論　文

Plant Succession on the Face of Slopes of Forest Roads (IV)*

The invasion and change of ligneous plants on road banking slopes in the warm-temperate zone

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林道のり面の植生遷移に関する研究(IV)

暖温帯地域の盛土のり面における木本植物の侵入と推移とについて

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要　旨　亜熱帯及び温帯地域における林道のり面の植生遷移を正確に把握するために，主として暖温帯林に位置する愛媛大学米野々演習林内と周辺との林道盛土のり面を利用して，1970年より1981年までの開設年別に5m×3mのコドラートを設定した。それらを利用して，木本植物の自然侵入の調査を実施し，若干の考察を加えた。その結果，のり面に撒布された木本植物の種子は，のり面の全体的あるいは局部的な土砂移動の停止とともに，発芽，生育を開始する。そして，侵入した木本植物は，経過年数が14年間と非常に短い期間内でもわずかながら推移していることが明らかになった。

Summary: In order to clearly understand plant succession on the face of slopes of forest roads in the subtropical and temperate zones, utilizing mainly the banking slopes of forest roads in the komenono University Forest of Ehime University and the surrounding forest situated in a warm-temperate zone, a 5m×3m quadrate was established every year opening of forest road between 1970 and 1981. The studies on natural invasion and utilization of ligneous plants was carried out. The results show that seeds of ligneous plants dispersed on the face of slopes initiate germination and growth thereby stopping the whole or partial movement of sediment. It was clarified that the invading ligneous plants under go a slight change in a short 14-year period.

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** University Forest　附属演習林

I. Introduction

The purpose of this study was to clarify the succession of vegetation in the district where the opening of forest roads is predetermined in the subtropical and temperate zones and then to determine a way of turf work, clarifying fundamental attention on the turf work executed on the face of slopes after the opening. The shape of the initial plant invasion on the face of slopes which becomes the starting point for plant succession is considered as follows: first the case in which invading plants germinate and fix stopping the movement of sediment, second the case in wich invading plants retard the movement of sediment, and third the case in which both cases progress in parallel (*6*).

The natural invasion of ligneous plants and their succession have been studied well in the execution areas of turf work on the face of slopes of forest roads in the subarctic and cool-temperate zones of Hokkaido, the Hokuriku district, the Tohoku district and others (*2～5, 14～19*). These were studied at the execution areas of erosion control work, and land slip. The execution areas of turf work on the face of slopes of expressways and general roads were studied in the subtropical and warm-temperate zones of west Japan, the Kanto and Kansai districts (*9～13, 20～32, 34,35*). However, these have been few detailed studies or analyses performed in the districts where turf work was neglected on the face of slopes of forest roads in the subtropical and temperate zones.

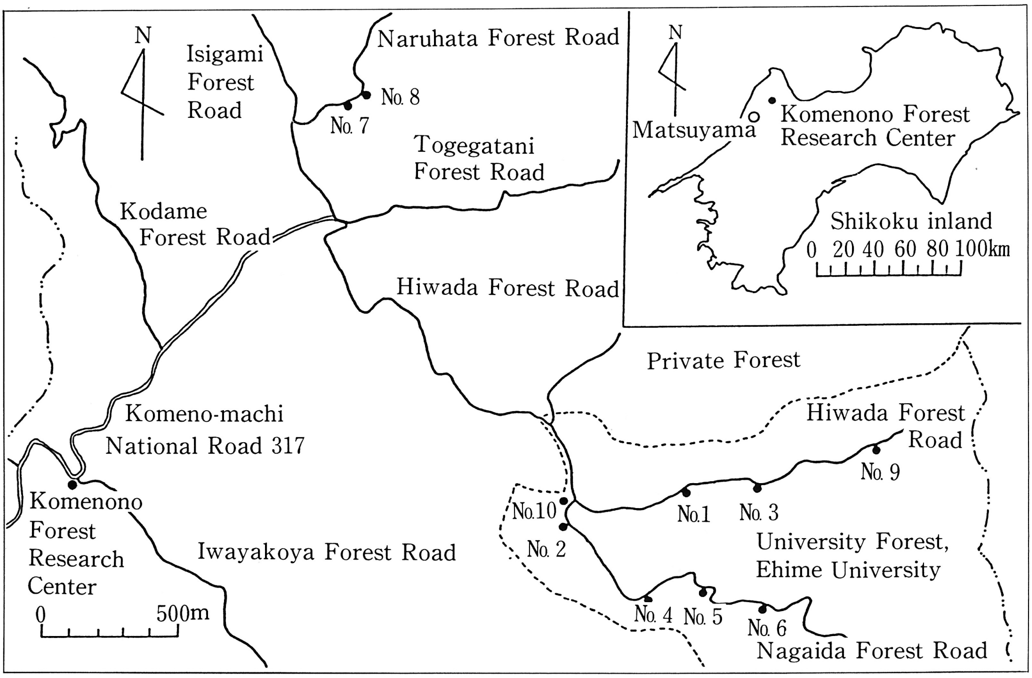

Fig. 1 Sketch map of the study area showing the locations of the 10 experimental plots

Therefore, in this report a study on the natural invasion of ligneous plants was carried out on the banking slopes of a forest road in the Komenono University Forest of Ehime University and the forest around the University Forest. The details of the invasion of herbaceous plants will be reported at some other time.

II. Methods

1. General condition of the study area

The study area was the banking slopes of forest roads opened in the years from 1970 to 1978 and 1981 in the Komenono University Forest of Ehime University and the forest around the University Forest, as shown in Figure 1. The study area was the face of slopes with 10m to 14m width, 4m to 40m length, and 21° to 42° angle of inclination which had not been turfed after opening. The elevation of the study area was 550m to 650m above sea level, and the gradient of the forest road was 8% to 12%, and the bedrock was grano diorite. The tree species in the neighbouring forest were mainly *Cryptomeria japonica* D. DON, *Chamaecyparis obtusa* SIEB. et ZUCC. and *Pinus densiflora* SIEB. et ZUCC., in plantations, and they were mainly *Quercus mongolica* FISCH., *Carpinus Tschonoskii* MAXIM., *Castanea crenata* SIEB. et ZUCC., *Quercus serrata* THUNB. and others in the secondary forest of the natural forest (*33*). The climate was the Seto Inland Sea type with an annual mean temperature of 12.2°C, a warmth index of 85.2°C•month, an annual precipitation of 1,946 ㎜ at the Komenono Forest Research Center, the University Forest, Ehime University (see Fig. 1) at 400m above sea level and situated about 2 ㎞ west and south-west of the study area (*7*).

