or in other word from residual stand damages amount 1.988 trees, 1.437 trees include heavy damage or they will die on definite time, as shown on Figure 4.

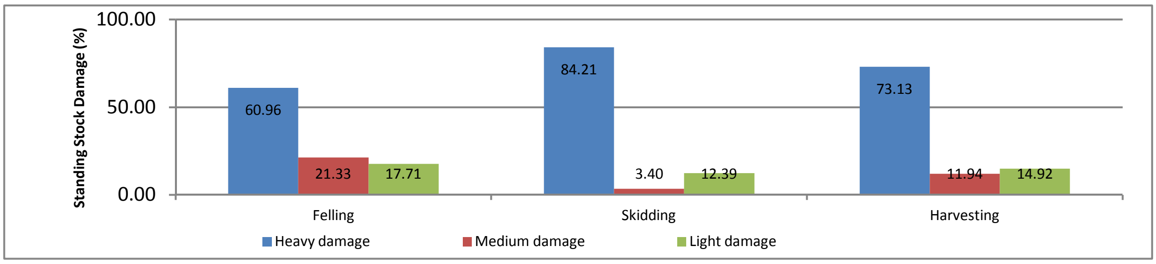

Figure 4. Residual Stand Damages Based on Damage Classification.

Referring to residual stand damages based on residual stand damages percentage according to Elias (1993) and Susilawati et al. (2003), residual stand damages on plots as amount as 23,98% includes light damage class (<25%). Compared to residual stand damages on several forest concessions that can reach around 35%, residual stand damages on plots is lower.

This condition expected is suitable for Elias observation result (1993) that states residual stand damages caused by harvesting tends to be lower related to time, technology development, experiment, and knowledge of forest concessionaires.

Based on t-test, there is no significant difference between mean residual stand damages after (Ø cutting ≥ 50 cm) and before (Ø cutting ≥ 60 cm) decreasing selective cutting diameter limit. It means decreasing selective cutting diameter limit from Ø ≥ 60 cm to Ø ≥ 50 cm gives effect to residual stand damages yet its effect not significant.

Unsignificant difference of mean residual stand damages between before and after decreasing selective cutting diameter limit occurs because harvesting intensity is almost the same. It caused by :

a. Unhealthy timber.

Based on company regulation, *chainsawman* only gets wage if he fells healthy timber so that unhealthy timber will not be felt although timber diameter more than 50 cm.

b. Economic value of timber.

Based on forest inventory, stand composition on plot dominated by mixed wood group, economically its price is Rp. 360.000/m^3 cheaper than meranti wood group and fancy wood group with price Rp. 600.000/m^3 and Rp. 1.086.000/m^3 so that in order to increase revenue, company minimizes to harvest mixed wood group and more focus to meranti and fancy wood group that their prices more expensive.

c. Timber position.

On the field, timbers can be harvested are not always closed one each other so that if timber located on the remute area, it will not be harvested because harvesting cost is unequal to volume of harvested tree.

d. Topography condition.

Existence of big and commercial tree on the steep topography is a limiting factor to timber harvesting. Based on topography survey there are some trees situated on steep and very steep area so that impossible to harvest them.

e. Operator's and vehicle's safety.

Timber harvesting on steep and very steep area is so dangerous and able to be a factor of work accidence both operator and vehicle.

3.3. Relationship among Stand Density, Harvesting Intensity, Slope Class, and Residual stand damages

In order to know effect of stand density, harvesting intensity, and slope class to residual stand damages analyzed by multilinear regression. The quation of multilinear regression of stand density, harvesting intensity, slope class, and residual stand damages is as follow :

$Y = -11,0254 + 0,0332SD + 0,9671HI + 0,4495SC; R^2 = 65,10\%$

Where :

Y = Residual stand damages (%)
SD = Stand density (pcs/ha)
HI = Harvesting intensity (pcs/ha)
SC = Slope class (%)

Moreover in order to recognize meaning of multilinear regression, correlation coefficient, and multilinear regression coefficient tested by F-test and t-test.

The result of F-test to meaning of multilinear regression and correlation coefficient shows multilinear regression above is meaningful or can not be avoided because $F\text{-}_{cal.} > F\text{-}_{tab.}$ at significance level 99% so that equation can be used to draw conclusion from effect of stand density, harvesting intensity, and slope class to residual stand damages.

From formula above can be known that stand density, harvesting intensity, and slope class go straight to residual stand damages. The more stand density, harvesting intensity, and slope class, the higher residual stand damages.

