論　文

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

The growth processes of invading woody plants and degree of soil formation 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(Ⅶ)

暖温帯地域の盛土のり面における侵入木本植物の生長過程と土壌化の程度について

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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、1984年10月に主として暖温帯林に位置する愛媛大学農学部米野々森林研究センターと周辺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5 m×3 mのコドラートを設定した。すでに、コドラート内の侵入木本植物の葉の形態、種数および優占種の変化から、わずかながらも植生遷移が進行していることは、明らかにしている。今回は、のり面に自然侵入した木本植物の詳細な植生遷移とそれに影響を及ぼすのり面の土壌化の程度を正確に把握するために、コドラート近辺の侵入木本植物の樹幹析解とその周辺で土壌調査を実施した。その結果、侵入した木本植物の生長過程にも、経過年数が15年間と非常に短いにもかかわらず、わずかながらも植生遷移の影響がうかがわれた。また、盛土のり面の土壌化は、経過年数の増加と共に、指数関数的に進行しており、コドラート内の侵入平均木の根元直径との間には、正の相関関係が認められた。

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** University Forest　附属演習林

Summary: In order to clearly understand plant succession on the face of slopes of forest roads in subtropical and temperate zones, utilizing mainly the banking slopes of a forest road in the Komenono Forest Research Center, the University forest, Ehime University and the surrounding forest situated in a warm-temperate zone, a 5m×3m quadrat was established for every year of clearing of forest road between 1970 and 1981. Stem analysis of invading woody plants and a soil survey carried out around these plants were done in order to clarify the succession of woody plants invading the banking slopes of forest roads and the degree of soil formation on the slopes which in turn affects plant succession. The results obtained revealed that the invading woody plants changed gradually within a very short period of only 15 years. Soil formation on the face of slopes progressed exponentially with time and showed a positive interrelationship with the mean diameter at ground level of the invading trees.

I. Introduction

The purpose of this study was to clarify the succession of vegetation in a district where the clearing of forest roads is predetermined in a subtropical and temperate zone and then to determine a method of turf work, focusing fundamental attention on the turf work executed on the face of slopes after clearing (*2~6*).

In our previous studies (*3,5*), the form of invading vegetation, the changes occurring after invasion, and the time of invasion were precisely determined in relation to the year of clearing for forest roads. In the present investigation, a stem analysis of tree of the mean diameter at ground level, used for estimating the year of invation, and a survey of the soil around these trees, were performed. On the basis of the data obtained, we were able to form some conclusions about the growth process of invading woody plants and the degree of soil formation associated with it.

II. Materials and Methods

The stem analysis was made on trees of the mean diameter at ground level which were felled on October 9, 1985 and which were analyzed in previous studies (*3,5*). The stem analysis was done by collecting trunk disks at intervals of 1m and by employing the sectional measurement of Huber. The general conditions of trees used for the stem analysis and their surroundings are shown in Table 1. The soil survey, based on a method in a handbook for soil surveys of national forest land, was conducted in the areas around felled trees with a mean diameter at ground level on October 8, 1986.

