Bull. Inst. Environ. Sci. Technol., Yokohama Natn. Univ. **15**:95～102 (1988)

報　文

Restoration of Natural Environment by Creation of Environmental Protection Forests in Urban Areas*

—— Growth and development of environmental protection forests on the Yokohama National University campus ——

都市における環境保全林形成による自然性の回復
—横浜国大キャンパスの環境保全林の生長・発達—

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SYNOPSIS

The creation of environmental protection forests is a basic ecological method for restoring the natural environment in urban areas which are utilized intensively and are dominated by non-biological materials and several forms of energy (Miyawaki 1982, Miyawaki, et al. 1987). The result of "Ecological greenery planting: Tree planting" shows that seedlings of 0.5m height grew to 9m and developed into true environmental protection forests over a period of 11 years. Maintenance was not required after the first two or three years. These forests developed gradually into multi-stratal communities by means of an ecological equivalent of "natural selection". The understorey develops later than the canopy, but it was seen that the development of these ecosystems and the restoration of natural conditions were proceeding.

1. Environmental protection forest planted with native tree species

Forests are the most stable type of natural ecosystem, given suitable moisture, temperature, and soil conditions. Forests are composed of multiple layers of trees, shrubs, and ground herbs. Forests also have an "underground ecosystem" of soil animals which decompose the litter.

The campus of Yokohama National University supports evergreen broad-leaved forests with

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* Contribution from the Department of Vegetation Science, Institute of Environmental Science and Technology, Yokohama National Universitue No. 201.
Part of this wark (cf Miyawaki and Fujiwara 1988) was made possible through a research grant from the Special Expenditure on Educational Research, 1987, Yokohama National University (delegate, K. Sato).

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(Accepted Sept. 16, 1988)

Quercus myrsinaefolia, Quercus glauca, Persea thunbergi, Castanopsis cuspidata var. *sieboldii,* etc. (Miyawaki et al. 1972). Evergreen broad-leaved forests, as multi-layer communities, embody the most stable sort of "naturalness". In urban areas, evergreen broad-leaved coppice forests are an easy and effective way to create natural forest conditions. We have examined creation of natural forests since 1982 (Miyawaki 1982, Miyawaki et al. 1983, etc.). Important keys are: 1) recovery of the topsoil, 2) selection of appropriate species, 3) dense initial planting, and 4) use of pot seedlings with well developed root systems.

In this report we present a survey of environmental protection forests at Yokohama National University, which are eight and 12 years old. We measured growth and development of each tree in permanent quadrats (height, diameter at breast height (DBH), and understorey species). Soil mites were surveyed by J. Aoki.

2. Purpose of the Research

It is necessary to use "living construction materials" to develop environments for healthy human living in urban areas, which are otherwise mostly constructed of artificial materials. Forest ecosystems are the most important living construction material. We should introduce the theory of devloping multi-layer, balanced forests and seek the results of ecological vegetation science. We establish a method to restore naturalness in urban areas.

3. Survey method and location

Three environmental protection forests on the campus of Yokohama National University were selected for study. One forest is 12 years old, the other two are eight years old. In them, 10 permanent quadrats of 25m each were installed for estimating the height and DBH of each tree and for surveying by phytosociology. Height and DBH were plotted graphically for comparison

