Early Historic Forest Clearance around the Ancient Castle Site of Tagajo, Miyagi Prefecture, Japan

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Introduction

THAT PREHISTORIC and historic man's activities had an important and increasingly complex role in determining plant population and habitats has been evident to any student of palaeoecology. Especially in England, remarkable work on this problem has been undertaken (Birks 1973; Birks and West 1973; Godwin 1956, 1967; Greig and Turner 1974; Hicks 1971; Oldfield 1960; Pennington 1965; Tinsley 1975; Turner 1965; Walker and West 1970).

In Japan, however, little is known in detail about the extent of man's influence upon the vegetation of the past. Recently the techniques of pollen analysis have been applied to this problem with success in Lake Nojiri (Tsukada 1967). Though prehistoric and historic forest clearance and farming activities have been recognized on pollen diagrams from Lake Nojiri, the interesting study of the relationships between past vegetational change and man's advancing culture during early historic times has not been made. In order to interpret the close interrelationship of the vegetation to human activities during this time, this paper discusses the results of pollen analysis of sediment taken from an archaeological site during the early historic period. With the results of this pollen analysis and the study of the local history of the area around the archaeological site, the author aims to elucidate the close correlation of past vegetational change and the changing social and agricultural practices of early historic Japan.

Pollen Dispersal

In order to interpret pollen spectra of the samples taken from archaeological sites in terms of past vegetation, it is necessary to know the mode of pollen dispersal

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around the area under study. Both pollen assemblages from surface soil and airborne pollen must be considered in relation to the present vegetation. From the result of this interpretation, some part of the relationships between modern pollen rain and present vegetation around the study area may be made clear.

The distribution of present vegetation in the area of the Tagajo site is shown in Figure 1. In this area there are six distinct forest types: *Fagus crenata* forest, *Quercus mongolica* var. *grosseserrata* forest, *Quercus serrata-Castanea crenata* forest, *Pinus densiflora*-deciduous broad leaf forest, *Abies firma*-deciduous broad leaf forest, and evergreen conifer plantation. Three geographical regions can be delimited in this area on the basis of both topography and surface geology. These are a mountainous region, a hilly district, and an alluvial plain.

In the mountainous region (altitude between 1300 m and 400 m) the woodland of *Fagus crenata* is prominent. But the woodland of *F. crenata* is not completely natural, and some part of it has been disturbed by man and replaced by evergreen conifers of *Pinus densiflora* or *Cryptomeria japonica*. The *Quercus serrata-Castanea crenata* forest type, which is the most widespread secondary forest around the site, covers the hilly district (altitude between 400 m and 25 m). Woodlands consisting of evergreen conifer plantations of *Cryptomeria japonica* and an equal amount of scattered *Abies firma* and *Fagus japonica* are also found in this hilly district. The alluvial plain, with an altitude of less than 25 m, has few trees and is dominated by Gramineae. Forests, except for a few plantations of *Pinus densiflora*, are not found on the plains.

The relationships between airborne pollen and living vegetation were studied from 13 March to 4 August 1971 (Hibino and Yasuda 1973). Airborne pollen collectors were set 1.2 m above ground level at ten stations (Fig. 1). Airborne pollen was collected on 1 cm^2 glass slides smeared with petrolatum oil (Fig. 2). The slides in the airborne pollen collectors were renewed each week and prepared for microscopic examination.

A total of 60,501 grains were collected in this way. Among these were 56,301 arboreal pollen grains. The percentage frequency of such main pollen grains obtained from this study is shown in Figure 2.

The relationship between the pollen percentage of the soil surface and the living vegetation of this area was also studied. Plant detritus or surface humic soil around each airborne pollen collector was collected. In the laboratory each sample was treated by the KOH/acetolysis method (Faegri and Iversen 1964) and was mounted in Glycerin Jelly. Usually more than 200 arboreal pollen grains were counted in each sample. The result obtained from study of the surface soil samples is shown in Figure 2 as the percentage value of total tree pollen.

Station 1 (S.L. 700 m) and station 2 (S.L. 650 m) were located in the forests of *Fagus crenata* mixed with *Carpinus laxiflora, Quercus serrata,* and *Quercus mongolica* var. *grosseserrata.* Parts of these areas have been deforested and planted with *Cryptomeria japonica* or *Pinus densiflora.*

Station 3 (S.L. 450 m) was located in a secondary forest of *Quercus serrata* mixed with *Prunus grayana, Corylus sieboldiana, Clethra barbinervis,* and *Hamamelis japonica.* Undisturbed herbs are very sparse here, in contrast to the *Fagus crenata* woodland.

