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Full Length Research Paper

Reestablishing the health of secondary forests "*Satoyama*" endangered by Japanese oak wilt: A preliminary report

Kuroda K.[1]*, Osumi K.[2] and Oku H.[2]

[1]Graduate School of Agricultural Science, Laboratory of Forest Resources, Kobe University, Nada-ku, Kobe 657-8501, Japan.
[2]Forestry and Forest Products Research Institute, Kansai Research Center, Momoyama, Fushimi, Kyoto 612-0855, Japan.

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Japanese oak wilt caused by the fungus *Raffaelea quercivora* is increasing in secondary forests known as "Satoyama" that are surrounding rural communities. Oak wilt is occurring in stands that are 40 to 70 years old that have been used for fuel wood and charcoal production and then left unmanaged because those wood fuels were replaced with gas and kerosene since 1950s. An ambrosia beetle, *Platypus quercivorus*, which vectors the pathogen, can propagate effectively in thicker trunks. Due to the extensive population growth of this beetle in aged "Satoyama" forests, the infested areas are increasing annually. A drastic change occurs in the vegetation after the mass mortality of oak trees. Deterioration of biodiversity and soil erosion are of concern. To reduce oak mortality, rejuvenation of trees will be effective because the vector beetle cannot propagate in thin trunks. We are conducting an experiment to reestablish the health of "Satoyama" forests that are slightly affected by this disease. In this experiment, aged forests were clear-cut to promote sprouting from the oak stumps. This is a coordinated effort among the local governments and researchers. The management of the "Satoyama" combined with the utilization of biomass as fuel wood in the local area is essential for the success of this project.

Key words: Oak, wilt, *Raffaelea quercivora*, biomass, management.

INTRODUCTION

Secondary forests near residential areas, long used by residents as fuel resources, are called "Satoyama" in Japanese. Recently, the "Satoyama" is becoming popular internationally because of their high degree of biodiversity. In the Satoyama forests, mass mortality of trees by Japanese oak wilt has been increasing annually since the 1990s (Hijii et al., 1991; Ito et al., 1992; Kuroda, 2008; Nunokawa, 1993) (Figure 1). This wilt disease is caused by the fungus *Raffaelea quercivora* (Kuroda and Yamada, 1996; Kuroda, 2001; Kubono and Ito, 2002). Trees of fagaceaeous genera, except for *Fagus*, have been killed by this pathogen (Kuroda, 2008). This disease occurs primarily in the secondary forests that had been used for firewood and charcoal production and then left unmanaged since the 1950s, when the energy revolution, that is the replacement of fuels from wood to gas and kerosene started (Kuroda and Yamada, 1996). Damaged oak stands ranged from 40 to 70 years old because the traditional coppicing by periodical cutting at 15 to 30 year intervals had been fully discontinued in Japan by 1980. An ambrosia beetle, *Platypus quercivorus*, which vectors *R. quercivora* from dead to living oak trees, propagates effectively in trunks thicker than 10 cm (Kinuura and Kobayashi, 2006; Sone et al., 1998). Due to the extensive population growth of this beetle in abandoned and

*Corresponding author. E-mail: kurodak@garnet.kobe-u.ac.jp.