Table 1 Outline of stem analysis trees and general condition of surroundings

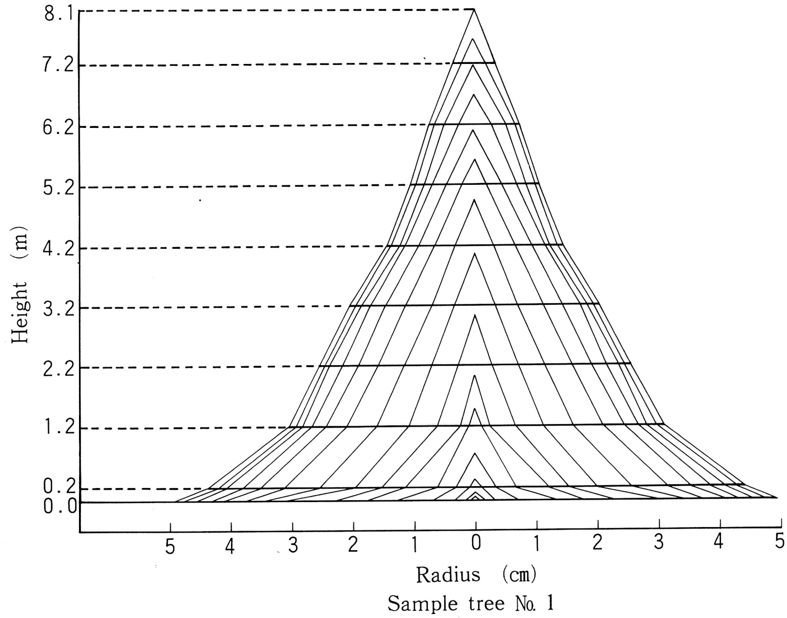
Plot No.		1	2	3	4	5	6	7	8	9	10
Clearing year of forest road	(yr)	1971	1972	1973	1974	1975	1976	1977	1978	1979	1984
Passage of time	(yrs)	15	14	13	12	11	10	9	8	7	2
Soil hardness	(mm)	5	4	1	6	2	1	3	3	4	4
Thickness of accumulation	(cm)	200	200	85	30	200	70	80	40	75	600
Mean diameter at ground level in quadrat	(cm)	9.2	8.3	3.3	2.5	3.8	4.1	4.6	1.6	3.3	0.3
Diameter at ground level of sample tree	(cm)	10.9	8.1	4.5	2.2	4.1	4.3	4.9	2.1	3.3	0.3
Species		*Euptelea polyandra* SIEB. et ZUCC.	*Phellodendron amurense* RUPR.	*Mallotus japonicus* MÜELLER, ARG.	*Cornus macrophylla* WALLICH	*Acer rufinerve* SIEB. et ZUCC.	*Rhus javanica* LINN.	*Rhus javanica* LINN.	*Weigela floribunda* K. KOCH	*Euptelea polyandra* SIEB. et ZUCC.	*Ligustrum japonicum* THUNB.
Number of annual ring		15	11	12	11	10	9	8	8	5	2
Diameter at breast height	(cm)	6.2	7.5	3.1	1.3	2.1	2.9	2.9	1.0	2.5	——
Height	(m)	8.10	9.57	6.85	2.85	4.40	4.80	5.30	2.90	5.10	0.20
Stretch of branch: Up and down	(m)	3.60	3.30	1.70	1.10	2.40	2.70	2.70	1.00	2.30	0.10
Stretch of branch: Right and left	(m)	3.10	2.40	1.50	0.90	1.60	1.40	1.40	1.40	1.60	0.15
Stem volume ($\times 10^{-2} m^3$)		1.168	2.076	0.329	0.033	0.111	0.200	0.226	0.025	0.141	——

Ⅲ. Results and Discussion

1. The growth process of invading woody plants

Stem analysis was conducted on nine trees growing in nine different places, as shown in Table 1, and the results were divided into three groups by the growth process. We will thus discuss the results obtained on the basis of data for the 7th, 11th, and 15th years, with regard to each of the three groups. The results of the stem analyses are shown in Fig. 1, 2, 3 and 4.

The annual height growth increment of ***Euptelea polyandra*** SIEB. et ZUCC. in the area cleared in 1970 showed a maximum at three locations and had a tendency to decrease from 9 years after invasion. This tendency was also observed for *Acer rufinerve* SIEB. et ZUCC. in an area cleared in 1974, where the annual height growth increment was maximum at two locations with the same tendency to decrease from 8 years after invation.