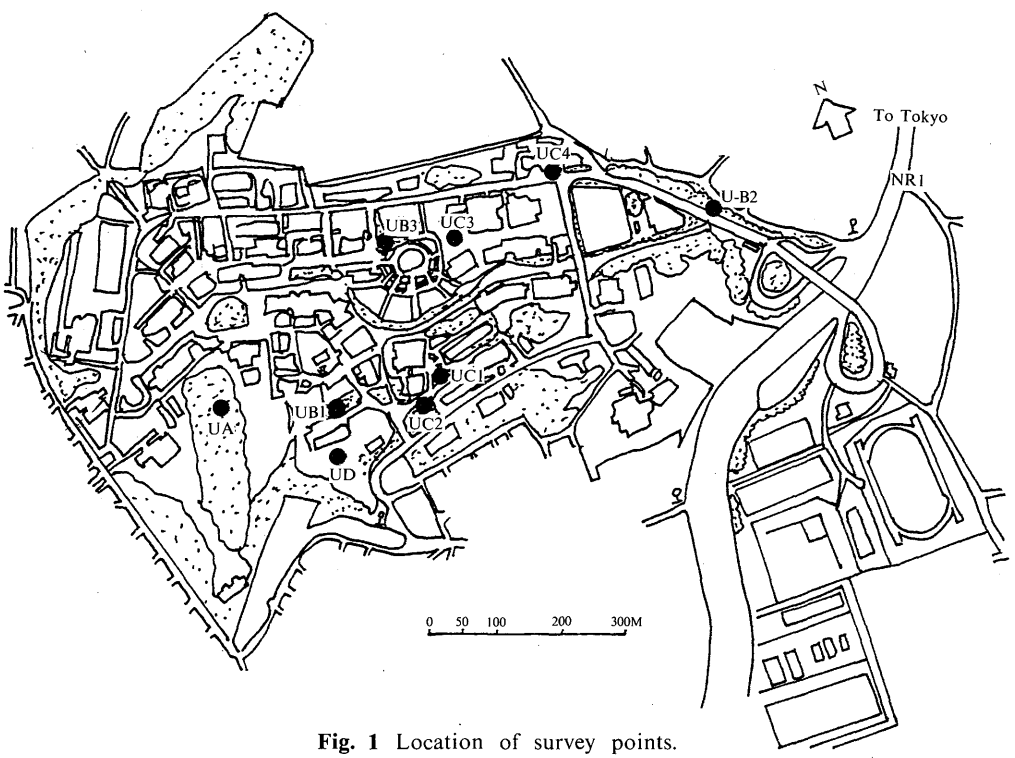

Fig. 1 Location of survey points.

Table. 1 Division of the survey area

Environment type	natural forest	environmental protection forests			landscape garden area			lawn area
Main plants	*Castanopsis cuspidata* var. *sieboldii*	evergreen broad-leaved trees			*Betula platyphylla*	*Prunus jedoensis*	*Rhodonrdon* spp.	*Zoysia japonica*
Quadrat number	UA	UB-1	UB-2	UB-3	UC-1	UC-2	UC-3	UD
Location	west side of Institute of Env. Sci. & Tech.	north side of Inst. of Env. Sci. & Tech.	west of main gate of YNU	north of cental open area	north of Natural Science Building	west of Economics Faculty	north of separate building of Education Faculty	south of Inst. Env. Scie. Tech.

Fig. 2. Environmental protection forest UB-1, planted in May 1976 on the north side of the Institute of Environmental Science and Technology.

of the growth of each tree. Then phytosociological surveys were conducted on a *Castanopsis cuspidata* var. *sieboldii* forest (west side of the Institute of Environmental Science and Technology) as a natural forest, as well as *Betula platyphylla, Zelkova serrata-Prunus yedoensis,* and *Zelkova serrata-Rhododendron* plantation areas as examples of "landscaping" (or "landscape gardening"), for comparison of the soil mites of natural forests and garden-planning areas. The survey method used was that of Braun-Blanquet (1964; Fujiwara 1987).

4. Results

In the environmental forests surveyed, the growth of the trees was different at each site (Figs. 2-5). The environmental protection forest on the north side of the Institute of Environmental Science and Technology, which is 12 years old, was planted as pot seedlings 0.5-1.2m tall and with well developed root systems, two individuals per m^2, in May 1976 (UB-1, Fig. 2). UB-2 and UB-3 were planted in March 1980 (Fig. 3, 4), UB-2 with two individuals per m^2 and UB-3 with one individual per m^2. UB-1 shows the best growth, while UB-3 is worse than UB-2 (Fig. 5-9). Comparing the forest composition (Fig. 10) of natural forest, environmental protection forest, and landscape gardening, one sees that natural forest develops a four-layer structure already and becomes a stable forest. The UB-1 environmental protection forest has not yet developed enough. The UB-2 environmental protection forest has developed about the same as UB-1, UB-

