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Creation of an Environmental Forest as an Ecological Restoration

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ABSTRACT: We created an environmental forest on the basis of ecological design around the incineration plant of Jindo Engineering and Construction Co., Ltd., which is located in Jeongwang-dong, Siheung-si, Kyunggi-do. To get ecological information of this site, physico-chemical properties of soil on salt marsh, which is located close to the syudy site and of forest soil transported from other sites for ecological restoration were analyzed. Texture of salt marsh and transported soils were loam and sandy loam, respectively. pH, organic matter, T-N, available P, and exchangeable K and Na contents of salt marsh and transported forest soils were 6.7 and 5.4, 4.1 and 0.4%, 1.0 and 0.3mg/g, 46.7 and 6.8ppm, 521 and 207ppm, and 3.8 and 0.5mg/g, respectively. Introduced plants were selected among the dominant species of forests and the species composing the potential natural vegetation around the present study site. Those plants were selected again by considering the tolerances to air pollution and to salt, and their availability. Selected trees were *Pinus thunbergii, Sophora japonica, Celtis sinensis, Quercus aliena, Q. serrata, Q. dentata,* and *Q. acutissima.* Selected sub-trees were *Albizzia julibrissin, Koelreuteria poniculata,* and *Styrax japonica* and shrubs were *Rhododendron yedoense* var. *poukhanense, R. mucronulatum, Callicarpa japonica, Euonymus alatus, E. japonica,* and *R. schlippenbachii.* On the other hand, introduction of herbs was not considered except for *Liriope platyphylla,* which was ornamentally planted in one site. Planting bed of mound type was adopted to provide the fine drainage system. Mound was designed to furnish litter, A, B, and C layers simuating the profile of forest soil. Slope of mound was mulched by rice straw of 2cm in thickness to prevent for sliding of litter and soil in cases of strong wind or heavy rain. Height of mound was designed to secure more than 1 m by combining A and B layers. Narrow zones, in which mound with stable slope degree cannot be prepared, was designed to equip the standard soil depth with the introduction of stone for supporting. On the other hand, plants with shallow root system were arranged in some zones, in which satisfactory soil depth cannot be ensured. Plants were arranged in the order of tree, sub-tree, and shrub from center to edge on the mound to make a mature forest of a dome shape in the future. Dispersion of plants was designed to be random pattern rather than clumped one. Problems on creation of the environmental forest by such ecological design were found to be management or inspection by non-specialized project operators and inspecting officers, and regulations for construction without ecological background. Alternative plans to solve such problems were suggested.

Key Words: Ecological restoration, Mound, Planting bed, Potential natural vegetation, Tolerances to air pollution and salt.

INTRODUCTION

Restoration is defined as "the intentional alteration of a site to establish a defined indigenous, historic ecosystem" and aims to emulate the structure, functioning, diversity, and dynamics of the specified ecosystem" (Aronson *et al.* 1993). That is, ecological restoration is the return of an ecosystem to a close approximation of its condition prior to disturbance (National Research Council 1991) and the re-creations of naturalistic and self-maintaining ecosystems (Berger *et al.* 1993).

Restorationists try to achieve the goal imitating structure and process of the nature (National Research Council 1991, Bradshaw 1992, Aronson *et al.* 1993, Berger 1993, Dobson *et al.* 1997).

In order to restore the degraded ecosystem, we have to get information from various scientific principles because holistic and

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synthetic alternatives have to be prepared (Aber 1987). First of all, we have to prepare such alternatives by obtaining diverse ecological information on factors causing environmental stress including pollutants from the developed spot (Aber 1987, MacMahon 1987). In particular, we have to get plentiful field information on an area to be restored because restoration efforts have to be practiced in the field (Hough 1984). Although much ecosystem or landscape restoration is still designed by engineers and landscape architects, ecologists have a great deal to offer in this regard (Urbanska 1997).

Many plans to maintain and conserve the ecologically healthy environment in the regional, national, and global levels are preparing against the radical change of our living environment or the environmental degradation including destruction of the natural environment, urbanization, and industrialization. In order to solve an environmental problem, preparing an alternative to each pollution source is important as a measure. At the same time, however, to keep biological communities including human and the environment for their survival is also important. Furthermore, to recover and restore positively the environment that we lost, can be also an important plan to solve the environmental problems.

