Damage Analysis of Pine Wilt Disease Using GIS in Komagane City Forest, Nagano Prefecture, Japan

Sourovi Zaman[1], Salah Uddin Siddiquee[2] and Masato Katoh[1]

1) Forest Measurement and Planning Laboratory, Education and Research Center of Alpine Field Science, Faculty of Agriculture, Shinshu University, 8304, Minami-minowa, Kami-ina, Nagano-399-4598, Japan.
2) Sahid Akbar Ali Science and Technology College, Thakurgaon, Bangladesh

Abstract　The purpose of this study is to detect and analysis of pine wilt damaged area in Komagane City, Nagano Prefecture. The pinewood nematode has introduced pine wilt which is an important non-native disease and causes harmful condition to the red pine tree and the forest. The aim of this study was to make a clear concept of damage and the present status of the red pine tree by applying GIS. This study is based on both primary and secondary data. The result determines the comparison of forest condition before and after the attack of pine beetles.

Key word : Komagane City, pinewood nematode, red pine beetle, GIS.

Introduction

The present forest cover in Japan is about more than 71% (FAO, 2004). The total 75% areas (12,457 ha) is covered by forest in Komagane City in Japan (Komagane City Office, 2006). Main tree species are Japanese red pine (*pinus densiflora*), Japanese oak, Japanese cedar and cypress in Komagane City and Japanese red pine is one of the most extensively planted tree species (Sasse, 1997). Japanese red pine tree grows abundantly in the northern and central regions of Japan, and sustains a large industry supplying structural lumber for domestic and export markets and, to a lesser extent, wood for appearance-grade products such as furniture (Conifer Specialist Group, 2004). Furthermore, the red pine is the symbol tree of Komagane City. About 32% red pine trees consist of the total forest in Komagane City ; representing the most common tree species in this region. In Komagane the red pine tree is also used for landscaping. It has long been a principal source of timber for all purposes, including firewood, construction and woodworking and also popular as ornamental tree (Matsuni, 1980). Especially red pine tree is used as an important compo-

nent in Satoyama a concept of Japanese rural landscape for the management of forests through local agricultural communities in Komagane (Tabata, 1997).

In Komagane the rapid wilt disease of the Japanese red pine trees have been occurring recently, The pine wood nematode, *Bursaphelenchus lignicolus* causes this disease (Morimoto and Iwaki, 1972), and the Japanese pine sawyer, Monochmus alternatts (Coleoptera : Cerambycidae) is a vector of the nematode (Kobayashi et al, 1971). The adult of the Japanese pine sawyer emerges from a dead pine tree in early summer carrying numerous nematodes. The beetle feeds on the soft bark of the healthy pine trees and nematodes come out from the spiracles of the beetles and enter the tree through the wound.

Once an infestation is established, the nematode reproduces rapidly and infected tree shows symptoms of wilt disease about three week's later (Kobayashi et al, 1984). Once the infestation started there is no effective way to save the trees. As in Komagane red pine trees are in the leading role in the total forest area, so the protection of the species is now very essential for the protection of the forest of this city. The purpose of the study was to detect red pine attack area and analysis the damage area by applying GIS. The study was also conducted to recommend the effective con-

trol method against the red pine beetle

Materials and Methods

The study area was in Komagane City of Nagano Prefecture. The total area of Komagane City is 165.92 km². The data information was collected from both primary and secondary sources. The primary data was gathered by survey and include interviews and discussion with the private forest owners and the foresters of Kamiina Forest Office and Forest Department, Komagane City. By field survey in different forest area collected the attacked and healthy tree information, also collected some general informations such as tree types, and forest type of Komagane City and used control methods to protect the red pines. The collected informations were verified by discussions with foresters, private forest owners and relevant literatures. Secondary data was collected from Kamiina Forest Office. Kami-ina forest department extracted the data. The data was obtained of 2002, 2004 and 2006.