2. Study methods

A 5m×3m quadrate was established on the face of slopes affected not at all by disaster, repair of forest roads and others after the opening in the study area, and all ligneous plants in this area were identified. Their base diameters, diameters at breast height (D. B. H) and heights were measured and these values were used in the analyses. Furthermore, invading ligneous plants were also indentified on the face of slopes outside the experimental plot. The establishment of the quadrate and the investigation were carried out from 5 October to 6 December in 1984 (Photo. 1～18).

III. Results and Discussion

1. Details of investigative results

The details of investigative results for each year are in shown Table 1. Coverage is 100% in all experimental plots except the first year. This fact indicates that when the condition is arranged, coverage of 100% with ligneous plants on the face of slopes is expected in about 6 years. The maximum height species of trees were mainly *Mallotus japonicus* MÜELLER, ARG., *Rhus javanica* LINN., although these were some broadleaf trees at the inital stage of invasion. Later, the broadleaf species with leaflets or thin-leaves increased and a gradual change of species occurred.

Table 1 Details of investigative results

Plot No.	1	2	3	4	5	6	7	8	9	10
Opening year of forest road	1970	1971	1972	1973	1974	1975	1976	1977	1978	1983
Passage years	14	13	12	11	10	9	8	7	6	1
Geology	Grano diorite	Grano diorite	Grano diorite	Grano diorite	Grano diorite	Grano diorite	Grano diorite	Grano diorite	Grano diorite	Grano diorite
Length of slope (m)	5	7	5	4	6	5	5	4	5	10
Situation in the basin	Mid-slope	Mid-slope	Mid-Slope	Mid-slope	Mid-slope	Mid-slope	Mid-slope	Mid-slope	Mid-slope	Mid-slope
Angle of inclination	40°	42°	40°	38°	36°	28°	21°	28°	36°	36°
Direction	N14°E	N60°E	N20°E	N55°W	N10°E	N24°E	N20°E	S50°W	N26°W	S30°W
Area of investigation (m²)	5 × 3	5 × 3	5 × 3	5 × 3	5 × 3	5 × 3	5 × 3	5 × 3	5 × 3	5 × 3
Soil hardness	13～15	10～18	15～18	13～16	15～18	10～13	16～18	10～16	15～18	13～16
Tree number	18	15	52	41	16	30	45	112	37	36
Number of species	7	5	12	8	9	11	8	17	14	5
Mean height (m)	5.41	3.23	1.37	1.36	3.04	2.26	2.51	1.14	1.19	0.12
Mean of the base diameter (cm)	9.16	8.33	3.29	2.46	3.76	4.10	4.57	1.60	3.31	0.30
Maximum height of tree (m)	11.95	10.55	6.20	4.85	6.71	7.48	8.07	5.67	5.54	0.33
Species of the maximum height of tree	*Fagara ailanthoides* ENGL.	*Albizzia Julibrissin* DURAZZINI	*Lindera erythrocarpa* MAKINO	*Clerodendron trichotomum* THUNB.	*Fagara ailanthoides* ENGL.	*Rhus javanica* LINN.	*Rhus javanica* LINN.	*Rhus japanica* LINN.	*Rhus japanica* LINN.	*Mallotus japanicus* MÜELLER, ARG.
Dominant species	*Stachyurus praecox* SIEB. et ZUCC.	*Rhus javanica* LINN. *Philadelphus satsumanus* MIQ.	*Parabenzoin trilobum* NAKAI	*Morus bombycis* KOIDZ. *Acer rufinerve* SIEB. et ZUCC.	*Acer rufinerve* SIEB. et ZUCC.	*Morus bombycis* KOIDZ.	*Philadelphus satsumanus* MIQ.	*Acer palmatum* T. subsp. *Matsumurae* KOIDZ.	*Cornus macrophylla* WALLICH *Pterostyrax hispidus* SIEB. et ZUCC. *Aralia elata* SEEM.	*Mallotus japonicus* MÜELLER, ARG.
Rate of number (%)	50.00	33.33	42.31	34.15	25.00	20.00	31.11	30.36	13.51	86.11
Characteristics	Deciduous shrub	Deciduous tree and shrub	Deciduous shrub	Deciduous tree	Deciduous tree	Deciduous tree	Deciduous shrub	Deciduous tree	Deciduous trees and tree	Deciduous tree
Coverage (Vagetation cover %)	100	100	100	100	100	100	100	100	100	15
Total of basal area at the base diameter (cm²)	1,184.25	817.72	441.70	195.43	177.30	395.66	737.40	223.86	318.11	2.52

