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The Significance of Sprouted Tree Shoots at the Early Stage of Succession Following the Swidden Burning in Northern Thailand

by

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八田洋章*: タイ北部における焼畑の植生調査－火入れ後の遷移初期段階で果たす萌芽枝の役割

In the autumn of 1996, the tree census of a total of fifteen fallow fields of swidden cultivation was conducted in two villages of the hill people, which villages are located at Chiang Mai and Chiang Rai

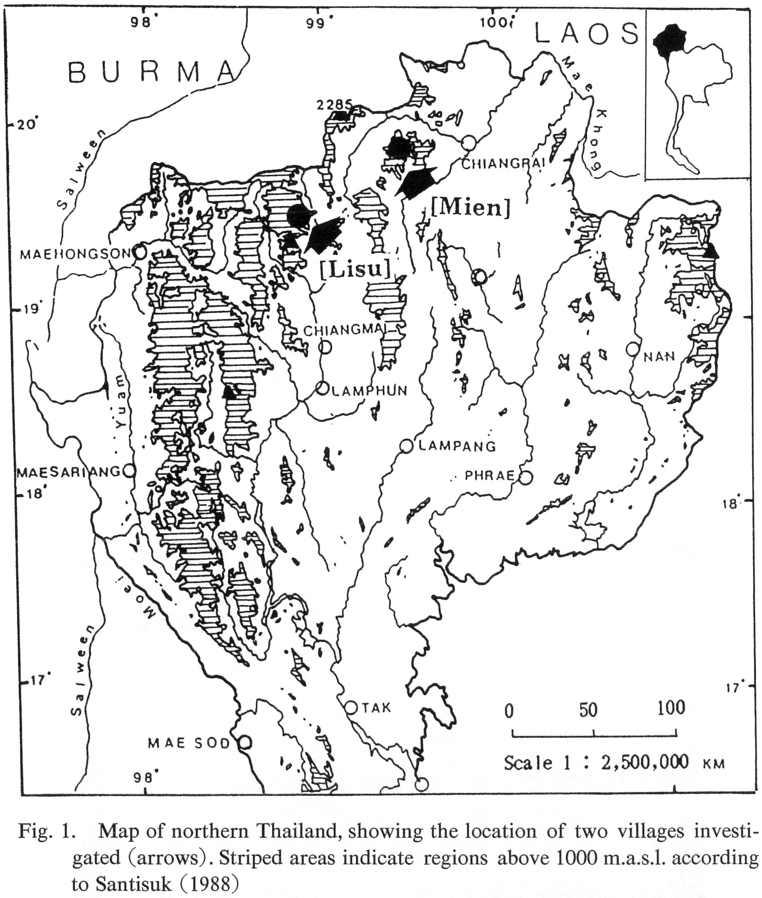

Fig. 1. Map of northern Thailand, showing the location of two villages investigated (arrows). Striped areas indicate regions above 1000 m.a.s.l. according to Santisuk (1988)

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Provinces in northern Thailand (Fig. 1).

Northern Thailand is strongly influenced by the monsoon climate, and is characterized by the remarkable alternation of hot dry and rainy seasons (Santisuk 1988).

As shown in Fig. 2, the rainy season is from May to September with the peak of precipitation (about 75% of the total annual rainfall, 1217 mm) in July, August, and September. From November to February, the temperature is relatively low temperature, the air is dry, and there is little or no rain. From March to April, it is very hot and dry. The swidden fields are burned during the dry season. The mean annual temperature is 25.8℃ with no great deviation during the year (Muller 1982).

The most common type of vegetation in the mountainous areas is represented by various

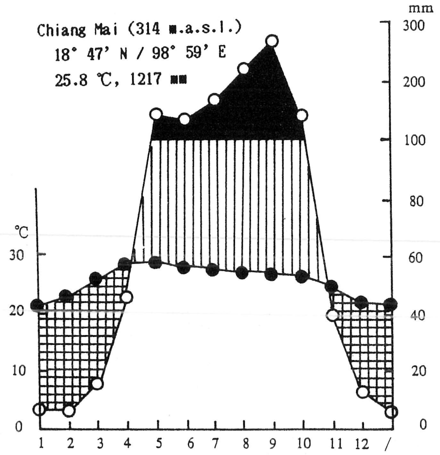

Fig. 2. Climate of Chiang Mai, indicated by the climatic diagram of Walter *et al.* (1975). Striped area: wet season. Checkered area: dry season. Black area: monthly rainfall more than 100 mm with scale reduced to 1: 5 (Muller 1982). ●—●: mean daily temperature, ○—○: mean precipitation

Fig. 3. Here and there fields are under active cultivation, which gives patchwork-like appearance to the vegetation.

successional stages recovering to the primary montane vegetation, which is cleared for a long or short period of swidden cultivation. Thus, the Vegetation has a patchwork-like appearance (Fig. 3). Here and there fields are under active cultivation. After cultivation, the exhausted fields are abandoned and the forest regrowth is thereafter left to the mercy of hill people (Anderson 1993).

Swidden farming is also called shifting cultivation, or slash-and- burn agriculture. This method involves clearing the land of forest, burning the cut debris, planting crops on the ash-rich soils for a period of one to several years, and abandoning the field to allow it to regenerate during a fallow period of a few to many years.

During the fallow period, it would be expected that vegetation would cover the land and that the soil would return to approximately the same condition as before the periods of cultivation (Anderson 1993).

This paper reports an investigation for elucidating how the fallow term correlates with the changes that occur in the vegetation, with special attention paid to the significance of sprouted tree

Fig. 4. Lisu village north of Chiang Mai at 980 m elevation. Tree trunks have remained in this kidney bean field.

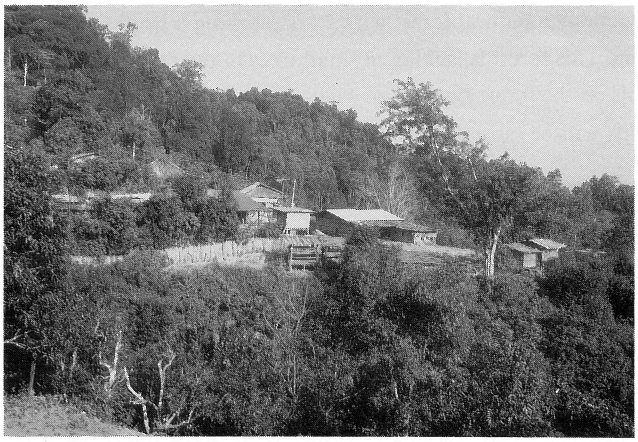

Fig. 5. Mien village west of Chiang Rai at 1180 m elevation. The forest behind the houses in this photo is the Site M investigated.

shoots at the early stage of succession and the invasion of tall grasses and bamboos.