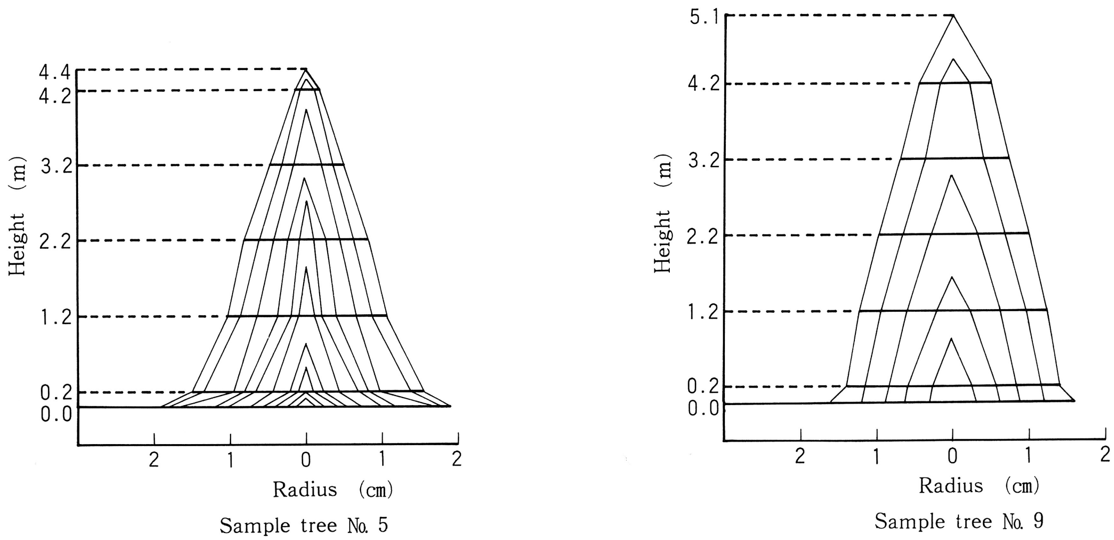


Fig. 1 Stem analysis of a sample tree No. 1, No. 5 and No. 9

