

A Statistical Analysis Carried out on the Cutting-Activity in Ryukyu Islands

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Introduction

Ryukyu Islands are located at the most southern part of the Japan-Islands. In this paper, Ryukyu Islands mean Okinawa Prefecture. Seen from the geographical view point, Ryukyu Islands have several characteristics. This area lies on a sub-tropical climatic zone, together with a part of Kagoshima Prefecture. This prefecture consists of the 41 populated islands. The biggest one is Okinawa main island. The area is 1,185km² in width, and it occupies 52% of the total area of Ryukyu Islands.

Recently in Japan, the cutting-area and -volume have been decreasing. There are several reasons for this tendency, and one of the main reasons is the gradual increasing of the timber-import from foreign countries. With the decreasing of the cutting-volume, the cutting-age has been also changing. In this paper, I am going to clarify the cutting-pattern in Ryukyu Islands, using mainly a statistical analysis. The main researching periods cover these 20 years. Generally, the statistical data on the cutting-activity are not complete, comparing to the other forestry activities. One reason is fixed to be the financial problem related to the income tax. As this area has several characteristics on forests and forestry, an observation of some specific cutting-pattern is expected.

Japan consists of a lot of islands, especially, Okinawa Prefecture is distinguished in these characteristics. Shinohara (1983, 1985, 1989) has pointed out the several characteristics and problems of forests and forestry in this sub-tropical area. However, the cutting-pattern is not analyzed sufficiently in those papers. It is quite important for the future construction of forest planning to be informed of the actual cutting-pattern statistically. Ryukyu Islands had been governed by U.S.A. 20 years before. National Government has executed a public investment through Okinawa Development Agency for these 20 years. Besides this historical characteristic, it is also quite important for the forest planning to pay attention on the fact that this area consists of a lot of islands. Generally speaking, islands have several common characteristics concerning economies (Kakazu, 1986). Of course, there are some common advantages observable in islands, however, there are several common weak points which have inevitably existed. In this paper, I am going to refer to this problem only partially, because of the limitation of space. I would like to make a discussion on this point in future. Asato (1991) has pointed out the fact that Ryukyu Islands have several problems on forests and forestry from the view point of forest policy. Owing to the several problems which have been existed in forests in Ryukyu Islands, forest-planning comes to have a special importance. Alison (1990, p.13) has pointed out the important viewpoint that "planning" is fundamental to a sustainable development of small islands. Nakama (1984) has analyzed Regional Forest Plan in Okinawa Prefecture, and clarified

several problems (see Note 1).

The main aims of this paper are as follows. First, I intend to analyze the cutting-area and -volume in Ryukyu Islands. Next, several statistical values, such as the mean value and the standard deviation of the cutting-age are going to be calculated. The basic parameters of Gintan Probability Method that is necessary to predict the future lumber-supply in this area are going to be clarified. The characteristics of these parameters are going to be clarified, too. The supply-prediction is not dealt with in this paper. In the last chapter, the difference between the actual cutting-activity and the cutting-volume planned in Regional Forest Plan is going to be discussed.

Cutting-Activity

1. Forest area in Ryukyu Islands

The total area of Ryukyu Islands is 226,281ha, and the forest area of those is 115,377ha (51% of the total area) by "1990 Census of Agriculture and Forestry". The rate of the man-made forest area to the total forest area is still at a low level (12%), comparing to the average of Japan (43%). The rate of the national forest is 29%, and it is approximately the same one as the average of whole Japan (30%). The forest area was 124,494ha in 1980, and it has decreased 9,117ha during the period of 1980-1990. One reason is that the several developmental works have been performed since the returning back to Japan.

The main part of the forest area in Ryukyu Islands has been located at the three islands, namely, Okinawa main island, Iriomote-jima and Ishigaki-jima. Table 1 lists the land area of the 40 populated islands in Ryukyu Islands excepting the Okinawa main island. The number of island the area of which is more than 1,000ha is 14, and the total area of these 14 islands shares 92% of the 40 islands. As to the forest, the total area of Iriomote-jima and Ishigaki-jima occupies 76% of the 40 islands. Iriomote-jima shows the highest forest-ratio among these 14 islands.

Okinawa Prefecture is divided into three areas of Regional Forest Plan, namely, "Northern part of Okinawa", "Middle and Southern part of Okinawa" and "Miyako and Yaeyama". The former two planning areas are located in Okinawa main island, and each planning area includes the neighborhood islands. Miyako Islands (main island is Miyako-jima) and Yaeyama Islands (main islands are Ishigaki-jima and Iriomote-jima) are situated far from Okinawa main island, and these islands are put together to form the one planning area. On the other hand, Ryukyu Islands are sometimes divided into 3 islands in this paper, namely Okinawa Islands, Miyako Islands and Yaeyama Islands. The former corresponds to the planning area of "Northern part of Okinawa" and "Middle and Southern part of Okinawa", and the latter two islands correspond to the planning area of "Miyako and Yaeyama".

In this paper, when I specify the planning area, I always put quotation marks like "Miyako and Yaeyama" to distinguish the place name. And, the term of "domestic" log means the log produced in Ryukyu Islands in this paper.

2. Cutting-area and cutting-volume

There are several statistics on the cutting-area and -volume in this area. However, these values

Table 1. The area of islands except Okinawa main island

	Total area ^{*1}	Forest ^{*2}		Farm land ^{*2}	
		Area	Ratio	Area	Ratio
1 Iriomote-jima	28,444	24,815	87	1,167	4
2 Ishigaki-jima	22,112	8,304	38	7,796	35
3 Miyako-jima	15,855	2,517	16	9,491	60
4 Kume-jima	5,682	2,481	44	2,257	40
5 Minamidaito-jima	3,074	0	0	1,900	62
6 Irabu-jima	3,049	0	0	1,729	57
7 Yonaguni-jima	2,852	1,255	44	1,201	42
8 Ie-jima	2,255	195	9	1,150	51
9 Iheya-jima	2,100	1,286	61	273	13
10 Tarama-jima	1,998	0	0	1,108	55
11 Tokashiki-jima	1,564	957	61	40	3
12 Izena-jima	1,384	423	31	730	53
13 Kitadaito-jima	1,271	21	2	657	52
14 Hateruma-jima	1,246	0	0	743	60
Other 26 islands	8,161	1,440	18	2,009	25
Total	101,047	43,694	43	32,251	32

Source: National Land Agency, Solitary islands statistical yearbook, p.15-16, p.28-29, 1991.

Note: This table lists the islands that the total area is more than 1,000ha. The total area of listed 14 islands reaches to 91.9% of the 40 populated islands.

As of October 1, 1985.

1) Geographical Survey Institute, Ministry of Construction.

2) Ministry of Agriculture, Forestry and Fisheries.

are not equivalent mutually, because it is quite difficult to get the information confirmed on the cutting-activity in a private sector completely and immediately. In addition, as is partially, these statistics are sometimes based on the estimations by prefectural officers or municipal officers. In this paper, I make it a rule to use the data in "Okinawa Statistical Yearbook", that is the general official statistics of Okinawa Prefecture.

Table 2 and Table 3 show the cutting-area and -volume assorted by districts. Table 4 shows the summary of Table 2 and Table 3. The average values for the respective 9 years are shown in Table 4. The annual cutting-area is 739ha during the period of 1963-1971, 315ha during the period of 1972-1980 and 374ha during the period of 1981-1989. As the total area of forest in Ryukyu Islands is 115,377ha in 1990, this annual cutting-area is approximately 0.6%, 0.2% and 0.3% of the forest-area, respectively, and these rates are not so high leveled. The maximum annual cutting-area is 921ha in 1967, and the minimum is 114ha in 1975. The important point is the fact that the annual cutting-area

Table 2. Cutting area

Fiscal year	Ryukyu Islands	Okinawa Islands			Others		
		Total	North	Middle and south	Total	Miyako Islands	Yaeyama Islands
1963	633	114	—	—	519	—	519
1964	417	160	—	—	257	—	257
1965	840	264	—	—	576	—	576
1966	502	166	—	—	336	2	334
1967	921	373	—	—	548	14	534
1968	824	352	—	—	472	6	466
1969	837	239	—	—	598	9	589
1970	837	150	—	—	687	124	563
1971	837	261	—	—	576	24	552
1972	165	137	137	0	28	—	—
1973	533	374	342	32	159	—	—
1974	198	110	101	9	88	—	—
1975	114	93	81	12	21	—	—
1976	199	185	179	6	14	—	—
1977	426	310	242	68	115	—	—
1978	376	318	315	3	58	—	—
1979	339	305	231	74	34	—	—
1980	487	322	270	52	165	—	—
1981	500	427	341	86	73	—	—
1982	335	276	271	5	59	—	—
1983	350	307	285	22	43	—	—
1984	283	230	200	30	53	—	—
1985	383	273	187	86	110	—	—
1986	354	206	155	51	148	—	—
1987	511	373	284	89	137	—	—
1988	393	329	271	58	64	—	—
1989	259	226	203	23	33	—	—

Source: Ryukyu Government, Ryukyu Statistical Yearbook, 1963-1966.

