Geostatistical Analysis of Damaged Area by Pine Wilt Disease

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Abstract

This study analyzed the spatial distribution characteristics of damaged trees or areas by pine wilt disease (Bursaphelenchus Xylophilus) using GIS and geostatistical techniques. The relationship between the spatial distribution of damaged positions and environmental factors were also analyzed.

Keywords : Geostatistical, pine wilt disease(Bursaphelenchus Xylophilus)

1. Introduction

The reason for fast biological spread of damages by blight and harmful insects is topographical & spatial change (Vitousek et al., 1996). This spread causes changes to ecosystem and destructs the variety of ecosystem (Parker et al., 1999). Recently, the study about structure and spatial scales for the spread of forest damages by blight and harmful insects is getting significant attention (Thrall and Burdon, 1999). Especially, spatial pattern is one of the most important variable because it environmentally affects the spread of damages by blight and harmful insects and its life cycles (Ristaino and Gumpertz, 2000). Because *Bursaphelenchus xylophilus* in the target damaged area of this study is not able to move to other trees for itself, it moves via vector insects and then it spreads to unaffected trees when the vectors performs maturation feeding for the bark of unaffected trees or when vectors lay eggs into torn bark of trees (Mamiya and Enda, 1972; Morimoto and Iwasaki, 1972; Wingfield and Blanchette, 1983; Edwards and Linit, 1992). Therefore, this study wanted to find out a solution for spreading prediction of damaged area by blight and harmful insects via spatial statistical method by taking into account the characteristics of blight and harmful insects. The comparison study which applies various statistical algorithms through ecological prediction model of habitat model (Antoine Gusian, Niklaus E., 2000) and the study on spreading prediction of Quercus serrata damage (Maggi, 2002, 2003) and (Qinghua Guo, 2005), etc. are actively under progress. Therefore, this study want to predict spreading of damaged area by blight and harmful insects through spatial and statistical method and GIS based on prior studies.

2. Methodology

2.1. Study area

It turns out long-horned beetles (*Monochamus* genus), known as a vector till now, are broadly distributed along southern coastal area (Korea forest research institute, 2003). *Bursaphelenchus xylophilus* is seriously spreading in Gijang DaeByun port area of Busan, which is damaged area by blight and harmful insects. According to analysis

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results of clinical distribution, pine trees are distributed more as it moves into inland from coastal line (Figure 1).

2.2.Method

This study is divided into three stages. The 1st stage - compensate the result of each variable by using DiGeM (Gottingen Dept, Geo, 2002) to prepare topographical variables, the 2nd stage - process data by using S-Plus (Insightful, 2003), ERDAS IMAGINE (ERDAS, 2001), and Arc Info (ESRI, 2002), the 3rd stage - perform Classification and Regression Trees model by using CART (Salford systems, 2002). The result values obtained from CART are analyzed by array program written in Visual Basic 6.0.

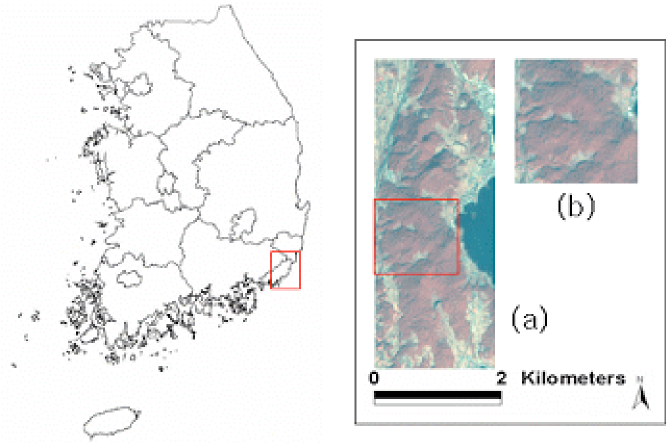


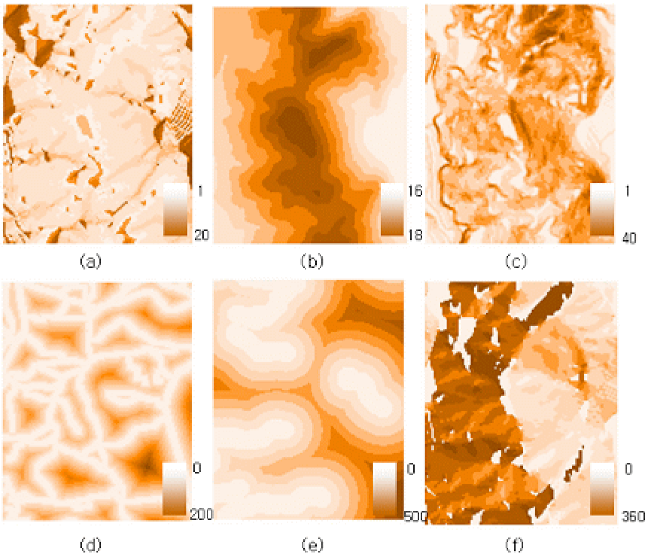
Figure 1. Damage area of *Bursaphelenchus xylophilus* in Busan, Korea
(a)Deabuyn harbor (b)study area