Table 2 Detailed list of invading ligneous plants

No.	Species	Characteristics	1	2	3	4	5	6	7	8	9	10	Total
	Plot No.		1	2	3	4	5	6	7	8	9	10	
	Opening year of forest road		1970	1971	1972	1973	1974	1975	1976	1977	1978	1983	Total
	Passage years		14	13	12	11	10	9	8	7	6	1	
1	*Carpinus Tschonoskii* MAXIM.	A								1			1
2	*Castanea crenata* SIEB. et ZUCC.	A			1	1							2
3	*Quercus serrata* THUNB.	A								1			1
4	*Morus bombycis* KOIDZ.	A				10		6					16
5	*Euptelea polyandra* SIEB. et ZUCC.	A					1	2					3
6	*Magnolia obovata* THUNB.	A					1						1
7	*Albizzia Julibrissin* DURAZZINI	A		2				2		1			5
8	*Cladrastis platycarpa* MAKINO	A									1		1
9	*Fagara ailanthoides* ENGL.	A	1		1		1				1	1	5
10	*Mallotus japonicus* MÜELLER, ARG.	A	1	2			1	4	3	6	4	30	51
11	*Rhus javanica* LINN.	A	1	5	4		2	3	8	8	4		35
12	*Ilex macropoda* MIQ.	A			2				6		2		10
13	*Acer palmatum* T. subsp. *Matsumurae* KOIDZ.	A								34			34
14	*Acer rufinerve* SIEB. et ZUCC.	A				10	4	1		6	1		22
15	*Cornus macrophylla* WALLICH	A	3		4		3	2		8	5	1	26
16	*Pterostyrax hispidus* SIEB. et ZUCC.	A						1			5		6
17	*Lindera erythrocarpa* MAKINO	B			3					4			7
18	*Styrax japonicum* SIEB. et ZUCC.	B				4		1			3		8
19	*Broussonetia Kazinoki* SIEB.	C					1		1	3	1		6
20	*Parabenzoin trilobum* NAKAI	C			22								22
21	*Philadelphus satsumanus* MIQ.	C	2	5	1	2	2	3	14	18	2	1	50
22	*Stachyurus praecox* SIEB. et ZUCC.	C	9	1					7	6	2		25
23	*Edgeworthia papyrifera* SIEB. et ZUCC.	C				8							8
24	*Aralia elata* SEEM.	C							3	1	5	1	10
25	*Rhododendron decandrum* MAKINO	C								5			5
26	*Clerodendron trichotomum* THUNB.	C				5					1		6
27	*Sambucus racemosa* L. subsp. *Sieboldiana* HARA	C	1										1
28	*Cryptomeria japonica* D. DON	D			3					4			7
29	*Neolitsea sericea* KOIDZ.	D								1			1
30	*Camellia japonica* LINN.	D			1								1
31	*Cephalotaxus Harringtonia* K. KOCH	E			4	1		5	3				13
32	*Ligustrum japonicum* THUNB.	E			6							2	8
33	*Eurya japonica* THUNB.	F								5			5
Total	28 families 32genera 33 species		18	15	52	41	16	30	45	112	37	36	402

Notes : A Deciduous tree, B Deciduous sub-tree, C Deciduous shrub, D Evergreen tree, E Evergreen sub-tree, F Evergreen shrub

2. Number of invading ligneous plants

The detailed list of investigative results for each year are shown in Table 2. The total of invading ligneous plants was 402 trees belonging to 33 species, 32 genera and 18 families, and in them the total of *Philadelphus satsumanus* MIQ., invading all experimental plots, was 50 trees, and it was counted many as the second, following the highest number-51 of *Mallotus japonicus* MÜELLER, ARG.. Eighty-two per cent of the invading species, that is, 91% of the total, were deciduous broadleaved trees, and evergreen trees were 6 species: *Neolistea sericea* KOIDZ., *Camellia japonica* LINN., *Cryptomeria japonica* D. DON, *Ligustrum japonicum* THUNB. *Cephalotaxus Harringtonia* K. KOCH and *Eurya japonica* THUNB., and the total was low. This is mostly likely due to the fact that this district belongs to the deciduous broadleaved forest zone. The species of ligneous plants invading outside the experimental plot were 12 species. The details are shown in Table 3. Furthermore, the total in the neighbouring natural

Table 3 Number of invading ligneous plants outside the experimental plots

No.	Species	Characteristics
1	*Pinus densiflora* SIEB. et ZUCC.	Evergreen tree
2	*Platycarya strobilacea* SIEB. et ZUCC.	Deciduous tree
3	*Prunus Jamasakura* SIEB.	Deciduous tree
4	*Acer mono* M. form. *heterophyllum* NAKAI	Deciduous tree
5	*Acer Sieboldianum* MIQ.	Deciduous tree
6	*Shirakia japonica* HURUSAWA	Deciduous sub-tree
7	*Salix Saidaeana* SEEM.	Deciduous shrub
8	*Deutzia crenata* SIEB. et ZUCC.	Deciduous shrub
9	*Deutzia gracilis* SIEB. et ZUCC.	Deciduous shrub
10	*Callicarpa japonica* THUNB.	Deciduous shrub
11	*Weigela floribunda* K. KOCH.	Deciduous shrub
12	*Caesalpinia japonica* SIEB. et ZUCC.	Deciduous twining shrub
Total	5 families 9 genera 12 species	

Table 4 Number of ligneous plants

Area \ Families, Genera, Species	Families	Genera	Species
Experimental plots	28	32	33
Whole on banking slopes	33	41	45
Natural broadleaved tree forest (a 40-year-old)	31	88	65
Whole of University Forest	68	134	250

broadleaved forest and whole University Forest is shown in Table 4. Inasmuch as the total of trees in the University Forest includes 250 species, 134 genera and 68 families, it results in that about 13% of the species of the total invaded for 14 years (*33*). In addition, although broadleaved trees in the neighbouring forest of this experimental area are mainly *Quercus mongolica* FISCH., *Carpinus Tschonoskii* MAXIM., *Quercus serrata* THUNB., *Castanea crenata* SIEB. et ZUCC., *Styrax japonicum* SIEB. et ZUCC., *Zelkowa serrata* MAKINO, *Clethra barbinervis* SIEB. et ZUCC., *Prunus Jamasakura* SIEB., *Pterostyrax corymbosus* SIEB. et ZUCC., and others, these species are few in invading ligneous plants. Accordingly, it is considered that judging from bird droppings and animal tracks, a few seeds of the germinated ligneous plants were dispersed by wind and others from the surrounding broadleaved forest, but almost all seeds were transported by birds and animals.

3. *Number of species and passage years, and rate of dominant species and passage years*

The relationship between the number of species and passage years is shown in Figure 2.