This research was made possible by the joint sponsorship of the National Science and Technology Development Agency, Thailand (NSTDA) and the New Energy and Industrial Technology Development Organization, Japan (NEDO).

Research sites and methods

Research sites of two villages situated at 19° -20° N latitude and 98.5° -99.5° E longitude (Figs. 4 and 5).

Ban Nae Ja Nua, Ban Lisu, Chiang Dao Region, Chiang Mai Province, is designated as "Lisu" in this report. Seven sites, **A, B, E, H, I, L,** and **O,** were surveyed. Also, Ban Huai Chompu, Ban Mien, Mae, Suai Region, Chiang Rai Province, is designated as "Mien". Eight Mien sites were Surveyed: **C, D, F, G, J, K, M** and **N.**

The habitat condition, topography, and miscellaneous characteristics such as degree of disturbance of each site are described briefly. Tree census at each site was carried out as follows: 1) individual trees were numbered in a quadrat (36~425 m²); 2) the diameter at breast height (DBH) and height for all trees were measured; 3) the distribution of trees within each quadrat was charted by plotting the location; 4) for identification of the tree species, herbarium specimens were collected; 5) herbaceous plants, including shrubs less than 50 cm in height, were clipped at the base and weighed; and 6) a profile diagram was drawn.

The identification of plant specimens was mainly made by Dr. Weerachai Nanakorn, Director, The Botanic Garden Organization, Chiang Mai, Thailand.

Results

Site A [Lisu]

A Natural Forest (Figs. 6-7, Table 1)

Elevation 1100 m; southern exposure slope of ca. 10° ; area surveyed: 15×20 m²; No. of woody species checked: 33 spp.; volume of ground vegetation: 39.2 g/m².

This site is presumably a natural forest with trees reaching a height of 30 m, and is scheduled for burning in next spring. This forest is lacking in small trees in the range of 3-8 m high. There are many sprouted young shoots on the forest floor (Fig. 6). There is a possibility, as a matter of fact, that many natural forest like this will be burned for swidden cultivation.

Site B [Lisu]

One Year After Having Been Burned (Figs. 8-10, Table 2)

Adjacent to Site A, this site was a natural forest before being burned and is now a kidney bean field in the first year of cultivation; elevation 1100 m; eastern exposure slope of 13°; area surveyed: 12×15 m².

Having been burned the previous year, post-burn stumps remain here and there. This location serves to illustrate condition under which cultivation is initiated following a burn. Though a large number of young shoots were observed, they were mostly sprouted branches. Large tree stumps remained untouched.

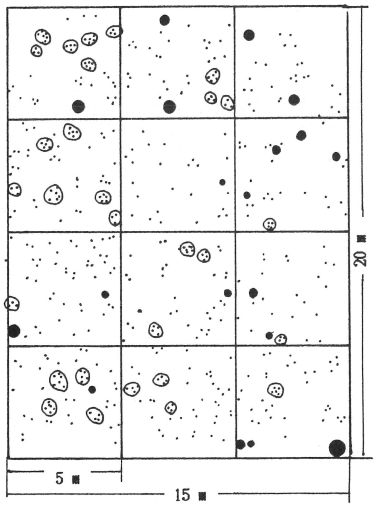

Fig. 6. Distribution of trees and shrubs (Site **A**: 20 m×15 m).
●: tree having a diameter of more than 8 cm ∵: forest floor vegetation of less than 0.5 m in height
○: sprouted shoots from the same mother stump

Fig. 7. Inside the forest at Site **A**.
A man who is collecting specimens on the tree.

Table 1. Frequency distribution of trees by diameter and height (Site **A**)

Diameter (cm)	No.	Height (m)	No.
8.1-10	5	8.1-10	5
10.1-20	3	10.1-15	2
20.1-30	3	15.1-20	2
30.1-40	3	20.1-25	5
40.1-50	3	25.1-30	6
50.1-60	2		
60.1-70	0		
70.1-80	1		

Site C [Mien]

Two Years After Having Been the Burned: An Upland Rice Field (Figs. 11-12)

A field with growing weeds immediately following the harvest; elevation 860 m; northern exposure slope of 18° ; area surveyed: 5×5 m^2; No. of woody species checked: 7 spp.; volume of ground vegetation: 424 g/m^2.

This upland rice field had just been harvested. The fluffs of a field weed, *Vernonia* sp., are in the air. Weeds are abundant in the field, but few trees are present.

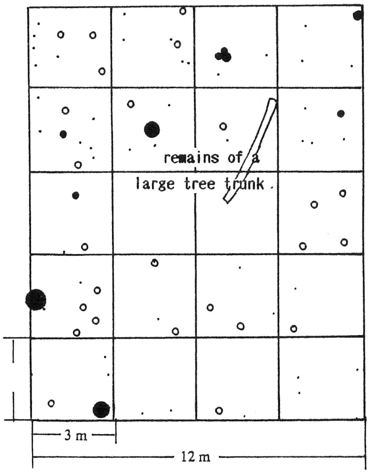

Fig. 8. Distribution of tree stumps remaining in a kidney bean field (Site **B**: 12 m×15 m).
●: more than 10 cm in diameter
○: 2–9 cm in diameter
⁚·: less than 2 cm in diameter

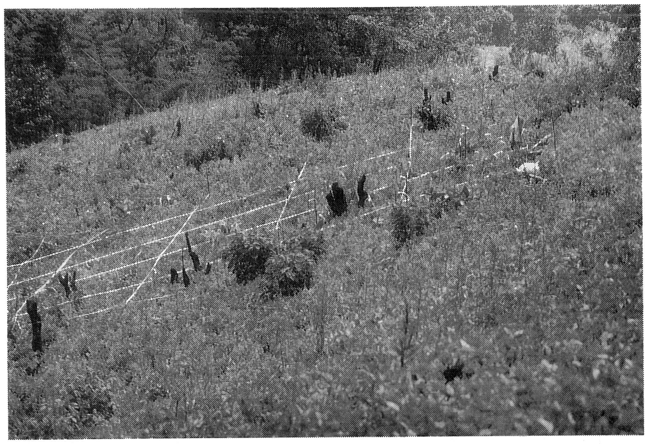

Fig. 9. Panoramic view of Site **B**.