Ryukyu Government, Okinawa Statistical Yearbook, 1967-1970.

Okinawa Prefectural Government, Okinawa Prefecture Statistical Yearbook, 1971-1990.

Note: Breakdown figures were not added to total, because figures were rounded to the nearest final digit.

Figures are total of national forest and non-national forest.

— Figures not available.

Table 3. Cutting volume

Fiscal year	Ryukyu Islands	Okinawa Islands			Others		
		Total	North	Middle and south	Total	Miyako Islands	Yaeyama Islands
1963	54,553	6,717	—	—	47,836	—	47,836
1964	—	—	—	—	—	—	—
1965	30,493	11,344	—	—	19,149	—	19,149
1966	33,177	10,806	—	—	22,371	87	22,284
1967	91,084	35,595	—	—	55,489	463	55,026
1968	59,979	20,561	—	—	39,418	370	39,048
1969	71,902	17,953	—	—	53,949	719	53,230
1970	61,986	13,874	—	—	48,112	6,703	41,409
1971	56,898	19,245	—	—	37,653	1,290	36,363
1972	10,236	5,801	5,801	0	4,435	—	—
1973	32,358	23,413	22,708	705	8,945	—	—
1974 ^{*1}	—	—	—	—	—	—	—
1975	6,367	5,655	5,209	446	712	—	—
1976	18,478	17,974	17,509	465	504	—	—
1977	20,545	17,773	17,308	465	2,772	—	—
1978	36,478	33,930	33,851	79	2,548	—	—
1979	31,953	29,414	23,148	6,266	2,539	—	—
1980	54,437	41,291	38,327	2,964	13,146	—	—
1981	47,771	42,072	40,119	1,953	5,699	—	—
1982	28,775	23,136	22,824	312	5,639	—	—
1983	36,594	34,895	33,803	1,092	1,699	—	—
1984	21,999	18,078	17,080	998	3,921	—	—
1985	27,357	21,534	17,704	3,830	5,823	—	—
1986	27,055	17,464	14,910	2,554	9,591	—	—
1987	30,393	20,893	17,012	3,881	9,500	—	—
1988	26,998	24,321	22,414	1,907	2,677	—	—
1989	23,938	21,402	20,514	888	2,536	—	—

Source: See Table 2.

Note: See Table 2.

1) Figures on non-national forest are not available.

has decreased to about half since the returning back to Japan. The main reason for this decreasing is that the cutting-area and -volume in Yaeyama Islands have decreased. Thus, the main cutting district has shifted to the northern part of Okinawa main island since 1972. The proportion of this northern area is about two thirds (see Table 4). However, the cutting-area and -volume in the northern part of Okinawa main island have not so much increased.

Table 4. Average of annual cutting

Item	Fiscal year	Ryukyu Islands (A)	Okinawa Islands			Others			Ratio of north of Okinawa Islands (B)/(A) (%)
			Total	North (B)	Middle and south	Total	Miyako Islands	Yaeyama Islands	
Cutting area (ha)	1963-71	739	231	—	—	508	20	488	—
	1972-80	315	239	211	28	76	—	—	66.9
	1981-89	374	294	244	50	80	—	—	65.2
Cutting volume (m ³)	1963-71	57,509	17,012	—	—	40,497	1,204	39,293	29.6
	1972-80	26,357	21,906	20,483	1,424	4,450	—	—	83.1
	1981-89	30,098	24,866	22,931	1,935	5,232	—	—	82.6
Average volume (m ³ /ha)	1963-71	78	74	—	—	80	61	81	—
	1972-80	84	92	97	50	59	—	—	109.5
	1981-89	80	85	94	39	65	—	—	106.3

Source: See Table 2.

Note: Figures were calculated from Table 2 and Table 3.

Average volume = Cutting volume / Cutting area.

— Figures not available.

As may be seen the movement since 1972, the cutting-area was recorded to be over 500ha in 1973, 1981 and 1987. Generally, no clear tendency can be found in these figures. On the other hand, as the characteristics of the annual cutting-area, it is pointed out that the year-to-year per-cent-change is large. As the index of change from the year $i-1$ to the year i is defined as $(X_i - X_{i-1}) / X_{i-1} \times 100$, the maximum is 223% (1972-1973) and the minimum is -80% (1971-1972). The average of the absolute value of this index since 1972 is 48%. This is clearly bigger than that of Japan main-land. As the size of economy of Ryukyu Islands is limited because of the condition that this area consists of a lot of islands, the annual cutting-area changes drastically every year by the specific reasons. This characteristic is disadvantageous to the development of the wood-based industries using domestic logs.

As to the cutting-volume, almost the same results as in case of the cutting-area can be observed. Before 1971, the average annual cutting-volume is 58,000m³, and the maximum volume is 91,000m³ recorded in 1967. The maximum volume since the returning back to Japan is 54,000m³ recorded in 1980. The year-to-year change is similarly large as in case of the cutting-area already shown, but the degree of the annual change is smaller. Since the returning back to Japan, the average cutting-volume is 26,000m³ during the period of 1972-1980 and 30,000m³ during the period of 1981-1989. This level had been approximately half of the one noted before 1971.

Generally speaking, any reliable cutting statistics are difficult for us to make ready. So, it is not possible to say clearly that these figures on the cutting-volume have a tendency to be exceeding the

figure of the log-production. The annual production of log during the period of 1981-1989 is 23,000m³. Considering the yield-percentage, this figure seems to be corresponding to the cutting-volume. Okinawa General Bureau (1981, p.24) reported the difference between the cutting-volume and the production of log. The report attributed this difference to the existence of the cutting operation neither for sale nor for usage. These not-used logs seem to be burned or left out on the cut-over area.

This cutting-volume is at an extremely low level, comparing to the lumber-demand in Ryukyu Islands. In 1989, the total timber-demand was 242,200m³, and the domestic log occupied 26,700m³. The self-supplying-rate shows only 11%, and is quite low, comparing to those all over Japan (26.4% in 1992). The self-supplying-rate showed less than 5% in the late 1970's, but, recently it has risen up to around 10%. The main reason for this increasing is the decreasing of the total timber demand in Ryukyu Islands. The main supply to Ryukyu Islands is the import from foreign countries, and the supplying-rate is 72%. The main supplying-area is South-sea countries. Next is the import from Japan main-land, and the share is 17%. Most of those are imported from Kyushu Island, and the main area is Miyazaki Prefecture (Shinohara 1989, p.38; Matsushita, 1993).

The average volume per hectare is low as shown in Table 4. The average of the total cutting is approximately 80m³/ha. The values of the planning area of "Middle and Southern part of Okinawa" and Miyako Islands are low particularly. Generally, the growing stock of forest in Ryukyu Islands is still low. The average growing stock of the non-national forest was 88m³/ha in 1990, being smaller than that of whole Japan (117m³/ha).

Table 5 and Table 6 are statistics fixed on the clear-cutting in Ryukyu Islands. The total volume is not equal to that shown in Table 2, because Table 2 is calculated on fiscal year basis and Table 5 is calculated on calendar year basis. In addition, the definition is different. As shown in Table 5, almost all of the clear-cuttings are made in the natural forest, and the area of the broad-leaved forest is large within the natural forest. The clear-cutting in the man-made forest is rare.