The data was about damaged area name, forest compartment numbers, forest group (including small group), diseased tree height, deep breast height (DBH), and tree volume. GIS is totally a different type of analysis doing by a computer (Chang, 2002). We made database by inserting in Microsoft Excel program, transferred into GIS data and worked with Komagane City polygon data for analysis. A geographic information system (GIS), the ArcView Ver.9 by ESRI was used to spatially analyze, organize and integrate the information about damaged trees with various control method used in the area. In this study GIS was mainly used to find feature and finding patterns of pine wilt disease area. It can be easily used also to comparison of the present and previous forest condition. The Komagane City map is divided by lots of polygon which shows the forest compartment-group in the forestry planning figure of Komagane City and the individual attribute of the forest compartment.

Results and Discussions

Damage area by pine wilt disease in different year

The results indicate the damage pattern by pine wilt disease in Komagane using GIS from the data of 2002, 2004 and 2006. Also the different images (Fig 1, 2 and 3) show the severe infestation area and the rate of the attack. A hectare is considered infested if it contains more than 10 wilt trees.

Year 2002

This year the first attacked trees were found in the different forest compartment. These all were the border side trees of the Komagane City forest. Maximum 53 trees were attacked in four forest compartment (Fig. 1). More than 100 trees are affected in 2002 that means about 0.85% trees of
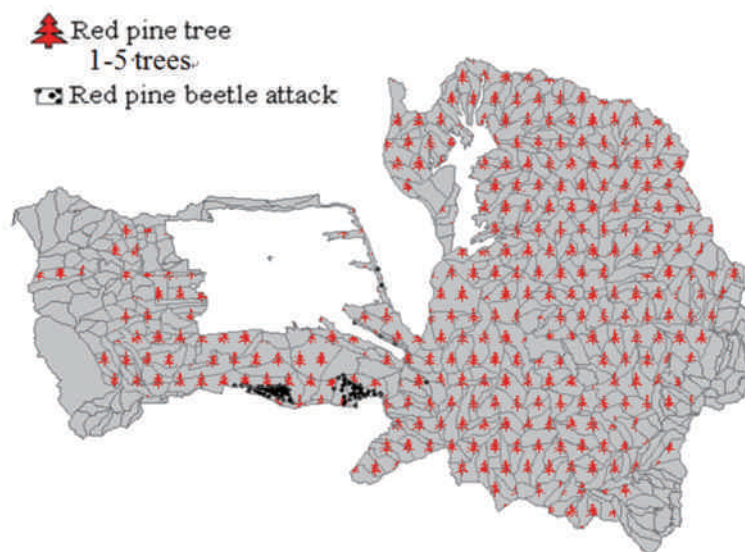

Fig 1 : Red pine beetle attacked trees in 2002

the total red pines. The first attacked tree was in 6 forest compartment which was the mainly border side area of the Komagane City forest, near Nakagawa village in which sawyer infect forest area first.

Year 2004

In 2004 the mainly attacked portion was the middle and the north border part of the city (Fig. 2). With in three year the infestation spread about all over the forest of Komagane City as the beetle is very tough to control. This year the attacked tree was about 714, seven times more than 2002, the maximum attacked tree was 89 in one compartment. This is the year the red pine beetles stirred far from the firstly attacked portion and entered to the next area Miyada Village forest.

Year 2006

In Komagane, the area of the wilt disease trees increased from a total of approximately 10% in 2002 to 2006 and now, the population has reached in epidemic levels. In 2002 about 0.85% of red pine trees were infected by pine wilt disease whereas in 2006 the infection rate was about 10%. This was the mostly swelling time for the red pine beetles to do violence to the red pine trees in the study area. In 2006 the beetle moved to the diverse part of the forest area with a large number of infestation by the nematode. In this year the total assailed tree was about 1275 (Fig. 3). Despite of taking precaution and used several method to control such as fumigation and burning the beetle it caused great lose of Komagane City symbol tree. The infestation is severe in middle north to south and spared in west part of the city. By this
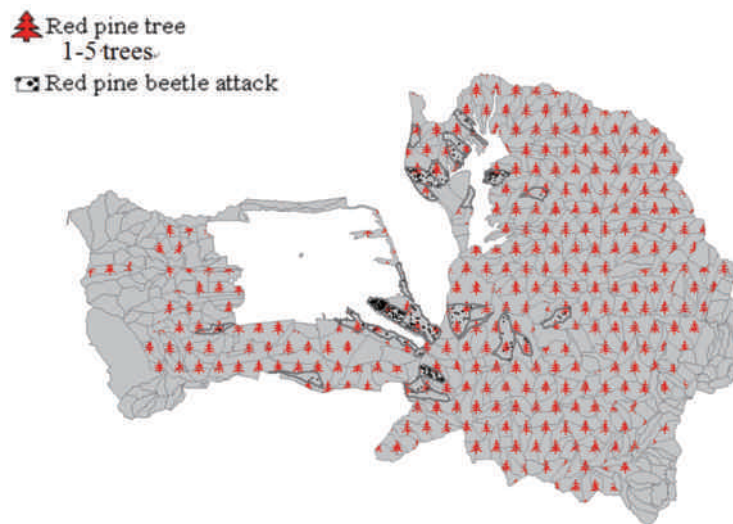