Fig. 10. Remaining stumps and sprouting shoots (Site **B**).

Table 2. Frequency distribution of diameters of remaining tree stumps (Site **B**)

Diameter (cm)	No.
2.1– 5	16
5.1–10	8
10.1–20	3
20.1–30	2
30.1–40	2
40.1–60	0
60.1–70	1
70.1–80	2

Site D [Mien]

Four Years After Having Been Burned: Appearance of Pioneer Trees (Figs. 13–15)

A corn field one month following the harvest; elevation 1150 m; eastern exposure slope of ca. 18° ; area surveyed: 5×5 m^2; No. of woody species checked: 5 spp.; volume of ground vegetation: 632 g/m^2.

It would appear that the field had not been weeded for one to two months. A mixture of corn and tobacco had been planted in a litchi field. At heights exceeding 50 cm, the *Clerodendrum paniculatum* had mixed with field grasses and sprouted abundantly. The circumstances of their distribution would suggest that they had grown from seeds. This is probably the early stage of the appearance of a pioneer

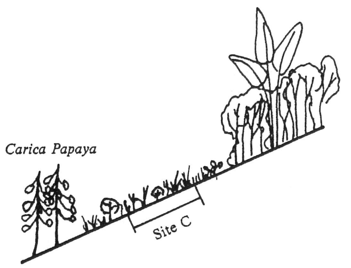

Fig. 11. Profile diagram of Site **C**.

Fig. 12. Upland rice cultivation immediately following a cutting (Site **C**).

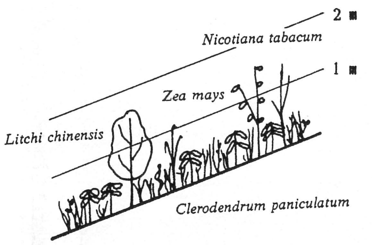

Fig. 13. Profile diagram of Site **D**. The pioneer plant, *Clerodendrum paniculatum* appeared in the field during cultivation.

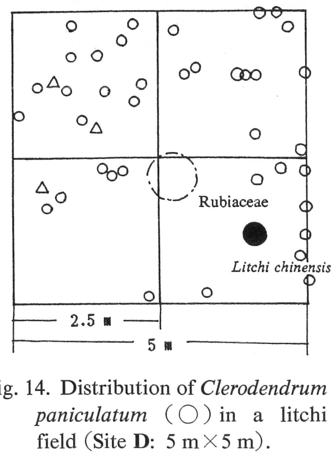

Fig. 14. Distribution of *Clerodendrum paniculatum* (○) in a litchi field (Site **D**: 5 m×5 m). △: *Nicotiana tabacum*

Fig. 15. The *Clerodendrum paniculatum* sprouted after having been cut back once (Site **D**).

Fig. 16. Panoramic view of Site **E** (5 m×7.5 m).

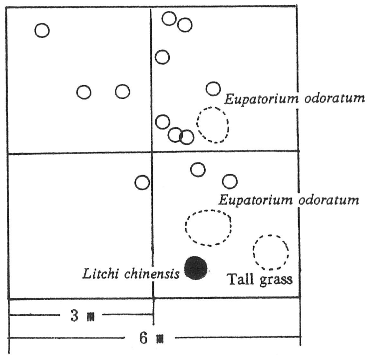

Fig. 18. Distribution of pioneer plants in weed clusters (Site **F**: 6m×6 m).
○: *Clerodendrum paniculatum*
●: *Litchi chinensis*

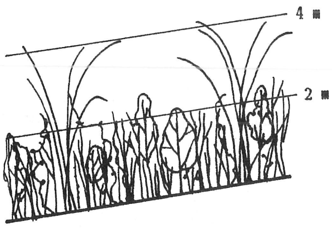

Fig. 17. Profile diagram of Site **F**.

Fig. 19. Weed clusters that include grasses reaching heights of up to 4 m (Site **F**).

plant in a swidden field. In addition, in an area adjacent to the surveyed plot that had been cleared off of weeds, it was confirmed that *Clerodendrum* thrived, exceeding 10 cm in height. *Clerodendrum* shoots had yet further sprouted from young original stumps within the research area (Fig. 15).

Site E [Lisu]

Four Years After Having been Burned: One Year Fallow Period (Fig. 16)

Three years' cultivation followed by a one-year fallow period; clumps of weeds; elevation 1000 m; eastern exposure slope of ca. 18° ; area surveyed: 5×7.5 m^2; No. of woody species checked: 10 spp.; volume of ground vegetation: 424 g/m^2.

The site is covered with many species of weed and only a few trees are present. This would be the first step toward recovery of secondary vegetation.

Site F [Mien]

Ca. Six Years After Having Been Burned: Three Years Fallow Period (Figs. 17-19)

Three years of crop cultivation mixed with litchi trees, then a fallow period of three years; tall grass and weed clusters; elevation 1080 m; northern exposure slope of 10° ; area surveyed: 6 ×6 m^2; volume of ground vegetation: 1608 g/m^2.

After crop cultivation the plot remained unattended for three years. A mixed growth of grasses reaching 4 m high, the shrub *Eupatorium odoratum*, and other weeds including the pioneer plant, *Clerodendrum paniculatum*, were identified. The weed production volume of 1.6 kg/m^2, the largest among the sites investigated, was presumed to have resulted from the manure used for fertilizing the soil around the litchi trees.

Site G [Mien]

Ca. Six Years After Having Been Burned: Bamboo Invasion (Figs. 20-22)

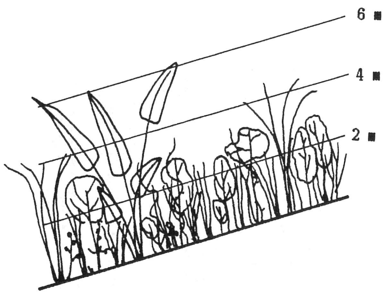

Fig. 20. Profile diagram of Site **G**.

