沖縄島におけるイタジイ優占の常緑広葉樹林の萌芽更新：I. 根株の枯死と腐朽に関する研究

Characteristics of sprout natural regeneration of evergreen broad-leaved forest dominated by *Castanopsis sieboldii* in Okinawa:
I. Studies on mortality and decay of stumps

Takakazu SHINZATO*, Lichao WU**, Osahiro NISHIHATA*, Kazuo TABA*, Tsutomu ENOKI* and Eiji HIRATA*

Summary

The mortality and decay of stumps were studied based on the investigations of 62 species and 1,893 stumps five years after clear-cutting. The results indicated that 20.2% of stumps were dead without living sprout. And 29.7% of them remained in original, 26.5% of them were decaying partly and 23.6% of them couldn't be seen but with living sprout. The decay states of stumps varied with species and D.B.H. The mortality rates of stumps varied significantly with species and life-form spectra, but not significantly with position, direction of slope. The relationship between mortality and D.B.H remained unclear. Of all species, 2 species had no living stumps, adversely 16 species had no dead ones, and 44 species had not only living ones but also dead ones. 37 species had the mortality rates equal to or below 20.0%, 16 species had the mortality rates higher than 20.0% and equal to or lower than 50.0%, and 9 species had the mortality rates higher than 50.0%. The paper strongly suggested that the evergreen broad-leaved forest dominated by *Castanopsis sieboldii* was appropriate for sprout natural regeneration.

Key words : evergreen broad-leaved forest, sprout natural regeneration, mortality rates of stumps, decay states of stumps

キーワード：常緑広葉林，萌芽更新、根株の枯死率、根株の腐朽状態

* University Forest, Faculty of Agriculture, University of the Ryukyus
** Teaching and Research Section of Environmental Science, College of Sources and Environment, Central South Forestry University, Zhuzhou, 412006, Hunan, China
Sci. Bull. Fac. Agr. Univ. Ryukyus. **47** :145～157 (2000)

Ⅰ. Introduction

Evergreen broad-leaved forests dominated by *Castanopsis sieboldii* are widely distributed in Yanbaru, the northern part of Okinawa, Japan. In this subtropical rain forest region, many important and endemic natural plant species and animal species of Ryukyu Islands are found there. However, during the recent two decades, the natural plant communities of the Yanbaru, both the summit of mountains and ravine areas were affected strongly by land uses and over-cutting. This has caused the disappearance of some endemic living creatures and has endangered other plants and animals. Many important vegetables and animals are faced extinction. Animal and vegetable conservation of Yanbaru has become more and more urgent. Natural regeneration is maybe one of the best ways to settle the problems. In the recent 20 years, several reports related to forest regeneration of *C. sieboldii* forest in Okinawa have been reported (Shinzato et al. 1987; Shinzato et al, 1995; Aromoto et al, 1981; Shinzato, 1988). However, some characteristics of its spout shoots, such as mortality of stumps and dynamics of decay states of stumps remain still unclear.

The main aim of the article is to study mortality of the stumps and decay states of the stumps five years after clear-cutting. The article compares results with the available guidance and discusses future prospects for the use of natural regeneration in Yanbaru, Okinawa.

Ⅱ. Study area and methods

1. Study site

The study was carried out at the University Forest, College of Agriculture, University of the Ryukyus, located in the northern part of Okinawa Island in Japan. The latitude and longitude of the site are 26° 45 30" N and 128° 05' E, respectively. The altitude ranges from 300m to 330m above sea level. The mean annual precipitation measured at Yona University Forest was 2650 mm, the mean annual temperature was 21.6℃, the mean monthly maximum temperature was highest in August (32.1℃), and mean monthly minimum temperature was lowest in February (10.8℃) during the recent two decades.

Table 1. Outline of plants in experimental plot before cutting

Species	Mean D.B.H (cm)	Mean tree height (m)	Tree density (trees/ha)
Castanopsis sieboldii	15.1	7.2	1,263
Schima wallichii ssp.*liukiuensis*	12.3	8.0	300
Elaeocarpus sylvestris	7.3	6.3	188
Schefflera octophylla	7.1	5.9	338
Camellia lutchuensis	3.8	4.0	675
Myrsine sequinii	2.2	3.1	1,263
Distylium racemosum	2.1	3.1	2,350
Ardisia quinquegona	1.0	2.2	6,363
others	2.6	3.3	11,125

The study site was covered with evergreen broad-leaved forests dominated by *C. sieboldii*. The composition of main tree species, their densities and sizes before cutting, are shown in Table 1.