Fig 2 : Red pine beetle attacked trees in 2004
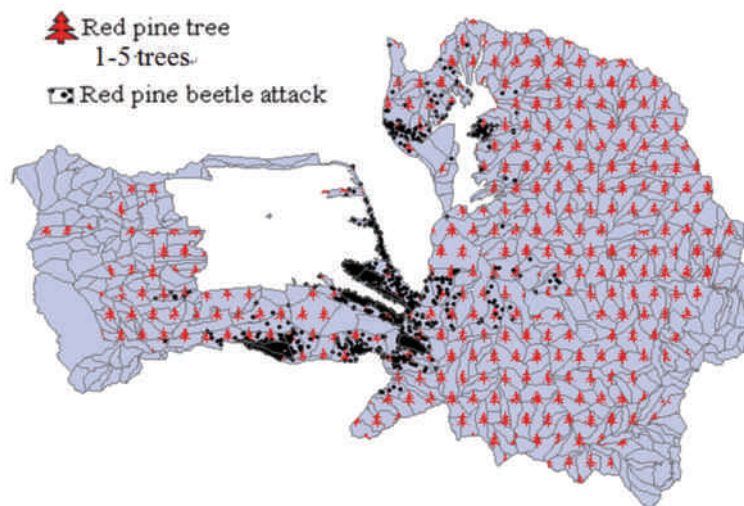

Fig 3 : Red pine beetle attacked trees in 2006
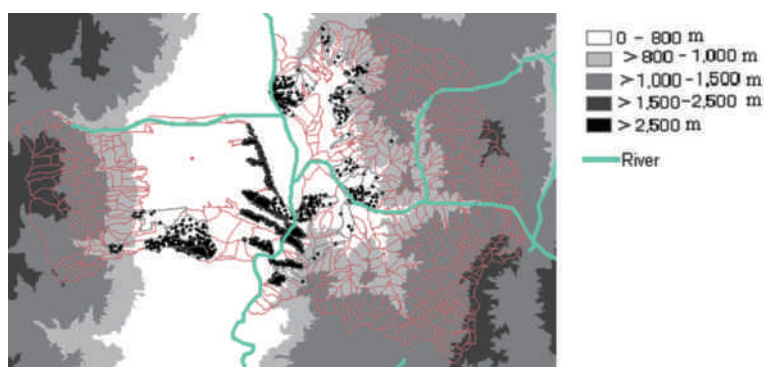
Fig 4 : Attacked red pine trees in 2002

Fig 5 : Attacked red pine trees in 2006

time it also spread and started to attack other city's forest. Day by day infestation is moving to north side from the south of the city.

Factors increasing the attack

The rate of the attack increase for different factors such as rivers exists in this area, elevation and temperature. The infestation mainly spread the same way of the flow of the Tenryu river (Fig. 4 and 5), it infection extend near the river side forest mainly.

Elevation is one of the important factors for the distribution of this beetle ; both nematode and vector pine sawyer are much active in less then 800 m from the sea level (Kiyohara et al, 1973). The infestation spread way is in central Komagane forest, Miyada forest and Nakagwa within 1500 m altitude (Fig. 4 and 5). Low-elevation stands are harder hit than high-elevation stands as the warmer temperatures at low elevations are more favorable for insect survival ; likewise, unusually warm summers aid beetle development. The favorable temperature for the beetle attack is 24℃, and less then 13℃ the beetle unable to survive (Kobayashi et al, 1984). In Komagane summer season is perfect time to spread the infec-

tion. These factors that have contributed to the successful expansion of beetle population include the large amount of mature pine, resulting in an increase in suitable areas.