Table 6 shows the clear-cutting area assorted by forest ownership. Public forest, especially municipal forest, is important for the cutting and the production of logs. 55.1% of the total clear-cutting during the period of 1979-1989 is owned by the municipal owners (including town and village). Next is the private forest, the share is 25.7%. Generally in Ryukyu Islands, the private forest owners do not seem to be depending on forestry (see Note 2). Okinawa Development Agency (1978, p.21) has pointed out the fact that the main motive for the cutting made in the private forest lies rather in the intention for the conversion of forests into another usage than the necessity in forest management. This tendency seems to be continuing. I am going to discuss on the conversion of the forest-land in the last chapter. The national forest covers 29% of Ryukyu Islands in the area-basis, but the share in the area of the clear-cutting is 12.3%. Now, Okinawa District Forestry Office is not planning the log-production in Ryukyu Islands. The main part of the national forest in Ryukyu Islands is located in the northern part of Okinawa main island and Iriomote-jima. The former is being used as the maneuvers-place of U.S.A. Army, and the latter is treated as Forest Ecosystem Protection Area. Accordingly, the log-production from the national forest is not expected in Ryukyu Islands.

Table 5. Clear-cutting area assorted by forest type

Year	Total	(ha, %)			
		Man-made forest		Natural forest	
		Needle leaved	Broad leaved	Needle leaved	Broad leaved
1979	439	—	—	49	390
1980	368	—	1	15	352
1981	333	2	3	25	303
1982	277	3	5	20	249
1983	252	2	—	33	217
1984	176	1	6	48	121
1985	232	3	13	33	183
1986	134	1	3	28	102
1987	205	4	1	44	156
1988	499	12	2	95	390
1989	194	1	2	50	141
Total	3,109	29	36	440	2,604
Percentage	100.0	0.9	1.2	14.2	83.8
Average	283	3	3	40	237

Source: Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, Annual statistics of forestry production.

Note: — Figures not applicable.

3. Cutting-area, excluding clear-cutting

Table 7 shows the area of the cutting, excluding the clear-cutting. This table also shows the area of the thinning. In this paper, these two types of cutting are not analyzed in detail. Brief explanation of these cutting-activities is as follows.

The cutting-area, excluding the clear-cutting has been on an increasing tendency, but the year-to-year change is similarly big as in case of the clear-cutting. Total area is 275ha during the period of 1979-1989, and this is 8.8% of the total area of the clear-cutting during the same period. The thinning grade is not clear, but the production of log by thinning seems to be negligible.

The thinning area showed a peak in 1982 (2,335ha), and the area has been decreasing since that time. In 1989, the thinning area is 360ha, and this is only 15% of the area in the peak year. According to "1990 Census of Agriculture and Forestry", the area of the man-made forest is 11,918ha, and 9,971ha of those is the non-national forest. The total thinning area during the period of 1979-1989 is 11,787ha, and it is approximately equal to the total area of the man-made forest. Accordingly, it seems that the first thinning has been done almost completely, from the view point of statistical data. However, as there are several problems in the man-made forest established in Ryukyu Islands, the thinning may have some problems. In addition, probably almost all of the logs produced by thinning

Table 6. Clear-cutting area assorted by forest ownership

Year	Total	National			Private
			Prefectural	Municipal* ¹	
1979	439	157	14	170	98
1980	368	60	47	193	68
1981	333	47	57	155	74
1982	277	14	23	209	31
1983	252	17	39	149	47
1984	176	2	—	134	40
1985	232	—	—	153	79
1986	134	1	2	70	61
1987	205	1	1	147	56
1988	499	52	17	246	184
1989	194	31	14	88	61
Total	3,109	382	214	1,714	799
Percentage	100.0	12.3	6.9	55.1	25.7
Average	283	35	19	156	73

Source: Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, Annual statistics of forestry production.

Note: — Figures not applicable.

1) Including town and village.

seem to be left untouched in the forest, not being used economically. Consequently, the thinning has had almost no influence on to the log-supply in Ryukyu Islands.

Cutting-Age

1. Material

To investigate the cutting-age, the cutting statistics assorted by age-class are necessary. A Notice of "On the enforcement of the official regulation on the establishment of the regional forest planning" was fixed by the notification of Director-General of Forestry Agency on May 13, 1971. This regulation requires the making of a summarized table of the checking made on the trend of the cutting-activity every fiscal year in all the prefectures. This table is to be calculated by Prefectural Government and reported to Forestry Agency.

The values of these statistics are not always equal to the actual cutting-activity estimated every year. A cutting reporting system has been fixed by Forest Act, but forest owners do not always report their cutting-activities. Thus, in this paper, I am going to use only the statistical value calculated from this table. As the annual change is conspicuous in the cutting statistics, I have to gather the figures covering several years to get a more stable result. Furthermore, the data in 1984 were not available

Table 7. Cutting area excluding clear-cutting

Year	Cutting area excluding clear-cutting	(ha)
		Thinning area
1979	7	345
1980	0	1,383
1981	10	1,374
1982	5	2,335
1983	12	2,092
1984	34	1,462
1985	8	577
1986	25	994
1987	115	434
1988	32	431
1989	27	360
Total	275	11,787
Average	25	1,072

Source: Statistics and Information Department, Ministry of Agriculture, Forestry and Fisheries, Annual statistics of forestry production.

because of lack. After all, I had to separate the researching periods into two periods, namely the period of 1979-1983 and that of 1985-1990.

Table 8 shows the areas and volumes of the cutting reported in accordance with this regulation. The rates of the natural forest and the broad-leaved forest are high. However, in the period of 1985-90, the proportion from the man-made forest increases a little, and that from the needle-leaved forest amounts to 18.7%.

In this paper, the age of forest is transformed on to the age-class, and in the class the age-interval is

Table 8. Contents of cutting statistics

	Fiscal year	Man-made forest	Natural forest	Needle leaved forest	(%)
					Broad leaved forest
Area basis	1979-83	0.4	99.6	12.5	87.5
	1985-90	6.0	94.0	15.6	84.4
Volume basis	1979-83	0.2	99.8	8.2	91.8
	1985-90	6.6	93.4	18.7	81.3

Source: Okinawa Prefectural Government, Data for business use.

5 years (see Note 3).

2. Statistical values of the cutting-activity

(1) Mean

Table 9 shows the statistical summary of the cutting-activity. Mean value, standard deviation (S.D.) and coefficient of variance (C.V.) are shown, assorted by the types of forest in each period.

Table 9. Statistical values of cutting

		(age-class)								
	Fiscal year	Man-made Forest			Natural Forest			Total		
		Needle leaved	Broad leaved	Total	Needle leaved	Broad leaved	Total	Needle leaved	Broad leaved	Total
Mean	1979-83	4.0	—	4.0	4.2	5.3	5.2	4.2	5.3	5.2
	1985-90	5.3	6.0	5.8	5.3	5.8	5.8	5.3	5.8	5.8
S.D.	1979-83	0.0	—	0.0	0.8	1.6	1.6	0.8	1.6	1.6
	1985-90	1.7	2.4	2.2	1.2	1.8	1.7	1.3	1.8	1.7
C.V.	1979-83	0.0	—	0.0	19.1	30.8	30.9	18.9	30.8	30.9
	1985-90	32.6	39.7	38.3	21.9	30.0	29.3	23.6	30.6	30.0

Source: See Table 8.

Note: — Figures not applicable.

S.D. = Standard deviation.

C.V. = Coefficient of variance.

Mean of the cutting-age-class is age-class of 5.8 during the period of 1985-90. Generally, the mean values of the broad-leaved forest are larger than that of the needle-leaved one. The difference between these two categories has become smaller. There has been almost no difference in the mean value between the man-made forest and the natural forest during the period of 1985-90.