Fig. 21. Area undergoing a gradual change from clumps of tall grasses to a bamboo forest (Site G).

Fig. 22. Inside of Site G, bamboo, trees, and tall grasses have grown thick.

Upland rice cultivation for one year following the burning, and then a five-year fallow period; elevation 860 m; northern exposure slope of 18° ; area surveyed: 6×10 m^2; No. of woody species checked: 15 spp.; volume of ground vegetation: 550 g/m^2.

This bamboo forest had been unattended for five years. There are burned stumps of bamboo from which several shoots have sprouted. Tall grasses and trees have been engulfed by bamboo shoots.

Site I [Lisu]

Ca. Seven Years After Having Been Burned: Stands of Grasses (Figs. 23–24, Table 3)

Three years of raising cereals followed by an approximately four-year fallow period; crowded clusters of *Imperata cylindrica*; elevation 860 m; southeast exposure slope of 15° ; area surveyed: 5 ×10 m^2; No. of woody species checked: 5 spp.; volume of ground vegetation: 402 g/m^2.

Imperata cylindrica 2 m high and tree shoots thriving at a height in excess of 3 m area are mixed. The pioneer plants, *Oroxylum indicum, Lagerstroemia villosa,* and *Gmelina arborea* have invaded as well. With the growth of sprouted shoots, it would appear that these grasses will be replaced by woody plants.

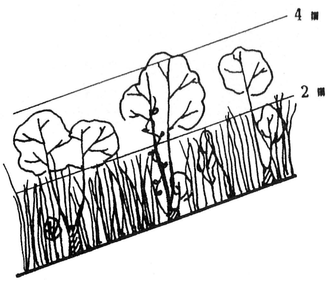

Fig. 23. Profile diagram of Site **I**.
Sprouting shoots gradually cover clusters of *Imperata cylindrica*.

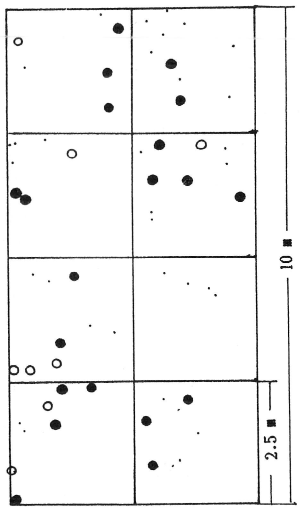

Fig. 24. Distribution of trees in crowded clusters of *Imperata cylindrica* (Site **I**: 10 m×5 m).
○●: Trees more than 1 cm in diameter
●: sprouted shoot confirmed
∵: small trees less than 1 cm in diameter.

Table 3. Frequency distribution of sprouted branch by diameter and height (Site **I**)

Diameter (cm)	No.	Height (m)	No.
1.1–2	10	1.1–2	4
2.1–3	15	2.1–3	16
3.1–4	6	3.1–4	12
4.1–5	3	4.1–5	2

Site J [**Mien**]

Ca. 13 Years After Having Been Burned: A Bamboo Forest (Figs. 25–26, Table 4)

Cultivation of upland rice for the first year following the burning, then approximately 12 years of fallow period; elevation 830 m; western exposure slope of 15° ; area surveyed: 5×30 m^2; No. of woody species checked: 21 spp.; volume of ground vegetation: 37.5 g/m^2.

This site is a mixture of sprouted bamboo shoots 13 m high and trees of approximately 6 m. The stumps of burned bamboo remain. It is presumed that this location was a bamboo forest in the past. There are also bamboo shoots which are not of sprout origin. It appears that the bamboo will expel the trees at this site.

Site K [**Mien**]

Ca. 16 Years After Having Been Burned: A Bamboo Forest (Figs. 27–28, Table 5)

Crops cultivated in the first year following the burning; abandoned for ca. 15 years; elevation

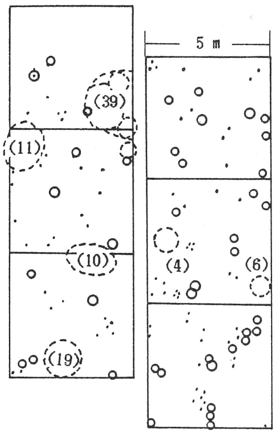

Fig. 25. Distribution of bamboo clones and trees (Site **J**: 5 m×30 m).
( ): bamboo (number of shoots)
○: tree of diameter more than or equal to 3 cm.
∴: trees of diameter less than or equal to 1 cm.

Fig. 26. Inside of Site **J**, several bamboo clones scattered.

Table 4. Frequency distribution of trees by diameter and height (Site **I**)

Diameter (cm)	No.	Height (m)	No.
1.1– 3	23	1.1–2	7
3.1– 5	20	3.1–5	25
5.1– 7	12	5.1–7	8
7.1– 9	5	7.1–9	13
9.1–11	3		
11.1–13	1		

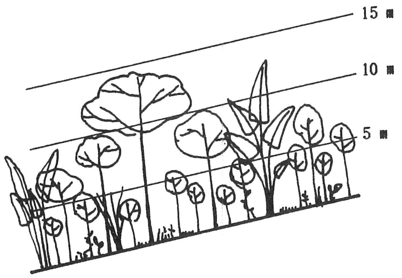

Fig. 27. Profile diagram of Site **K**.

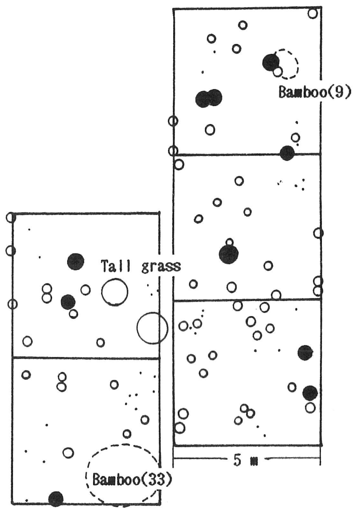

Fig. 28. Distribution of trees in bamboo forest (Site **K**: 5 m×25 m).
●: tree of diameter more than 10 cm
○: tree of diameter 1–10 cm
∴: tree of diameter less than 1 cm

Table 5. Frequency distribution of trees by diameter and height (Site **K**)

Diameter (cm)	No.	Height (m)	No.
1.1– 3	12	1.1– 3	4
3.1– 6	31	3.1– 5	33
6.1–10	12	5.1–10	10
10.1–20	7	10.1–15	3
20.1–30	2		
30.1–40	1		

1110 m; northwestern exposure slope of 8° ; area surveyed: 5×25 m^2; No. of woody species checked 43 spp.