Station 4 (S.L. 250 m) and station 5 (S.L. 130 m) were located on the surface of

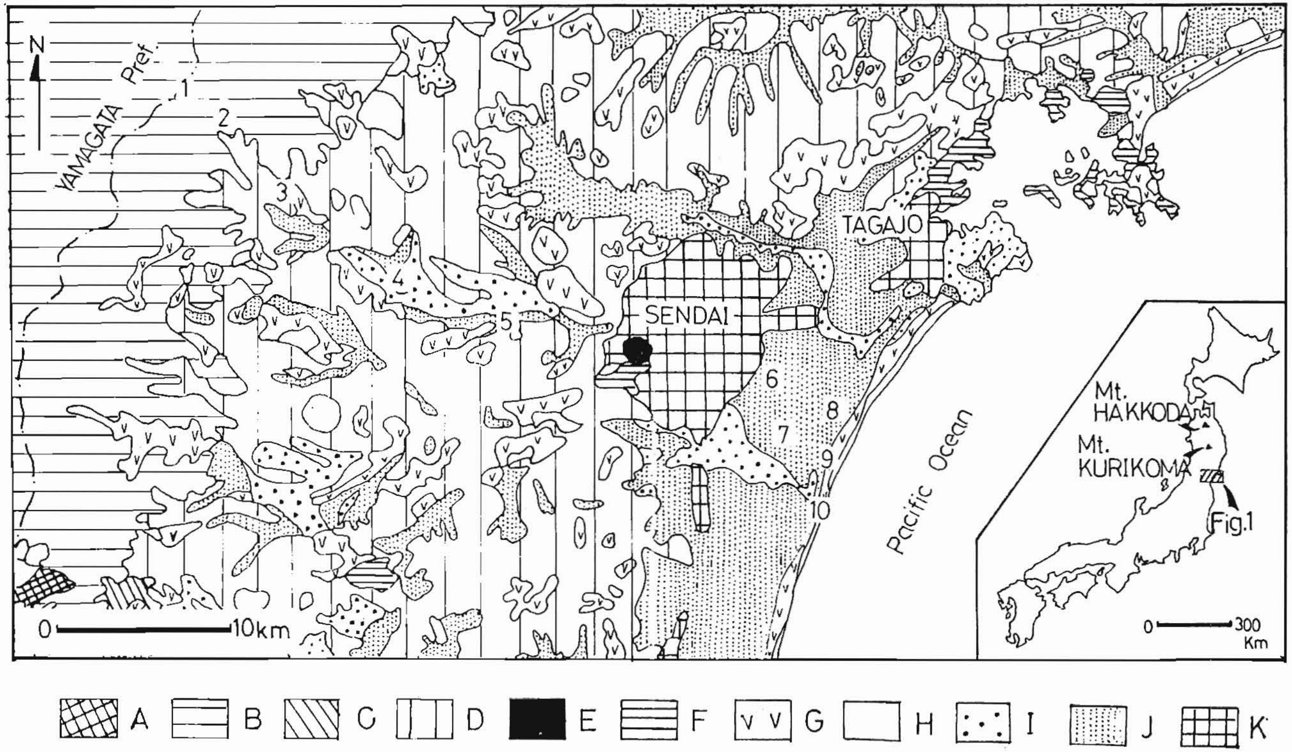

Fig. 1 Vegetation map of Miyagi prefecture (source: Agency for Cultural Affairs, Ministry of Education, 1973). *A*, alpine shrub communities; *B*, *Fagus crenata* forest; *C*, *Quercus mongolica* var. *grosseserrata* forest; *D*, *Quercus serrata-Castanea crenata* forest; *E*, *Abies firma*-deciduous broad leaf forest; *F*, *Pinus densiflora*-deciduous broad leaf forest; *G*, evergreen conifer forest; *H*, grassland; *I*, field; *J*, paddy field; *K*, residential district. The numbers 1–10 are locations of stations for collecting airborne pollen.

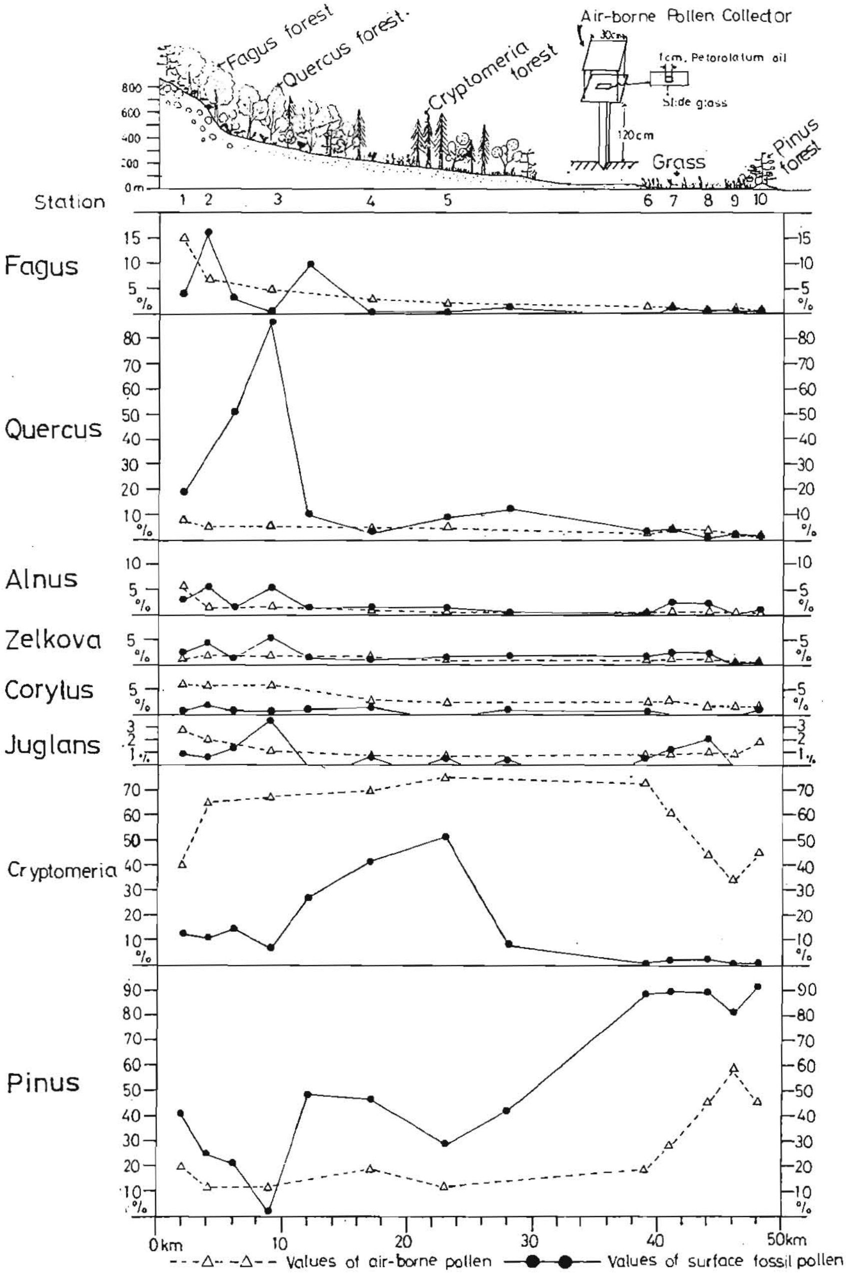

Fig. 2 Percentage values of modern pollen rain.