It is empowered by Indriyati (2010) and Rohidayanti (2012) that state residual stand damages influenced by stand density, harvesting intensity, and slope class.

Besides that from the equation above can be also concluded that 65,10% variation on residual stand damages can be explained by stand density, harvesting intensity, and slope class so that there is 34,90% on residual stand damages can be explained by others variables, such as stem and crown diameter.

According to Ruchanda (1993), the bigger stem and crown diameter, the higher residual stand damages. Then MacArthur and MacArthur (1961) on Volin and Buongiorno (1996) state that there is strong correlation between crown coverage and stem diameter so that high variation on stem dimension expected can describe stratification on crown coverage.

Correlation between crown diameter (CD) and stem diameter (D) for each wood group at forest concession of PT Tri Tunggal Ebony Corporation, according to Harianto (2012) can be explained by formula as follow :

CD Meranti wood group = 12,3859482 + 0,0915141SD + 0,0005D^2

CD mixed wood group = 11,8269793 + 0,120558SD + 0,0002D^2

The result of t-test to multilinear regression coefficient of stand density, harvesting intensity, and slope class shows that $t\text{-}_{cal}. > t\text{-}_{tab}$. It means that stand density, harvesting intensity, and slope class has significant effect to residual stand damages.

In other word, every addition/reduction of stand density 1 (one) tree each hectar, harvesting intensity 1 tree each hectar, and slope class 1% will increase/decrease residual stand damages as amount as 0,0332%, 0,9671%, and 0,4495% with assumption others independent variables are constant.

4. Conclusion And Recommendation

4.1. Conclution

Based on research carried out can be drawn conclusion :

1. Mean residual stand damages after decreasing on selective cutting diameter limit caused by timber harvesting is 23,98%, bigger than before such as 21,06% and both of them included light damage class (< 25%).
2. Residual stand damages after decreasing on selective cutting diameter limit affected by stand density, harvesting intensity, and slope class at significance level 99%.
3. There is no significant difference on mean residual stand damages caused by timber harvesting between after and before decreasing selective cutting diameter limit.

4.2. Recommendation

In order to minimize residual stand damages as impact from decreasing on selective cutting diameter limit as regulated on Minister of Forestry decree Nomor : P.11/Menhut-II/2009 dated February 9, 2009 PT Tri Tunggal Ebony Corporation should apply Reduced Impact Logging (RIL) or Reduced Impact Timber Harvesting (RITH) on manage its forest concession.

References

Bertault, J.G and Syst, P. 1997. An Experimental Comparison of Different Harvesting Intensities with Reduced Impact and Conventional Logging in East Kalimantan, Indonesia. Forest Ecology and Management Vol. 94 (1997) p 209 – 218. Elsevier Science Publishers.

Elias. 1993. Residual Stand Damages on Wet Tropical Forest Caused by Timber Harvesting with Indonesian Selective Cutting and Planting (TPTI) System. Paper presented in Home Coming Day IX 1993. Faculty of Forestry, Bogor Agriculture University. Bogor (in Indonesian).

Elias. 1997. State of The Art of Timber Harvesting Operations in The Tropical Natural Forest in Indonesia. Paper Presented on Exchange Meeting Between Staffts of Faculty of Forestry, Bogor Agriculture University and Staffts of Shimane University, Japan 30 June 1997 in Shimane. Japan.

Elias. 2002. Reduced Impact Logging on TJTI and TTJ System. Bogor Agriculture University Press. Bogor (in Indonesian).

Elias, S. Manan dan U. Rosalina. 1993. Study of Guidance Implementation of Indonesian Selective Cutting and Planting (TPTI) at Forest Concession (PT. Kiani Lestari and PT. Narkata Rimba), East Kalimantan. Faculty of Forestry, Bogor Agriculture University. Bogor (in Indonesian).

Harianto, M. 2012. Working Plan of Forest Concession PT Tritunggal Ebony Company Based on Periodic Forest Inventory Year 2013-2015. Jakarta (in Indonesian).