Degradation or loss of diverse natural environments, in particular a green area, appear in a severe regional or global problem without any relation to our wish when we construct new cities, industrial facilities, transportation services, and so on. At this time, a study to improve the quality of the degraded natural environment or to reinforce it by restoring or creating natural environment in an area where we destroyed it, is required urgently (Lee 1992, Lee *et al.* 1999, Lee and You 2001).

In this study, we suggested a method for selection and arrangement of plant species and a technology for design for planting bed to be used as a guidance for ecological restoration design. This study also aimed to find out problems existing in the process of carrying out this ecological restoration and to discuss a measure to resolve the problems.

STUDY AREA

This study was carried out around the incineration plant of Jindo Engineering and Construction Co., Ltd., which is located on Jeongwang-dong, Siheung-si, Kyunggi-do. Soil properties of the study area were shown by classifying into salt marsh soil regarded as bed soil and transported soil to make the planting bed (Table 1). The transported soil contained lower organic matter, nitrogen, phosphorus, and potassium compared with mean values of forest soil in Korea (Forestry Research Institute 1997). Supplement of those elements is, therefore, required. On the other hand, sodium content was higher than the value. Moreover, rising of salt through capillary action from bed soil with high salinity is expected, since this is a landfill site bordering the coast. However, soil texture and pH were in normal range as a forest soil.

Vegetation of the area corresponded to deciduous broad-leaved forest zone, as this area is located in the middle part of cool temperate region. But a natural forest reflected such a climatic character hardly appears because the area is under human interference and is located on the coast geographically. Instead, secondary forest composed of *Pinus thunbergii - P. densiflora* and *Quercus acutissima* communities and substitute vegetation of *Robinia pseudoacacia, P. koraiensis, Larix leptolepis*, and so on, dominated this area (Ministry of Environment 1988).

Table 1. Physico-chemical properties of salt marsh and transported soils to make the planting bed

Soil properties	Salt marsh	Planting bed
Soil texture	Loam	Sandy loam
pH	6.7 ±0.4	5.4±0.5
Organic matter (%)	4.1 ±1.4	0.4±0.1
Total nitrogen (mg/g)	1.0 ±0.5	0.3±0.1
Available phosphorus (ppm)	46.7 ±10.0	6.8±1.9
Exchangeable potassium (ppm)	521 ±57	207 ±21
Exchangeable sodium (mg/g)	3.8 ±0.5	0.5±0.2

METHODS

Selection of plant species for planting

Field surveys to select plant species for planting were carried out in *Pinus thunbergii-P. densiflora* stands, which dominate the forest around the study area by applying a phytosociological method (Braun-Blanquet 1964, Muller-Dombois and Ellenberg 1974). Plant species were also chosen among component species of a potential natural vegetation of this region to reflect enough natural environmental properties (refer to Kim 1993). In addition, tolerances to salt and air pollutants were added as considerations for selection of plant species regarding that this area is an industrial complex located on seashore. Tolerance to air pollution was evaluated by referring to the following results; field surveys around the industrial complex damaged severely, pollution gas fumigation tests, and transplant experiments carried out in the polluted spot (Kim *et al.* 1996). Tolerance to salt was assessed by referring to Han *et al.* (1994). Finally, a condition of seedling supply for transplant was considered for selection of plant species.

Arrangement of plant species

Arrangement of plant species on the planting bed (alias,

mound) was designed to be the order of shrub, sub-tree, and tree from an edge to center. Shrubs were arranged between sub-trees in the sub-tree lines and sub-trees, and shrubs were between trees in the tree lines. Planting interval was 50 cm, 75 cm, and 150cm for shrubs, sub-tree, and tree, respectivly. Arrangement by species was designed for a pattern as diverse as possible.

Design of planting bed

Planting bed was designed by considering soil profile of A, B, and C layers and mean inclination of mountain slope in Korea (10-30°) to ensure a smooth drainage system. The study area contains a probability that a salt might be risen from bed soil. Moreover, the possibility that wastewater is likely to flowed out is also worried because the treatment systems of surrounding factories are imperfect. We, therefore, designed the planting bed as high as possible within a given space. On the other hand, in a narrow zone, we heightened the planting bed by introducing supporting stone to assure stable slope or we arranged plant species with shallow root system to overcome such problems.