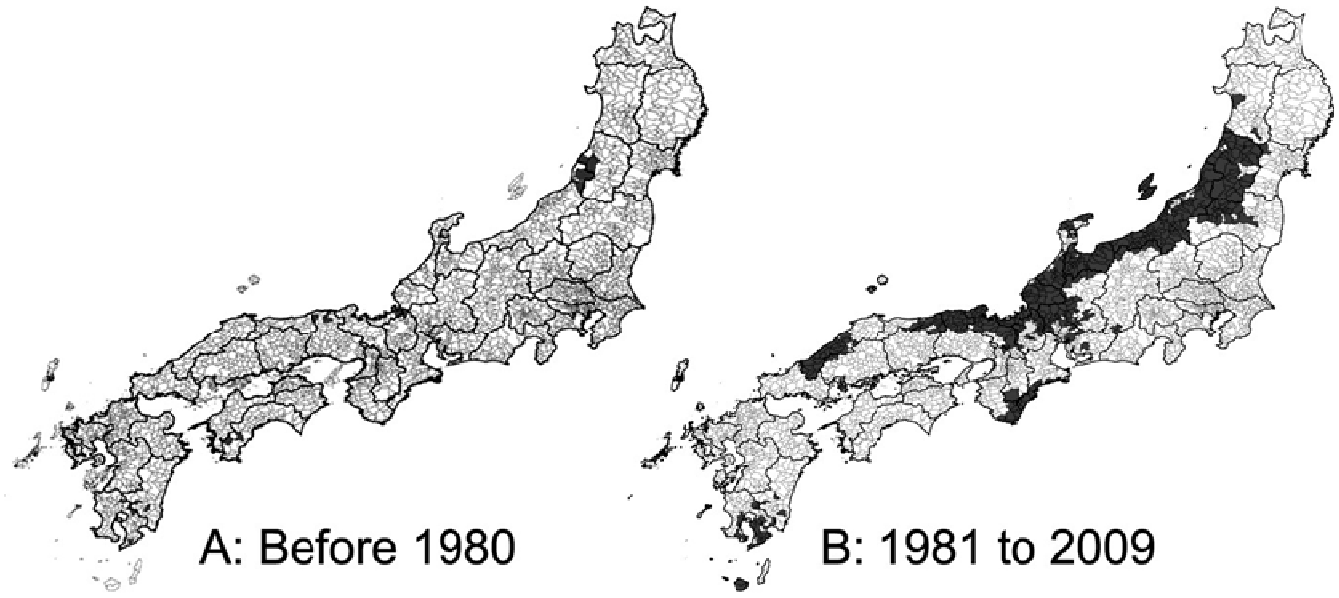

Figure 1. The Japan districts experiencing increased incidents of Japanese oak wilt after the 1980s. Infested areas (cities) are indicated in black."

aged forests, infested areas are expanding annually. Fundamental pathological aspects of this disease have been revealed in research over the last two decades (Kubono and Ito, 2002; Kuroda, 2001; Kuroda and Yamada, 1996; Murata et al., 2005). Although pesticides and fungicides for this disease have been developed (Kuroda, 2008) and an aggregation pheromone of the beetle became applicable for tree protection (Tokoro et al., 2007), the eradication of the disease is difficult, especially in severely damaged forests. In Korea, similar oak wilt as a result of fungus and a vector beetle of the same genera is increasing (Hong et al., 2006; Seo et al., 2010).

Some scientists believe that damaged oak stands will recover if left alone because of their natural resilience. However, a drastic change in vegetation is occurring following the mass mortality of thick trees. Itô et al. (2008) reported that only shrubs, small trees, and short-lived species are predominantly replacing the stands damaged by wilt. Tall deciduous species, including oak, did not grow under the shade of other trees. Deterioration of biodiversity and soil erosion are also of concern in these areas. As a strategy to reduce mass mortality by the Japanese oak wilt, rejuvenation of oak trees by the sprouting from stabs after the cutting of main stems will be effective to reduce the population growth of the vector beetle, *P. quercivorus*, because the beetle cannot propagate in young and thin oak trunks (Kinuura and Kobayashi, 2006). Clear-cutting of aged coppices will promote the regeneration of broadleaved trees, including oak species, by sprouting from stumps (Kuroda et al., 2009). We recommend this method to local governments and NPOs that have been trying to manage abandoned forests while failing to stop wilt damage. Simultaneously, we planned this experiment to reestablish the health of "Satoyama" forest that has not been affected by the disease or just slightly affected (Kuroda et al., 2010a, b).