As compared to the value during the period of 1979-83, all of the mean values during the period of 1985-90 were apt to be increasing. As to the total cutting, the mean value increases by the age-class of 0.6, namely from age-class 5.2 to age-class 5.8. This age-class is approximately equal to the standard rotation age determined in Regional Forest Plan (see Note 4). Table 10 shows the statistical values on the forest resources in Ryukyu Islands. The mean age-class of the forest resources is 6.5 in 1990. Thus, the mean age-classes in 1980 and 1985 are estimated to be around 4.5 and 5.5, respectively. These figures are near the ones shown in Table 9. Consequently, the mean age-class of the total cutting is approximately equal both to the mean age-class of the forest resources and to the standard rotation age.

S.D. of the total cutting are 1.6 and 1.7 during the periods of 1979-83 and of 1985-90, respectively. The change is not so large, and C.V. ($= \text{S.D.}/\text{Mean} \times 100$) is not equal. Generally, S.D.

and C.V. of the broad-leaved forest are larger than those of the needle-leaved one. These results are corresponding to the considerations of the forest resources shown in Table 10.

Table 10. Statistical values of forest resources

	(age-class)								
	Man-made Forest			Natural Forest			Total		
	Needle leaved	Broad leaved	Total	Needle leaved	Broad leaved	Total	Needle leaved	Broad leaved	Total
Mean	5.0	4.6	4.8	6.4	7.0	6.9	5.9	6.8	6.5
S.D.	1.9	2.2	2.1	1.3	1.8	1.7	1.7	1.9	1.9
C.V.	38.6	48.8	42.5	20.0	25.2	24.7	28.6	28.2	29.1

Source: Okinawa Prefectural Government, Forestry in Okinawa, 1990ed., 184-187.

Note: S.D. = Standard deviation.

C.V. = Coefficient of variance.

(2) Distribution of age-class

Fig. 1 shows the distribution of the age-class of the cutting and the forest resources. Several characteristics are going to be clarified from Fig. 1. At first, the respective distribution curve shows one peak. It is interesting that this type of clear curve is observed in spite of the specific condition that this area consists of a lot of islands. However, I have to pay attention to the fact that the distribution-curve moved to the right direction. Why did the distribution curve move?

One of the reasons may be the fact that the period of rotation has become longer. However, the peak is age-class 4 (year, 15-20) during the period of 1979-83, and it is an age-class which is too low for the final cutting-age. I have to pay attention to the fact that no thinning is included in these figures. Thus, I have to ascertain the main causes of the cutting under such a low age-class in disregard of forest management. As shown in the chapter of discussion, I would like to find the reason in the various kinds of developmental work introduced into this area. As discussed already, the peak in case of the period of 1985-90 was approximately equal to the standard rotation period, and it was impossible for me to conclude the same results only by using Fig. 1.

Next, I have to notice the relationship between the forest resources and the cutting-activity. The distribution-curve of age-class of the forest resources in 1990 is also shown in Fig. 1. Although not exactly, it was possible for me to get the distribution-curve of the forest resources in 1985 by simply shifting the distribution-curve in 1990 to the left of one age-class. Similarly, by shifting the two age-classes, the distribution-curve of the forest resources in 1980 was estimated. Let's calculate the relationship between the cutting-curve and the forest resources, by dividing the distribution-curve of the cutting by that of the forest resources. To express the results in a form of percentage, next, let's multiply the results by 100. The results are shown in Fig. 2. These curves have important characteristics. Both the curves are in possession of one peak, which is quite important. The peaks of

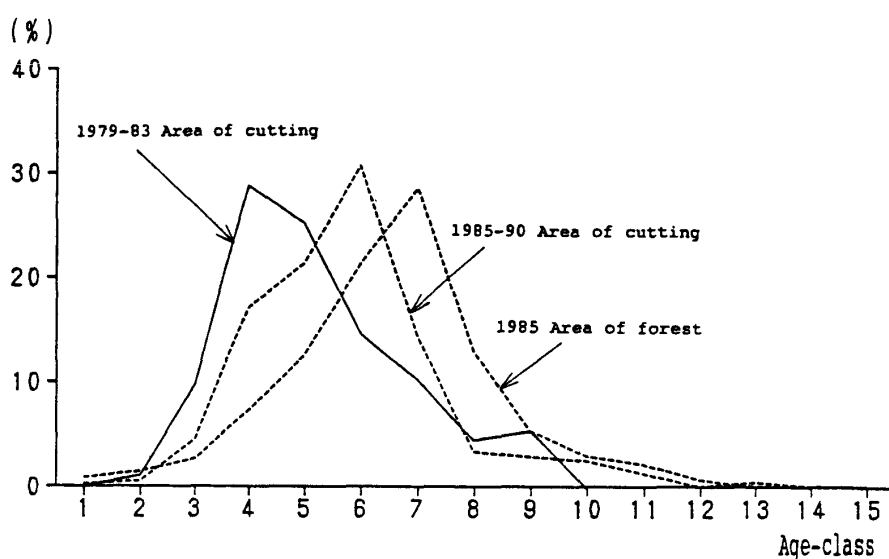


Fig. 1. Area of cutting and area of forest by age-class.

Source: Okinawa Prefectural Government, Forestry in Okinawa, 1990ed., p.184-187, 1991.
Okinawa Prefectural Government, Data for business use.

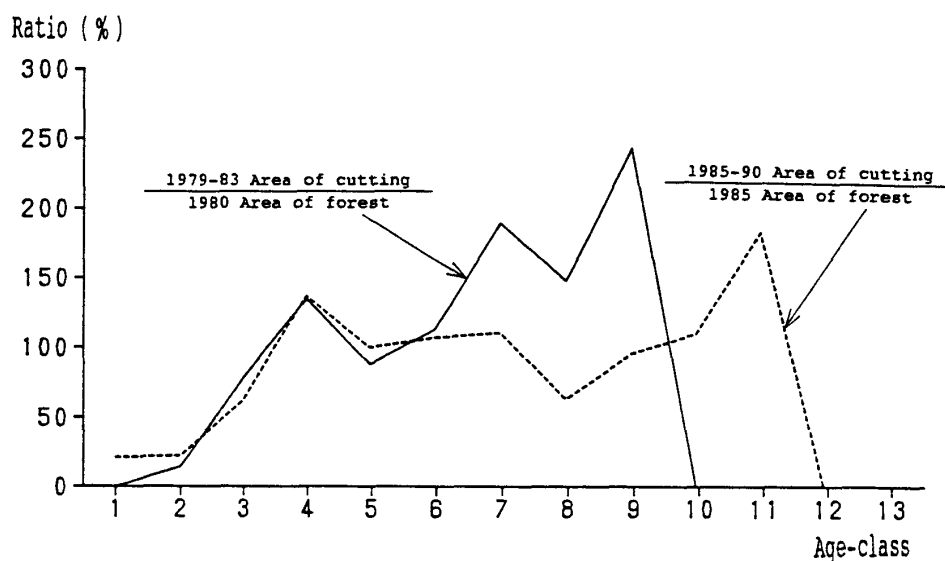


Fig. 2. Relationship between cutting and forest-resource by age-class.

Source: See Fig. 1.

Note: The areas of forest in 1980 and 1985 are estimated values calculated back to from the area of forest in 1990.

Excluding data in age-class 13 and 14 for 1985-90.

the cutting-curve during the periods of 1979-83 and of 1985-90 are age-class 9 (year, 40-45) and age-class 11 (year, 50-55), respectively. As shown in Fig. 1, the absolute area of the forest resources of these age-classes is low, and the cutting-possibility is high. As is clearly pointed out especially concerning the cutting during the period of 1985-89, what is more important is the fact that the values between age-class 4 (year, 15-20) and age-class 10 (year, 45-50) is about 100. Accordingly, the share of the cutting assorted by age-class is approximately equal to that of the forest resources, excepting

those at the low age-class, the high age-class and the peak age-class. As shown in Fig. 1, the area of the forest resources of the low age-class and the high age-class is so small, that these resources are thought to be an exceptional case. Both curves are alike, and it means that the cutting-activity is not always caused by forest management having a sort of rotation.