Regenerated bamboo forest has remained unattended. Taller trees reach 15 m in height. The forest floor is almost bare.

Site L [Lisu]

Ca. 20 Years After Having Been Burned: A Secondary Forest (Figs. 29–31, Table 6)

About 17 fallow years; elevation 910 m; southern exposure slope of 10° ; area surveyed: 10×10 m^2, No. of woody species checked: 40 spp.; volume of ground vegetation: 304 g/m^2.

This is a young secondary forest. The forest canopy is generally uniform at a height of 10 m with the trees covering ca. 90% of the ground, and the forest floor is fairly dark.

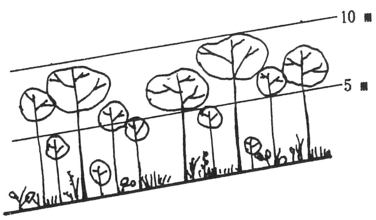

Fig. 29. Profile diagram of Site **L**.

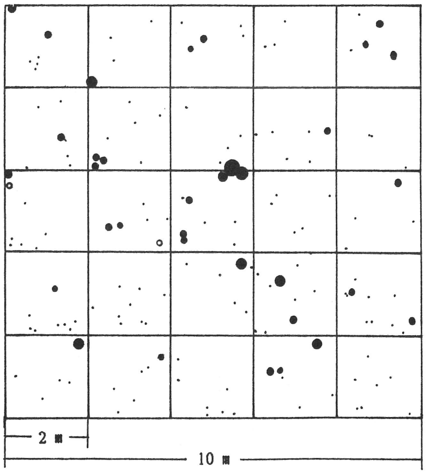

Fig. 30. Distribution of trees in Site **L** (10 m × 10 m).
●: tree of diameter more than 1 cm
·⁚: tree of diameter less than or equal to 1 cm

Fig. 31. An overview of Site **L**: litchi field is in the right foreground.

Table 6. Frequency distribution of trees by diameter and height (Site **L**)

Diameter (cm)	No.	Height (m)	No.
1.1– 5	11	1.1– 3	3
5.1–10	16	3.1– 6	7
10.1–15	5	6.1– 9	14
15.1–20	3	9.1–12	6

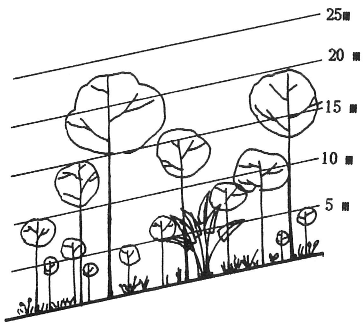

Fig. 32. Profile diagram of Site **M**.

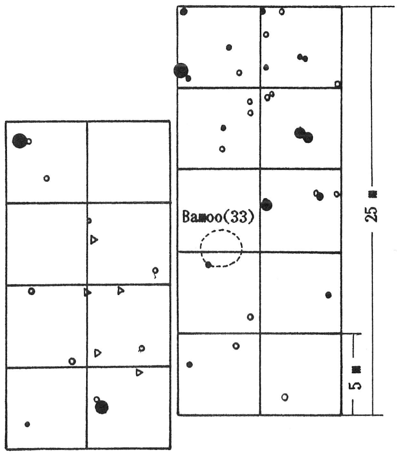

Fig. 33. Distribution of trees in Site **M** (10m×45m).
●: tree of diameter more than 10 cm
○: tree of diameter 1–10 cm
△: *Camellia sinensis* var. *assamica*

Table 7. Frequency distribution of trees by diameter and height (Site **M**)

Diameter (cm)	No.	Height (m)	No.
1.1–10	23	1.1– 5	17
10.1–20	10	5.1–10	16
20.1–30	3	10.1–15	5
30.1–40	1	15.1–20	2
40.1–50	1	20.1–25	2
50.1–60	0		
60.1–70	1		
70.1–80	0		
80.1–90	3		

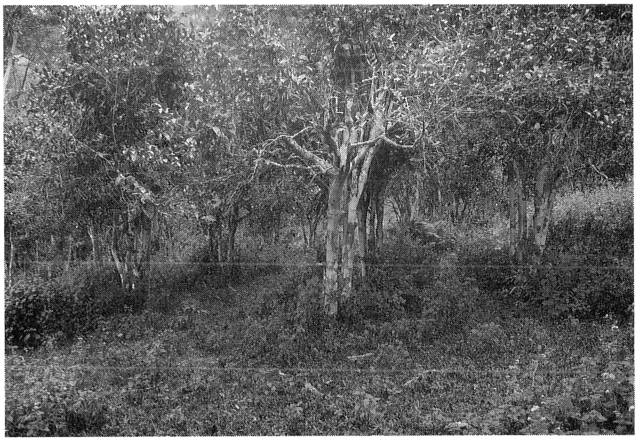

Fig. 34. Tea tree garden; the area has been weeded (Site **N**).

Site M [Mien]

Ca. 60 Years More Past Burning: A Secondary Forest (Figs. 32–33, Table 7)

Elevation 1130 m; southern exposure slope of 16° ; area surveyed: $10 \times 45\ m^2$; No. of woody species checked: 39 spp.; volume of ground vegetation: 264.5 g/m^2.

Trees are 24 m tall. This site has remained due to it proximity to a village. Though tea trees (*Camellia sinensis* var. *assamica*) grow in the area studied and are managed by local residents, they were not planted for cultivation.

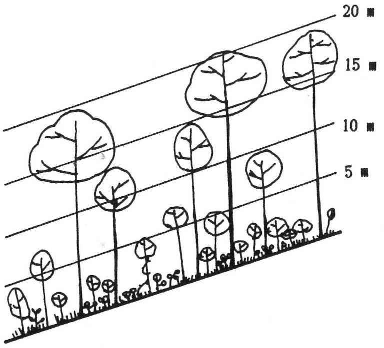

Fig. 35. Profile diagram of Site **O**.