The parent bedrock is shale, and the soil is classified as yellow soil. In addition, the thickness of soil horizon is more than 80 cm, and the thickness of soil humus horizon is between 4 ~12 cm.

2. Methods

Four plots (20 m×10 m, in size) were established in natural forest in 1992. Each plot was divided into two subplots. The distribution of plots and direction of slope and the position of slope of each plot are shown in Fig 1.

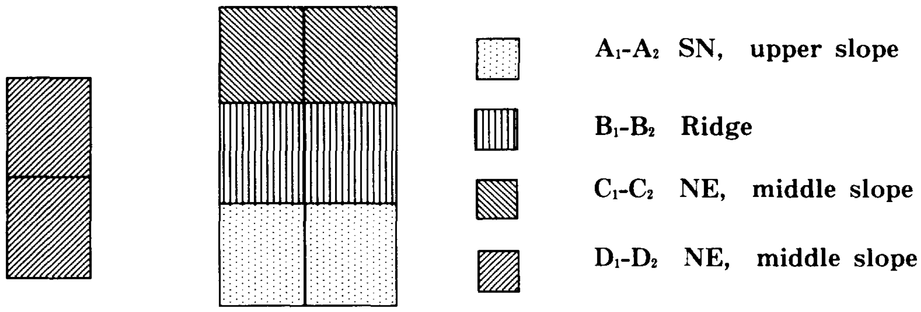
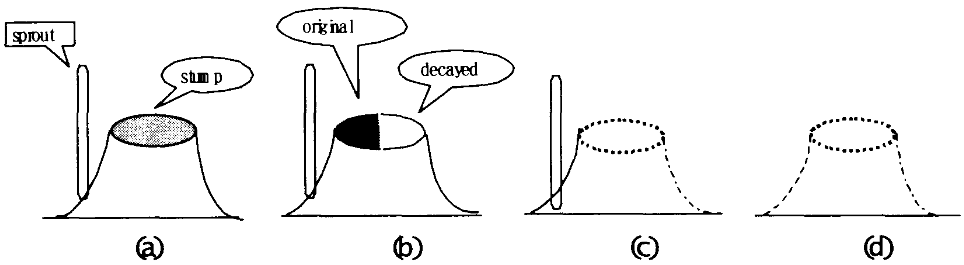


Fig. 1 Distribution of plots on the experimental area

At the first inventory in 1992, 1893 trees taller than 1.2 m in the study plots were recorded including species name, tree height, D.B.H (diameter at breast height). The permanent number was tagged on the stem of each tree at the base.

In February 1993, all trees were felled at the base about 20cm height above the ground. In January 1994, all living trees were identified; the state of survival of the original trees with tagged number in 1992 was checked.

Field investigation was performed in 1998 between May and July. The species of all the living trees taller than 1.0 m was recorded (about 8900 stems). Especially, the original trees



(a) The stump is remained original figure with living sprout
(b) The stump is decaying partly with living sprout
(c) The stump can not been seen but with living sprout
(d) The stump is dead without living sprout

Fig. 2 The decay states of stumps

with tagged number in 1992 were rechecked including states of survival, number of sprout shoots of each tree and decay state of the stumps.

The decay states of stumps were divided into 4 states as shown in Fig 2. Each subplot was sub-divided into 25 quadrates (2m×2m each) for convenience of investigation.

Ⅲ. Results

1. Mortality of stumps

Five years after clear-cutting all stumps were rechecked to verify whether they lived. The result showed that 20.2% of all stumps were dead, which was larger than that of the first year (Shinzato et al, 1994), and while 79.8% of all stumps were survived with living sprout. There was not significant difference for the mortality rate amongst 4 plots through variance analysis [$F=1.5$, $F_{0.05}(1,6)=5.99$, $F<F_{0.05}$]. The mortality rates of stumps varied with species and life form spectra. But the mortality rate changed by D.B.H remained still unclear.

1) Changes of mortality rate by species

Significant differences were found among species for mortality rates as shown in Table 2. Of all species, 2 species had no living stumps, adversely about 16 species had no dead ones, and 44 species had not only living ones but also dead ones. In general, 37 species had the mortality rates equaled or below 20.0%, 16 species had the mortality rates higher than 20.0% and equaled or lower than 50.0%, and 9 species had the mortality rates higher than 50.0%.