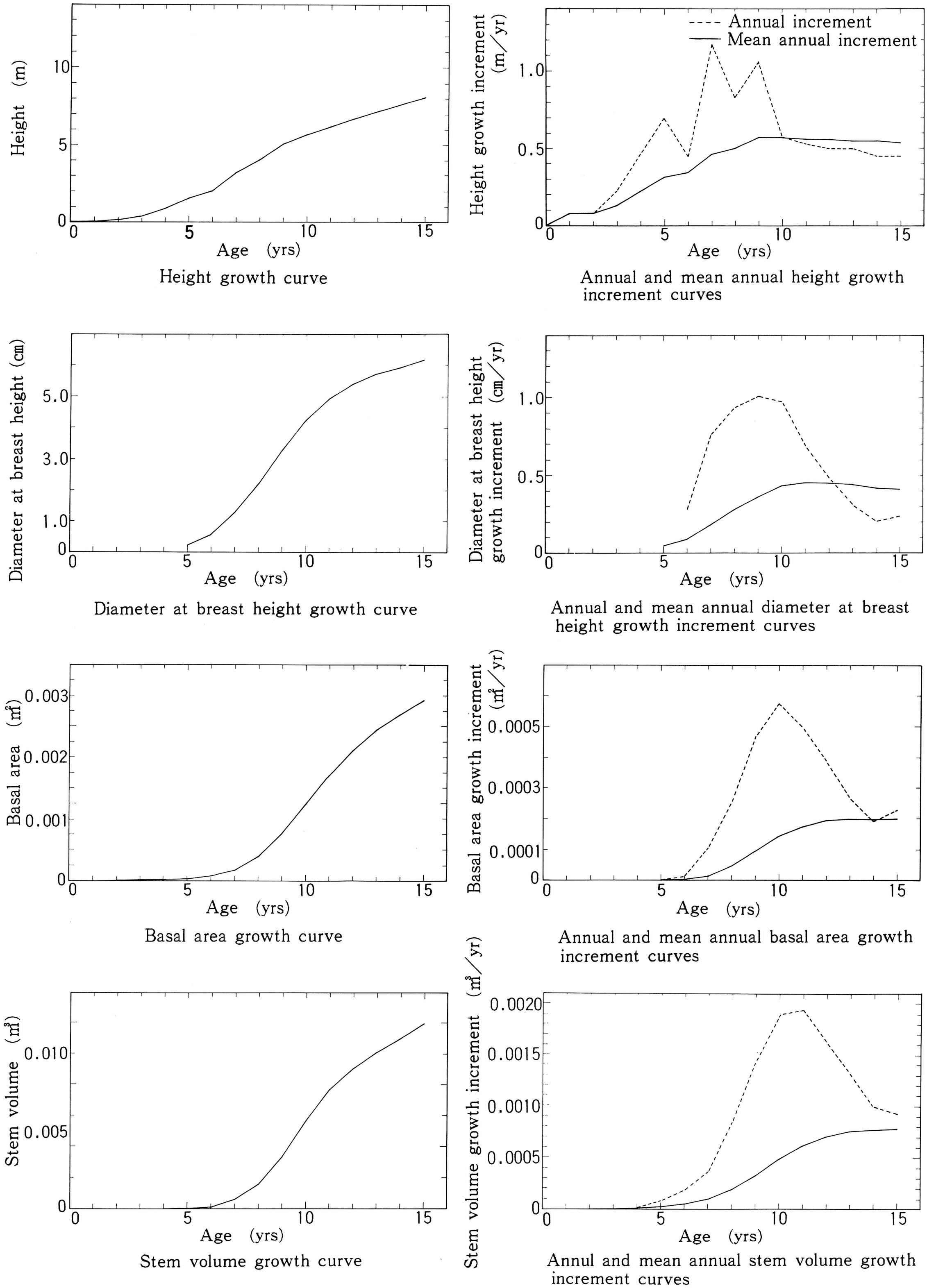


Fig. 2 Growth curves of a *Euptelea polyandra* SIEB. et ZUCC. (Sample tree No. 1)