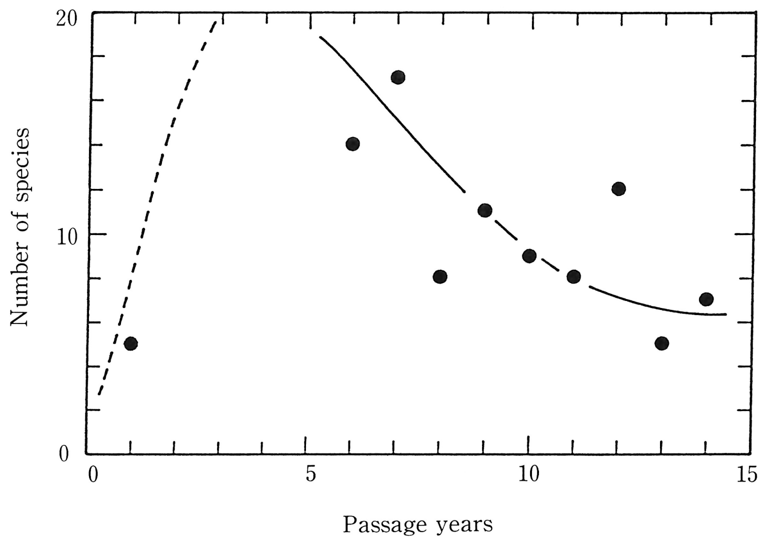

Fig. 2 Relationship between the number of species and passage years

Although a conclusion cannot be made because of the lack of data from the 2nd to the 5th year, the number of species increases with passage years and reaches a peak in about 3 to 4 years, then decreases, However, with regard to the pattern of general succession, it is considered that it may increase again with the invasion of tolerant species (*18*). It is considered that although the invading seeds germinated and fixed successively with the stop of movement of sediment wholly and partially, and the germination and the fixation finished in the 3rd or 4th year, they were naturally selected by the difference in growth gradually and tended to decrease. The relationship between the rate of dominant species to the total number and passage years is shown in Figure 3. The tendency reversed to the relation with number of species was shown, but in regard to that the decrease of number of species results naturally

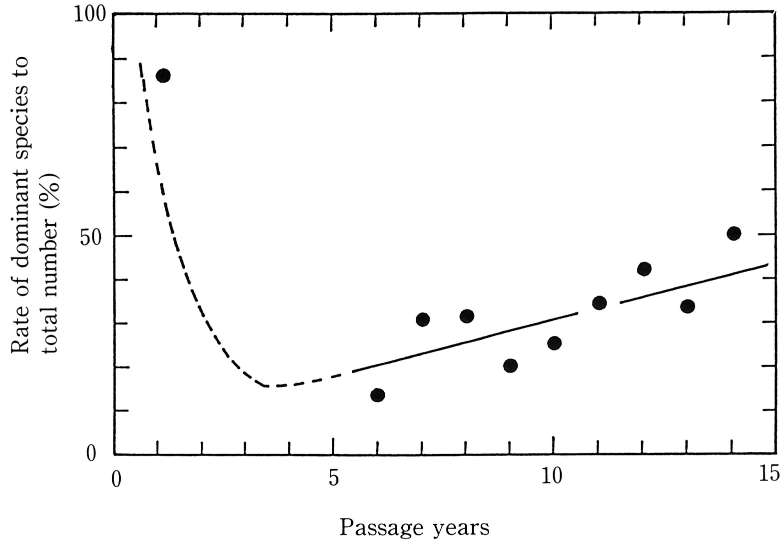

Fig.3 Relationship between the rate of dominant species to total number and passage years

in the increase of dominant species rate to the total number, which is considered understandable.

4. Mean height, maximum height, total tree number and passage years

The relationships among mean height, maximum height, total tree number and passage years are shown in Figure 4. Although mean height and the maximum height increase with passage years, a constant relationship was not found for the total tree number. In this