a small river terrace around which spread paddy fields and farm houses. On the hillsides surrounding the surface of this small river terrace was an evergreen conifer plantation of *Cryptomeria japonica.*

Station 6 (S.L. 20 m) and station 7 (S.L. 20 m) were located on the alluvial plain which is now cultivated and covered by paddy fields. Here treeless vegetation dominated by Gramineae is present.

Stations 8 (S.L. 5 m), 9 (S.L. 5 m), and 10 (S.L. 5 m) were located behind modern coastal dunes on which *Pinus densiflora* have been planted as a windbreak and to hold sand on the present seacoast. *Phragmites* moors, with *Typha latifolia* and *Carex michauxiana* var. *asiatica,* were present around stations 9 and 10. Differences between the present distribution of vegetation and the observed frequency of airborne and soil surface pollen can be described as follows.

Cryptomeria

Airborne pollen: 31,733 total grains were collected. Throughout all the stations abundant grains were collected. More than 70 percent of the total tree pollen was *Cryptomeria.*

Surface assemblages: The percentage values of surface samples fluctuated strongly among the stations. At all stations the values are lower than those of airborne pollen. At stations 4 and 5, located in hilly districts, *Cryptomeria* accounts for more than 50 percent of total tree pollen. These high percentage values decline abruptly toward both the mountain and the coastal regions.

On the soil surface at station 6, located on the alluvial plain, *Cryptomeria* pollen is rare. At this station, however, it accounts for more than 70 percent of the total airborne tree pollen.

Pinus

Airborne pollen: 17,889 total grains were collected. The fluctuation in number of grains gradually decreases toward the mountains. *Pinus* pollen may have been dispersed from the mother plants consisting of both *Pinus densiflora* and *P. Thunbergii.* Abundant grains were collected at stations 8, 9, and 10 located on the alluvial plain.

Surface assemblages: The percentage values of surface fossil pollen are higher than those of airborne pollen at most stations. The values reach more than 90 percent at stations 6, 7, and 8, located on the alluival plain. The abundant pollen grains of these stations may have been dispersed from *Pinus* forests growing on the coastal dune. The percentage values show a gradual decrease toward the mountains. At station 1, located near the summit of the mountain, *Pinus* shows a relatively high percentage value. Pollen grains of *Pinus* at this station may have been dispersed from the mother plant of *Pinus densiflora* growing on the summit of the mountain.

Fagus

Airborne pollen: 1355 total grains were collected. The grains of *Fagus* were dispersed from the mother plants of both *Fagus crenata* and *F. japonica.* The percentage values decrease gradually toward the sea. The highest value is obtained at station 1, located in the *Fagus* forest.

Surface assemblages: The highest percentage value is shown at station 2. Away from this station there is a gradual decrease of *Fagus* values, and at station 10, located nearest the sea, only a small percentage of the pollen obtained was *Fagus*. Considering the predominant west wind during the research season, it must be concluded that practically all *Fagus* pollens collected away from the mountains were brought by air-transport from mother plants growing in mountainous regions.

Quercus

Airborne pollen: 2024 total grains were collected. Pollen grains were dispersed from mother plants of both *Quercus serrata* and *Q. mongolica* var. *grosseserrata*. At all stations, *Quercus* pollen accounted for a small percentage of the total tree pollen collected.

Surface assemblages: The percentage value of surface fossil pollen abruptly increased at station 3, where *Quercus* comprised more than 80 percent of the total tree pollen. But this high value was confined to station 3 and abruptly declined toward both the mountainous and the coastal regions.

Alnus, Corylus, Juglans, Zelkova

The percentage values of these pollen grains in both airborne and surface samples are relatively low. The percentage values were comparatively higher in both categories within the mountainous and the coastal regions. The regional distribution of these genuses is quite uniform.

Abies, Tsuga

Pollen grains of *Abies* and *Tsuga* appear only rarely in either airborne or surface samples. Airborne pollen of *Tsuga* may have been transported long distances.

The regional distribution of these main pollen grains as the percentage values of total tree pollen is shown in Figure 2. The distribution of surface pollen shows rather strong fluctuation while airborne pollen has a more uniform spread. The strong fluctuation seen in surface pollen seems to be related directly to the local abundance of mother plants. The frequencies of airborne *Fagus, Quercus, Alnus, Juglans, Corylus,* and *Zelkova* also vary more or less directly with the local abundance of mother plants. From this fact it is supposed that pollen grains of these plants do not disperse to any great distance from their sources.

SITE AND STRATIGRAPHY

The ancient castle site of Tagajo lies at the northern part of Tagajo city in Miyagi Prefecture (Fig. 3). The site is situated on a hill at an altitude of 10 m to 50 m. The western and southern parts of the hill descend to the valley of the Sunaoshi River. This valley is divided into two landform types: natural levee and backswamp (Fig. 3). In the backswamp, most of which is now cultivated as paddy field, peat has developed to a depth of over 3 m. The present vegetation around Tagajo is almost treeless: there is paddy-field vegetation dominated by Gramineae, and there are farm houses with occasional scattered trees of *Pinus densiflora* or *Cryptomeria japonica*.