RESULTS

Plant species selected to create an environmental forest

Finally selected plant species and their ecological characteristics were shown in Table 2. *P. thunbergii, Sophora japonica, Celtis sinensis, Q. aliena, Q. serrata, Q. dentata,* and *Q. acutissima* were selected as tree species, *Albizzia julibrissin, Koelreuteria paniculata,* and *Styrax japonica* were as sub-tree species, and *Rhododendron yedoense* var. *poukhanense, R. mucronulatum, R. schlippenbachii, Callicarpa japonica, Euonymus alatus*, and *E. japonica* were as shrubs. On the other hand, we did not arrange any herbaceous plants except *Liriope platyphylla* introduced for classical landscape architecture in only one site. In addition, *Lindera obtusiloba, Zelkova serrata, Acer* spp., *Prunus* spp., *Fraxinus* spp., *Cornus controversa, C. kousa, P. densiflora*, and so on, are in harmony with climatic characteristics of this area. But they were excluded from a plant species list for planting because they are not suitable for the ecological or artificial characteristics of this area as a big industrial complex located on seashore or the standards of planting plants referred in regulations on building of Siheung-si.

Practices for creation of the environmental forest

The environmental forest is made based on the potential natural vegetation of the region. A series of works from design of the planting bed through selection of plant species to their arrangement have to be, therefore, planned based on investigations about vegetation and environmental condition around a spot, which we intend to create it. The environmental forest needs different method from the silvicultural or landscape architectural one to achieve the original goal. This study chose a method, which is generally applied in many foreign countries as a basic tool, and improved it by considering the actual in Korea (International Ecology Center 1995).

Constitution of the planting bed

When we intend to restore the degraded environment, the soil condition occupies the important status (Dobson *et al.* 1997). The forest soil is usually divided into 3 layers of surface soil (A layer or organic matter layer), substrate soil (B layer, inorganic layer), and fundamental layer (C layer or gravel layer). In this study, we made C layer by mixing forest soil with gravel (Fig. 1). Intact forest soil was used as B layer soil. On the other hand, a forest soil mixed with litter debris fragmented into small particles was used as surface soil. In addition, we covered litter debris of 10 cm thickness on the surface soil to improve function of soil

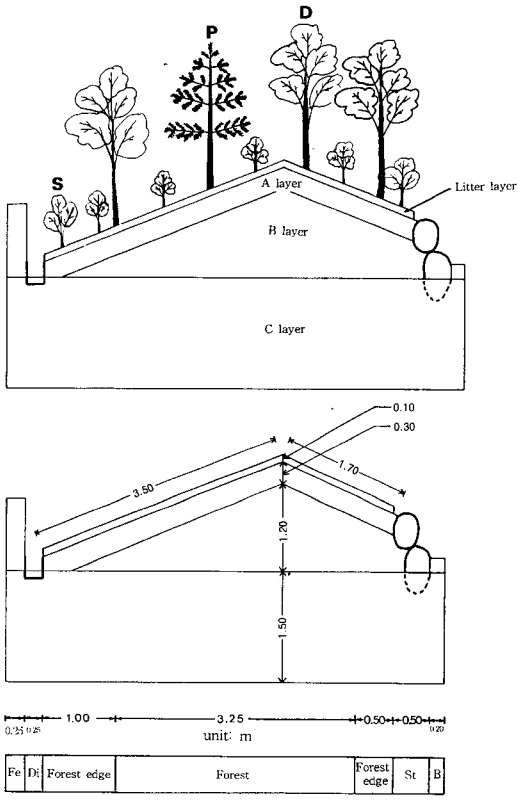

Fig. 1. Arrangement of plants on mound as a planting bed and its constitution. D: deciduous broad-leaved tree, P: *Pinus thunbergii*, S: shrub, Fe: fence, Di: ditch for drainage, St: stone for support, B: frame forming border.