Fig. 37. *Dipterocarpus obtusifolius*, height 20 m (Site **O**).

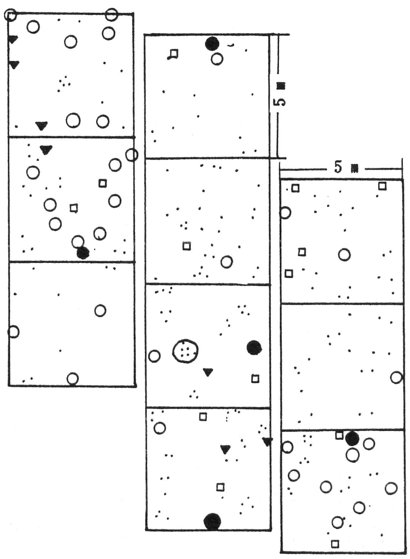

Fig. 36. Distribution of trees (Site **O**: 5 m × 50 m)
●: *Dipterocarpus obtusifolius*
○: *Shorea obtusa*
△: *Shorea siamensis*
□, ∴: other lower trees and shrubs

Table 8. Frequency distribution of trees by diameter and height (Site **O**)

Diameter (cm)	No.	Height (m)	No.
1.1– 5	28	1.1– 3	29
5.1–10	11	3.1– 5	8
10.1–15	5	5.1– 7	3
15.1–20	2	7.1– 9	3
20.1–30	2	9.1–10	2
30.1–40	2	10.1–15	3
40.1–50	3	15.1–20	5

Site N [Mien]

Ca. 60 Years More Past Burning: A Semi Cultivated Tea Garden (Fig. 34)

Elevation 1140 m; southern exposure slope of 5° ; near the Site **M.**

This location was also a cultivated field more than 60 years ago. It is said that tea was not planted but grew naturally, and was left uncut. This site is weeded, and tea is picked three or four times annually. The tea trees have 4～6 stems, are 7～10 cm in diameter, and are 2～4 m high.

Site O [Lisu]

Natural Dipterocarp Forest (Figs. 35–37, Table 8)

Elevation 850 m; southern exposure slope of 15° ; area surveyed: 5×50 m^2; No. of woody species checked: 24 spp.; volume of ground vegetation: 364 g/m^2.

The forest canopy, which is open or discontinuous at a height of about 20 m is made up of one species, *Dipterocarpus obtusifolius*, which appears to occupy the land at a density of one tree per 50 m^2. The composition of other species in this location is simple and consists of *Shorea obtusa* and *S. siamensis*, which make up a large portion of the lower trees and shrubs. All leaves of almost all of the trees drop during the dry season.

Discussion

Successional Sequence of Investigated Sites

The fifteen sites surveyed are arranged according to the number of years elapsed since the swidden burning as follows:

→Annual cultivation (in the vicinity of the village)
→Fruit tree cultivation (manuring)
→ ⟨N⟩ (Tea-garden: no manuring)
⟨O⟩ (dry)
⟨A⟩ →burning→cultivation→fallow→ ⟨E⟩ → ⟨F⟩ • ⟨G⟩ → ⟨H⟩ →
⟨I⟩ → ⟨J⟩ → ⟨K⟩ → ⟨L⟩ → ⟨M⟩ →→ ⟨A⟩ (wet)
⟨B⟩ , ⟨C⟩ , ⟨D⟩

We can draw a successional pattern toward the recovery of vegetation from the cultivated field in Sites **B, C,** and **D** to the natural forests found at Sites **A** and **O**, through Sites **E-M** investigated. Both Site **A** and the dipterocarp forest at Site **O** are in the same ecological zone, but they differ in their location; i.e., the former is located lower on a slope than the latter. In other words, they are discriminated in their availability of soil moisture. Accordingly, it is conceivable that the process to reach the condition described above for Site **A** and that for Site **O** does not differ largely.

A typical successional sequence in cyclical swidden field would be one or two years of intensive cultivation, with a crop, followed by a fallow period dominant with herbs and grasses during the first two or three years, and then followed by trees including a regrowth from stumps (Anderson 1993).

In Site **B**, one year after the swidden burning, a number of sprouted shoots growing out of the burned remains of the mother stock were found. It is presumed that if cultivation continues for three or more years, almost of these shoots will be cut down. In Site **E**, which was cultivated for three years and fallowed for one year, the dominant presence of weeds and a small number of trees are conceivably the result of the thorough cutting out of sprouted branchings during the cultivation period. The fact that there are few field weeds in Site **B**, on the other hand, is conceivably related to the fact that this location was previously been a natural forest.

As seen in Sites **H** and **I**, the fields were not cleared so completely and recovery during the fallow period was therefore rapid. The sprouting shoots play a significant role in the recovery process of vegetation. The survival of an adequate number of cut stumps is, therefore, important for the regeneration of a forest.

The Invasion of Tall Grasses

At Site **E**, as in Sites **B, C,** and **D**, there was no invasion by tall grasses during the cultivation period and the Site was not invaded during the one year fallow period. But with the passage of three or more years, as may be seen in Sites **F, G, H,** and **I**, the invasion of tall grasses reaching a height of 2～4 m was conspicuous. Moreover, the sprouting of tree branches was observed even in locations where tall grasses appeared to grow thick. Their growth would suggest that in the near future these locations will change to secondary forests. In this research, tall grasses were not present in the sites for which more than ten years had elapsed since the burning. But if abandoned fields are repeatedly disturbed by burning and cutting after short fallow periods, the hardy fire-resistant grass, e.g., *Imperata cylindrica*, would eventually dominate, and trees would not easily sprout therein, a facile advancement to the forest condition might not occur (Anderson 1993).

In this research, two locations, i.e., one where grasses were mixed with other weeds (as in Sites **E** and **F**) and the other where tall grasses dominated (as in Sites **H** and **I**) were found. In considering the process of succession, most likely a progression from the former to the latter will occur.