During the Nara Period, the area around Tagajo was the northern frontier zone of the Nara empire, which had first brought most of Japan under a single authority. The Nara government intended to extend its rule to the far north and encompass the uncivilized people of that district. At this time, the uncivilized people were called *ezo*. Many frontier forts were constructed as army bases in order to combat the *ezo*. Tagajo was constructed as one of the main frontier forts in the first half of the 8th century A.D. A great many *fushu*, landless farmers, were sent as soldiers to these frontier forts. Thus, the *Nihonkoki*, one of the records of this time, states

「延暦十五年，發相模，武藏，上總，常陸，上野，
下野，出羽，越後等國民九千人，配置陸奥伊治城」

From this description it is inferred that in A.D. 796 more than 9000 landless people from the country of Sagami, Musashi, Kazusa, Hitachi, Kōzuke, Shimotsuke, Dewa, and Echigo were sent to the ancient castle of Ichijo. Similar descriptions of the movement of people into the frontier region are found in other ancient records. The *Shokunihongi*, for example, also mentions that an army of more than 52,800 was concentrated at the castle of Tagajo in A.D. 788, in preparation for a war with the *ezo*. Some of these descriptions may not always report the facts exactly. But it is clear that a great population movement into the frontier region had been supervised by the Nara court.

As the result of archaeological excavation, it has become clear that the Tagajo castle was rebuilt or repaired several times before it finally disappeared. One rebuilding took place in A.D. 780, after the castle was burned down in an *ezo* uprising. However, the reconstructed building was damaged by an earthquake in A.D. 869.

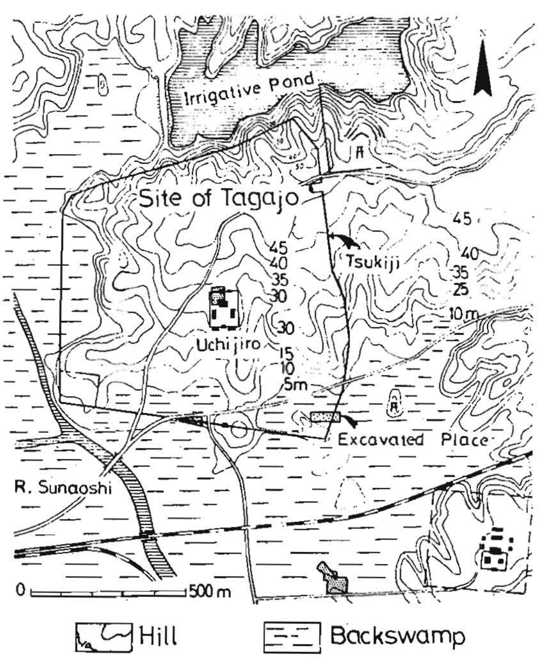

Fig. 3 Location of the ancient castle site of Tagajo.

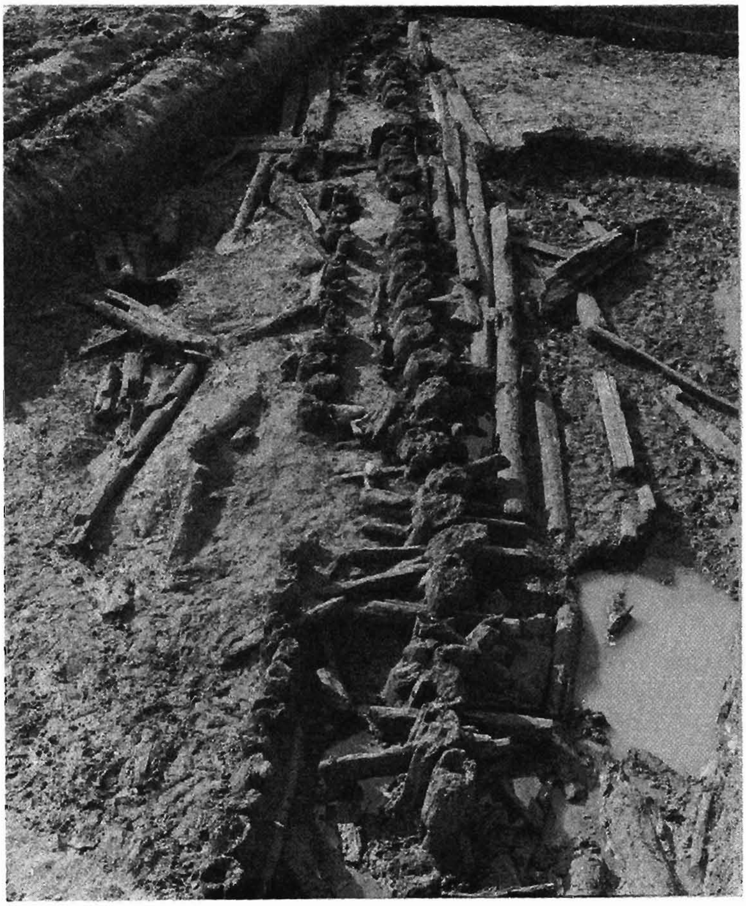

Plate I　Large logs used to protect fence *(tsukiji)* from soil erosion.

Plate II The structure of heavy timber constructed as a building foundation.