In this experiment, "Satoyama" forests are being managed by the local district residents with the assistance of forestry researchers. Researchers in the field of forest ecology, forest pathology, forest economy, and landscape management cooperate and provide the residents with techniques suitable for reestablishing forest health. Educational programs on forest ecosystems were prepared for the understanding of the purpose of forest management and to obtain good results in experimental fields, targeting citizens who seldom have the opportunity to study science after finishing school. People's activities without fundamental knowledge on forestry sometimes induce unexpected bad effect for forests and therefore education is very important. Another important activity included in this plan is to restart the utilization of biomass as firewood in the districts. All activities related to the Satoyama management, including procedures and expected effects were monitored by researchers. After analyzing the factors behind the recent decline of oak trees, we discussed possible ways to reestablish the health of the "Satoyama" forests. In the present report, we show the process and preliminary results of our project in two experimental sites that is open to public.

MATERIALS AND METHODS

Analysis of the factors that promoting recent oak decline

The methods and results of the procedures used by local governments to control damage caused by this oak disease were surveyed

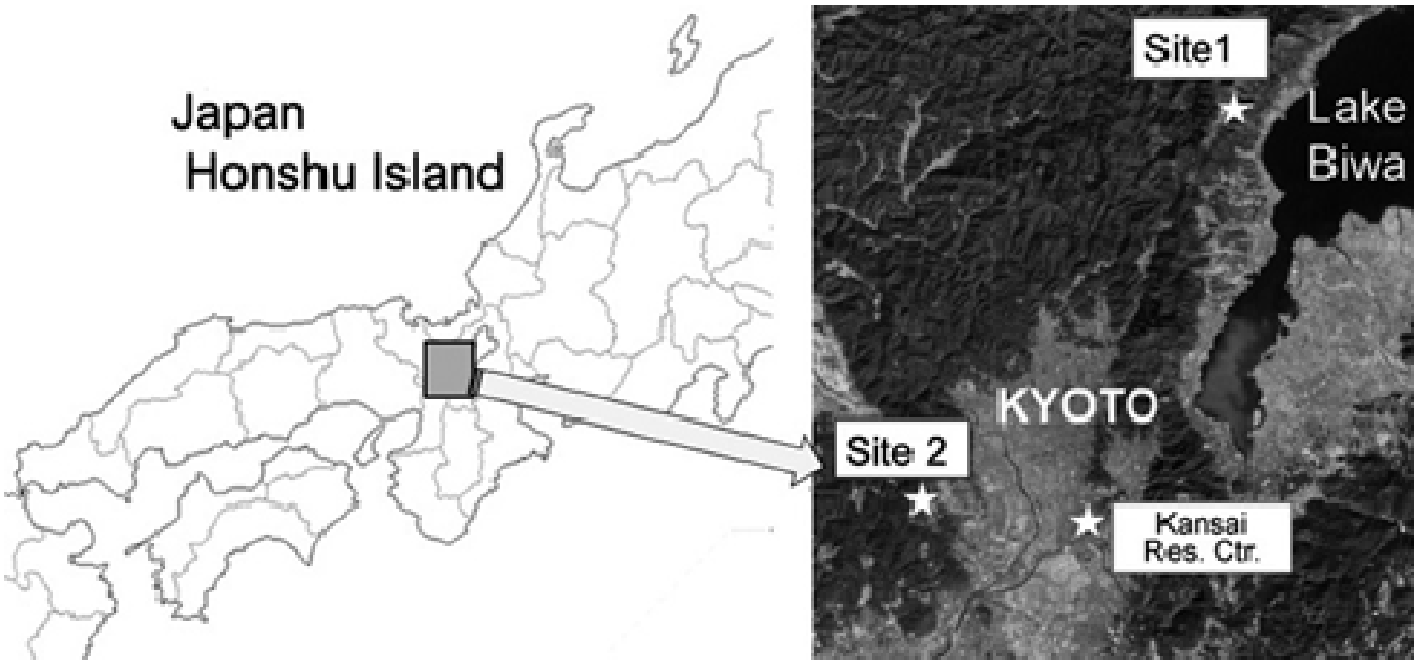

Figure 2. Two sites for the forestry experiments that started in 2008. Site 1: Shiga Prefecture, Otsu City, Site 2: Kyoto Prefecture, Nagaokakyo City.

in the Kansai District (Western Honshu Island, Japan). The survey focused on the effects of pesticide use in the area along with the delayed or nonexistent response of the local governments to the damage. We also examined the suitability of the methods used to control the forests. Based on the results, a useful and practical strategy against the mass mortality of oak trees was discussed.