2.3. Determining factor

A variety of variables are created through proved methods based on the basic data from the prior study on Quercus serrata damaged area. DEM was prepared based on 1:25,000 topographical map and satellite images. Elevation was calculated through compensation based on DiGeM (Guttingen Unvi, 2002) and slope was calculated based on Arc Info8.0 (ESRI, 2001). Surface temperature was applied to the study target area based on the research result representing growth and spreading of blight and harmful insects are very active from April to July, which is from the study about variables affecting the growth of blight and harmful insects (Jae-ho Go, et al., 1969 and Young-beom Lee, et al., 1987) (Fig. 2).

2.4. Spatial pattern

The most widely used method in ecological spatial pattern analysis is Ripley's K equation by Haase(1995) (Ripley, 1976). The Ripley's K function used to check second order effect in understanding point distribution can not be regarded as the result from spatial effect when we think the phenomenon across all target areas is first order effect even there is a displacement in point distribution. Therefore, to analyze spatial distribution pattern, we need to analyze second order effect. That is, the second order effect spatial distribution pattern analysis method, which is isotropic process, is used. As a function in which points in a space representing specific pattern in an arbitrary space, the equation representing point intensity is like (1).



(a) (b) (c) (d) (e) (f)

Figure 2. Derived environmental variables used CART model
(a)TMI, (b)Temperature, (c)Slope, (d)Road, (e)Drainage, (f)Aspect

$$\hat{\lambda} = \frac{N}{S} \qquad (1)$$

Where, N is description of number by points , S is spatial area of randomness. Using of Equation (1) was spatial pattern description equation(2) (Ripley, 1977).

$$\hat{K}(t) = \frac{1}{\hat{\lambda}} \frac{1}{N} \sum_{j=1}^{N} \sum_{j \neq i} k_{ij} \qquad (2)$$

Where, if t is distance, k_{ij} = 1, between point i and $j \leq t$ distance, k_{ij} =0, between i and $j > t$ distance. Lhat(transformed K) type of equation Ripley's K transform equation (3) (Goreaud, 1999).

$$\hat{L}(t) = \sqrt{\frac{\hat{K}(t)}{\pi}} - 1 \qquad (3)$$

If L function is larger than 0, it becomes category pattern, and if it's smaller than 0, it shows a regular form. When L function is shown in a graph versus distance, a straight line with slope 1 from the origin represents arbitrary pattern. If actual point distribution is in a category, L function is located above the straight line and if it's regular form, L function is located below the straight line.

2.5. Classification tree

The classification tree extracts a rule predicting target variables from prediction variables (description variables). This classification equation is most widely used because of its benefits of creating rules easy to understand, easy classification, being able to handle both continuous type and categorical type data, clear identification of the most excellent variables. CART (classification and regression trees) model, which is based on classification tree, was proposed by Breiman (1984). This method was developed to escape from complex learning and structure of neural network, and is being used very usefully in pattern recognition and regression analysis.

3. Result

3.1. Dispersion pattern

The spatial pattern in Lhat (L-function) of Ripley's K equation is grouped within 100m range (Figure 4). The spreading pattern means migration range which affects second damaged category from first damaged category with 100m range. In addition, the study result by Maggi (2003) also shows a category within 150m, so the spreading range of most blight and harmful insects is approximately 100m~200m at most (Fig. 3).

3.2. CART

High prediction results are obtained when we applied variables with topographical and spatial characteristics to CART model. Classifying variables according to their objectives is indispensable to apply them to CART model. Set damaged trees as a primary target and set category to damaged trees and directions. Direction is composed of 0°~360° distribution, so we applied direction to the model by grouping 1~8, and selected Poisson Pattern Classification by setting topographical variables as prediction values. We generated Monte carlo random numbers to use them together with damaged trees of a target area as input data and finally used them as training data for damaged area (1) and undamaged area (0). Figure 5 shows conceptual results. That is, statistically select the most influencing variable and then select next influencing variable based on the previous variable and repeat this process to statistically assign weight to all the variables and induces functional equation for these values. Figure 6 shows the detail simulation results of CART model. The model accuracy was 80% and variable importance was affected more by slope rather than watershed (Table 1). Therefore, we can understand watershed and slope are variables highly affecting the spreading of blight and harmful insects, and road and direction have relatively less effect on it. Elevation and surface temperature are also important factors.