Along with the repair of earthquake damage, white tuff was laid down around the castle perimeter. In the latter half of the 11th century, Tagajo lost its role and was finally abandoned. It also has become clear that the main site of Tagajo, for which the archaeological term is *uchijiro*, is on the hilltop at an altitude of 40 m. The size and structure of this main building is estimated by the arrangement of buried pillar-base stones. Enclosing this main area there was a fence, or *tsukiji*, which may have been built as a defense against barbarian groups. Remains of the *tsukiji* were found under the peat which developed in the backswamp of the Sunaoshi River. Archaeological excavation of this part of the site was carried out in February 1971. In this excavation the sewerage for a palisade of large logs (Plate I) and the base of a heavy timber bastion (Plate II) were found. The large logs were used for a soil-erosion guard and the structure of heavy timber prevented the building from subsiding into the soft ground. The logs of the palisade were more than 30 cm in diameter and reached a length more than 3 m. Most of these logs were from deciduous broad leaf trees such as *Castanea crenata, Quercus mongolica* var. *grosseserrata,* and *Fagus crenata.* The excavated area was only a small part of the total site of Tagajo (Fig. 3), so that it is clear that a substantial number of large logs and timbers were used for the building materials of the Tagajo castle and fortification.

In relation to this excavation, the author sampled the peat for the purpose of pollen analysis. The stratigraphy of the pit chosen for a pollen profile was as follows:

Depth (cm)	Description
0–30	dark brown clay which is currently cultivated soil.
30–80	dark gray clay with obvious small plant remains and occasional archaeological relics. This dark gray clay covers the remains of *tsukiji.*
80–90	green gray humic clay with abundant plant remains.
90–100	white humic tuff which was carried and laid down in this place in A.D. 869.
100–140	dark brown unhumified peat with a high content of inorganic deposits.
140–185	very well humified dark brown peat with obvious macro plant remains.
185–215	dark brown unhumified peat.
215–235	dark brown well humified peat with abundant fragments of wood.

Samples for radiocarbon dating were collected from depths of 165–170 cm and 225–230 cm; ages of 1890 ± 115 B.P. and 2740 ± 120 B.P. were obtained (Yasuda 1973).

POLLEN DIAGRAM

Pollen samples were collected from the section of archaeological trenches. Most of the samples were collected at intervals of 5 cm. Close interval sampling allows for the study of the dynamic response of vegetation to human impact. Thus, the samples between 100 cm and 140 cm in the profiles were subdivided into 0.5 cm slices of peat in the laboratory. All of the samples used in this investigation were treated by the simplified Erdman's method (boiling with KOH, followed by acetolysis; see Faegri and Iversen 1964). After this process, they were also treated with a saturated solution of $ZnCl_2$ in order to concentrate the pollen grains. Usually more than 200 arboreal pollen grains were counted, together with all other grains and spores. The pollen diagram was constructed using a percentage value of total tree pollen; the values for the individual pollen types were expressed as percentages of this number. However, if pollen assemblages are expressed only by percentage values, they may not record the extent of forest disturbance, since a change in abundance of one type will cause changes in percentage values of all the others. With this problem in mind, the author counted an absolute pollen number per gram (APF) (Tsukada 1966).

The main pollen diagram for the ancient castle site of Tagajo is shown in Figure 4. As can be seen, the diagram is divided into three pollen zones.

Zone III

The lower portion of Zone III is characterized by the abundant temperate species in which the leading elements are *Quercus* and *Alnus*. *Quercus* and *Alnus* show high percentage values of more than 40 percent of total tree pollen. The former has a decreasing trend and the latter is increasing toward the upper end of the zone. In nonarboreal pollen, Cyperaceae and Gramineae show high percentage values.

Zone II

Zone II is distinguished from Zone III by an increase of *Fagus*. *Fagus* accounts for 20 to 45 percent of total tree pollen. The fluctuation of *Fagus* contrasts with that of *Alnus*. *Fagus* attains percentage values of more than 40 in the 140–160 cm and 172–190 cm depth ranges, while in the middle of Zone II, between depths of 160 cm and 172 cm, *Fagus* values decrease. The percentage values of *Alnus* increase in the middle of Zone II and reach more than 40 percent of total tree pollen. In the middle part of Zone II, *Ilex* shows a temporary increase. The fluctuation of *Carpinus* is similar to that of *Fagus*, although the percentage values of *Carpinus* are lower than those of *Fagus*. The *Quercus* values are nearly 20 percent of total tree pollen throughout Zone II. The insignificance of nonarboreal pollen is shown by the very small percentage of this category.

Zone I

Above the line marking the transition between Zone II and Zone I there is clear indication of human interference with vegetation, and this upper section of the diagram was subdivided into four Subzones on the basis of pollen changes indicating varying degrees of human interference. The features of each period will be discussed here in some detail.

Subzone 4: The opening of this period is indicated by an abrupt decline of APF. At the same time *Quercus* pollen decreases. However, neither cereal pollen nor