Planning of a Social experiment to reestablish forest health

The purpose of this social experiment was to demonstrate the process of "Satoyama" regeneration to residents and local governments and its effectiveness to reduce the damage caused by Japanese oak wilt. Experiment sites in Shiga and Kyoto Prefectures were selected (Figure 2). This experiment was conducted as follows, and the outline of the experiment is shown in Figure 3.

1. Permission from the landowners (20 families at the Kyoto site and two families at the Shiga site) for clear-cutting was obtained through the local government (Kyoto) or from an influential person of the community (Shiga) (Figure 4).
2. The following activities were conducted by the district residents following our instructions. Ecological monitoring and survey of the biomass was made before cutting. Then, clear-cuttings were made during the winter, and firewood was obtained. Firewood was removed from the forests to prevent the vector beetle of wilt from being attracted to neighboring oak forests and was given to local residents along with wood stoves.
3. Regeneration from stumps was assessed the following summer at the experimental sites by counting and measuring sprouts and seedlings.
4. Wood stoves were furnished to families living near the experimental sites (Kyoto and Shiga) and public spaces including an elementary school (Kyoto). Fuel wood consumption, changes in lifestyle, and economy were monitored.

The results were analyzed to construct a more practical method.

Education and feedback on the "Satoyama" ecosystem and management

To educate individuals who are interested in nature and forests, including the participants of the social experiment, symposia and seminars on the ecosystem, Japanese oak wilt, forest health, and use of forest resources were hosted by local governments and the research group of Kansai Research Center, FFPRI. From the questions of the participants, the education programs were refined. To support the activities of citizens, a manual reporting the detailed process of "Satoyama" management was written on the basis of the present experiment.

RESULTS AND DISCUSSION

Factors preventing damage control

Difficulties of damage control

Eradication techniques with insecticides and fungicides have developed during the two decades. Infection can be reduced in oak stands by the extensive control of the vector beetles in the initial stage of transmission. However, landowners of private forests in "Satoyama" did not always follow those techniques and failed to remove dead trees from their forests, although they have a legal obligation to eradicate pests from their land. Because logs in "Satoyama" do not currently have economic value, landowners are indifferent to the condition of their forests. Despite pesticide application in the selected area, damage was not reduced due to the population growth of the vector beetle in the many dead trees left in wide areas