For the dominant species before cutting, such as *C. sieboldii, S. wallichii* ssp. *liukiuensis,* their mortality rates were below 20.0%. On the other hand, the mortality rates of the species, those dominated in stems before cutting, such as *A. quinquegona, D. racemosum, M. sequinnii* were 16.9%, .14.9% and 46.5%, respectively. The endemic species, *S. Japonica* var. *lutchuensis,* whose 7 ninths of stumps (77.8%) were found dead.

Species had the mortality rates higher than 50.0% were *S. japonicus, E. osimensis* var. *kanehirae, D. trifidus, T. gracilipes, T. ternatai, L. fordii, H. cochinchinensis, S. japonica* and *A. ryukyuensis.* And species had mortality rates lower than 20.0% species were *C. sieboldii, D. racemosum, S. wallichii.* ssp. *liukiuensis, S. buxifolium, A. quinquwgona, P. thunbergii, S. octophylla, E. sylvestris* and *O. marginatus* et al.

2) Changes of mortality rate by life-form spectra

The distributions of mortality rates by life form spectra were shown in Table 3～4. For mega (MM), most of MM species, had mortality rates lower than 20.0%, and few (5.9%) of MM species, had mortality rates higher than 50.1%. For mesophanerophyte (M), 54.5% of them lower than that of MM had mortality rates lower than 20.0%. On the other hand, 27.3% and 18.2% of them more than that of MM, had mortality rates 20.0-50.0% and higher than 50.0%, respectively. For microphanerophytr (NM), nearly half of them, had mortality rates lower than 20.0%, which lower than that of MM, and the number of species had mortality rates over 20.0% more than that of MM. As for nanophanerophyte (N), 71.4% of them more than that of M and NM, but lower than that of MM, had mortality rates lower than 20.0%. None of them shared mortality rates 20.0～50.0%. 28.6% of them, more than all other life-form spectra, had mortality rates higher than 50.0%. The result indicated that the MM shared the lowest average mortality rate as 13.5% and the NM suffered the highest average mortality rate as 29.4%. In general, the mortality rate consequence were MM<M<N<NM.

Table 2. Mortality rates of stumps by species

Species	Total stumps	Living stumps	Dead stumps	Mortality rate (%)
Eurya osimensis var. *kanehirae*	5	0	5	100
Turpinia ternata	1	0	1	100
Dendropanax trifidus	21	2	19	90.5
Skimmia japonica	9	2	7	77.8
Lasianthus fordii	6	2	4	66.7
Helicia cochinchinensis	3	1	2	66.7
Styrax japonicus	5	2	3	60.0
Tarenna gracilipes	25	10	15	60.0
Adinandra ryukyuensis	7	3	4	57.1
Illicium anisatum	2	1	1	50.0
Litsea acuminata	2	1	1	50.0
Ilex maximowicziana var. *mutchagara*	10	5	5	50.0
Microtropis japonica	4	2	2	50.0
Rhododendron tashiroi	15	8	7	46.7
Myrsine sequinii	101	54	47	46.5
Dephniphyllum glaucescens ssp. *teijsmannii*	11	6	5	45.5
Meliosma lepidota ssp. *squmulata*	14	8	6	42.9
Symplocos anomala	13	8	5	38.5
Camellia japonica	48	30	18	37.5
Gardenia jasminoides f. *grandiflora*	29	20	9	31.0
Persea japonica	13	9	4	30.8
Ardisia sieboldii	17	12	5	29.4
Wendlandia formosana	4	3	1	25.0
Tutcheria virgata	38	30	8	21.1
Neolitsea aciculata	34	27	7	20.6
Ficus erecta	5	4	1	20.0
Ilex goshiensis	10	8	2	20.0
Schefflera octophylla	27	22	5	18.5
Ardisia quinquegona	509	423	86	16.9
Castanopsis sieboldii	85	71	14	16.5
Viburnum japonicum	20	17	3	15.0
Distylium racemosum	188	160	28	14.9
Psychotna rubra	69	59	10	14.5
Myrica rubra	7	6	1	14.3
Schima wallichii ssp. *liukiuensis*	24	21	3	12.5

(cont.)