The Invasion of Bamboo and Subsequent Change

It is likely that the invasion of bamboo will delay the transition to a natural forest. We can

Fig. 38. Bamboo forest occupying land that was a swidden field 10 years ago.

presume that many bamboo shoots are the sprouts coming from the burned remains of the mother stock, as observed in Sites **G, J**, and **K**. As seen in the profile diagram of Site **G**, bamboo growth far outstripped tree growth; consequently, bamboo dominated in the open space. The slope of a mountain near the Mien settlement was field cultivated ten years ago and is now entirely covered by a bamboo forest (Fig. 38), which will be preserved for a substantial period without change. Large bamboo stumps were seen at Sites **K** and **M**, and the invasion of bamboo in Site **L** is also recognized from a photograph that was taken from a distance (Fig. 31).

It is not easy to forecast at this point in time which is stronger in competition, bamboo or broad-leafed tree. But, as we have seen at Site **M**, which has lain fallow more than 60 years, the successional process has progressed toward a climax forest, since some trees are much taller than the bamboo. It would appar that bamboo grows faster and taller than other trees until about 13 years past burning (Site **J**).

Thus trees have grown somewhat taller than the bamboo at Site **K**, fallowed for ca. 16 years. Moreover, most trees have reached a superior position at Site **M**, where burning was practiced about 60 years ago, and bamboo does not appear in the natural forests at Sites **A** and **O**. It would seem, then, that even though the bamboo achieves a superior position in the process of succession, as long as bamboo grows in association with woody plants, a transition to a broad leaf tree forest will ultimately occur.

The Significance of Sprouted Shoots for Recovery of a Forest

The seedlings of two pioneer plants, *Clerodendrum paniculatum* and *Oroxylum indicum*, were observed at Sites **D** and **I**, respectively. The former species grew en masse during the cultivation period, and the latter was flowering at Site **I** with a four-year fallow period. It is questionable whether the *Clerodendrum paniculatum* at Site **D** will survive through the dry season without shading by other plants. It would be necessary for seedlings, in other words, to grow mixed with weeds as we have seen at Sites **F** and **I**.

The majority of trees observed in the early stages of the regeneration of a secondary forest were sprouted shoots that grew from stumps that remained after the burning. Sprouting shoots flourished in their early growth, contributing to the acceleration of forest recovery. In almost all sites investigated, sprouting branches grew mixed with other plants. And even among the thick clumps of weeds, sprouting branches continued to grow as observed at Sites **H** and **I**. When tree growth exceeds the height of the weeds, the flourishing growth of weeds is suppressed by shading, and then the first step toward a secondary forest has begun. Accordingly, as described above, the survival of a suitable number of mother stumps is important to the regeneration of a forest. If the cultivation period of the field is too long before the field is allowed it to lie fallow, most stumps and shrubs will be removed or killed, with the consequence being that regeneration might be prevented greatly.

The Length of the Fallow Period and the Formation of the Forest Canopy

We found that when the fallow period exceeded three to four years, trees reached a height of about 3 m, exceeding the height of the weeds (Sites **H** and **I**). When the fallow period spanned 12–15 years, the forest exceeded 7～8 m in stature; then, the forest become clearly tiered into four layers, i.e., tree, sub-tree, shrub, and herb (Sites **J** and **K**). At Site **L**, where as many as 20 years had passed since the burning, the tree height exceeded 10 m; and the forest floor became fairly dark. At Site **M**, where

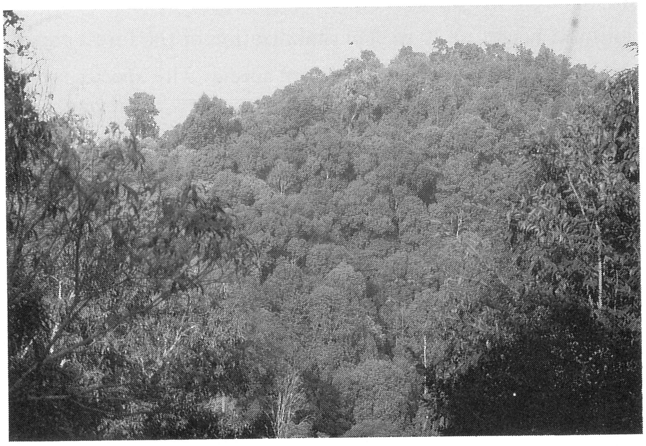

Fig. 39. Secondary forest, this mountain was a cultivated field more than 60 years ago, just like as Site M.

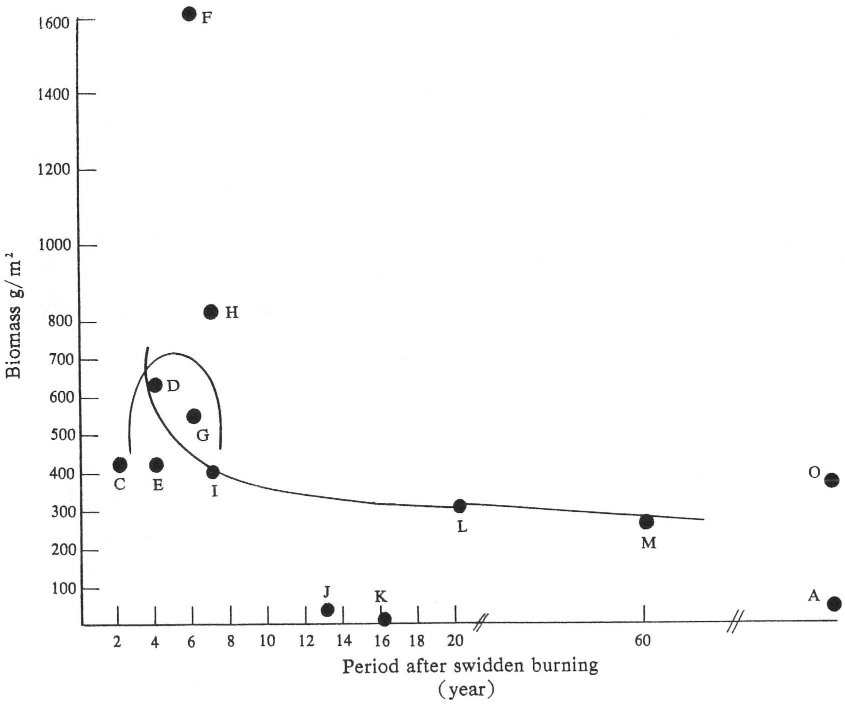

Fig. 40. Relation between biomass and fallow period.

seemingly more than 60 years had elapsed since the burning, the trees had reached a height of 25 m; and several giant trees had a maximum diameter of 0.8 m (at breast height). The tiered structure of this forest became more complex (Fig. 39). It is likely that the species-specific characteristics of those trees became prominently clear after more than 60 years.