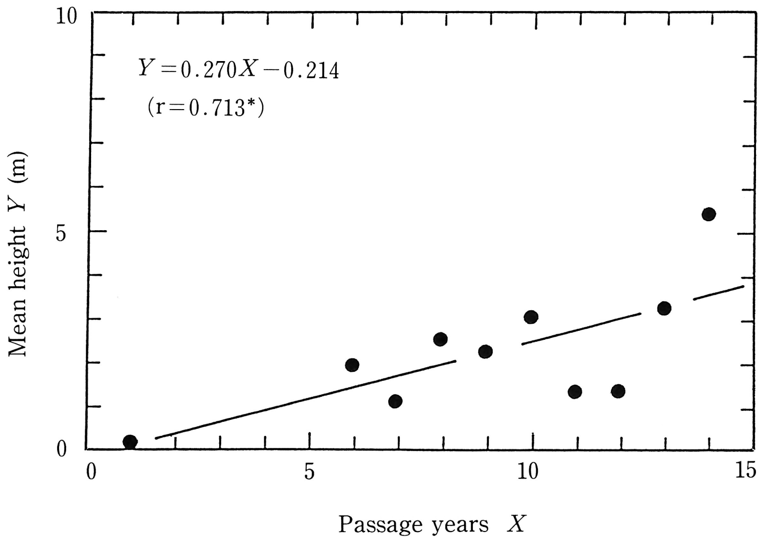

Fig. 4-1 Relationship between mean height and passage years

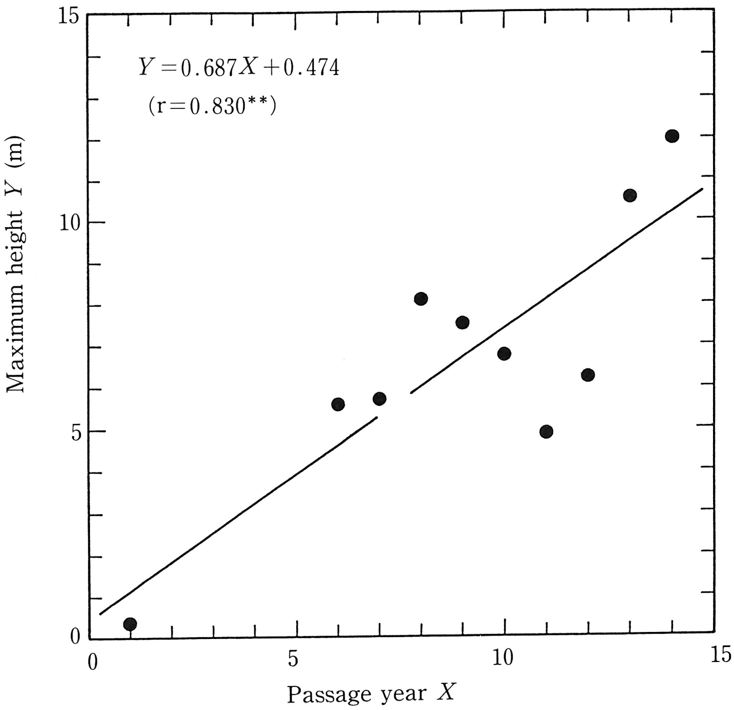

Fig. 4-2　Relationship between the maximum height and passage years

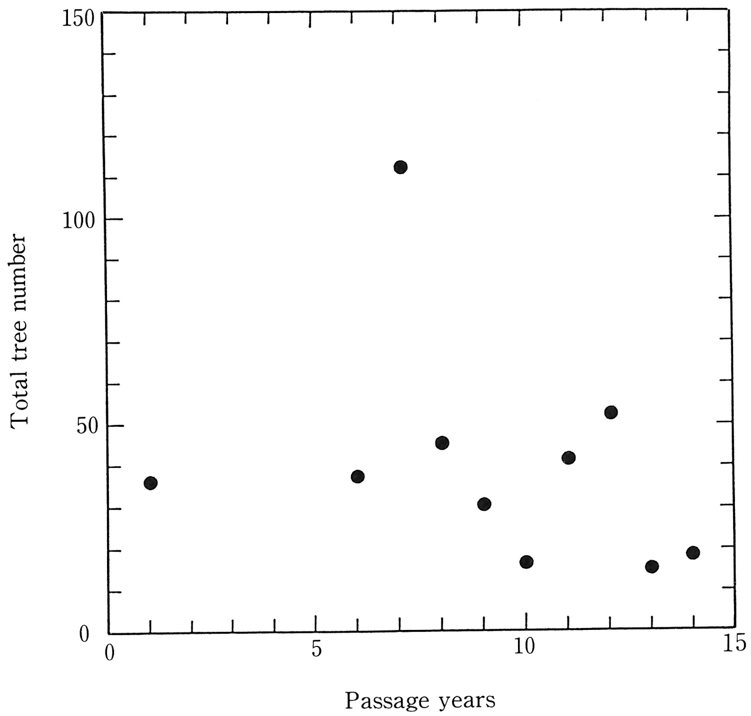

Fig. 4-3　Relationship between the total tree number and passage years

study, the direction of slope was not considered, but the growth of plants is affected by the direction of slope (*2, 30*). Accordingly, it is considered that in regard to slope direction, the more distinct relationship is recognized between mean height, maximum height and passage years. It is presumed that a constant relationship may be recognized also between the total tree number and passage years.

5. Total of basal area at the base diameter and passage years

The relationship between the total of basal at the base diameter and passage years is shown in Figure 5. The total of basal area at the base diameter increases with passage years (age of stand), and it is assumed to be proportional to the square of the passage year. From this fact it is judged that ligneous plants naturally invading the banking slope show allometry as well as the even-aged uniform forests *Crypotmeria japonica* D. DON and *Chamaecyparis obtusa* SIEB. et ZUCC. in plantations (*1*). Such an allometry means that there is little difference in passage years (age of stand) of ligneous plants invading every slope. Accordingly, it is presumed that ligneous plants invaded in the short period after the stop of whole or partial movement of sediment on the face of slopes.

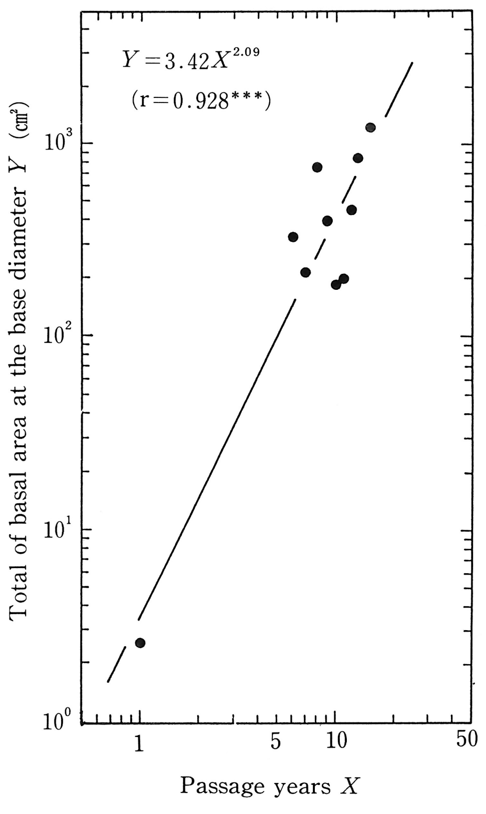

Fig. 5 Relationship between the total of basal area at the base diameter and passage years

6. Basal area at the base diameter, tree number and passage year, and tree species

The relationships among basal area at the base diameter, tree number and passage years, and tree species are shown in Figure 6. The tendency that the basal area at the base dimeter increases and the number of tree species decreases with passage years has been previously mentioned. It appears that few if any of the tree species and its number have not direct relation to the size of the basal at the base diameter, but the peculiarity of each ligneous plant to become a tree (generally height over 7m), sub-tree (2 to 7m) or shrub (under 2m) greatly affects the basal area at the base diameter.