I can show this from another point. Provided that a cutting rate is defined in the form of the proportion of the area of the cutting to the area of the forest resources assorted by age-class, the cutting-rate-curve is to be shown in Fig. 3. As the researching period of 1985-90 includes 6 years, I have to

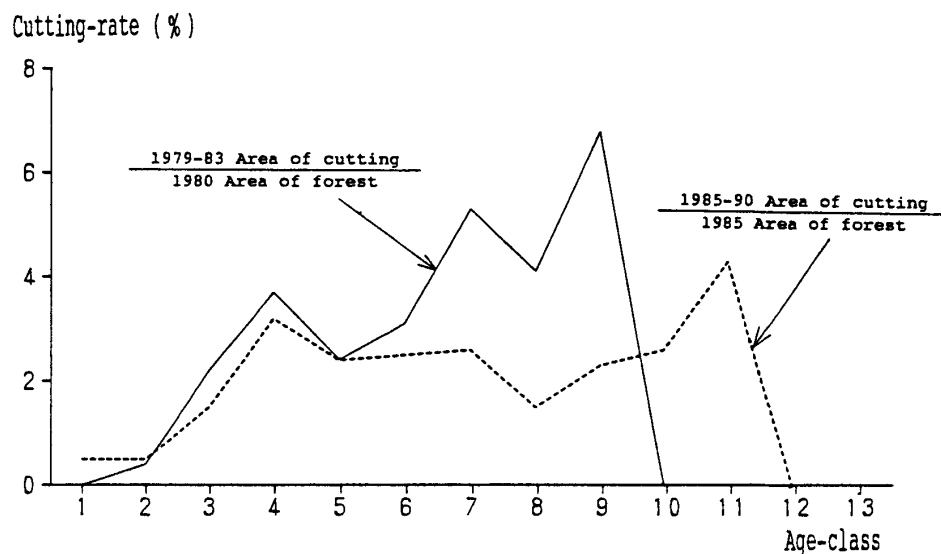


Fig. 3. Cutting rate by age-class.

Source: See Fig. 1.

Note: See Fig. 2.

multiply the result by 5/6 to get the cutting rate during 5 years (one age-class). Two peaks are observed in each case. Both curves have the same peak in age-class 4 (year, 15-20), and the value of this peak is not so high. The values of this peak in both curves are around 3-4%. This age-class is too young for the final cutting, as defined by the standard rotation period. Although the reason is unknown, the forest showing the peak in the cutting rate was cut previously or planted around the period when Ryukyu Islands were returned back to Japan. As shown later, the cutting-activity in Ryukyu Islands is related to the developmental works in the various fields. As shown in Table 8, most of the cutting areas are the natural forest. This results may show the fact that the cutting-activity in the natural forest around at that time was not concerned with the future change of the land use. To check this assumption clearly, more detailed on-the-spot surveys on the cutting-activity will be required. I can point out another peak in each curve, at age-class 9 (year, 40-45) in case of the cutting during the period of 1979-83 and at age-class 11 (year, 50-55) in case of that during the period of 1985-90. The values of these peaks are highest in the whole age-classes for the respective curve. These peaks may show the final cutting carried out for the purpose of the forest management, but, it is impossible for me to conclude it without a further research carried out on the actual conditions in whatever survey area I may come across.

(3) Annual change in cutting-age-class

As the researching covers so short a period as 11 years in this analysis, I can only show the results ascertained during the two separated periods. As the cutting-activity seems to be on a change every year, I can not get a stable result from the data obtained only in one year. However, to get the annual change in the cutting-activity, let's calculate every year the statistical values for the cutting data. The results are shown in Table 11. As previously expected, the results do not show any clear trend. There is no room left for more analyses on this result in this paper, but the understanding of annual change is also very important. To investigate this relationship, several factors, for example, lumber price, the developmental works, business conditions and so on, have to be considered.

It is necessary for us to take a notice on the fact that the results shown in Table 9, Fig. 1, Fig. 2 and Fig. 3 are obtained from these unstable elements. In this sense, the results shown in Table 9 and so on are only a sort of trial. For example, in case of S.D., the values in 1989 and 1990 are apparently high comparing to those in the previous years. The same is also confirmed in the value of C.V. Therefore, if I defined the second half period as 1985-1988, the results may be different to a certain degree.

Table 11. Annual change of cutting

Fiscal year	Mean	S.D.	(age-class)
			C.V.
1979	4.0	1.1	27.5
1980	4.9	1.2	24.5
1981	5.7	1.4	24.6
1982	4.8	1.2	25.0
1983	6.4	1.9	29.7
1984	—	—	—
1985	5.2	1.6	30.8
1986	5.4	1.1	20.4
1987	6.0	1.3	21.7
1988	5.3	1.0	18.9
1989	5.9	2.2	37.3
1990	6.9	2.3	33.3

Source: See Table 8.

Note: See Table 9.

Discussion

1. Forest planning and actual cutting-activity

(1) Abstract of forest planning system

In Japan, forest planning system was defined first in Forest Law of 1951. After that, this system was improved several times. The most recent revision was done in 1991. National Forest Plan and Regional Forest Plan are important ones, and these were introduced in 1962. At first, I am going to explain about the planning system revised in 1983.

National Government should make a Basic Plan of Forest Resources and a Long Term Outlook of Demand and Supply of the Important Forest Products, being based on Sec. 5 of Forestry Basic Law. Under these plan and outlook, Minister of Agriculture, Forestry and Fisheries should make a 15-years plan called National Forest Plan covering all over Japan, with the condition that this plan should be revised every 5 years (Sec. 4 of Forest Law).

For the non-national forest, Prefectural Governor should make Regional Forest Plan under National Forest Plan (Sec. 5 of Forest Law). As Japan was divided into 255 planning areas, average number of the area of Regional Forest Plan in one prefecture was 5.4. As this plan is a 10-years-planning which is to be revised every 5 years, if the number of planning area should be 5, the Prefectural Government may well revise one plan every year successively. Thus, the planning period may be different for each regional plan within the same prefecture. As already referred, Ryukyu Islands consist of three areas of Regional Forest Plan.

On the other hand, in case of the national forest, Director-General of Forestry Agency has to make a Basic Management Plan covering all of the national forests. This is a 15-years-planning which is to be revised every 5 years. Under this basic plan, Director-General of Regional Forestry Office has to make a management plan for 80 of management planning areas. The national forest managed by Okinawa District Forestry Office is a part of the area of the Nansei-tou Regional Management Plan. In this planning area, there are four District Forestry Offices including the Okinawa District Forestry Office. In the system, before the revision in 1991, generally, Regional Forest Plan of the non-national forest and Regional Management Plan of the national forest had been fixed separately.

In 1991, forest planning-system was changed. Now, the Regional Forest Plan has been dealing not only with the non-national forest but also with the national forest. The main changing-point of the system in 1991 is the introduction of the forest management system and the planning area based on the watershed. New Regional Forest Plan has come to hold the common planning area covering both the non-national forest and the national forest. To this common planning area, the Governor has to make a Regional Forest Plan for the non-national forest, and the Director-General of Regional Forestry Office has to make a Regional Forest Plan for the national forest. Both plans require to have a mutual cooperation. The number of planning areas has decreased to 158. In Okinawa Prefecture, there has been no change in the area of Regional Forest Plan.

(2) National Forest Plan

Most recently, the National Forest Plan was revised in 1991. National Forest Plan shows a few values on to the total area in Japan and the 44 separated planning areas. These separated areas have been based mainly on the wide-area-watershed. Ryukyu Islands have been dealt with as an area of the wide-area-watershed called "Okinawa". According to this new plan, Japan and Okinawa are determined as follows:—

At first, the goal of National Forest Plan is shown in Table 12. The total area of the man-made forest is planned to be enhanced to 650,000ha in Japan. Provided that this plan is going to be completely realized, the rate of the area of the man-made forest to the total forest area will be enhanced from 41.1% to 43.7%. The increase of the area of the multiple-storied forest is worth considering. In

the comparison of the increase-rates, the area of the single-storied forest increased in the rate of 3.7%, but the areas of the multiple-storied forest are planned to become about 4 times as large as the present ones. In case of Okinawa Prefecture, the areas of the single-storied forest are planned to undergo no change, on the other hand, the areas of the multiple-storied forest are planned to be enhanced from 100ha to 2,400ha, this meanings 24 times. The resource distributions assorted by the age-class will be shifted to 2007, as shown in Table 12. Nearly 62% of the areas of the total man-made forests will be available for the cutting in 2007, from the view point of the standard rotation periods.