Species	Total stumps	Living stumps	Dead stumps	Mortality rate (%)
Randia canthioides	84	74	10	11.9
Camellia lutchuensis	54	48	6	11.1
Osmanthus marginatus	9	8	1	11.1
Rhaphiolepis indica	10	9	1	10.0
Antidesma japonicum	51	46	5	9.8
Syzygium buxifolium	36	33	3	8.3
Elaeocarpus japonicus	61	56	5	8.2
Cinnamomum pseudo-pedunculatum	28	26	2	7.1
Elaeocarpus sylvestris	15	14	1	6.7
Persea thunbergii	44	42	2	4.5
Ilex ficoidea	49	47	2	4.1
Callicarpa japonica var. *luxurians*	5	5	0	0.0
Vaccinium wrightii	3	3	0	0.0
Cinnamomum doederleinii	1	1	0	0.0
Neolitsea sericea	9	9	0	0.0
Diplospora dubia	5	5	0	0.0
Diospyros morrisiana	11	11	0	0.0
Symplocos lucida var. *nakaharae*	3	3	0	0.0
Nageia nagi	1	1	0	0.0
Cinnamomum sieboldii	6	6	0	0.0
Rhus succedanea	2	2	0	0.0
Eurya japonica	3	3	0	0.0
Symplocos glauca	1	1	0	0.0
Symplocos confusa	1	1	0	0.0
Ilex integra	6	6	0	0.0
Meliosma rigida	8	8	0	0.0
Ilex liukiuensis	6	6	0	0.0
Total	1,893	1,511	382	20.2

3) Changes of mortality by D.B.H

The mortality rates of all stumps by D.B.H were shown in Table 5. Along with the increase of D.B.H from 2.0 to 20.0 cm, the increasing trend of mortality was found. However, compared with D.B.H class from 2.0 to 4.0cm, mortality rate of D.B.H class from 0 to 2.0 cm increased. When the diameter was over 20.0 cm (20.0～80.0 cm), the mortality rate decreased remarkably as 7.5%, which hit the lowest value in all diameter classes.

The number distributions of dead stumps by D.B.H were shown in Fig. 3. The inverse "J" shaped number distribution was also found. The D.B.H lower than 6.0 cm shared the mortality percentage as 87.4%.

Table 3. The mortality rate with life-form spectra*

Mortality rate	Life form			
	MM	M	NM	N
0≦MR≦10	*C. sieboldii* *E. japonicus* *E. sylvestris* *I. liukiuensis* *N. nagi* *P. thunbergii* *R. succedanea* *S. buxifolium* *S. confusa*	*C. pseudo-pedunculatum* *D. morrisiana* *M. rigida* *N. sericea* *S. lucida* var. *nakaharae*	*C. doederleinii* *D. dubia* *E. japonica* *I. ficoidea* *I. integra* *R. indica* *S. glauca* *V. wrightii*	*A. japonicum* *C. japonica* var. *luxurians*
10<MR≦20	*C. sieboldii* *D. racemosum* *M. rubra* *O. marginatus* *S. wallichii* ssp. *liukiuensis*	*I. goshiensis* *S. octophylla*	*C. lutchuensis* *F. erecta* *R. canthioides*	*A. quinquegona* *P. rubra* *V. japonicum*
20<MR≦30		*N. aciculata* *T. virgata*	*A. sieboldii* *W. formosana*	
30<MR≦40	*P. japonica*		*C. japonica* *G. jasminoides* *S. anomala*	
40<MR≦50	*D. glaucescens* ssp. *teijsmannii*	*L. acuminata*	*I. anisatum* *I. maximowicziana* var. *mutchagara* *M. japonica* *M. lepidota* ssp. *squmulata* *M. sequinii* *R. tashiroi*	
>50%	*H. cochinchinensis*	*S. japonicus* *T. ternata*	*A. ryukyuensis* *D. trifidus* *E. osimensis* var. *kanehirae*	*L. fordii* *S. japonica* var. *lutchuensis* *T. gracilipes*

* MM: stand for Mega; M: Mesophanerophyte; NM:Microphanerophyte; N: Nanophanerophyte.
** MR: stand for mortality rate.