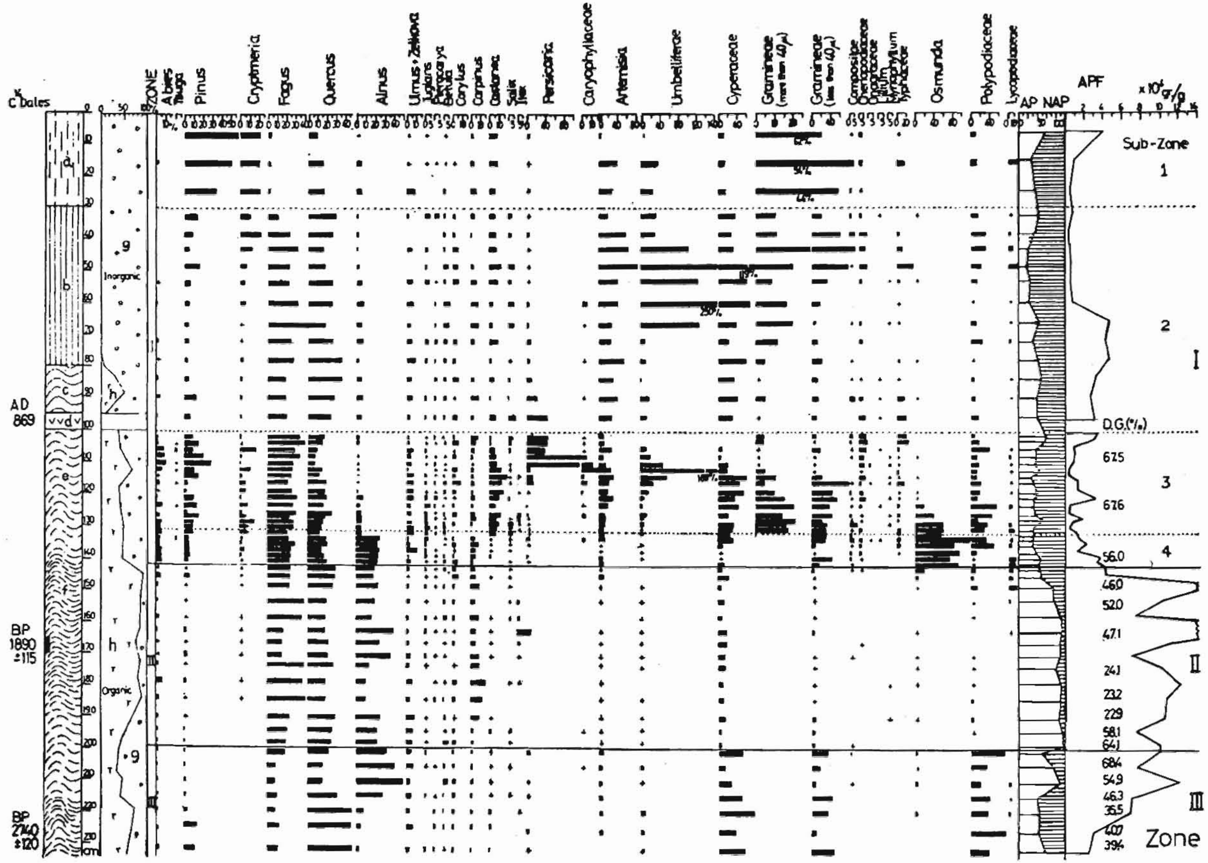

Fig. 4 Pollen diagram of the sediment from Tagajo. *a*, ploughed clay; *b*, dark gray clay; *c*, peaty clay; *d*, white tuff; *e*, weakly humified peat; *f*, highly humified peat; *g*, inorganic matter; *h*, organic matter; *D.G*, decomposition grade of peat.

pollen of all the cultivation indicators is present. Spores of *Osmunda*, an indicator of woodland clearance, rapidly increase.

Subzone 3: This period is the most prominent feature in the diagram. It is marked by a sudden and severe reduction in the quantities of tree and shrub pollen and an equally sudden increase in clearance indicators (Gramineae, Compositae, *Artemisia, Osmunda*, Umbelliferae, Cryperaceae). There is a sharp rise in cereal pollen and other ruderals at a depth of 131 cm, accompanied by a marked decrease in tree and shrub pollen, especially *Alnus*. The values of *Alnus* decline to 4 percent of total tree pollen. The values of *Quercus*, which mainly grew in hilly districts, decline to as little as 8 percent in the upper part of Subzone 3.

Subzone 2: This is a rather complex period. In the lower portion it begins with a phase characterized by fairly high frequencies of tree and shrub pollen. *Quercus, Fagus*, and *Castanea* increase slightly and, at the same time, the APF shows a similar increase. However, the tree and shrub pollen curves and the APF do not regain their former levels. Accompanying the increase of *Quercus, Fagus*, and *Castanea* is an equally gradual rise of *Pinus* and *Cryptomeria*. These features suggest a period of woodland regeneration rather than deforestation.

In the upper portion of this period there is renewed agricultural activity. Indications of intense human activity are also present again. Umbelliferae, *Artemisia*, Cyperaceae, and *Persicaria* abruptly rise, as do cereal pollen grains. The values of Umbelliferae and Cyperaceae exceed 200 percent (i.e., twice the number of tree-pollen grains) in several layers.

Subzone 1: In this period, *Quercus, Fagus*, and *Alnus* decline into the minimum values. But the most marked features are abrupt increases of *Pinus* and *Cryptomeria*, the latter being an exotic genus and hence indicating human introduction and the planting of trees. This pollen assemblage reflects the present vegetation in Miyagi Prefecture.

Discussion

The Quercus-Alnus *Woodland*

In the pollen diagram of Zone III, *Quercus* and *Alnus* show high percentage values, reaching more than 40 percent of the total tree pollen. *Quercus* decreases and *Alnus* increases toward the end of Zone III. The pollen grains of *Quercus* at the lower part of Zone III were probably derived from *Quercus* forest growing in the hilly districts. Our study of airborne pollen indicates that *Quercus* pollen is not transported far from its source. Therefore, the high *Quercus* values of Zone III indicate that *Quercus* woodland at this time had extended to the area investigated. The pollen grains of *Alnus* at the upper part of Zone III were probably derived from *Alnus* shrubs growing on the alluvial plains. The scattered *Alnus* trees in the present backswamp are evidence that *Alnus* forest grew extensively on the swampy alluvial plain and sides of streams during the time of Zone III. The high percentage value of Gramineae during Zone III suggests that the *Phragmites* moor also extended onto the alluvial plain at this time. The period of Zone III is assumed to correspond to Tsukada's R II from Nojiri Lake (Tsukada 1967). The climate of this period may have been warmer than at present. The lowland vegetation on the alluvial plain during this period consisted of *Alnus* bushes and *Phragmites* moors. The highland woodlands during this period were composed of forests of *Quercus*.