Table 2. Ecological characteristics of plant species selected for creation of an environmental forest in the Shihwa Industrial Complexes. T1: Tree layer, T2: Subtree layer, S: Shrub layer

Stratum	Species	Tolerance to air pollution	Tolerance to salt	Ecological characteristics
T1	*Pinus thunbergii*	Medium	Tolerant	Dominant species of forest around the seashore as an evergreen needle-leaved tree
T1	*Sophora japonica*	Medium	Medium	Fertilizing tree as a leguminous plant with greenish branch
T1	*Celtis sinensis*	Tolerant	Tolerant	Shape of mature tree is graceful and tolerant species to air pollution
T1	*Quercus aliena*	Tolerant	Medium	Tolerant species to air pollution as a species appearing frequently in lowland of mountainous area
T1	*Q. serrata*	Tolerant	Medium	Tolerant species to air pollution as a dominant species in lowland of mountainous area
T1	*Q. dentata*	Medium	Tolerant	Species appearing frequently in lowland of mountainous area near seashore
T1	*Q. acutissima*	Medium	Medium	Comparatively tolerant species to air pollution as dominant oak around the Sihwa Industrial Complex
T2	*Koelreuteria paniculata*	Medium	Tolerant	This species is mainly distributed around seashore and flower blooming in summer is beautiful
T2	*Styrax japonica*	Tolerant	Tolerant	Both flower and fruit are beautiful as a species showing a tolerance specific to air pollution
T2	*Albizzia julibrissin*	Medium	Medium	Fertilizing tree as a leguminous plant with beautiful f lower
S	*Rhododendron yedoense* var. *poukhanense*	Medium	Medium	Flower is beautiful and it appears frequently in shrub layer of lowland forest of mountainous area
S	*R. mucronulatum*	Sensitive	Medium	Flower is beautiful and it appears frequently in shrub layer of lowland forest of mountainous area
S	*Callicarpa japonica*	Medium	Medium	Fruit is beautiful and it appears frequently in shrub layer of lowland forest of mountainous area
S	*Euonymus alatus*	Sensitive	Medium	Greenish branch with wing is characteristic and it appears frequently in shrub layer of lowland forest of mountainous area
S	*E. japonica*	Medium	Tolerant	Fruit is beautiful and it grows well around the coast as an evergreen shrub
S	*R. poukhanense*	Medium	Medium	Flower is beautiful and flowering period can be prolonged because this species begins to blooms when blossoms of *R. mucronulatum* begin to fall
S	*Ligustrum obtusifolium*	Medium	Medium	This species appears frequently and grows well around the industrial complex

(Fig. 1). Such litter debris improves physico-chemical properties of soil and facilitates development of the root system (International Ecology Center 1995).

It is known that soil depth necessary for plant growth were15-30 cm for herbs, 45-60 cm for shrubs, and more than 90 cm for trees. In a forest soil profile, 57-73% of root system was distributed within 30 cm from the surface and 79-94% was within 60 cm (International Ecology Center 1995). Root system of trees is divided into deep and shallow ones. To make the planting bed, in which both of them can grow, we have to design a mound with 30 cm thickness as surface soil and with 60 cm as substrate soil. In this study, we designed to sufficiently satisfiy a standard based on the facts that this area is a landfill site located on seashore. But in narrow zones below 3.5 m in breadth, we reduced thickness of B layer to 50 cm to keep stable slope, and instead arranged the plants with shallow root system there.

Form of the planting bed

Bad drainage system of soil usually inhibits plant growth when an environmental forest is created in flat area (Dobson *et al.* 1997). Therefore, a planting bed in a form of dome is required. Making the planting bed is similar to making cropland. That is to say, planting bed is made by accumulating soil similarly to natural gradient of a mountain slope not so as to slide rather than by

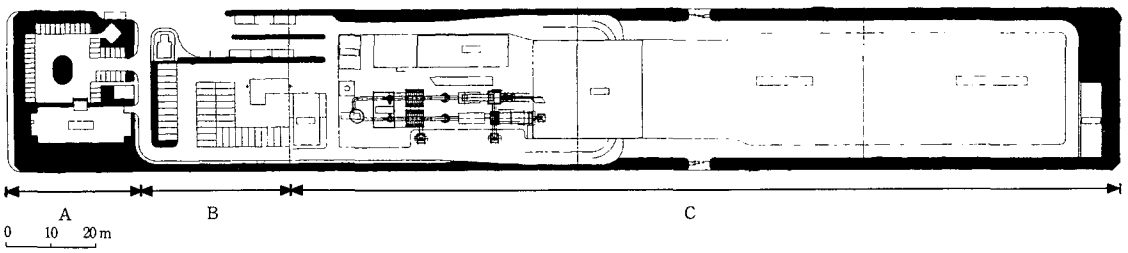

Fig. 2. A ground plan showing the planting zone (black part) and facilities. A: office building and parking lot, B: parking lot, C: incinerating facilities.