Table 4. Mortality rates and distribution by life-form spectra

Life form	Total stems	Dead stems	Mortality rate	Distribution of mortality by species (%)		
				≦20	20<Mortality≦50	>50
MM	512	69	13.5	82.3	11.8	5.9
M	173	29	16.8	54.5	27.3	18.2
NM	523	154	29.4	42.3	46.2	11.5
N	685	130	19.0	71.4	0	28.6

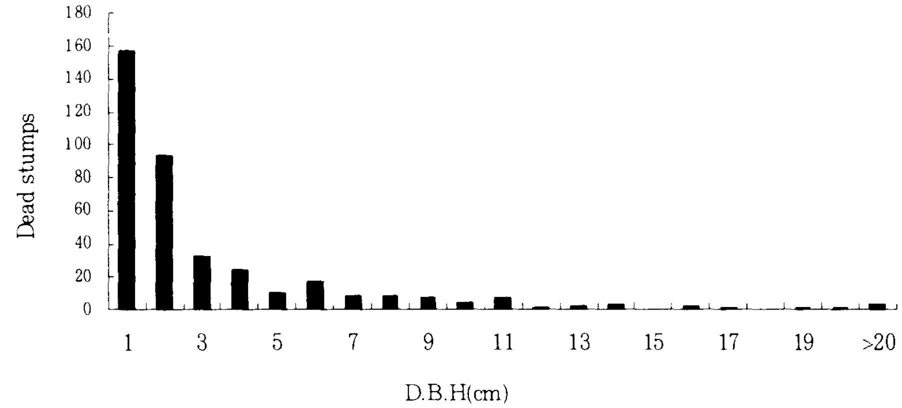


Fig. 3 Distribution of dead stumps by D.B.H

Table 5. Mortality distribution by D.B.H

D.B.H (cm)	Mortality rate(%)
0～ 2.0	20.5
2.1～ 4.0	17.0
4.1～ 6.0	21.3
6.1～ 8.0	25.4
8.1～10.0	26.2
10.1～15.0	26.0
15.1～20.0	31.3
>20.0	7.5
Total	20.2

Table 6. Decay state of stumps

Plot	Total stump	a		b		c		d	
		Number	%	Number	%	Number	%	Number	%
A	419	119	28.4	108	25.8	107	25.5	85	20.3
B	471	182	38.6	112	23.8	84	17.8	93	19.7
C	381	104	27.3	110	28.9	79	20.7	88	23.1
D	622	157	25.2	172	27.7	177	28.5	116	18.6
Total	1,893	562	29.7	502	26.5	447	23.6	382	20.2

Table 7. Changes of Decay State by D.B.H

D.B.H (cm)	Total stump	a		b		c		d	
		No	%	No	%	No	%	No	%
0<D≦2	1,220	408	33.4	286	23.4	276	22.6	250	20.5
2<D≦4	335	100	29.9	87	26.0	91	27.2	57	17.0
4<D≦6	127	33	26.0	29	22.8	38	29.9	27	21.3
6<D≦8	63	7	11.1	20	31.7	20	31.7	16	25.4
8<D≦10	42	7	16.7	14	33.3	10	23.8	11	26.2
10<D≦15	50	3	6.0	25	50.0	9	18.0	13	26.0
15<D≦20	16	2	12.5	8	50.0	1	6.3	5	31.3
>20	40	2	5.0	33	82.5	2	5.0	3	7.5
Total	1,893	562	29.7	502	26.5	447	23.6	382	20.2