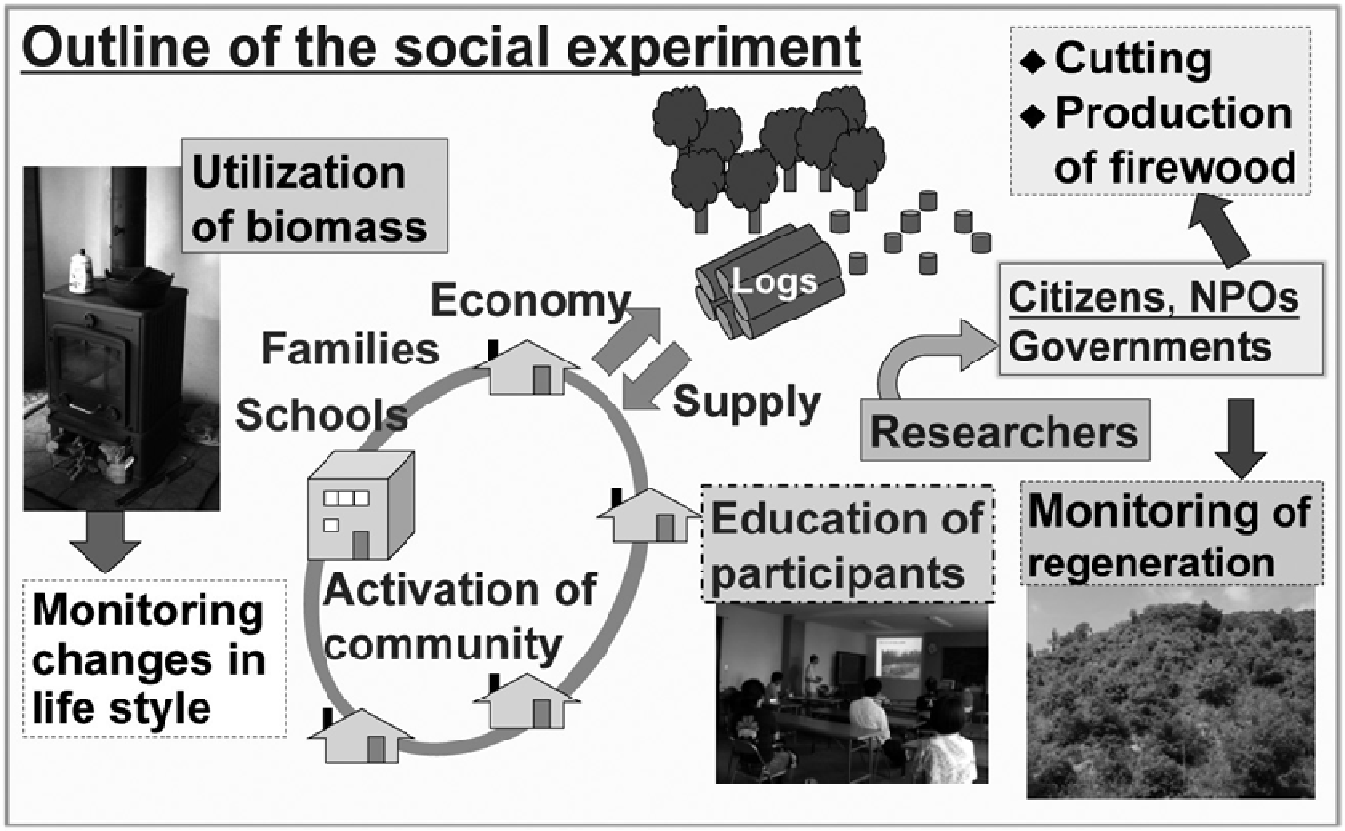

Figure 3. Illustration of the social experiment to reestablish healthy forests.

Figure 4. Clear-cutting at the experiment site in Kyoto (Figure 2, Site 1).

of private forests.

Local governments in Japan (prefectures, cities, towns, and villages) lack the funds to control infectious tree diseases, let alone another epidemic forest disease, pine wilt (Zhao et al., 2008), which is causing serious damage annually in Japan. Some local governments are seriously trying to stop wilt damage. However, cutting down dead trees and applying pesticides on the logs have been conducted only in limited areas even after the disease was widespread. Such methods are mostly ineffective to reduce future damage. In some parks or temple gardens, the trunks of valuable oak trees were wrapped with plastic from the ground level to a given height (at least 4 m) to prevent the beetle's invasion. This method seems to be effective in some cases. On the other hand, some local governments do not survey the damage in the forests or have a task force for damage control. These present conditions suggest that a strategy with expectant treatments with chemicals or plastic firm alone is not effective to reduce infection and damage in the forests. In severely damaged forests, the falling of big branches and trees that occurs due to the rapid decay after wilt is of concern. As to the reason that damage control had never been implemented in some prefectures or cities, it seems that governments did not realize the seriousness of the tree diseases and lacked sufficient funds in their budgets to combat them.