pressing hard. The soil has to be accumulated in the order of deep soil, substrate soil, and surface soil. However, each layer has to be harmonized as a set rather than to be separated. We depicted a planting bed designed to create the environmental forest in Fig. 1. The planting bed of 2 types were designed; the one needs supporting stone but the other does not. The former was to make the higher planting bed to prevent the flowing out of salt and wastewater. We arranged such higher planting beds with supporting stone in the zones, in which the probability of rising of wastewater is high and at the same time, space is narrow (zone A, Fig. 2). But even in such zone, if there is a wide space, we designed a planting bed without supporting stones. In addition, we designed a narrow and lower planting bed without supporting stones in an open space around parking lot (zone B). Instead, we decided to introduce plants with lower height and shallow root system in the zone.

Planting method

Seedlings in particular, grown in pot are desirable for creation of an environmental forest. But most regulations related to landscape architecture in Korea prescribe to juveniles more than 2 m in height rather than seedlings. Moreover, people who want such planting are also many. But transplant of such grown trees is harder than that of small seedlings. When we prepare to transplant by excavating them, they usually lose some root system or branch and sometimes they experience more severe damage. Such impair leads to inhibition of tree growth. Therefore, we have to revise such regulations related to landscape architecture so as to choose seedlings for planting. If we use seedlings for planting, we can get the following advantages; 1) mass transportation is possible, 2) cost is cheap and the establishing rate is higher, 3) additional works, such as the install of supporting poles are not necessary. 4) no specialists are necessary for planting, 5) dense planting is possible, 6) simultaneous planting throughout the wide area, which was impossible due to the cost in case of juvenile planting, is possible.

A period required for completion of the environmental forest depends on the state of seedlings. Seedlings within 0.5 m in height are usually suitable for transplant. In addition, seedlings cultivated in nearby area are desirable. Seedlings cultured in warm area or in greenhouse require an acclimation in the field.

The environmental forest has to be planted at high density. Seedlings in an initial stage have small branches and leaves, and hence the soil is likely to dry due to the effects of wind and light. A forest is usually closed with canopy and maintains homeostasis by forming the inherent microclimate in the forest. In order to get such forest as soon as possible, dense planting is absolutely required.

When we plant densely, the canopy is closed after 2 or 3 years and it begins to have the functions of a forest since then (International Ecology Center 1995). Planting densities depend on region or biome, although 1 to 3 individuals/m^2 is a criterion in the case of seedlings with above-mentioned size. However, it was hard to apply this standard because planting samples used in this study area, where has to follow regulations of Siheung-si, were juveniles. Therefore, we designed tree density to 0.4 individuals/m^2 by applying the rule. But we increased shrub density into 1.2 individuals/m^2 on the average and 4 individuals/m^2 at the forest edge.

It is desirable that the environmental forest develops into dome or reverse U shapes in the future by arranging plants composing tree or sub-tree, and shrub layers in the central part and the forest edge, respectively. Besides, random planting is recommendable rather than homogenous one (International Ecology Center 1995, Lee 1997).

Hollows as large as 2 times of seedling root system are necessary for planting. Seedlings have to be planted as pulling slightly after placed them in the pits and buried by heaping up surface soil on them. At this time, do not plant seedlings too deeply. Planting seedling as deep as the upper part of root system can be exposed is proper.

A forest buffers external effects by accompanying edge communities named as mantle and sleeve communities. A forest ecosystem holds stable microclimate and diversity through the roles of those communities. In general, mantle and sleeve communities are composed of shrubs and herbs, respectively, which

grow at forest edge. When we intend to create the environmental forest, it is necessary to arrange plant species composing mantle community at the edge of the planting bed by imitating such organization. In this case, planting by hedgerow type is desirable to get the effect of wind protection as soon as possible. In this study, we designed mantle community by planting shrubs at high density as 4 individuals/m^2 but did not arrange sleeve community. However, we arranged sleeve community in only a zone where the classical landscape architecture was requested.