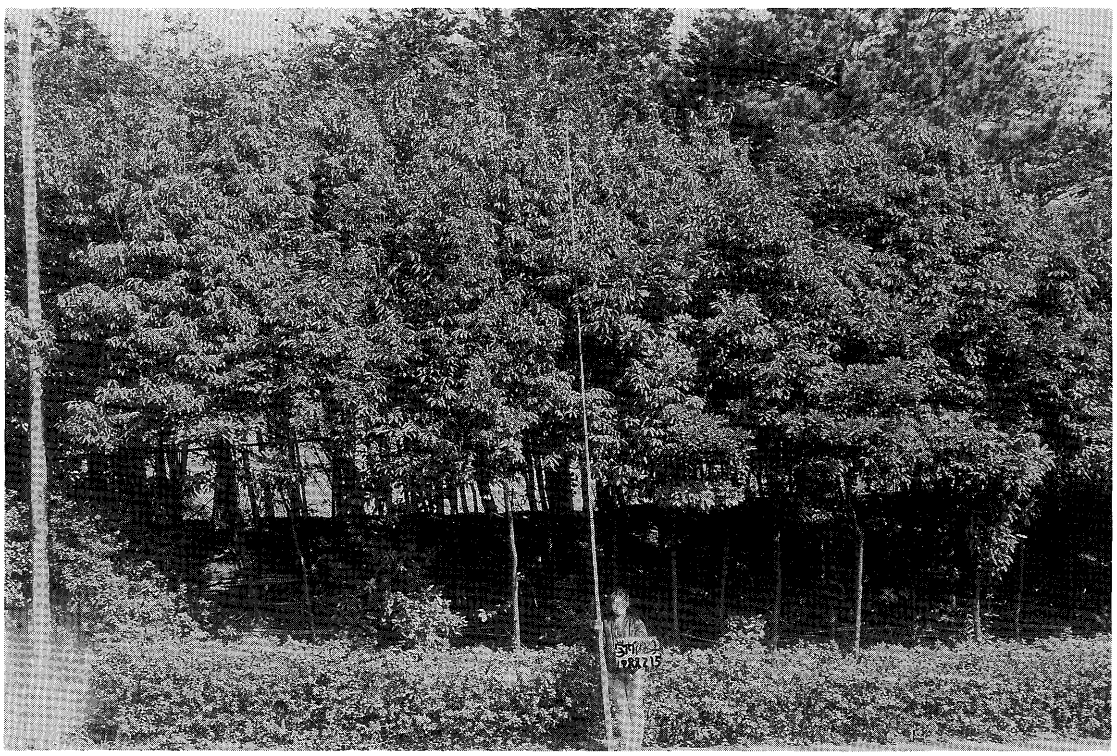

Fig. 3. Environmental protection forest UB-2, planted March 1980 to the west of the main gate of Yokohama National University.

Fig. 4. Interior of environmental protection forest UB-2.

Fig. 5. Environmental protection forest UB-3, north of the central open area.

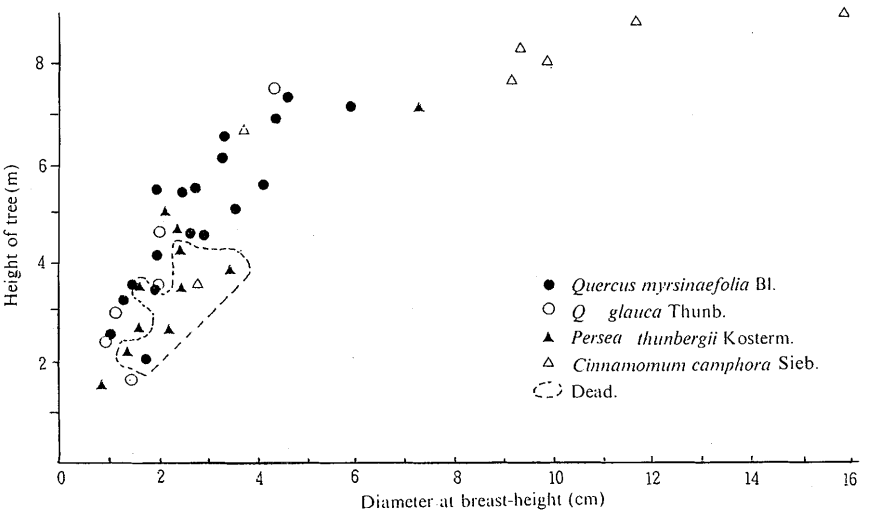

Fig. 6 Relationship of tree height and diameter at breast height (DBH), in forest UB-1.