The Fagus-Alnus *Woodland*

The opening of Zone II is marked by the increase of *Fagus*. The frequency of *Fagus* is more than 40 percent in the 140–160 cm and 172–190 cm depth intervals. In the middle of Zone II, between 160 cm and 172 cm, the frequency of *Fagus* decreases. The percentage values of *Alnus* increase toward the middle part of Zone II. *Alnus,* in this middle part of Zone II, accounts for more than 40 percent of total tree pollen. Our study of the modern pollen rain suggests that *Allnus* does not disperse its pollen to any great distance. Therefore a small variation in the density of alder trees may produce large percentage fluctuations in the pollen diagram. It is probable that a change in density of the *Alnus* forest growing near the site caused the percentage change in this part of the pollen diagram. The fluctuation of percentage values of *Fagus* during Zone II may have been reduced by the small localized change of *Alnus.*

At the present time *Fagus* woodland is confined to the mountainous region above 400 m. Study of modern surface fossil pollen suggests that *Fagus* woodland currently has a value of about 15 percent. In the alluvial plain the percentage values of *Fagus* in surface samples are very low. Study of airborne pollen established that *Fagus* values greater than 5 percent of total tree pollen rarely occurred far from a source. Therefore, the increase of *Fagus* along with the decrease of *Quercus* must represent a real downward expansion of *Fagus* woodland to a lower altitude. It is also suggested that during the time of Zone II, *Quercus* forest was partially replaced by *Fagus* forest. At the present time in Miyagi Prefecture, *Fagus* woodland is found at a slightly higher altitude than are *Quercus* forests (Fig. 1). Thus, the increase of *Fagus* seen during this period may be due to climatic cooling, providing the first sign of sub-Atlantic climatic deterioration (Yasuda 1974). Evidence for an increase in the extent of *Fagus* forest comes from the high occurrence of *Fagus* pollen throughout Zone II. In Zone II, *Fagus* comprises more than 40 percent of the total tree pollen. Surface samples from the present *Fagus* forest in Miyagi Prefecture were about 15 percent of the total tree pollen. The *Fagus* woodland of this region is not completely natural since some parts have been disturbed by man. Figure 5 shows the percentage values of surface pollen from the undisturbed *Fagus* woodland. As shown in Figure 5, natural *Fagus* woodlands from both Mt. Hakkoda in Aomori Prefecture and Mt. Kurikoma in Iwate Prefecture *Fagus* account for more than 40 percent of total tree pollen. The percentage values of *Fagus* in Zone II are similar to those of natural *Fagus* woodland. From this fact it may be said that the densities of *Fagus* woodland during the period of Zone II were similar to those of undisturbed *Fagus* woodland growing on both Mt. Hakkoda and Mt. Kurikoma.

From this evidence, it can be concluded that forests were much more widespread around the region of Tagajo immediately before the beginning of intense human interference with vegetation. The lowland forest may have consisted of *Alnus* bushes along with *Phragmites* moor. The upland forest probably consisted of *Fagus* forests mixed with *Quercus* and *Abies*. At the present time, scattered trees of *Fagus crenata, F. japonica,* and *Abies firma* remain as relict vegetation of this formerly widespread tree cover.

The Major Clearance

Above the line marking the Zone II/Zone I transition there are indications of

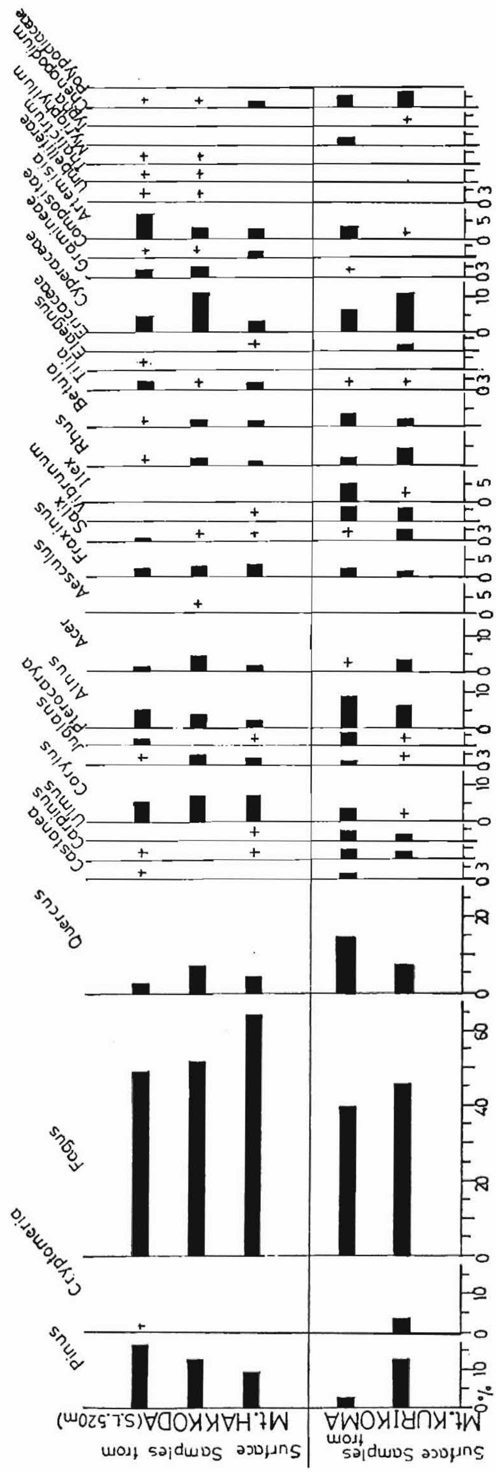

Fig. 5 Assemblage of surface samples from the undisturbed *Fagus* woodland.

intense human interference with vegetation, and this section of the diagram has been divided into four subzones. At this time there is an abrupt decline in the APF. At the same time, *Quercus* pollen decreases. This, according to Tsukada (1966), is indicative of the beginning of human occupation and forest clearance. However, neither cereal pollen nor pollen of the cultivation indicators has yet appeared. Spores of *Osmunda* as an indicator of forest clearance rapidly increase. This section of the pollen diagram suggests that the forests of the surrounding foothills were destroyed by human occupation. Clearance of the forest in the foothills probably resulted mainly from the activities of the people of the Kofun Period. Archaeological evidence of these people is seen in the mound tombs which are found on the margin of surrounding valleys. The building of these ancient tombs was almost entirely responsible for the deforestation of the foothills.