Table 12. Goal of National Forest Plan on man-made forest

Type of man-made forest	Item	All of Japan		Okinawa	
		1990*	2007*	1990*	2007*
Single-storied forest	Area (1,000ha)	10,238	10,617	12	12
	Age-class (%) 1 – 3	20	11	23	16
	4 – S.R.P.	68	42	60	22
	S.R.P.–	12	47	17	62
Multiple-storied forest	Area (1,000ha)	89.8	360.4	0.1	2.4

Source: Ministry of Agriculture, Forestry and Fisheries, National Forest Plan, Table 1, p.12-13, 1991.

Note: S.R.P. = Standard rotation period.

This value is weighted mean of standard rotation period of each species.

The weight used in calculation is area of each species.

* As of March 31.

Several interesting characteristics may be deduced from this table. At first, the areas of the single-storied forest are planned to remain unchanged, in another word, the areas of the increasing of the single-storied forest are fixed to be equal to the areas of the decreasing of the single-storied forest. On the other hand, the areas of the multiple-storied forest are planned to be enhanced drastically, and this type of forest is to be established from the single-storied forest having at least one specific age-class that is suitable for harvesting. There are several problems in increasing this type of forest in Ryukyu Islands. As shown in Table 12, there has not been enough forest in which the age-class is exceeding the standard rotation period. The actual cutting-age is assumed to be generally higher than the standard rotation period defined in the plan. In addition, the demand for the domestic log is quite low. Under such circumstances, the cutting-area of the man-made forest is considered to be too small from the view points of forest management and of timber demand-and-supply in Ryukyu Islands. Thus, the decreasing in the area of the single-storied forest that has been transformed into the multiple-storied forest has to be compensated by the newly planted area of the man-made forest. Considering the timber situation in Ryukyu Islands, the area of reforestation is too small even now, and is worried to be at a low level still in future. The increasing of the area of the single-storied forest may probably be achieved

through the execution of planting-policy in wasteland and so on. Judging from the forest-resource-statistics on April 1, 1989, the total area of the forest is 73,874ha, involving 104ha of the cut-over land, 3,938ha of the treeless land, 4,102ha of the land that is difficult to be regenerated and 1,478ha of Ginnemu (*Leucaena leucocephala*) and Yashi (*Palmae*) and so on. The total area of these lands reaches to 13.0% of the total forest land. Efforts should be made so that a part of these land might be used for the establishment of the man-made forest in future.

At the end of the planning period of the now effective National Forest Plan, 62% of the total man-made forest seem to be of the age-class exceeding enough the standard rotation period to be cut over. This result is also of great interest. In the plan, this rate is higher than that of all over Japan (47%). Although the total area may comparatively be small, the man-made forest is expected to get richer on the resource structures. The demand for the domestic log is not so high. Most of the wood-based industries located in Ryukyu Islands are far from expecting log-supply from local areas. They are in the habit of using the timber imported from the foreign countries and the Japan main-land. Hence, it becomes dubious that the man-made forest that is supposed to be capable of being cut over, judged only from the view point of the age-class, may well be used for timber production in near future.

National Forest Plan has a goal aiming at the improvement of the forest-road. The rate of the actual road-length to the goal one that is fixed in the Basic Plan of Forest Resources is limited to 33% now, and is intended to be enhanced to 75% at the end of the planning period of National Forest Plan. 2.3 times multiplications of the forest-road are shown as a final goal. Although the relationship between the forest-road and the forestry production activities can not be shown clearly, generally, both seem to have been closely connected. All goals and planned values in the National Forest Plan may well be changeable according to the basic condition such as this.

National Forest Plan shows some planning values which are necessary for achieving the above mentioned goals. As to the cutting-volume during the 15-years planning period, 570,000m³ has been planned, and 20,000m³ of which is assumed to be produced by thinning. Accordingly, the annual cutting-volume comes to be 38,000m³. This volume is bigger than that of the actual trend. As shown in Table 4, the average cutting-volume during the period of 1981-89 is around 30,000m³. This planning-volume is raised approximately 25% of the recent 9-years actual results. Why is the cutting-volume planned to be increasing in such a high rate as this?

National Forest Plan shows the total cutting-volume in Japan in the figure of 728,240,000m³. This comes to be 48,550,000m³ in annual base. Recently in Japan, the domestic supply of industrial woods is fixed to be around 30,000,000m³. More than 60% of increasing is planned. Shortly speaking, in constructing National Forest Plan, this total volume is determined first. If this figure should be too big, comparing to the actual results, the same problem occurs in all of the plans at the level of the wide-area-watershed.

Although Forestry Agency shows no basis of the detailed calculation of National Forest Plan, the increase of the growing stock and the improvement of the forest-road are assumed to be basic reasons for the increasing of the cutting-volume. These are the some considerations paid on to the supplying-side, and in this planning system demanding-side considerations has been put out of considerations.

The main utilization-field of the domestic log in Ryukyu Islands is made of chippings. For example, if the production of chippings changes, the demand-and-supply relationships will change largely too. Furthermore, if there is only small demand for the domestic logs, it is needless to say that this plan is not to be fulfilled.

(3) Regional Forest Plan

Ryukyu Islands consist of the three areas of Regional Forest Plan fixed for the non-national forests. As to the national forests, basically, Okinawa District Forest Office has no planning for a cutting. In a few exceptional cases, trees standing as obstacles for the construction of the forest-road or the bed-logs for Shiitake-mushroom are to be cut down, but quantitatively these are quite negligible. Hereinafter, I am going to analyze the cutting-activities in Regional Forest Plan applicable for the non-national forest.

Table 13 shows the cutting-volume planned in Regional Forest Plan, and the actual cutting-volume assorted by the planning area. At first, I am going to point out several characteristics observable on the planning area of "Northern part of Okinawa". This planning area is the main area producing timber in Ryukyu Islands. The broad-leaved forest is the major one in the cutting field. The total volume of the planned cutting is increasing. The rate of the actual cutting-volume to the planned one is 105% during the planning period of 1979-83. It is nearly 100% in the total volume, but the actual cutting-area is too large in the broad-leaved forest, and at the same time is too small in the needle-leaved forest. In case of the planning period of 1984-88, the rate of the actual cutting-volume to the planning-volume decreased to the rate of 49%. This rate is 51% in case of the broad-leaved forest, and it is 15% in case of the needle-leaved forest. In spite of such low value as 13% in the needle-leaved forest observable in the previous plan, the planned cutting-volume increases reversely though slightly. As already commented on the National Forest Plan, the cutting-volume is mainly planned in accordance with the supplying-side factors, for example, contents of the forest resources. The demanding-side factors have not been made much account of. In addition, the cutting-volume of Okinawa in National Forest Plan has been planned in disregard of the actual cutting-activity. Okinawa Prefectural Government has to allocate these excessive planning-values to the three areas of the Regional Forest Plan in Ryukyu Islands. As planning area of "Northern part of Okinawa" is a unique area in which forestry and wood-based industries have been working continuously in Ryukyu Islands, and moreover as the other two planning areas are not expected to produce logs, Prefectural Government could not afford to decrease the cutting-volume in the planning area of "Northern part of Okinawa" according to the actual results. This is a basic problem of the forest-planning system in Japan. The similar situation seems to occur anywhere in the area of the Regional Forest Plan in Japan.

The planned cutting-volume is so small in the planning area of "Middle and Southern part of Okinawa". The actual activity is also at a low level. The ratio of the actual cutting-activity to the planned volume during the planning period of 1981-85 is 242%. The actual cutting-volume is not so large, being around 29,000m³. However, as the planned volume is too small, this rate has become big one in comparison. Moreover, various types of developmental works have been introduced into this area. The excess in cutting is not caused by forest management. The actual movement during the planning period of 1986-90 is only 2,000m³, being 14% of the planned volume.