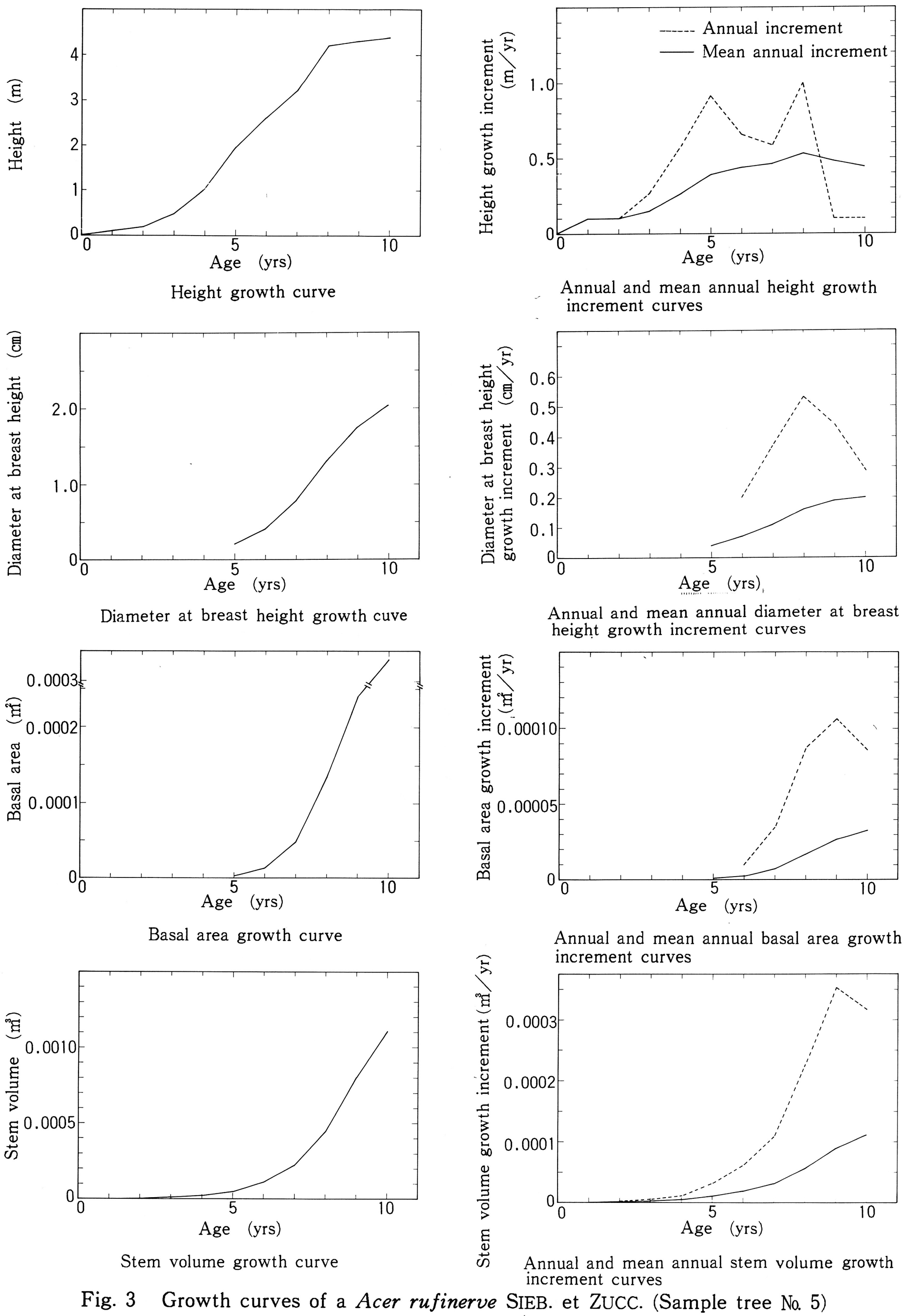
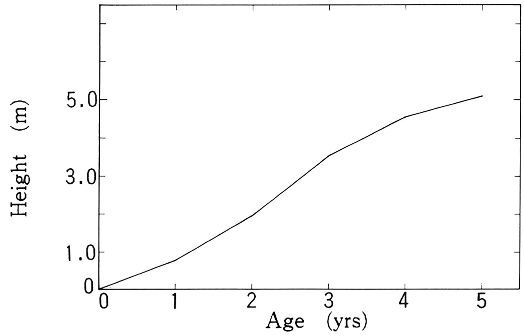
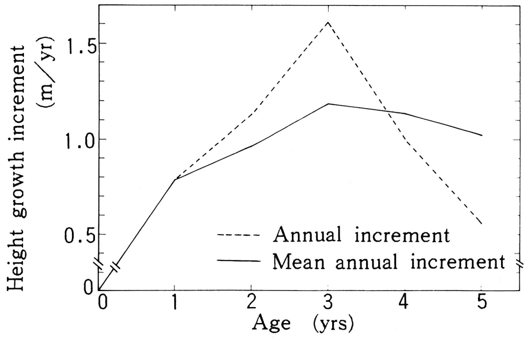


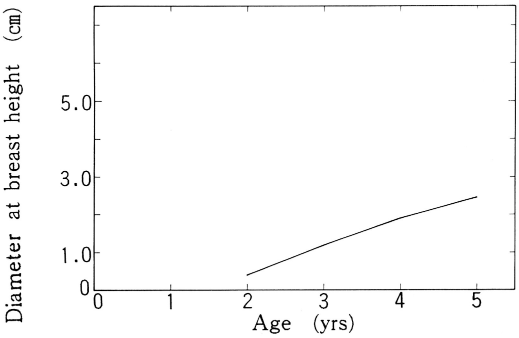
Fig. 3 Growth curves of a *Acer rufinerve* SIEB. et ZUCC. (Sample tree No. 5)