The environmental forest in initial stage does not hold stable environment like mature forest ecosystem. Mulching is, therefore required for prevention of desiccation of soil surface, maintenance of soil temperature in winter, inhibition of weeds, protection of soil erosion, and so on. Mulching by rice straw is desirable because not only cost is cheap but also it is easy to get. We covered surface soil with litter debris of 10 cm thickness and added rice straw on it. Next, we installed wood poles at 0.75 m intervals and made rice straw adhere on the soil surface by fastening straw ropes among poles to prevent litter sliding and soil erosion.

On the other hand, we can also consider using wood chip as a mulching material when cut trees occur from a development. In these days, a machine that can demolish thin stem or branch is available and we can get a mulching material easily by using it.

Management after planting

Mulching with rice straw after planting inhibits weeds occurrence well. However, surface soil usually contains many weed seeds and wind also transports them. Therefore, weeds have to be removed not so as to impede seedling growth as soon as possible. Uprooted weeds need not to be thrown out. Moreover, when they leave in the very spot, they provide also a mulching effect. The season suitable for removing weeds is before they form seeds. We have to remove weeds 2 or 3 times a year. However, when the light intensity on forest floor decreased by canopy closing as seedlings gow, occurrence of weeds is naturally reduced. When 2 or 3 years have passed after an environmental forest is created, canopy is closed and any weeding works are not required since then.

Basically, healthy plants are hardly infected by a disease or impaired by insects. Therefore, excessive exterminating works including chemical applications need not to be applied if severe disease or insect did not occur. Diseases or insects often occur from aggravation of surrounding environment or bad weather. But we can generally find such damages earlier and can also reduce the damage if we pay attention to the surrounding environment including plants around the environmental forest created. Making an environmental forest by imitating natural system has an advantage that we can reduce the cost for management. However, fertilization is required as a tool for management at the least. Fertilization is carried out just after planting or in the fall of the planting year by using a slow effective composite fertilizer. Fertilizers are applied around canopy edge and the amounts applied are 3 or 4 lumps for tree and sub-tree, and 1 or 2 lumps for shrubs. Any additional fertilization is not required after establishment.

DISCUSSION

Concept and necessity of the environmental forest

In the study to create the nvironmental forest as an ecological restoration we have to determine the type of natural environment, which we intend to restore and create. Forest is a system maintaining dynamic stability as an ecosystem with the most diverse community in stratification among all ecosystems on the earth. Moreover, most of the whole country had been originally occupied by forests in Korea. In these days, forests are decreasing in area and are devastated in terms of quality by degrees. The area of forest decreased because we constructed industrial complex, new city, recreation facilities, and so on by occupying it. Additionally, its function is also degrading due to the effects of pollutants emitted from industrial complex and urban area in Korea (Kim *et al.* 1996). Also in global dimension, the tropical forests, which hold the highest biological diversity in the world, are decreasing rapidly or devastated and disappearing locally. However, we cannot halt completely cutting down of forests and construction of city, industrial complex, and transportation facilities to maintain our plentiful and convenient lives. Moreover, we cannot stop to use iron, cement, petrochemicals and energy when we construct those artificial establishments by exploiting the nature. Such result led to the functional unbalance between natural environment and artificial environment, and consequently caused environmental problems (Lee and You 2001). In order to meet 21C, in which such environmental problems should be reduced, we have to carry out the followings. First of all, we have to introduce a green area as a symbiont of human life. Furthermore, we have to recover diversities of the nature and biological society in response to using the nonbiological materials, such as iron, cement, and so on when we will accomplish the developing projects (Lee *et al.* 1999).

Kinds of green area are diverse. Grassland, a green area designed aesthetically by introducing exotic species, and a plantation for forestry are also required. However, what is a green area, on which human existence is based? That is, what is a green area, which keeps life, mind, and culture of people who have been born, grown, lived, and worked there, and furthermore, which can keep the future of the children who will be born newly? Human is a component of biological society and is just a consumer depending on photosynthesis of green plants among many components in the diverse ecosystems as far as he is existed on the earth even though he can develop any scientific technology. Even in new century when we will reconfirm such

clear facts, just traditional economic or aesthetic green area is not so enough as to keep intelligence, emotion, and healthy body of all the people. Only forest vegetation, which is producer and moreover, main axis of the regional landscape, can recover, regenerate, and maintain the diverse and stabilized environment for human survival among many environmental resources on the earth. Vegetation forms communities with diverse stratification depending on environmental conditions. A forest with multi-layers has surface area as 25 to 30 times as that of grassland composed of single layer.