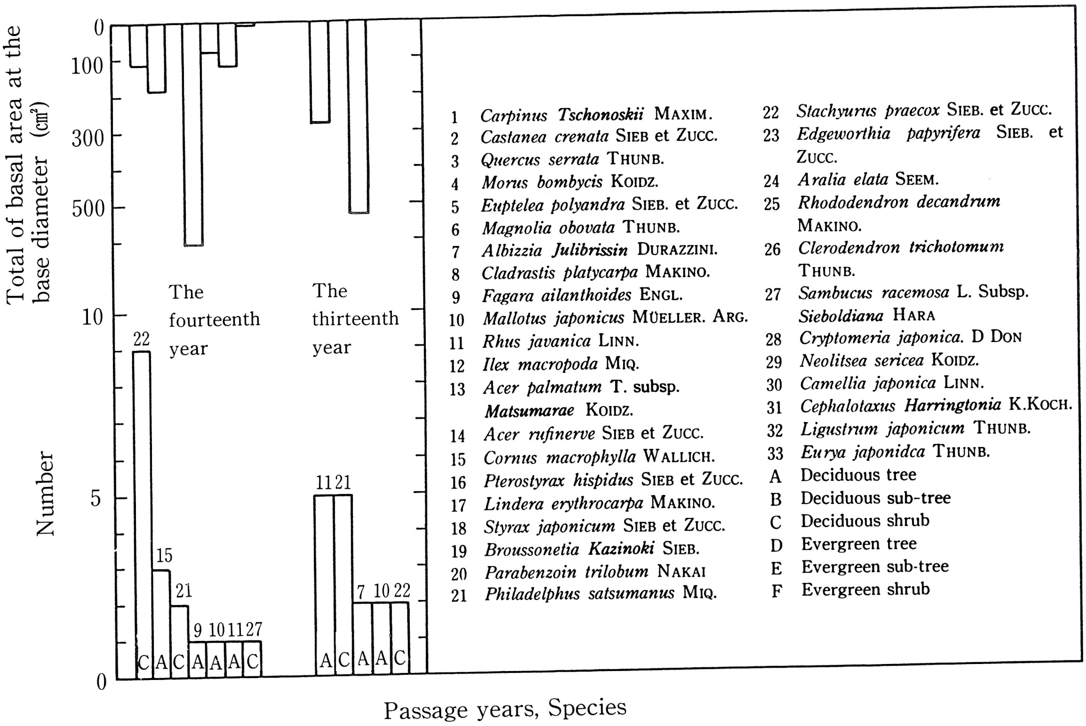

Fig. 6-1 Relationships between the total of basal area at the base diameter, number and passage years, and species

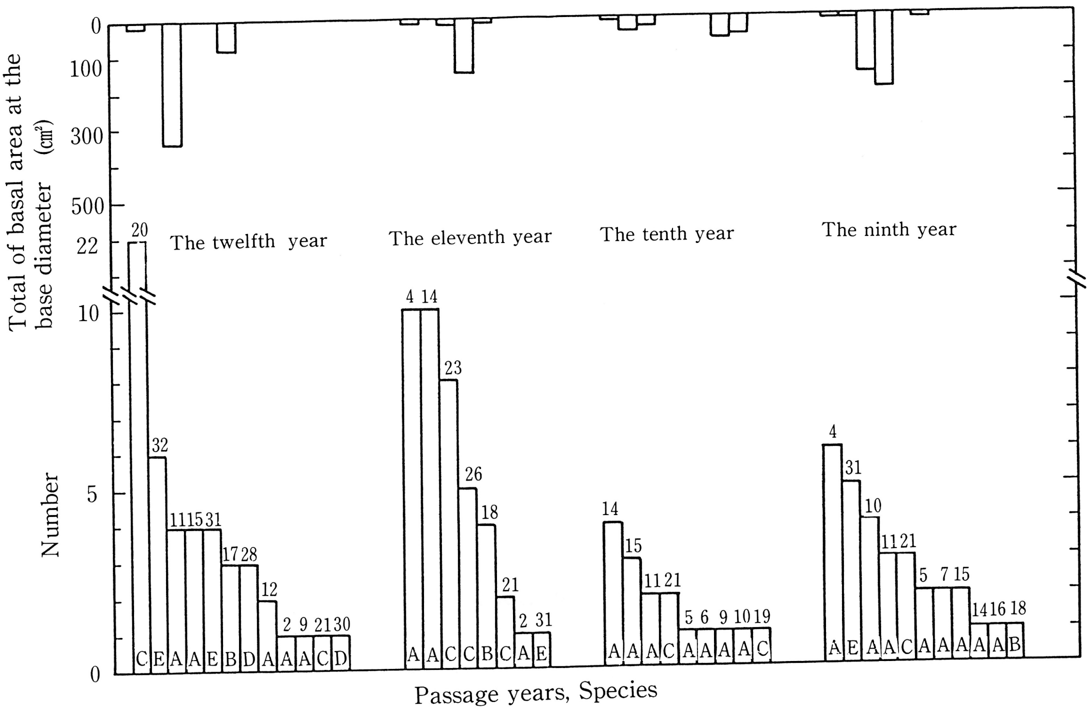

Fig. 6-2 Relationships between the total of basal area at the base diameter, number and passage years, and species

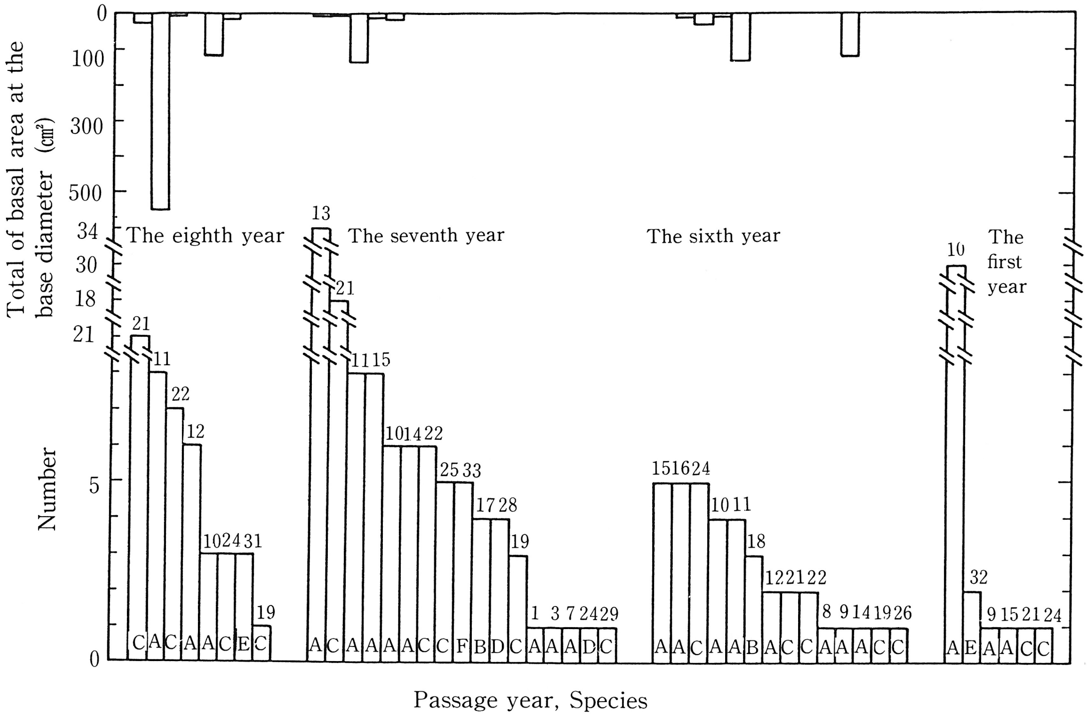

Fig. 6-3 Relationships between the total of basal area at the base diameter, number and passage years, and species

IV. Conclusions

Invasion and change of ligneous plants on the banking slopes of forest road were considered on the basis of investigative results. The conclusions obtained by this investigation are as follows.