Problems related to the activities of citizens

Recently, citizens activities in the "Satoyama" are becoming popular. Residents usually rely on the combination of two methods, the removal of the undergrowth and the thinning of tall trees. The purpose is to make a beautiful stands suitable for walking or light trekking in the forest park. Although citizens contented that the forests look beautiful just after the activity, this method is not recommended for the following reason. Thinning of broadleaved forests prevents the regeneration of deciduous tall trees due to the shortage of light, and, therefore, shrubby evergreen species increase (Kuroda et al., 2009; Nishinaka et al., 2010). Due to the use of this garden type of forest management, the old oak trees scattered in the forest are liable to infect with the wilt disease because such low density stands attract the vector beetle.

Some citizen groups and NPOs that have joined Satoyama management are actively engaging in the cutting of living trees (thinning of undamaged forests). Mostly, cut logs are unused and abandoned in the stands. Fresh oak logs attract the vector beetle, *P. quercivorus*, and induce the infection and death of healthy oak trees surrounding those cut logs. In fact, this has been occurring in recently managed Satoyama. For suitable Satoyama management, we published a booklet of scientific guidelines" (Kuroda et al., 2009). However, this garden type method is still used in many sites. It is unfortunate that the activities of "Satoyama" management sometimes promote infection and decline due to lack of knowledge in forest health.

Social experiment to recover forest health

Forest management by citizens

An NPO (Shiga site) and two groups (Kyoto site) that are conducting activities for nature conservation and forest maintenance in "Satoyama" were selected as partners in our experiment. No landowner from the experimental sites was included. Surveying, cutting, and monitoring were conducted by volunteers from the groups identified above, mostly retired individuals over 60 years old and researchers of the Forestry and Forest Products Research Institute, Kansai Research Center. The natural conservation corps at the Kyoto site belongs to a committee established and managed by the Nagaokakyo City government. Preliminary surveys of vegetation before cutting, clear-cutting, and wood chopping were conducted in 2008, 2009, and 2010. Trees thicker than 20 cm were cut by professionals to avoid accidents. Nonetheless, cutting of thinner broadleaved trees is risky for untrained volunteers. Thus, a training program for tree cutting with a chainsaw and related logging skills must be prepared. A booklet of instructions with detailed procedures for "Satoyama" regeneration was prepared for the volunteers (Figure 5). A trial version will be improved on the basis of the feedback from this year's users.

Utilization of cut logs as fuel in homes and school

We are monitoring various aspects related to the use of the wood stoves that were furnished to two families, the library room of an elementary school, and a public space in the city park: the amount of used firewood, room temperature and humidity, hours of use for the wood stove, and energy usage relative to the cost of gas and electricity. Volunteers delivered firewood to the elementary school. After one winter using the wood stove, the participating families expressed satisfaction with the results. They valued highly that family members including children were apt to gather around the stove and spent longer hours with family. When enough data is accumulated, it will be analyzed and published by researchers on forest resources. The result of monitoring will be used to promote the utilization of biomass obtained from Satoyama in the future.

Education and feedback

Citizens believed that cutting trees was bad for the ecosystem, and that forests should not be cut because