Human have made agricultural fields by burning and logging forest with multi-layer and have also formed villages as constructing the residential area by exploiting it. And as entering in the modern ages, human has destroyed the nature thoroughly by forming the urban area. But our ancestors had conserved the nature sensitive to human activities corresponding to human eyes in a face of the nature, such as mountain foot, steep slope, stream side, and so on. At the same time, they had created "the forest of hometown" at the hilltop or peak, which provides a good view, at the mouth of village, and so on. In addition, they had remained "a forest endemic to their village" by constituting a wind protection forest, a shrine forest, and so on. Furthermore, they had also utilized religious consciousness to prevent being damaged the forest by indiscreet people. They had conserved sensitive and weak natural element to human activities by applying diverse methods. A forest endemic to village of 21C born by synthesizing such a traditional method to make a hometown forest and ecological theory is a basis fundamental to the human existence and mother of a culture as far as we exist as a component of ecosystem in each life of us.

In a modern viewpoint, such an endemic forest to village is an environmental forest, which displays environmental conservation functions, such as noise protection, dust collection, and air purification. Furthermore, as a holistic system, it insures also the present and the future of mankind including unknown factors overlooked in the present imperfect science, technology, and medical science as well as all the intelligence and emotion of the local residents. This environmental forest does not only play roles that reduce noise, prevent wind, and purify dust or pollutant. The effects reducing these factors individually might be inferior to those of physical and technical methods in temporary and local viewpoints. But those individual and partial facilities are getting worse over time. In addition, the more rapidly operate them, the more secondary and third pollutants, and carbon gas occur as in a case of the incineration plant. The endemic forest looks shabby at a glance but has long longevity, does not need cost for management, and recover, restore, and create the survival environment of human. In this respect, it is a real environmental forest in a modern standpoint.

Applying only traditional aesthetic and simple landscape architectural method cannot create the endemic forest, which displays the diverse functions as an environmental forest. Also, it cannot be achieved by only a greening method that elaborates the landscape partially. Besides, the aim as an environmental forest cannot be reached by constructing simple plantation or a conifer stand with one layer.

Problems on creation of the environmental forest based on ecological design

We can find the first problem related to an ecological restoration in the administrative organization. For example, the aims of landscape architecture have to include not only to repair a beauty of landscape around a developed place but also to supplement natural environment lost through the exploiting project. Furthermore, it also aims to prevent expansion of the influences from the developed area into surrounding natural environment. Therefore, an inspection on landscape architecture have to be carried out under a regime, in which the specialty can be reflected at the maximum by segregating from inspection on building differently from the system that have applied up to now. That is, in order to improve specialty, "Department of green area" or "Department of park construction" have to charge the service. When such reorganization is realized, whether or not of a harmony between planted plants and environment of the site can be inspected. Moreover, in order to satisfy the specialty really, officials in charge have to have a professional knowledge. The professional knowledge required here is certainly the ecological ones as all of us know well. Ecology is a part of biology and sometimes it contains the whole aspects of biology. Therefore, lectures that provide professional knowledge on ecology are opened in all the major fields related to biology without regards to pure or applied sciences and biology major is located on the center. We can find another conflict here. As was mentioned above, ecology is located on the center of professional knowledge related to landscape architecture and biology major constitutes a core of major fields that provide professional knowledge on ecology. Even though so, applies of people who majored in biology for those departments that treat such businesses are restricted. In this respect, we would like to point out such administrative system as one of the important problems as well.

We can find the second problem in a regulation on building. According to most regulations related to building in Korea, evergreen and deciduous trees have to be planted in a rate of 40:60%. But we cannot find this distribution ratio anywhere except an infinitesimal part of ecotone that evergreen forest confronts with deciduous forest as in warm temperate or sub-alpine zones. Therefore, this regulation should be replaced by modifing it into "to create a forest that natural characteristics of a region are reflected". And as will be mentioned later, kinds of plants to be introduced and arranging pattern suitable for the characteristics of a region or site should be presented in the detailed articles.