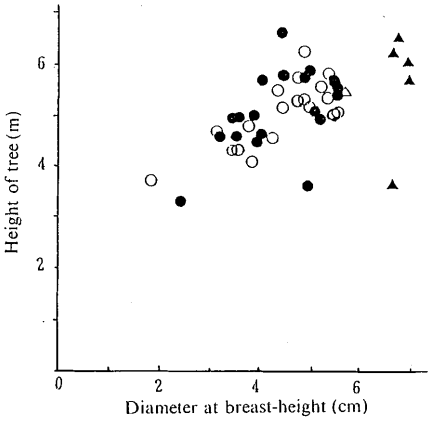

Fig. 7 Relationship of tree height and DBH in forest UB-2.

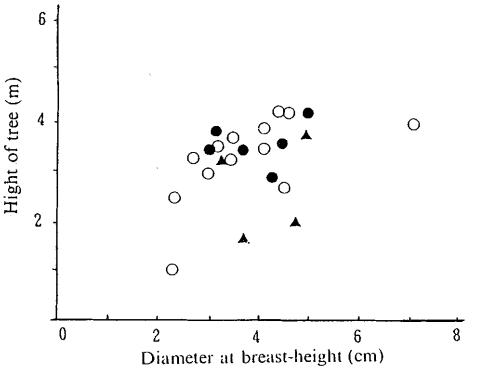

Fig. 8 Relationship of tree height and DBH in forest UB-3.

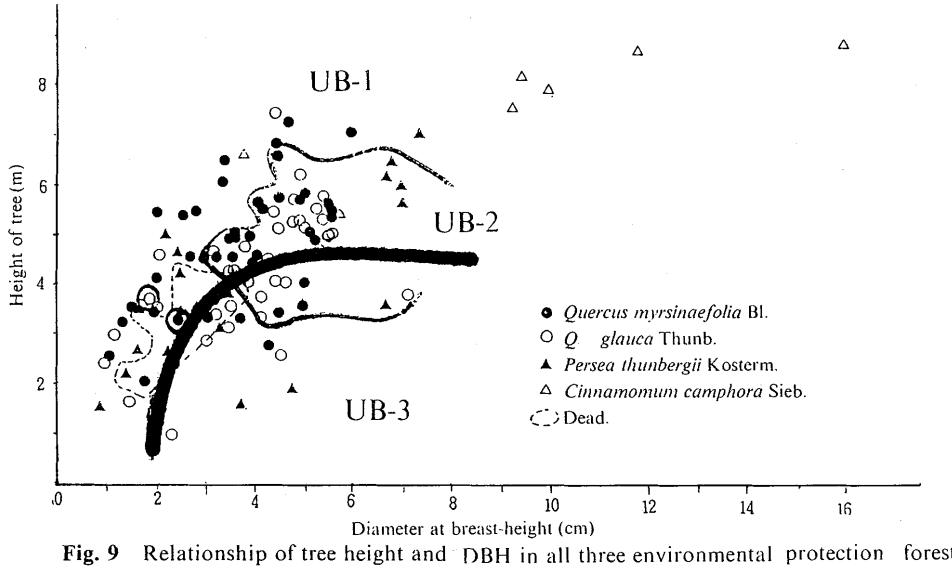

Fig. 9 Relationship of tree height and DBH in all three environmental protection forests.