Incidentallg, in a natural forest or a very long fallowed forest such as Site **A**, big trees reached nearly 30 m in height, and even the dipterocarp forest that grew in the somewhat dry location at Site **O** reached a nearly uniform height of 20 m. The stabilization of the forest canopy in height would be showing the difference of growth potencial in different species with species-specific growth characteristics.

The tea plants found at Site **M** and **N** could not observed at almost other locations. Naturally growing tea plants can be rarely found in this area. Those plants therefore, may be those escaped from the gardens of domesticated tea, cultivated in the vicinity of those sites. According to local informants in this place, they had not planted these plants but weeded them in a protective manner.

Weed Clusters and Biomass Production on the Forest in Relation to the Time Elapsed Since Burning

In order to estimate roughly the soil fertility of each site, we measured the biomass production on the forest floor by weighing the herbaceous plants and small shrubs growing on the floor (Fig. 40). Biomass production at Sites **C, D** and **E** (two to four years after burning) was 400–600 g/m^2, while that at Sites **G** and **H** (six to seven years after burning) was 500–800 g/m^2 mainly due to the invasion of tall grasses and vines together with the growth of sprouting branches of trees. Site **F** showed the largest biomass of 1608 g/m^2, resulting from the application of manure to the litchi trees planted at this location. The low production of Site **I**, 402 g/m^2, may be explained by a depletion of the soil fertility resulting from three years of cereal cultivation.

On the other hand, the forest floor vegetation in the bamboo forest at Sites **J** and **K,** fallowed about 15 years, was very poor. Generally speaking, a similar tendency is shown in the bamboo forest with the scarceness of humus. Biomass production at Sites **L** and **M,** where 20–60 years had passed since the burning was 200–300 g/m^2. This value is not so different from that of natural forest at Sites **A** and **O**. Of course, as grasslands and forest floor differ fundamentally, they shoud be considered separately. However, here we could be present an index for the change that occurs in vegetation after the swidden burning.

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Summary

The tree census of a total of fifteen fallow fields of swidden cultivation was conducted in northern Thailand in 1996. This paper reports how the fallow term correlates with changes that occur in vegetation, with special attention paid to the significance of sprouted tree shoots and the invasion of tall grasses and bamboos.

The majority of trees observed in the early stages of the regeneration of a secondary forest were sprouted shoots that had grown from stumps remaining after the burning. Sprouting shoots flourished in their early growth, contributing to the acceleration of forest recovery. Accordingly, the survival of a suitable number of mother stumps is important for the regeneration of a forest. If the cultivation period is too long before a field is allowed to lie fallow most stumps and shrubs will be removed or killed, as a consequence, the regeneration might be prevented greatly.

The sprouting of tree branches was observed even in locations where tall grasses appeared to grow thick, and their growth would suggest that these locations will be change to secondary forests in the near future.

I could confirm that many bamboo shoots were also sprouts coming from the burned remains of the mother stock. It is likely that the invasion of bamboo will delay the transition to a natural forest. It would seem that even though bamboo may achieve a superior position in the process of succession, as long as it grows in association with woody plants, a transition to a broad-leaved tree forest will ultimately occur.

The relationship between the duration of the fallow period and the changes in the canopy were also discussed.

摘　　要

北タイの焼畑農耕地における休閑期間の長さと植生回復の関係を調べた。その際，焼け残った伐り株から発生した萌芽枝が植生回復に果たす役割に注目するとともに，大型のイネ科雑草やバンブーの侵入がその後の植生の遷移に及ぼす影響についても留意した。15調査区の植生を火入れ後の経過時間を軸に記載し，考察した。

まず樹木はパイオニア種の *Clerodendrum* や *Oroxylum* が耕作期間中に現れた。しかし二次林回復の初期における，樹木の大部分は**萌芽由来**であることが多くの調査区で確認された。初期生長が旺盛であり，その分森林の回復を早めている。密生する雑草群落中にも，萌芽枝や実生が生長を続けており，やがて樹高が雑草を超えるようになると，被陰して，二次林形成への一歩を踏み出す。したがって火入れの際に，切り株が適当に残されることが森林の早期回復に重要である。また耕作期間が長いほど地力の消耗とともに，除草作業により萌芽枝の生存量が減少し，森林回復の遅滞が予測される。今後時代の趨勢として休閑期間の短縮化が計られようとするとき，萌芽枝利用の再生は確実性が高く，重要である。

大型イネ科雑草の侵入は耕作期間中認められなかったが，休閑3年目以降になると顕著であった。しかしイネ科雑草の密生する調査区でも，樹木の萌芽枝が認められ，その生長によって，近い将来二次林への遷移が予測された。また火入れ後10年以上たった場所では大型イネ科植物は出現していない。

竹林は休閑5年以上で認められ，バンブーの場合もほとんど萌芽由来であることが確認された。伸長生長は，樹木より圧倒的に早く，その分空間を優先する機会が多い。一旦竹林が成立すると安定した持続群落としてかなり長期間維持し，遷移の停滞が予測される。しかし同所に生育する高木の生長により，バンブーを凌ぐ高さの樹種で林冠が構成されるようになると，結局広葉樹林への遷移が進行する。

休閑期間が3～4年を過ぎると，萌芽枝が雑草の丈を超すようになった。休閑期間の長さに伴い林冠も変化した。12～15年で樹高7～8mを超え，階層構造が明かとなってくる。火入れ後15～20年では林冠はバンブーの高さを超え，60年以上で樹高はおよそ25mに達し，構造がより複

雑になった。

本報告では植生回復で萌芽枝が果たす役割を強調する結果を得たが，樹木の肥大とともにそれらの個体が萌芽枝由来であるか否かは不明瞭となった。数百年を経て，遷移は極相林に至ると推定されるが，おそらく萌芽枝は遷移の初期段階で二次林の回復を促す役割を果たしていると考えられる。

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