Table 8. The changes of decay state by species

Species	Total stumps	a		b		c		d	
		No	%	No	%	No	%	No	%
Adinandra ryukyuensis	7	1	14.3	1	14.3	1	14.3	4	57.1
Antidesma japonicum	51	20	39.2	7	13.7	19	37.3	5	9.8
Ardisia quinquegona	509	154	30.3	170	33.4	99	19.4	86	16.9
Ardisia sieboldii	17	3	17.6	6	35.3	3	17.6	5	29.4
Callicarpa japonica var. *luxurians*	5	1	20.0	0	0.0	4	80.0	0	0.0
Camellia japonica	48	17	35.4	7	14.6	6	12.5	18	37.5
Camellia lutchuensis	54	24	44.4	6	11.1	18	33.3	6	11.1
Castanopis sieboldii	85	8	9.4	38	44.7	25	29.4	14	16.5
Cinnamomum doederleinii	1	1	100.0	0	0.0	0	0.0	0	0.0
Cinnamomum pseudo-pedunculatum	28	9	32.1	8	28.6	9	32.1	2	7.1
Cinnamomum sieboldii	6	3	50.0	2	33.3	1	16.7	0	0.0
Dendropanax trifidus	21	0	0.0	0	0.0	2	9.5	19	90.5
Daphniphyllum glaucescens ssp. *teijsmannii*	11	0	0.0	1	9.1	5	45.5	5	45.5
Diospyros morrisiana	11	0	0.0	2	18.2	9	81.8	0	0.0
Diplospora dubia	5	0	0.0	5	100.0	0	0.0	0	0.0
Distylium racemosum	188	66	35.1	65	34.6	29	15.4	28	14.9
Elaeocarpus japonicus	61	9	14.8	16	26.2	31	50.8	5	8.2
Elaeocarpus sylvestris	15	2	13.3	6	40.0	6	40.0	1	6.7
Eurya japonica	3	1	33.3	2	66.7	0	0.0	0	0.0
Eurya osimensis var. *kanehirae*	5	0	0.0	0	0.0	0	0.0	5	100.0
Ficus erecta	5	0	0.0	1	20.0	3	60.0	1	20.0
Gardenia jasminoides f. *grandiflora*	29	5	17.2	6	20.7	9	31.0	9	31.0
Helicia cochinchinensis	3	0	0.0	0	0.0	1	33.3	2	66.7
Ilex ficoidea	49	21	42.9	16	32.7	10	20.4	2	4.1
Ilex goshiensis	10	4	40.0	3	30.0	1	10.0	2	20.0
Ilex integra	6	2	33.3	2	33.3	2	33.3	0	0.0
Ilex liukiuensis	6	4	66.7	0	0.0	2	33.3	0	0.0
Ilex maximowicziana var. *mutchagara*	10	2	20.0	2	20.0	1	10.0	5	50.0
Illicium anisatum	2	0	0.0	1	50.0	0	0.0	1	50.0
Lasianthus fordii	6	1	16.7	0	0.0	1	16.7	4	66.7
Litsea acuminata	2	0	0.0	1	50.0	0	0.0	1	50.0
Meliosma lepidota ssp. *squmulata*	14	1	7.1	2	14.3	5	35.7	6	42.9
Meliosma rigida	8	2	25.0	1	12.5	5	62.5	0	0.0
Microtropis japonica	4	0	0.0	1	25.0	1	25.0	2	50.0
Myrica rubra	7	2	28.6	3	42.9	1	14.3	1	14.3
Myrsine sequinii	101	39	38.6	9	8.9	6	5.9	47	46.5
Nageia nagi	1	0	0.0	1	100.0	0	0.0	0	0.0

(cont)

Species	Total stumps	a		b		c		d	
		No	%	No	%	No	%	No	%
Neolitsea aciculata	34	6	17.6	5	14.7	16	47.1	7	20.6
Neolitsea sericea	9	0	0.0	2	22.2	7	77.8	0	0.0
Osmanthus marginatus	9	2	22.2	3	33.3	3	33.3	1	11.1
Persea japonica	13	2	15.4	5	38.5	2	15.4	4	30.8
Persea thunbergii	44	5	11.4	16	36.4	21	47.7	2	4.5
Psychotna rubra	69	28	40.6	20	29.0	11	15.9	10	14.5
Randia canthioides	84	50	59.5	14	16.7	10	11.9	10	11.9
Rhaphiolepis indica	10	6	60.0	1	10.0	2	20.0	1	10.0
Rhododendron tashiroi	15	5	33.3	3	20.0	0	0.0	7	46.7
Rhus succedanea	2	0	0.0	1	50.0	1	50.0	0	0.0
Schefflera octophylla	27	1	3.7	2	7.4	19	70.4	5	18.5
Schima wallichii ssp. *liukiuensis*	24	5	20.8	11	45.8	5	20.8	3	12.5
Skimmia japonica	9	0	0.0	0	0.0	2	22.2	7	77.8
Styrax japonicus	5	0	0.0	1	20.0	1	20.0	3	60.0
Symplocos anomala	13	5	38.5	1	7.7	2	15.4	5	38.5
Symplocos confusa	1	1	100.0	0	0.0	0	0.0	0	0.0
Symplocos glauca	1	0	0.0	0	0.0	1	100.0	0	0.0
Symplocos lucida var. *nakaharae*	3	1	33.3	0	0.0	2	66.7	0	0.0
Syzygium buxifolium	36	10	27.8	15	41.7	8	22.2	3	8.3
Tarenna gracilipes	25	5	20.0	2	8.0	3	12.0	15	60.0
Tutcheria virgata	38	21	55.3	6	15.8	3	7.9	8	21.1
Turpinia ternata	1	0	0.0	0	0.0	0	0.0	1	100.0
Vaccinium wrightii	3	3	100.0	0	0.0	0	0.0	0	0.0
Viburnum japonicum	20	3	15.0	3	15.0	11	55.0	3	15.0
Wendlandia formosana	4	1	25.0	0	0.0	2	50.0	1	25.0
Total	1,893	562	29.69	502	26.519	447	23.613	382	20.2