Table 13. Planning and actual cutting volume

			(1,000m ³ , %)		
Planning area	Planning period * ¹		Plan * ² (A)	Actual (B)	Ratio (B)/(A)
North part of Okinawa * ³	1974-78	Total	96	—	—
		Needle leaved	3	—	—
		Broad leaved	92	—	—
	1979-83	Total	130	136	105
		Needle leaved	32	13	41
		Broad leaved	98	123	126
	1984-88	Total	144	71	49
		Needle leaved	34	15	44
		Broad leaved	110	56	51
Middle and south part of Okinawa * ⁴	1976-80	Total	6	3	50
		Needle leaved	5	1	20
		Broad leaved	1	2	200
	1981-85	Total	12	29	242
		Needle leaved	7	14	200
		Broad leaved	5	15	300
	1986-90	Total	14	2	14
		Needle leaved	6	0	0
		Broad leaved	7	2	29
Miyako and Yaeyama * ⁵	1973-77	Total	34	—	—
		Needle leaved	0	—	—
		Broad leaved	34	—	—
	1978-82	Total	33	14	42
		Needle leaved	6	0	0
		Broad leaved	27	14	52
	1983-87	Total	41	33	80
		Needle leaved	3	2	67
		Broad leaved	38	31	82

Source: Okinawa Prefectural Government, Regional Forest Plan.

Note: — Figures not available.

- 1) Fiscal year. Period of regional forest planning is 10 years. As the regional forest planning is revised every 5 years, all figures of this table are as of the first half of planning periods.
- 2) Breakdown figures were not added to total, because figures were rounded to the nearest final digit.
- 3) North part of Okinawa Main Island (north of Onna-Village and Kin-Town) and neighborhood islands.
- 4) Okinawa Main Island except the area shown in Note 3 of this table and neighborhood islands. Including Daito Islands (Kitadaito-Jima and Minamidaito-Jima).
- 5) Miyako Islands and Yaeyama Islands.

The planning area of "Miyako and Yaeyama" is important next to the planning area of "Northern part of Okinawa" from the view point of the cutting-volume. The ratio of the actual cutting-volume to the planned volume is 42% in the planning period of 1978-82. In spite of such a low rate, in the following plan, the planned volume increased to the ratio of 20%. The reason for this increasing is the same one as in case of the planning area of "Northern part of Okinawa". More important, there are

almost no wood-based industries using the domestic logs in some degree in this planning area. Wood-working plant using specific broad-leaved trees, bed-log for mushrooms and several small wood-based industries are located, but the consumption is negligible. Of course, there is almost no log-export from this area to another one. What is the purpose of this cutting-plan? It is obvious that the cutting is not occasioned by the long-term forest management. Various kinds of the developmental works have been introduced in this area, and major of those has been the construction of agricultural-land.

Although I have explained the planned cutting-volume and the actual cutting-volume in the three planning areas, respectively, these are based on the data obtained from the past planning. In the present effective plans, the cutting-volume in each planning area is as follows: —

In the planning area of "Northern part of Okinawa", the total cutting-volume for 10 years is planned as 270,200m³. The volume of the first half of the 10-years planning-period is not shown in Regional Forest Plan. Assuming that it is a half of the total cutting-volume in 10 years, it is fixed to be 135,100m³. This is the decreasing of 6%, comparing to the planned volume during the planning period of 1979-83. This downward revision is considered to be favorable by the regional planner for keeping the adjustment between the planning and the actual activity. In the planning area of "Middle and Southern part of Okinawa", the cutting-volume is planned to be 11,400m³ for 10 years. Assuming that the cutting-volume of the first half of 10 years is 5,700m³, this value is "down" of around 60%, and is near the planned volume in 1976-80. In the planning area of "Miyako and Yaeyama", the cutting-volume is planned to be 66,100m³ for 10 years. Similarly above, with the assumption that the first half of 10 years is 33,050m³, this rate is approximately equal to the planned volume in 1978-82.

The downward revision is observed in all the three planning areas in Ryukyu Islands. Why was this revision possible in spite of the increasing of the cutting-volume planned in the National Forest Plan? An officer of Prefectural Government comments that the adjustment between Forestry Agency and Okinawa Prefectural Government was carried out and the Forestry Agency accepted the requirement of the downward revision of the cutting-volume to a certain degree. On the other hand, in the plan listed in Table 13, the allocation of the cutting-volume based on National Forest Plan was carried out by Forestry Agency. It is necessary to make more detailed investigations on the adjustment of the cutting-volume in the National Forest Plan and the total cutting-volume of the Regional Forest Plan.

The Regional Forest Plan determines also the planning to the forestation. The multiple-storied forest is established by cutting a part of the single-storied forest that has reached a specific age-class. In the planning area of "Northern part of Okinawa", the forestation-area of the man-made forest for 10 years is 4,090ha, and 2,800ha of those is the multiple-storied forest. The cutting-volume produced by leading the single-storied forest to the multiple-storied forest is not clear. Considering the demand-and-supply conditions of the needle-leaved log in Okinawa main island, most of them are fixed not to be used for industrial woods. So there seems to be almost no influence on to the total cutting-volume in Ryukyu Islands. The problem is that the area of the existing multiple-storied forest is now only 10ha counted in 1990. Why was so many multiple-storied forest planned in spite of the fact there were almost no actual results obtained? A reason may be that one of the main new policies introduced in now effective

National Forest Plan is the increasing of the various kinds of forest establishments including the multiple-storied forest. Briefly speaking, to carry out the excessive goals in the forest establishment, Forestry Agency has to allocate the total areas planned in the National Forest Plan to the respective prefectures.

2. Conversion of forest land

There has been almost no wood-based industry using the domestic log except those at the planning area of "Northern part of Okinawa". Hence the question: what is the main object of the cutting? The answer is the chip production and the land establishment for the various kinds of developmental works. Table 14 shows the area of the conversion of the forest land to the various objectives. The area of 1,870ha has been developed during the period of 1975-89, and 40% of which is for the agricultural use. The constructions of golf course, road and dam are fixed next in the objectives.

The annual developed area is 125ha. Through multiplying this area by $80\text{m}^3/\text{ha}$ as an average volume per hectare in Ryukyu Islands (see Table 4), $10,000\text{m}^3$ of logs come to be available annually from the developmental works. The total cutting-volume in Ryukyu Islands is approximately $30,000\text{m}^3$ as shown in Table 4, and these developmental works are not negligible.

Generally, in the northern part of Okinawa main island, the logs produced from the various developmental works are sold to the chip mills. However, in the other area, the felled trees are to be burned out on that ground. It seems to be quite wasteful from the view point of an effective utilization of the forest resources, but to our regrets there has been no wood-based industry using these logs. And even if a new chip mill should be constructed in this area, probably an excessive cutting will be cause of worry. Furthermore, the cutting-volume shown in Table 13 is too small to be used for a continuous production of a chip mill. In addition, as the cutting-activity based on the developmental works has not been planned, they are quite unstable. Under such circumstances concerning the materials, it seems to be impossible to settle a new mill using only the domestic logs.

The transformation of forest into other objectives occurs as shown in Table 14. On the other hand, the total area of the forest land is not so much decreasing. Table 15 shows the area of the land-utilization in the private land of Ryukyu Islands. The area specified in the category of "Forests" has obtained fixed figures between 90km^2 and 99km^2 . The area specified in the category of "Land for building" has a unique figure that shows an increasing trend. On the other hand, the area specified in the categories "Paddy fields" and "Grassland" have been decreasing. A reverse phenomena in which the area of forest increases are also observed. The main tendency is the conversion from the grassland and agricultural land into forests. In case of the planning area of "Northern part of Okinawa" during the period of 1984-88, the area which has been changed from the forest to the areas of various objectives is 805ha, and the area which has been changed from the grass-land and the agricultural land and so on into the natural forests is 204ha. In the other two planning areas, almost the same results are going to be observed. Although there exist both tendencies, the general direction seems to be the decreasing of the area of the forest land. This tendency is found clearly in several islands excepting Okinawa main island (see Table 1). I would like to discuss on the relationship between the land-use-

Table 14. Conversion of forest land

(ha)

Category	Objectives	Periods* ¹			
		1975-79* ²	1980-84	1985-89	Total
Permission* ³	Industries	52	7	6	65
	Housing	4	25	17	46
	Villas	2	—	—	2
	Golf course	36	—	300	336
	Leisure facilities	10	10	13	33
	Agricultural use	53	92	163	308
	Mining* ⁵	8	12	7	27
	Others	11	22	13	46
	Total	176	168	519	863
Notification* ⁴	Industries	—	—	2	2
	School and museum	8	12	—	20
	Housing	—	1	12	13
	Parks and playground	—	3	35	38
	Agricultural use	62	164	217	443
	Mining* ⁵	—	11	2	13
	Road	46	80	69	195
	Dam and etc.	48	164	21	233
	Others	2	41	7	50
	Total	166	476	365	1,007
Total		342	644	884	1,870

Source: Okinawa Prefectural Government, Forestry in Okinawa, 1990ed., p.19-22, 1991.