Control method

Management of pine wilt disease is primarily limited to prevention, there are no cures for pine wilt disease once a susceptible tree becomes infested with the pinewood nematode. The foresters of Komagane gave much attention not only to kill the red pine beetles also tried to save the tree. In Komagane City there uses three types of method to control red pine beetles- fumigation, burning (Fig. 6 and 7) and inject medicine into tree. For fumigation method-at first pile up the damaged tree trunk, cut down the branches, wrap this trunk by polythene sheet and use insecticide (Carbam, Metham Sodium) for fumigation. The long-horned beetle and the nematode both are killed at the same time in this way. For the burning method firstly cut down the tree, collect the trunk with branches and burn that with fire. The other control method is a preventive method where inject insecticide into the tree trunk.

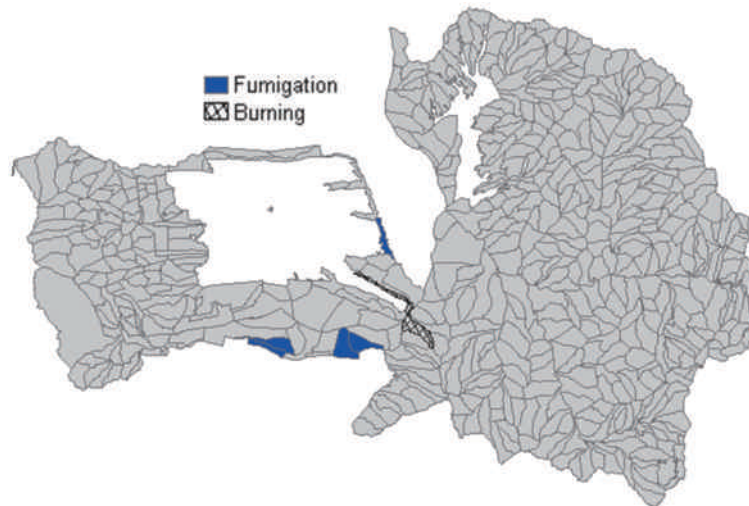Though foresters used various types of control
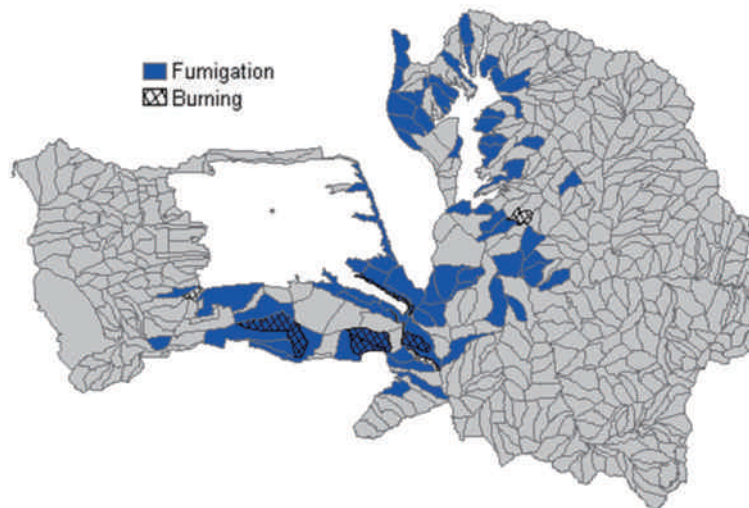
Fig 6 : Control method used area in 2002

Fig 7 : Control method used area in 2006

method in Komagane, the attack expanding speed increased. The burning method needs very high cost and dangerous so the use is decreasing. The fumigation method was popular to the forester and maximum practiced in Komagane as for safety and cheep than the burning method.

Recommendations

From this study several recommendations are featured such as awareness of the general people about red pine beetle. Local government should keep more concentration to prevent this problem and also need to give high research priority to formulate effective control method. Private forest owner need to learn the technology to prevent this beetle. Finally as the study mainly based on secondary data, more trees may be affected which has

no record. So to integrating all tree information we need to use Remote Sensing technique.

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