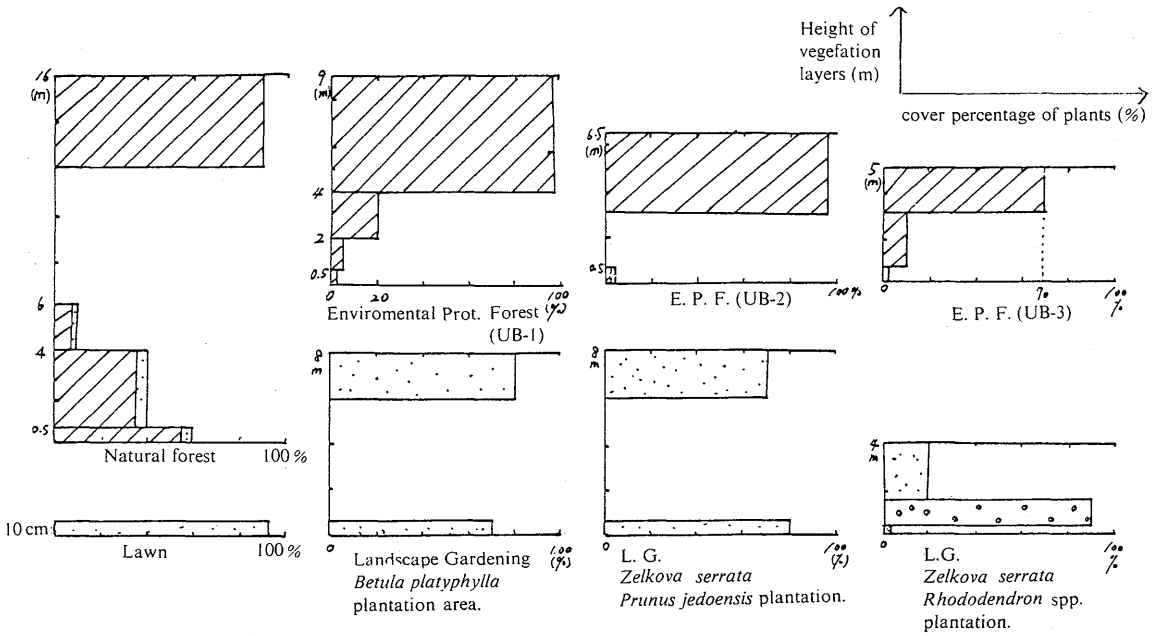

Fig. 10 Vegetation cover of each forest layer in the permanent quadrats.

Evergreen Semi-Evergreen Deciduous

3 still has open space in its canopy. Although UB-2 and UB-3 forests are the same age, the UB-2 forest was constructed on a slope and UB-3 on a flat area. The site of UB-3 has especially bad drainage, and its density of seedlings is different. UB-3 was planted with one individual per m^2. The lawn area UD is quite different from other areas. From Figure 6, it is understood that UC1-3 have about the same composition. Based on the survey results of mites by J. Aoki (1988), UC1-3 have six special species which do not live in UB1-3 or UD. UB1-2 have nine special species which are common to natural forests. UB-3 has only one. The natural forest has 13 characteristic species.

5. Conclusion

From the results and comparison with data in 1983. (Fujiwara 1983), the following points are concluded:

1) When environmental protection forests are constructed, it is necessary to restore the topsoil, select pot seedlings with well developed root systems, plant densely, and provide good drainage.
2) Mixed plantations with many species planted densely lead to good growth because of differences in crown space.
3) Over 10 years, the environmental protection forests planted on the basis of criteria in 1) and 2) were thinned naturally, by inter-plant competition.
4) Ten years, however, are not enough to develop and restore natural forests completely. Such forests are still young. It is possible to make the forests develop faster by additional planting of some native species of shrubs and herbs in the understorey of the environmental protection forests.
5) Environmental protection forests grow up and surpass the "landscape gardening" trees within three to five years. Environmental protection forests also spread their vegetative cover resulting from the dense planting of seedlings much more than the "landscape-gardening" or lawn areas.

Thus, the best effect is produced by creating green corridors by means of environmental protection forests satisfying points 1)-5) for restoration of natural conditions in urban areas.

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