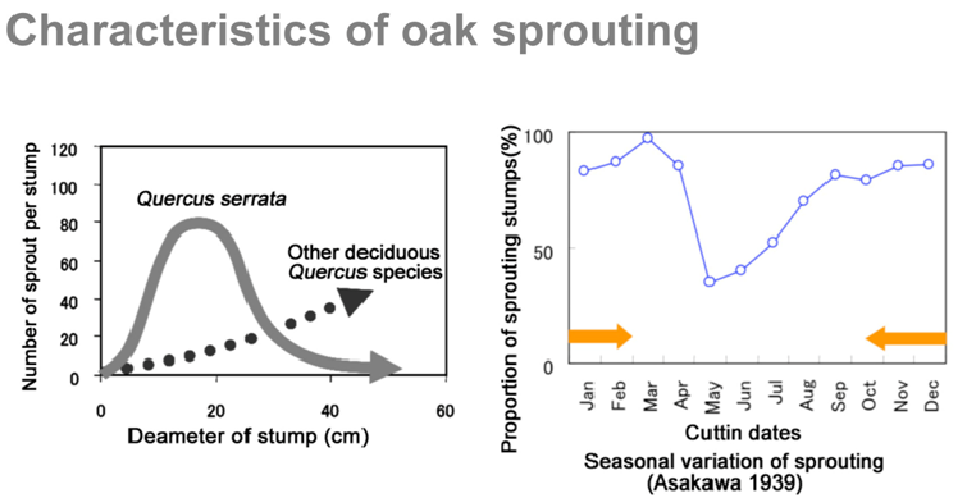

Figure 5. Page from the booklet for Satoyama management. Explanation of the sprouting of oak trees and monitoring the regeneration (Prepared by Osumi).

they will sustain themselves without management. At first, members of the cooperative found it difficult to agree on decisions about clear cutting, even in small areas smaller than 0.1 ha. Two or three times of explanations were necessary for them to understand that clear cutting is necessary for the regeneration of healthy forests dominated by deciduous broadleaved trees.

Two common perceptions expressed at symposia and seminars were that the eradication techniques needed to be improved and that chemicals should not be used in the forests. The opinions can be attributed to a lack of scientific knowledge regarding the chemicals. On the other hand, some individuals insisted on leaving green cut logs in the forests to decompose without regard for the admonitions that such logs attract vector beetles of the disease. For those people, "Satoyama management" is a hobby or just an amusement. A more forceful response from local governments may be necessary to prevent these harmful practices.

In areas where severe damage is evident, the need for rejuvenation of the forests is more readily understood. Our attempts to restore the forests are currently receiving media attention. These reports help convey the positive aspects of this work to the public. Education at all levels

is essential for the success of these efforts, and that includes the retired volunteers as well as school children. Programs for the younger generations, who will be in charge of the periodical cutting of trees (at 20 to 30 year intervals) that is necessary for the maintenance of healthy “Satoyama” forests, must be developed.

Conclusion

“Satoyama” areas include ca. 30% of the forests in Japan. Governments cannot continue to maintain such broad areas with the current level of budget. Two strategies are necessary to recover the health of “Satoyama”. From the standpoint of natural science, rejuvenation of secondary forests are effective for reducing damage due to wilt. In addition, public education is required. Encouraging local communities to take an active interest in the management of the forests is also important. However, we cannot return to the inconvenient lifestyle of a half century ago when we relied on forest biomass as energy source. Our proposal is to establish a new life style in which we utilize biomass as a part of our energy source and maintain the forest health. Forest management combined with the utilization of biomass and the contribution of the people of the district will be important (Kuroda et al., 2009). For that purpose, local government should play an active role by providing basic knowledge on sustainable forest management.

The framework of our proposal on “current style Satoyama management system” is as follows. Our primary approach requires the rejuvenation of forests by clear cutting and the maintenance of healthy secondary forests. Small-scale clear cutting is preferable as the traditional coppicing. Arboreal and deciduous species will grow dominantly after clear cutting. In addition, biodiversity will be kept high for the mosaic environment. Local participation of the citizenry, both urban and rural, is essential to the success of forest management. After that if there is some economical profit for selling coppice, it will attract the landowners to this activity. The utilization of forest biomass is key to the continued management by the local community. If woodstoves are used by a part of local residents, it will help to reduce CO_2 emission substituting petroleum. Biomass from the forests as a renewable energy may be an attractive aspect to the younger generation.

REFERENCES

Hijii N, Kajimura H, Urano T, Kinuura H, Itami H (1991). The mass mortality of oak trees induced by *Platypus quercivorus* (Murayama) and *Platypus calamus* Blandford (Coleoptera : Platypodidae) - The density and spatial distribution of attack by the beetles -. J. Jpn. For. Soc. 73: 471-476.

Hong KJ, Kwon YD, Park SW, Lyu DP (2006). *Platypus koryoensis* (Murayama) (Platypodidae : Coleoptera), the vector of oak wilt disease. Korean J. Appl. Ent. 45(2): 113-117.