1. The species changes even in such a short period as 14 years.
2. The seeds of invading ligneous plants are transported from the surrounding forest.
3. The number of species shows the tendency to attain a maximum value during the 3rd and 4th year after a stop of movement of sediment on the face of the slopes and then decreases.
4. Ligneous plants are the invader in the short period after the stop of whole or partial movement of sediment.
5. The peculiarity of each ligneous plant to become tree, sub-tree and shrub greatly affects the basal area at the base diameter of the invadnig ligneous plants.

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Literature cited

(*1*) ANDO, T., SAKAGUCHI, K., NARITA, T. and SAITO, S. : Growth analysis on the natural stands of Japanese Red Pine (*Pinus densiflora* SIEB. et ZUCC.) 1. Bull. Gov. For. Exp. Stn. **144** : 1～30, 1962*

(*2*) ARAYA, T., YAJIMA, T. and NAITO, M. : Slope failure and vegetation on the face of forest road. Res. Bull. Exp, For. Hokkaido Univ. **37**(1) : 165～208, 1980*

(*3*) ———, ——— and KATSURO, H. : Invasion of trees on the cutting slopes of forest roads. Res. Bull. Exp. For. Hokkaido Univ, **37**(3) : 631～674, 1980*

(*4*) ———, KATSURO, H., YAJIMA, T. and HASHIDA, K. : Invasion of plants on the slopes of road with the artificial vegetation works. Res. Bull. Exp. For Hokkaido Univ. **38**(1) : 1～30, 1981*

(*5*) ——— : (Invasion of plants on the face of forest road.) Ringyo Gijutsu **506** : 17～20, 1984*

(*6*) EZAKI, T. : Studies on the conservation of the face of slopes of the forest roads. Bull. Ehime Univ. For. **21** : 1～116, 1984*

(*7*) FUJIHISA, M. : (Results of meteorological observation in 1984 at the Komenono Forest Research Center, the University Forest, Ehime University.) Bull. Ehime Univ. For. **23** : 164, 1984**

(*8*) HACHIYA, K. : (Ecological view of forest.) 97pp, Japan Forest Technical Association, Tokyo, 1970**

(*9*) KATO, H. : The growth progress of planting trees on artificial slopes. Rep. Res. Landscaping Slopes **3** : 15～26. 1981*

(*10*) KOBASHI, S., SHIMAZU, H, YOSHIDA, H, SASAKI, T. and SASAKI, I. : Stability and vegetation recovery of cutting slopes on Asiu forest road. Bull. Kyoto Univ. For. **51** : 164～174, 1979*

(*11*) ——— : A forecasting method of the vegetation growth and its change on slopes. Rep. Res. Landscaping Slopes **3** : 1～14. 1984**

(*12*) ——— : A forecasting method of the vegetation growth and its succession on slopes (2). Rep. Res. Landscaping Slopes **4** : 1～16, 1982**

(*13*) ———, MORIMOTO, Y., YOSHIDA, H. KOBASHI, T. and SAKAMOTO, K : Soil conditions for vegetation growth on man-made slopes (1). Rep. Res. Landscaping Slopes **4** : 36～66, 1982**

(*14*) KITAHARA, H., MASHIMA, Y. and SHIMIZU, A. : Early process of invasion of trees on the cut slopes of forest roads (1). J. Jpn. For. **68** : 171～176, 1986**

(*15*) MARUYAMA, K. : Secondary succession on cutting slopes of forest road in Nukumidaira, located at the footbase of Iede Mts. Yamagata Prefecture (I). Bull. Niigata Univ. For. **12** : 43～63, 1979*

(16) ———, DOI, I., ISHIKAWA, M. and SHIDA, T. : Secondary succession on cut slopes of forest roads in Nukumi-daira at the base of the Iide Mountains, Yamagata Prefecture (II). J. Jpn. For. Soc. **64** : 429～437, 1982*
(17) ———, SHIDA, T., ISHIKAWA, M. and ASAI, Y. : Secondary succesion on cut slopes of forest roads in Nukumi-daira, at the base of the Iide Mountains, Yamagata Prefecture (III). J. Jpn. For. Soc. **66** : 43～51, 1984*
(18) ———, ———, ——— and ——— : Secondary succession on cut slopes of forest roads in Nukumi-daira, at the base of the Iide Mountains, Yamagata Prefecture (IV). J. Jpn. For. Soc. **66** : 83～91, 1984*
(19) ———, ISHIKAWA, T., ISHIKAWA, M. and ASAI, Y. : Secondary succession on cut slopes of forest road in Nukumi-daira, at the base of the Iide Mountains, Yamagata Prefecture (V). J. Jpn. For. Soc. **66** : 219～228, 1984*
(20) MASUDA, T. : Vegetation on the roadside cutting slopes in Shikoku (1). Rep. Res. Landscaping Slopes **4** : 16～26, 1982**
(21) ——— : Vegetation on the roadside cutting slopes in Shikoku (2). Rep. Res. Landscaping Slopes **4** : 27～35, 1982**
(22) MOROMISATO, H., SHINZATO, T. and NAKATA, E. : (Studies on the plant succession on the face of motor road in Okinawa. The Association of Forest Ecology Research, Faculty of Agriculture, Ryukyu University.) 1～91, 1981**
(23) MORIMOTO, T. : The recovering process of richness of the soil on artificial slopes of tree planting. Rep. Res. Landscaping Slopes **3** : 27～41, 1981**
(24) ———, KOBASHI, S. and YOSHIDA, H. : Effects of planting density and soil improving tree on the forest establishment. An interim report of the experimental artificial slopes of tree planting, Koga. Bull. Revegetation Research **7** : 138～155, 1985*
(25) NAKAMURA, T. : Vegetation recovery of landside scars in the upper reaches of the Oi River, Central Japan. J. Jpn. For. Soc. **66**(8) : 328～332, 1984
(26) ——— : Seed dispersal on a landside scars on the upper reaches of the Oi River, Central Japan. J. Jpn. For. Soc. **66**(99) : 375～379, 1984
(27) OMURA, H., SHIBATA, M. and TAKAHASHI, T. : On the effect to forest by earth and newly founded road. Trans. 87th Mtg. Jap. For. Soc. 369～370, 1976**
(28) OHTE, K., HONJYO, T., and SENOO, T. : Studies on the succession in the plant community established by executing the hill-side planting works 1. Scie. Rep. Kyoto Pref. Univ. Agr. **30** : 58～71, 1987*
(29) ———, and KATO, H. : Studies on succession in the plant communities established by executing the hill-side planting work II. Scie. Rep. Kyoto Univ. Agr. **31** : 78～92, 1979*
(30) ——— : A proposition for the method of estimation, to the vegetation established on the cutting slope of the forest road. Bull. Kyoto Pref. Univ. For. **26** : 52～71, 1982*
(31) SAKAMOTO, K. : Invasion of Pinus densifiora and its growth of early stage on cut slopes. Rep. Res. Landscaping Slopes **5** : 57～65, 1982**
(32) SHIMOKAWA, E. : (Vegetational recovery on land slip). Ringyo Gijutsu **496** : 23～26, 1983**
(33) TOKUI, O. and SAKAUE, M, : Notes on the trees and shrubs in tho"KOMENONO" University Forest. Bull. Ehime Univ. For. **2** : 27～54, 1964**