2. Decay states of stumps

Table 6~8 showed the decay states of all stumps five years after clear-cutting. 29.7% of all stumps remained in original state without decay in comparison with 26.5% of them partly decayed and 23.6% of them couldn't been seen owing to decayed completely of the underground part of the stump. These counted up as 79.8% of all stumps, which had living sprout. And 20.2% of all stumps were dead without any living sprout. For type "d", it belonged to dead stump, which was studied on mortality rate part. In the paper no further attention was paid to it. As for other types including type "a", "b" and "c", significant differences were found amongst the D.B.H and species.

1) Changes of decay states by D.B.H

The decay states of diameter classes were significantly different as shown in Table 7. The diameter group <2.0 cm had the biggest distribution with type "a", while the diameter group >20.0 cm had the biggest distribution with type "b" and 6.0~8.0 cm with type "c". Along with the increase of D.B.H, the type "a" had a decreasing trend although there was exception situation. Oppositely the type "b" had increasing trends. For type "c", along with the increase of D.B.H, increasing trend was found at first, then decreased.

2) Changes of decay states by species

The changes of decay states of stumps by species were showed in Table 8. For types including type "a", "b" and "c", significant difference was found among the species. Species such as *V. wrightii, C. doederleinii* and *S. confusa,* had only the decay state of type "a ", while the species such as *D. trifidus, S. glauca, H. cochinchinensis* and *Skimmia japonica,* had the decay state of type "c" only, and species such as *I. anisatum, D. dubia, N. nagi* and *L. acuminata,* had type "b" only. It could be concluded that most stumps including type "b" and type "c" had been decaying or completely decayed of the underground part of the stump. For the dominant species *C. sieboldii,* 14.7% of them remained in original state without any decays, and most of them were decaying or could not been seen.

Ⅳ. Discussion

Hirata et al (1979) reported that the survival rates of stumps 4 months after cutting varied with species and D.B.H. Shinzato et al (1994) had also revealed that the survival rates of stumps one year after cutting varied with species and life-form spectra. And the survival rates of MM stumps and big size of D.B.H ones were higher than those of N ones and small size of D.B.H ones were, respectively. In the present study, similar results were found. It showed that the mortality rates of stumps varied significantly with species and life-form spectra. Shineng (1990) reported that for Acacia mangium forest after 6-7 months the survived stumps didn't wither any more. However, in the present study, the total mortality rate of the stumps at the fifth year was 20.2%, which higher than that of first year (Shinzato T. et al, 1994). This suggested the mortality rate of stumps increased with years.

The mortality rates of stumps five years after cutting varied strongly with species. From Table 2, it suggested 37 species, which shared 59.7% of all species, had the mortality rates equal to or lower than 20.0%, whereas 9 species, which shared 14.5% of all species, had the mortality over 50.0%. For dominant species in volume before cutting such as *C. sieboldii, S. wallichii* ssp. *liukiuensis* and *S. octophylla,* due to low morality rates, the method using sprout natural regeneration to restore forest is appropriate. For dominant species in number of stems before cutting, such as *A. quinquegona, D. racemosum* and *M. sequinii,* had the mortality rates 16.9%, 14.9% and 46.5%, respectively. To *D.racemosum* and *A. quinquegona,* were also appropriate for sprout natural regeneration. But to *M. sequinii,* other methods must be considered simultaneously because of high mortality rate. However, species such as *E. osimensis* var. *kanehirae* and *T. ternata* were found dead without any living stumps. *D. trifidus* and *S. japonica,* had the most dead stumps. These four species may be inappropriate for sprout regeneration because of heavy mortality rates. Much attention should be paid to these species when the method of intensive cutting was used to restore the forest.