Itô H, Osumi K, Kinuura H, Takahata Y, Kuroda K (2008). Stand structure of a forest damaged by a wilt disease of oak trees caused by *Raffaelea quercivora* at Kutsuki area in Shiga Prefecture. Bulletin of FFPRI 7(3) (No.408): 121-124. (in Japanese with English summary)

Ito S, Yamada T, Kuroda K (1992). Investigation of oak trees mortality in the Kansai district. Ann. Phytopathol. Soc. Jpn. 58: 545. (In Japanese)

Kinuura H, Kobayashi M (2006). Death of *Quercus crispula* by inoculation with adult *Platypus quercivorus* (Coleoptera: Platypodidae) Appl. Entomol. Zool. 41: 123-128.

Kubono T, Ito S (2002). *Raffaelea quercivora* sp. nov. associated with mass mortality of Japanese oak, and the ambrosia beetle (*Platypus quercivorus*). Mycoscience 43: 255-260.

Kuroda K (2001). Responses of *Quercus* sapwood to infection with the pathogenic fungus of a new wilt disease vectored by the ambrosia beetle *Platypus quercivorus*. J. Wood Sci. 47: 425-429.

Kuroda K (2008). Mass mortality of oak trees and the health of "Satoyama," Zenkoku ringyo kairyo fukyu kyokai: 166pp. (in Japanese).

Kuroda K, Osumi K, Oku H (2010a). Current style Satoyama utilization to recover the forest health. Proceedings of the 2nd International Conference of Urban Biodiversity and Design, Nagoya, Japan, 18-23 May 2010, S14-3: 167.

Kuroda K, Osumi K, Oku H (2010b). A social experiment for the reconstruction of resilience in Satoyama Social-Ecological System in Japan. XXIII IUFRO World Congress, 2010 Seoul, Korea, Technical Session H-02, Abstract No.S01504.

Kuroda K, Yamada T (1996). Discoloration of sapwood and blockage of xylem sap ascent in the trunks of wilting *Quercus* spp. following attack by *Platypus quercivorus.* J. Jpn. For. Soc. 78: 84-88. (in Japanese with English summary)

Kuroda, K, Ito H, Osumi K, Oku H, Kinuura H, Takahata Y, Matsumoto K (2009). How to manage "Satoyama" forest: Instruction for the volunteers and local governments, Forest and Forest Products Research Institute, 37pp. (in Japanese)

Murata M, Yamada T, Ito S (2005). Changes in water status in seedlings of six species in the Fagaceae after inoculation with *Raffaelea quercivora* Kubono *et* Shin-Ito. J. For. Res 10: 251-255.

Nishinaka Y, Matsumoto K, Hino T, Ishii M (2010). Structure and species diversity of butterflies in a traditional coppice. Transactions of the Lepidopterol. Soc. Jpn. 61(2):176-190 (in Japanese with English summary).

Nunokawa K (1993). Distribution of oak trees attacked by *Platypus quercivorus* in Niigata Prefecture. For Pests 42: 210- 213. (in Japanese).

Seo MY, Matsuda Y, Ito S (2010). Morphological characteristics of *Raffaelea* spp. associated with oak wilts from Japan and Korea. XXIII IUFRO World Congress, 2010 Seoul, Korea.

Sone K, Mori T, Ide M (1998). Life history of the oak borer, *Platypus quercivorus* (Murayama) (Coleoptera: Platypodidae). Appl. Entomol. Zool. 33: 67-75.

Tokoro M, Kobayashi M, Saito S, Kinuura H, Nakashima T, Shod-Kagaya E, Kashiwagi T, Tebayashi S, Kim C, Mori K (2007). Aggregation pheromone, quercivorol: (1S,4R)-p-menth-2-en-1-ol, isolated from the ambrosia beetle *Platypus quercivorus* (Maruyama) (Coleoptera: Platypodidae). Bulletin of Forestry and Forest Products Research Institute 6(1): 49-57.

Zhao BG, Futai K, Sutherland JR, Takeuchi Y (2008). Pine Wilt Disease, Springer: 459pp.