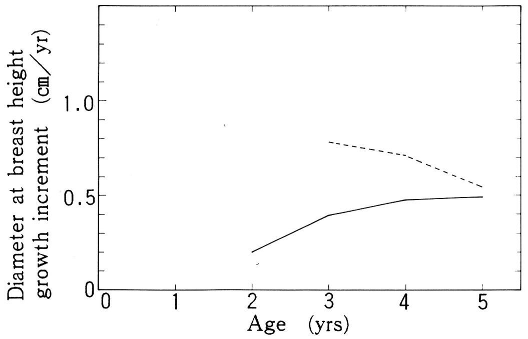
Height growth curve



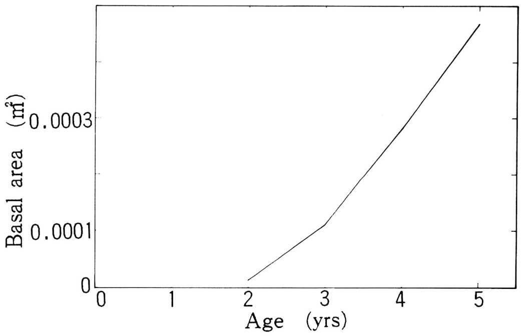
Annual and mean annual height growth increment curves



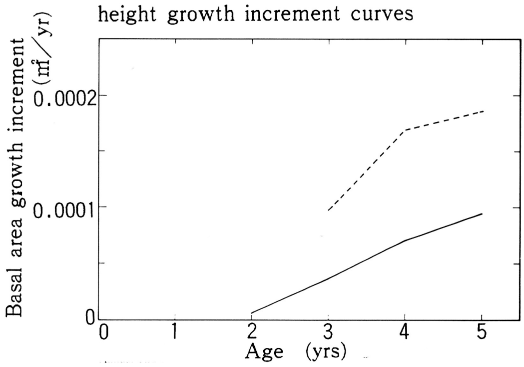
Diameter at breast height growth curve



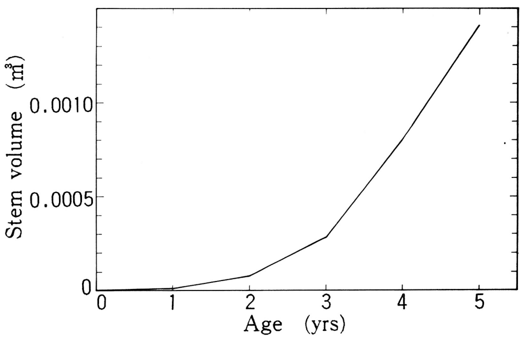
Annual and mean annual diameter at breast height growth increment curves



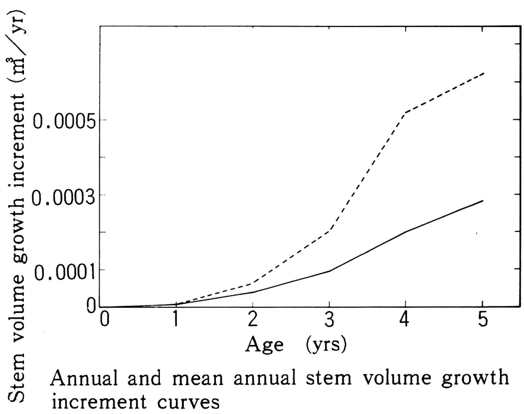
Basal area growth curve



Annual and mean annual basal area growth increment curves



Stem volume growth curve



Annual and mean annual stem volume growth increment curves

Fig. 4 Growth curves of a *Euptelea polyandra* SIEB. et ZUCC. (Sample tree No. 9)

Furthermore, the annual growth increment corresponded to the mean annual growth increment at around 8 to 11 years after invasion. The presence of more than two maxima may have resulted from breakage of tree tops caused by meteorological disasters, or by disease and insects. *Euptelea polyandra* SIEB. et ZUCC., growing in an area cleared in 1978, showed a decline in the annual and the mean annual growth increment from the third year, indicating that this tree would lose its position as the dominant tree in the near future and would be suppressed earlier than the above-metioned species.