In this study, the result showed that small diameter stump group (D.B.H<2.0 cm) had the biggest distribution of type "a". Most stumps of them remained in original. On the other hand, bigger stumps shared the type "b" and "c". It is possible that bigger diameter stumps had highly xylemfied and had lager basal cut exposed in the air, which result in lower metabolism ability than smaller ones had. The decay states of stumps maybe related to the mortality rates of stumps and liability of death in the future. However, there have been few detailed studies about them. The further study is needed.

Acknowledgments

We would like to thank all staffs of University Forest, College of Agriculture, University of the Ryukyus, for their assistance in fieldwork. We are also indebted to students of College of Agriculture, University of the Ryukyus, for their assistance in field investigation. Special thanks to Kuroda Yasushi and Nakazono Masashi, students of College of Agriculture, University of the Ryukyus, for their help in field work. Great thanks to Mrs. Liu Fang, a lecturer of Central South Forestry University, China, for her assistance in managing and analyzing of database.

Literature cited

1. Aromoto M. and Sunakawa S., 1981. Studies on the working techniques of forest in the subtropical (VII). On the secondary succession after burning. The Science Bulletin of the College of Agriculture, University of the Ryukyus, No.**28**:339～344 (in Japanese).
2. Hirata E., Sunakawa S., Nishizawa M., Yamamori N., Aramoto M. and Taba K. 1979. Studies on the working techniques by selection system for the broad leaved forest in the subtropics (I)-- On the sprout percent and sprout number of a tree-- The Science Bulletin of the College of Agriculture, University of the Ryukyus, No.**26:**717～721(in Japanese).
3. Shineng H., 1990. Study on the effect of stump diameter and height on sprout regeneration in Mangium (*Acacia mangium*). Forest Research, vol.**3,** No.3:242-249 (in Chinese).
4. Shinzato T. 1988 Regeneration of *Castanopsis sieboldii* forest in Okinawa 3. Effects of shading on the growth of *C. sieboldii* seedings (preliminary report). The Science Bulletin of the College of Agriculture, University of the Ryukyus, No.**35**: 137～145(in Japanese).
5. Shinzato T. and Aramoto.M. 1995 The secondary succession of natural forest growth seven years after clearing in Iriomote Island, Ryukyus. Transaction of the Japanese Forestry Society, No.**106**: 347～350 (in Japanese).
6. Shinzato T., Miyagi S., Taba K., Hirata E. and Yamamori E. 1987 Regeneration of *Castanopsis sieboldii* forest. 2. Effects of temperature and storage on th e germination of *C.sieboldii* seeds. The Science Bulletin of the College of Agriculture, University of the Ryukyus, No. **34**: 199～208 (in Japanese).
7. Shinzato T., Taba K., Hirata E. and Yamamori N. 1994 The secondary succession of natural forest growth after clearing in Okinawa (I) Vegatation growth one year after the cutting, Transaction of the Japanese Forestry Society, No.**105**: 285～286 (in Japanese).

沖縄島におけるイタジイ優占の常緑広葉樹林の萌芽更新

Ⅰ．根株の枯死と腐朽に関する研究

新里孝和*、呉　立潮**、西端統宏*、田場和雄*、榎木　勉*、平田永二*

摘　要

与那演習林の天然生広葉樹林における皆伐５年後の天然更新の状況を調査した。調査根株は62種、1,893個体であった。全根株の20.2%は枯死し、萌芽枝が発生した根株のうち29.7%が健全、26.5%が部分腐朽、23.6%が枯死根株であった。根株の腐朽状態は樹種と胸高直径によって違いがみられた。枯死率は樹種、生活形による有意差が認められたが、斜面の位置と方位による差はなかった。枯死率と胸高直径の直径の関係は明らかでなかった。調査樹種のうち、２種は生存株が16種は枯死株がみられず、44種は生存株も枯死株もみられた。枯死率は37種が20.0%以下、16種が20.0%以上50.0%以下、9種が50.0%以上であった。沖縄島におけるイタジイの優占する常緑広葉樹林皆伐跡地の天然更新は主として萌芽によるものと考えられた。

* 琉球大学農学部附属演習林

** 中国中南林大学資源環境学院環境科学講座