Profound changes appeared at the period of Subzone 3. This period is marked by sudden and severe reduction in the quantities of tree and shrub pollen and an equally sudden increase of the clearance indicators (Gramineae, Compositae, *Artemisia, Osmunda,* Umbelliferae, Cyperaceae). There was a sharp rise in the pollen of cereals and other ruderals. At a depth of 131 cm, there was a sharp increase in a cereal type which may be *Oryza*, accompanied by a marked fall of *Alnus*. These features may indicate that the intensive cultivation of *Oryza* was introduced into the lowland. *Alnus,* which had been a major feature of the swampy lowlands, was cleared by this introduction of the intensive cultivation of *Oryza.*

The pollen of *Quercus,* a genus which grew mainly on hillsides, declined to only 8 percent in the upper part of Subzone 3. This decline of *Quercus* suggests a major impact on the upland vegetation. It seems likely that the clearance of the upland vegetation reflects the cutting of the forest for materials to build Tagajo itself. Further points of interest occur at depths of 115 cm, 110 cm, and 105 cm. At these layers the Gramineous cereal pollen temporarily declined to minimum values and the tree pollen also decreased. Pollen of other indicators of human activities, however, did not decrease. Thus it is possible that the temporary decline of cereals was due to an interruption of lowland cultivation caused by the construction of Tagajo. The woodland clearance which occurred during this period is far more intensive and probably more prolonged than any previous phase of human interference with vegetation.

The Later Clearance and Soil Erosion

The time of Subzone 2 was a rather complex period. In the lower portion of this zone there is a phase of fairly high tree and shrub pollen. *Quercus, Fagus,* and *Castanea* increased slightly and at the same time the APF showed a slight rise. This suggests a degree of forest regeneration rather than clearance. Accompanying the increase of these pollens were equal increases in *Pinus* and *Cryptomeria.* These increases indicate that in addition to the probable regeneration of the forest, it is likely that the composition of the surrounding forest was also profoundly altered at this time. These features suggest some regeneration of woodland after Tagajo was abandoned.

In the upper portion of Subzone 2, there was renewed agricultural activity. Indications of activities are also represented. Umbelliferae, *Artemisia,* Cyperaceae, and *Persicaria* abruptly rose, as did cereal pollen grains. It may be said that following the temporary forest regeneration, there occurred a further phase of intensive activity. Abundant Umbelliferae and *Persicaria* in this phase confirm the prevalence of forest clearance. This feature is thought to represent the activities of the people during the Kamakura Period following the withdrawal of the authority of the central government. It is postulated, from the accumulation ratio of the peat, that the intensive clearance of the upper portion of Subzone 2 began about A.D. 1300.

The peat deposited before the beginning of human interference with vegetation contained relatively low amounts of inorganic matter. Before the beginning of forest clearance by early historic people, a stable and continuous forest cover occupied the drainage basin, so that erosion was minimal during this period. The peat, deposited after the period of forest clearance, contains high amounts of inorganic matter. A significant increase in the amount of inorganic matter was shown from Subzone 2 (Fig. 4). The increase of the amount of inorganic matter suggests that the soil is beginning to be unstable. This soil instability may not have resulted from climatic change, but rather probably resulted from forest clearance by early historic farmers and builders.

Summary

A pollen analysis was made on peat material collected from the archaeological site of Tagajo castle in Miyagi Prefecture. The modern mode of pollen rain and the relation to present vegetation was also studied. From the results of the pollen analysis and from the study of the local history, the author described the impact of early historic man on natural vegetation. The pollen sequence of this site is divided into three pollen zones (Zone III, Zone II, and Zone I). The lowest zone, III, is characterized by abundant temperate species in which the leading elements are *Quercus* and *Alnus*. The abundant *Quercus* pollen indicates a temperate forest developed in a climate warmer than that of the present time. Zone II is distinguished from Zone III by the increase of *Fagus*. The increase of *Fagus* in this zone may be due to climatic deterioration. An increase of *Fagus* with a decrease of *Quercus* represents a massive expansion of *Fagus* woodland to lower altitudes. Just before the opening of the historic period and intense human interference with the vegetation, the upland forest of this area may have consisted of *Fagus* forest mixed with *Quercus* and *Abies*. Zone I corresponds to the stage of intensive agricultural activity marked by a sudden decline in the APF value, a decrease in such tree pollens as *Fagus, Quercus, Alnus, Castanea,* and *Juglans,* and an increase in NAP, that is, Gramineae, Cyperaceae, *Artemisia, Persicaria, Osmunda,* and Polypodiaceae. It is concluded that intensive activities of early historic man made a great impact on the natural vegetation. *Alnus* and *Juglans* were burned to make farmland. *Quercus, Fagus,* and *Castanea* were cut down for building materials to be used in the castle itself. After this catastrophic forest destruction, some regeneration of the woodland took place. Migrations of *Pinus* and *Cryptomeria* into this region can be detected in the upper part of Zone I.

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