(*34*) YOSHIDA, H. : Studies on landscape evaluation of roadside cutting slopes. Rep. Res. Landscaping Slopes **3** : 50～109, 1981**
(*35*) ———, MORIMOTO, Y. and KOBASHI, S. : The problems for revegetation on road slopes of Express-way in Inland-Sea Area. Bull. Revegetation Research **8** : 129～149, 1986*

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** Only in Japanese
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Photo. 1 Experimental plot No.1 on banking slope of forest road construction in 1970 (Dec. 5, 1984)

Photo. 2 Experimental plot No.1 on banking slope of forest road construction in 1970 (Oct. 6, 1985)

Photo. 3 Experimental plot No.2 on banking slope of forest road construction in 1971 (Dec. 5, 1984)

Photo. 4 Experimental plot No.2 on banking slope of forest road construction in 1971 (Oct. 6, 1985)

Photo. 5 Experimental plot No.3 on banking slope of forest road construction in 1972 (Oct. 6 1985)

'Photo. 6 Experimental plot No.3 on banking slope of forest road constrution in 1972 (July 25, 1986)

Photo. 7 Experimental plot No.4 on banking slope of forest road construction in 1973 (Dec. 5, 1984)

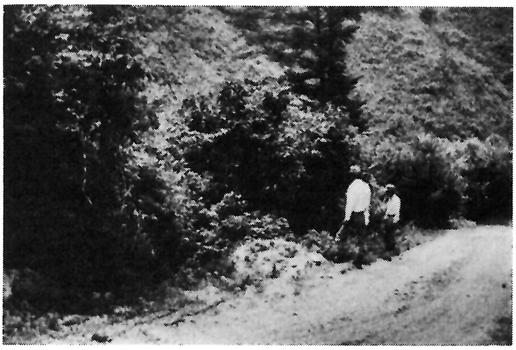

Photo. 8 Experimental plot No.4 on banking slope of forest road construction in 1973 (Oct. 6, 1985)

Photo. 9 Experimental plot No.5 on banking slope of forest road construction in 1974 (Dec. 5, 1984)

Photo. 10 Experimental plot No.5 on banking slope of forest road construction in 1974 (Oct. 6, 1985)

Photo. 11 Experimental plot No.6 on banking slope of forest road construction in 1975 (Dec. 5, 1984)

Photo. 12 Experimental plot No.6 on banking slope of forest road construction in 1975 (Oct. 6, 1985)

Photo. 13 Experimental plot No.7 on banking slope of forest road construction in 1976 (Oct. 6, 1985)

Photo. 14 Experimental plot No.8 on bankng slope of forest road construction in 1977 (Oct. 6, 1985)

Photo. 15 Experimental plot No.9 on banking slope of forest road construction in 1978 (Dec. 5, 1984)

Photo. 16 Experimental plot No.9 on banking slope of forest road construction in 1978 (Oct. 6, 1985)

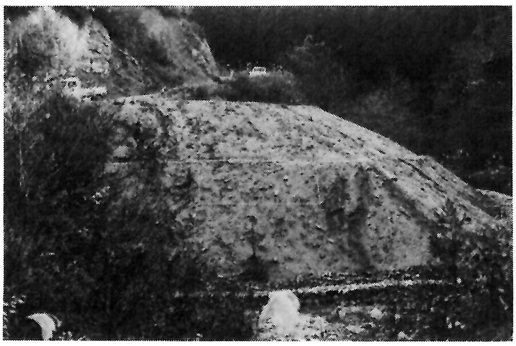

Photo. 17 Experimental plot No.10 on banking slope of forest road construction in 1983 (Dec. 5, 1984)

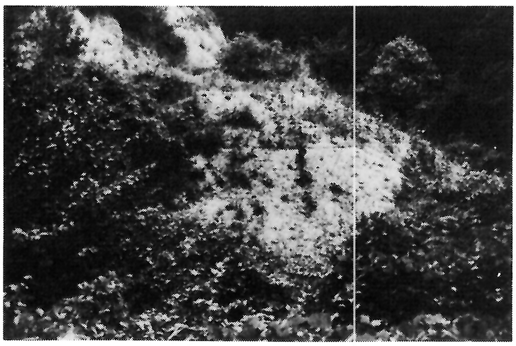

Photo. 18 Experimental plot No.10 on banking slope of forest road consturction in 1983 (Oct. 6, 1985)