With regard to stem volume growth, the annual growth, the annual growth increment in 1970 and 1974 became maximal in 9 to 11 years after invasion. On the other hand, the mean growth increment was considered to become maximal around 13 to 16 years after invasion, if the stem were to continue growing at the present rate. The annual and the mean annual growth increment for *Euptelea polyandra* SIEB. et ZUCC. in the area cleared in 1978 has not yet reached its maximum. However, judging from the height growth, it will reach a maximum within a few years.

The annual growth increment of the diameter at breast height in the areas cleared in 1970 and 1974 showed maxima 8 to 9 years later. If these trees were to continue growing at the present rate, their mean annual growth increment in the area cleared in 1974 would reach a maximum with in 11 to 12 years.

The annual and the mean annual growth increment in the basal area reached respective maxima 1 to 2 years later in comparison with growth in the diameter at breast height, but showed a similar tendency to the growth in diameter at breast height. As there are few data available on the diameter at breast height and the basal area growth of trees in the area cleared in 1978, it is difficult to discuss this aspect, although judging from height growth, it appeared they would be suppressed in the near future (*8*).

It was considered that the annual and the mean annual growth increment of invading broadleaved trees would reach their respective maxima within a shorter period than coniferous *Cryptomeria japonica* D. DON or *Chamaecyparis obtusa* SIEB. et ZUCC. in plantations, and that this might be due to the gradual progress of succession (*7,9,11,13,14*).

2. Soil formation on road banking slopes

The relationship between the thickness of the soil (A+B horizons) and the passage of time is shown in Fig. 5 (Photo.1～2). In the experimental plot investigated in the present study, although we did not take into account the direction of the slopes, soil formation was observed to progress with time and there was a positive interrelationship between the two. The massive amount of plant growth, a major source of organic matter which affects soil formation, and the levels of microbes decomposing this organic matter, differed according to the direction of slope. Therefore, if the process of soil formation is classified according to slope direction, a more remarkable relationship between these parameters should be detected (*1,10,12*). Furthermore, if data on passage of time is added, and if meteorological factors such as temperature, precipitation, were to be taken into consideration, the degrees of soil formation on road banking slopes in a granite area could be clarified.