Note: — figures not applicable.

1) Calender year.

2) As of 1977-1979, notification only.

3) To develop forest land, a permission is required in following cases.

a. non-national forest under the regional forest planning.

b. excluding protection forest and so on.

c. the area of development is more than 1 ha.

These conditions are determined in Forest Act (Sec.10.2).

4) Development of forest land that are not required a permission.

5) Mining of earth, sand and stone.

Table 15. Private land area by land category

Category	Year* ¹				
	1973	1975	1980	1985	1989
Land for building* ²	79	84	97	104	110
Paddy fields	40	39	31	24	21
Fields	482	474	484	487	490
Forests	90	99	93	90	95
Pastures	21	20	13	18	19
Grassland	273	271	269	254	248
Others	113	118	121	122	118
Total	1,098	1,105	1,108	1,099	1,101

Source: Prime Minister's Office, Japan statistical yearbook, 1975ed., 1977ed., 1982ed.

Management and Coordination Agency, Japan statistical yearbook, 1987ed., 1992ed.

1) As of January 1.

2) Including land for non-dwelling building.

policy and the cutting-activity in Ryukyu Islands in a future analysis.

Summary

In this paper, I analyzed the cutting operation in Ryukyu Islands from the view point of statistical analysis. The researching periods are set mainly in those after 1972 when Ryukyu Islands were returned back to Japan from U.S.A.

The main conclusions clarified from the cutting statistics and the related statistics are as follows:

(1) The main cutting area is the northern part of Okinawa main island. The share is more than 80% in volume. Before the returning back to Japan, Yaeyama Islands had been a main production area.

(2) The annual cutting-volume is 58,000m³ during the period of 1963-71, 26,000m³ during the period of 1972-80 and 30,000m³ during the period of 1981-89. Since the returning back to Japan, the annual cutting-volume has decreased to near half of the original one.

(3) The average volume per hectare of the cutting area has been around 80m³/ha during the whole researching periods. Generally, as the forest resources in Ryukyu Islands are now under a process of recovering, the average volume per hectare is still at a low level.

(4) As to the clear-cutting during the period of 1979-89, the broad-leaved forest in the natural forest occupies a main part (84%). The needle-leaved forest in the natural forest is the next (14%). The cutting of the man-made forest shares only 2%.

(5) The clear-cutting area assorted by forest ownership during the period of 1979-89 is municipal forest (55%), private forest (26%), national forest (12%) and prefectural forest (7%). The municipal forest plays an important role in this area. In another word, the private sector is not so active.

(6) Mean age-class of the cutting area is age-class 5.2 and 5.8 during the periods of 1979-83 and 1985-90, respectively. Standard deviations of age-class of the cutting area are age-class 1.6 and 1.7 during the

both periods. Coefficients of variance are 30.9 and 30.0, respectively, showing almost no change.

(7) Distribution of age-class of the cutting area had shifted to a right side. As to the cutting rate defined by the cutting-area per forest-resources assorted by age-class, the cutting-rate-curve has 2 or 3 peaks. In case of the period of 1979-83, the peak is age-class 4 (year, 15-20), 7 (year, 30-35) and 9 (year, 40-45). Age-class 9 shows the highest rate (6.8%). In case of the period of 1985-90, it is age-class 4 (year, 15-20) and 11 (year, 50-55). Age-class 11 shows the highest rate (4.3%).

(8) National Forest Plan that is now effective shows that the total cutting-volume for 15 years is 570,000m³, namely the annual cutting-volume is 38,000m³. This is an increase of 26% comparing to the recent 9-years actual results.

(9) The Regional Forest Plan has a tendency to fix the cutting-volume excessively owing to the allocation of excessive planned volume shown in the National Forest Plan. Recently, these planning values have been revised downward.

(10) The multiple-storied forest is strongly recommended by Forestry Agency recently, and is planned to establish too large an area, comparing to the actual results. The log-production derived from the induction to the multiple-storied forest is not desired, considering the circumstances of demand-and-supply of the domestic log in Ryukyu Islands. Also concerning the thinning of the man-made forest, the log-production is not to be expected.

(11) Various kinds of the developmental works have been introduced into Ryukyu Islands since the returning back to Japan. The log-production from the locations of these works is not negligible in the domestic log-market in Ryukyu Islands. The relationship between the land-use-policy and the cutting is very important.

Notes

1) Nakama (1984, p.294-296) pointed out the estrangement between the planned value and the actual results in the Regional Forest Plan of Okinawa Prefecture, especially in the field of the forestation and the construction of the forest-road. It is worth noticing that he pointed out the financial aspects of forests and forestry. His main idea is that the forest plan has been constructed, ignoring the financial limitations. He pointed out also the problem on the forest establishments.

2) Asato (1991, p.30) pointed out the fact that the share of the protection forest in Ryukyu Islands is only 15%, and this is quite a low rate, comparing to that of all of Japan (32%). As a reason for this low rate settled in spite of the fact that the importance of protection forest has been stressed in Ryukyu Islands, he pointed out that a difficulty in getting understanding of the specification of the protection forest due to a sense of uneasiness of forest owners for the free sale of forest land and against the limitation of forest operations. Various developmental works have been introduced into Ryukyu Islands mainly by a public sector, and the forest land is valuable for the location of these works. Thus, a part of forest owners come to be uninterested in the trees on the forest land. Shinohara (1985, p.24) also pointed out the problem that the private forest owner's will on the forest management is somewhat low. The problematic fact that the timber marketing system is not prepared in Ryukyu Islands has been pointed out as a reason.

3) In this paper the cutting-age is summarized by the concept as the age-class. Forest-Management-Study-Group (1992, p.26) pointed out the problem on the age-class. Owing to the procedure in which the different types of forests are to be gathered as a similar age-class only by the age of forest, the gap inevitably occurs between the planning and the actual results. Ryukyu Islands are different from the Japan main-land in

the various aspects. As this area consists of a lot of islands, the conditions are not homogeneous. As Konohira pointed out in the symposium of Forest-Management-Study-Group (1992, p.26-27), for the performance of the more detailed research on this point, it may be necessary to collect the individual data on forests.

4) The standard rotation age in the Regional Forest Plan in the planning area of "Northern part of Okinawa" is as follows: 30 years for Ryukyu-Matsu (*Pinus luchuensis*), 40 years for Inumaki (*Podocarpus macrophyllus*) and Sugi (*Cryptomeria japonica*), 25 years for Mokumaou (*Casuarina stricta*) and Taiwan-Hannoki, 30 years for the broad-leaved trees, respectively.

Acknowledgements

The author thanks Mr. Setoguchi M. (Okinawa District Forestry Office), Mr. Shiroma K. (Okinawa Prefectural Government), Mr. Ueno K. (Kunigami-Village Forestry Co-operative), Mr. Minei M. (Okinawa-Hokubu Forestry Co-operative), Mr. Kakazu N. (Okinawa Prefecture Lumber Association), Mr. Yoshima T. (Okinawa Prefectural Government, Miyako Branch Office), Mr. Okudaira G. and Mr. Miyakuni K. (Hirara Municipal Office), Mr. Syokida M. (Okinawa Prefectural Government, Yaeyama Branch Office), Mr. Kuroshima Y. (Ishigaki Municipal Office) and Mr. Ishigaki S. (Yaeyama Forestry Co-operative). This research was funded by the Scientific Research of Ministry of Education, Science and Culture (fiscal year 1991, research number 3760103).

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