The third problem is found in the regulations on building that

specify seedling size and planting density. Seedling size designated in the regulation was more than 2 m in height. And the standard of planting density is inevitably low due to the seedling size. It is estimated that this criterion did not also reflect an ecological consideration. As is shown in transplanting process of crops, which is annually practicing in rural areas, transplanted plants experience a severe hardship in the establishing stage. And the larger the transplanted plants, the more severe a pain. Therefore, if we select larger plants as seedlings for landscape architecture, they would suffer more severe hardship and the effects may also influence on vitality and longevity of the plants. To plant trees is a project for the future. In these days, urban environment is getting aggravated due to a shortage of green area (Lee *et al.* 1999). Furthermore, it is known that a cause of global warming, one of the environmental problems in global level is also related to a deficiency of green area (Barbour *et al.* 1999, Lee 2000). Considered such facts, a transformation of landscape architecture in a form of displaying the diverse and vital ecological functions can be recognized as an epochal demand. In recent days, we can often see examples of landscape architectural project excuted by using trees far exceed the size criterion of 2m, those trees usually show low vitality. Moreover, they look an appearance likely to be excavated from a place in natural area rather than that cultivated as seedlings. Operators of this landscape architecture say that those trees were obtained from an area developed before. However, we need reconsideration about whether or not that all of so many trees were got from the legally developed area. If they were excavated illegally from a forest as telecasted through mass communication at one time, it is certainly an activity impairing the nature in direct opposition to the inherent meaning of landscape architecture, viz., compensation on the impaired nature.

Alternatives to overcome problems on ecological restoration

We would like to regard alternatives of the problems above mentioned as presenting items that we have to prepare for ecological restoration. First of all, we have to prepare diverse recommendable plants and a guidance for planting based on natural environmental characteristics of a corresponding region. We cannot expect greatly the ecological functions of plants that have been planted for landscape architecture up to now because of the following reasons. As it were, landscape architectural projects that we are running after in these days (It is reasonable to express as a restoration if the original objective that intends to supplement function of the damaged natural environment, is revived.) do not reflect such respects. Therefore, exotic species are sometimes selected as plants for planting and introduced plants and their arranging pattern are also far from natural environmental characteristics of the corresponding region. In this viewpoint, as was mentioned earlier, specialty on the business is required.

Secondly, we have to prepare seedlings based on such guidance. Even though we involve endemic plants in landscape architectural design, we cannot find any suppliers who can provide such seedlings. When we listen to opinions of seedling suppliers on the reason, they say that they do not prepare those seedlings because they cannot get any economic benefit due to a lack of demand. Even though so, many people, in particnlar citizens with the proper common sense on our environment agree with an opinion that an ecological planting based on natural environmental characteristics is desirable. Taking into consideration in this standpoint, we can find another fundamental cause that ecological restoration could not be carried out up to now in a regulation on building. Therefore, we should replace the regulation by a form that the corresponding environment requires as well as satisty an epochal request.

Thirdly, we have to practice environmental education to the people. Environmental science and ecology hold the same meaning, although the latter is usually more inclusive. Moreover, ecology provides basic concepts and theories, which are indispensably required to understand the original shape and characteristics of environment including environmental problems. However, we are familiar with a term of environmental science rather than that of ecology. We can find a cause of such recognition in shortage of environmental education, namely ecological education. Even in environmental education that is in progress at present, central subjects are just pollution, environmental problem originated from pollution, and so on. But if it is the systematized environmental education, the education should teach the followings. What is the original form of environment? How was the shape of environment in the past? Which process and mechanism changed environment and how should we cope with environmental problems to resolve them? But we cannot find such environmental education anywhere in Korea. In consequence, recognition of the people on the environment is still stay on very low level. We can confirm such facts easily around as. For example, citizens themselves decide tree species and a planting site in "a project to plant trees of 10 million" that the Seoul City is promoting. When we evaluate recognition level of citizens on environment from their decision, most choices were far from environmental characteristics. But when we explained a mistake of the choice and a right selection to them, they agreed immediately with us. We could confirm a necessity and possibility of environmental education from such experience.

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