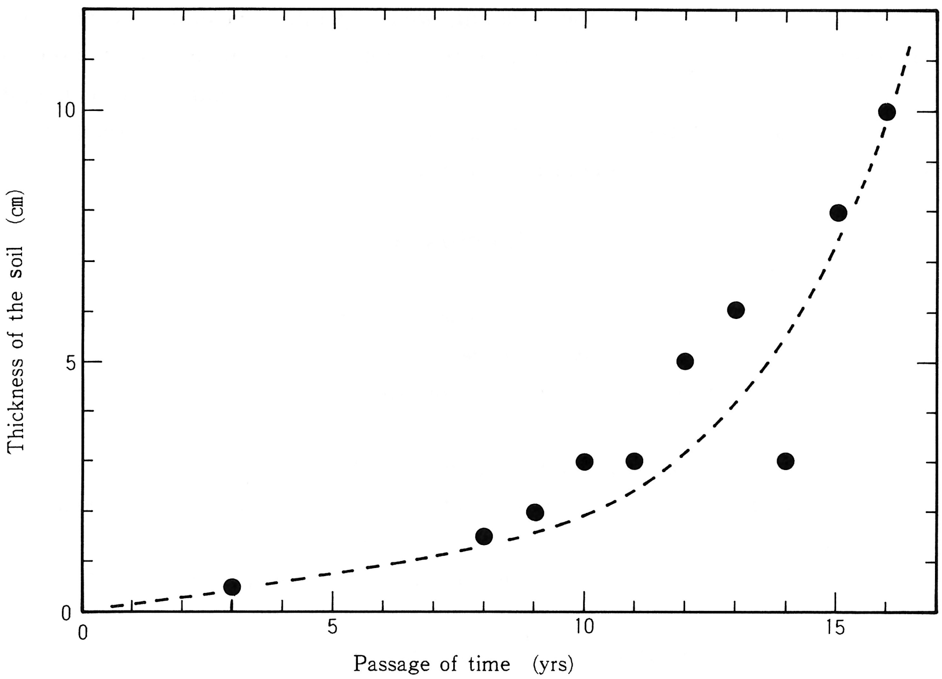


Fig. 5 Relationship between the thickness of the soil and passage of time

3. Mean diameter at ground level and degree of soil formation

The relationship between the mean diameter at ground level and the thickness of the soil is shown in Fig. 6. The mean diameter at ground level increased with an increase in the thickness of the soil and there was a positive interrelationship between the two. This results

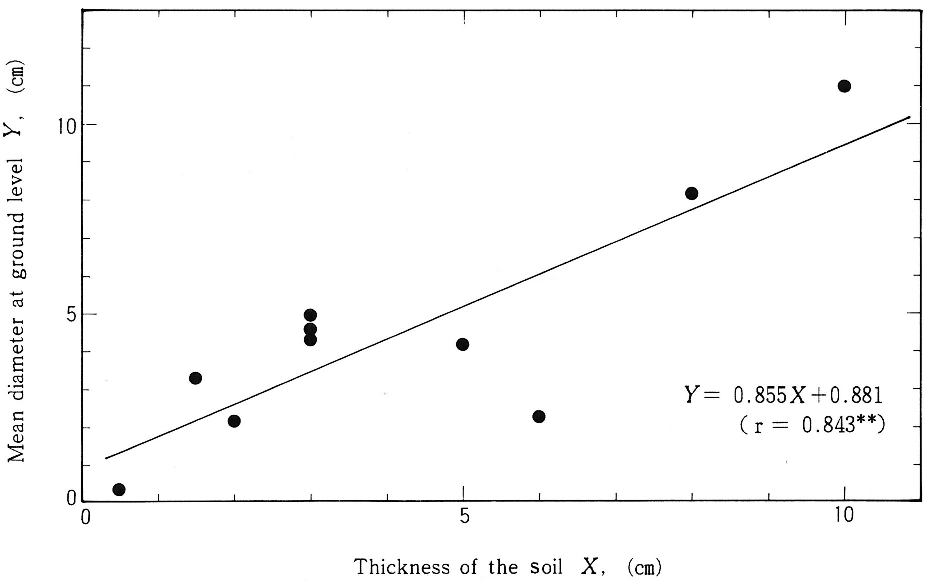


Fig. 6 Relationship between the mean diameter at ground level and the thickness of the soil

was expected, since the growth of the invading woody plants accelerates when the degree of soil formation is advanced. However, we were unable to determine any relationship with other growth factors, such as the soil and the diameter at breast height or tree height. This might be due to the characteristics of broadleaved trees, which spread their stems and branches to a greater extent than needleleaved trees.

Ⅳ. Conclusions

The process of the growth of invading woody plant and the degree of soil formation were discussed on the basis of the investigative results, which were as follows.

1. The results obtained from stem analysis confirmed that the invading woody plants changed within the short period of 15 years.
2. The annual and the mean annual growth increment of invading broadleaved trees showed respective maxima within a very short period compared with *Cryptomeria japonica* D. DON and *Chamaecyparis obtusa* SIEB. et ZUCC. in plantations.
3. The soil formation on road banking slopes progressed exponentially with the passage of time.
4. There was positive interrelationship between the thickness of the soil and the mean diameter at ground level of the trees.

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The titles in the parentheses are tentative translation from the original Japanese titles by the present authors.

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Profile No. 1

Profile No. 2

Profile No. 3

Profile No. 4

Photo. 1　Soil profiles of each plots

Profile No. 5

Profile No. 6

Profile No. 7

Profile No. 9

Photo. 2 Soil profiles of each plots