Indriyati, I.N. 2010. Residual Stand Damages Caused by Forest Harvesting at PT Salaki Summa Sejahtera,

Siberut Island West Sumatera. Forest Management Departement. Faculty of Forestry, Bogor Agriculture University. Bogor (in Indonesian).
Kuswandi, R. 2001[a]. Impact of Forest Exploitation to Standing Stock on Forest Management with Indonesian Selective Cutting and Planting (TPTI) at Forest Concession PT Mamberamo Alasmandiri, Serui. Technical Information No. 10 : 19-25. Manokwari Forestry Research Agency. Manokwari (in Indonesian).
Kuswandi, R. 2001[b]. Impact of Forest Exploitation to Standing Stock on Forest Management with Indonesian Selective Cutting and Planting (TPTI) at Forest Concession PT Kaltim Hutama Nabire. Technical Information No. 10 : 40-46. Manokwari Forestry Research Agency. Manokwari (in Indonesian).
Muhdi. 2001. Study of Residual Stand Damages Caused by Tree Harvesting with Reduced Impact Logging and Conventional Logging on Natural Forest (Case Study at Forest Concession PT Suka Jaya Makmur, West Kalimantan). Bogor Agriculture University Postgraduate Programme. Bogor (in Indonesian).
Muhdi and Diana Sofia Hanafiah. 2007. Impact of Reduced Impact Logging to Residual Stand Damages on Natural Forest (Case Study at Forest Concession PT Suka Jaya Makmur, West Kalimantan). Journal of Indonesia Agriculture Sciences. Volume 9 No. 1 : 32-39 (in Indonesian).
Nasution, A. K. 2009. Opened Areas and Residual Stand Damages Caused by Felling and Skidding (Case Study at PT. Austral Byna, Central Kalimantan). Forest Product Departement. Faculty of Forestry, Bogor Agriculture University. Bogor (in Indonesian).
Parthama, I.B.P. 1999. Yield Regulation Problems in Indonesia. In : H.L. Wright and D. Alder (editors). 1999. Proceedings of a Workshop on Humid and Semi-humid Tropical Forest Yield Regulation with Minimal Data. Oxford Forestry Institute, Department of Plant Sciences, University of Oxford. O.F.I. Occasional Papers No. 52 : 77-84.
Rohidayanti, T. 2012. Residual Stand Damages and Potency of Stored Carbon Caused by Tree Harvesting at Forest Concession PT Indexim Utama, Central Kalimantan. Forest Management Departement. Faculty of Forestry, Bogor Agriculture University. Bogor (in Indonesian).
Ruchanda, A. 1993. Study of Composition and Forest Stand Structure Before and After Tree Harvesting with Indonesian Selective Cutting and Planting (TPTI) at Forest Concession PT Narkata Rimba (Alas Kusuma Group) East Kalimantan. Faculty of Forestry, Bogor Agriculture University. Bogor (in Indonesian).
Sianturi, A. 1997. Effect of Residual Stand Damages on Forest Management with Indonesian Selective Cutting. Reforestation Technology Bulletin No. 7. Palembang Reforestation Technology Agency. Palembang (in Indonesian).
Sukanda. 1996. Residual Stand Damages Caused by Tree Harvesting on Indonesian Selective Cutting and Planting (TPTI). Samarinda Forestry Research Agency. Samarinda (in Indonesian).
Sularso, N. 1996. Analysis of Residual Stand Damages Caused by Controlled and Convensional Logging on Indonesian Selective Cutting and Planting (TPTI). Bogor Agriculture University Postgraduate Programme. Bogor (in Indonesian).
Susilawati and I Nengah Surati Jaya. 2003. Evaluation of Residual Stand Damages Caused by Harvesting Uses Landsat 7 ETM+ at Forest Concession PT Sri Buana Dumai Provinsi Riau. Journal of Tropical Forest Manajement Vol. IX No. 1 : 1-16 (in Indonesian).
Thaib, J. 1989. Residual Stand Damages Caused by Felling at Two Forest Concessions in West Kalimantan. Journal of Forest Product Research Vol. 6 No. 2 : 137-141. Center of Research and Development of Forest Product Technology. Bogor (in Indonesian).
Volin, V. C. and J. Buongiorno. 1996. Effect of Alternative Management Regimes on Forest Stand Structure, Species Composition, and Income : A Model for Italian Dolomites. For.Ecol.Manage. 87: 107 -125.

Pepi Saeful Jalal, e-mail : pepisaeful.jalal@yahoo.com
Undergraduate: Faculty of Forestry Bogor Agriculture University.
Postgraduate : Magister of Agriculture Mulawarman University.
: Candidat of Doctor on Forestry Science Mulawarman University.
Supervised by : Afif Ruchaemi, Muchlis Rahmat, Abubakar M Lahdji.