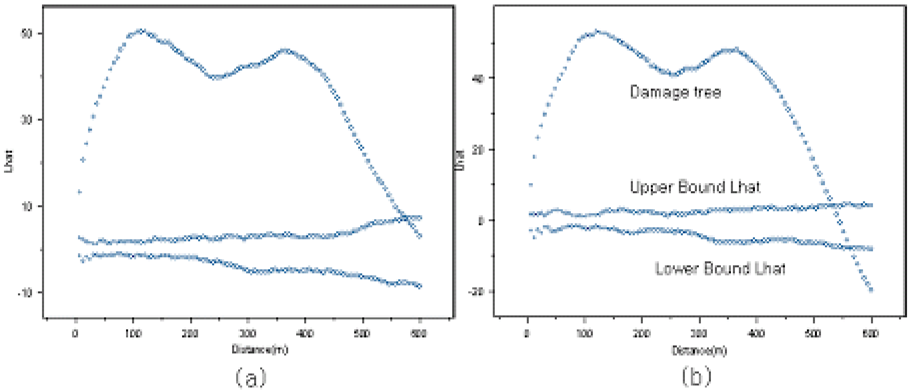


Figure 3. Diagram of the Lhat(h)-h transformation for damage tree (a)2002, (b)2003

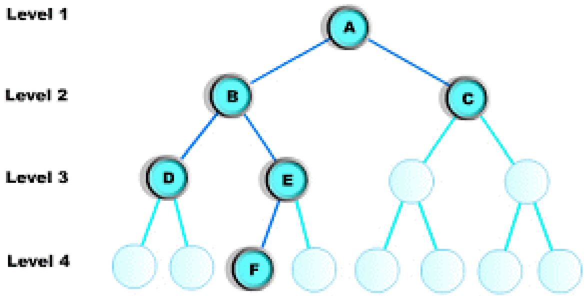


Figure 4. Classification tree model of disease risk result of CART model
(a) slope, (b)altitude, (c)waters, (d)road, (e)temper, (f)aspect

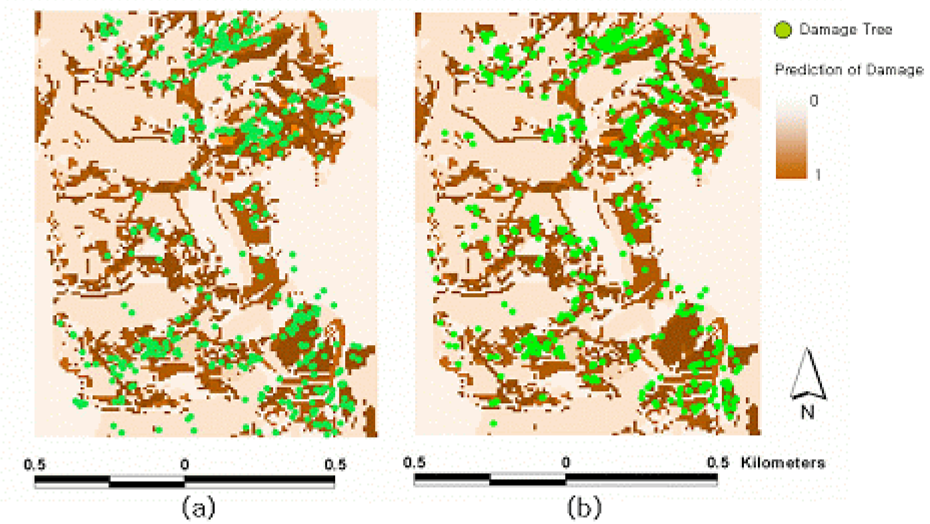


Figure 5. Classification tree model of disease risk (a)2002 year damage point and damage simulation result, (b)2003 year damage point and 2002 year prediction result

4. Discussion

High accuracy was achieved by applying CART model which is tree-based classification model and other results are as follows: First, the features of spatial distribution of areas damaged by blight and harmful insects was identified. Second, by showing the feasibility of predicting the spreading of forest blight and harmful insects (*Bursaphelenchus xylophilus*) via CART model, it's proved that spreading or dangerous areas can be predicted if CART model is used by applying the same variables to similar spreading of blight and harmful insects. Third, it's proved the spreading range of blight and harmful insects is initially within 100m~200m range through this study and prior studies. In addition, this study presents future research topics to consider. First, this study limited target study area mostly to pine trees, so there is no category for clinical study. However, if the effect of blight and harmful insects to other trees is required or the target area is very broad, categorizing clinical information and applying variables highly related to blight and harmful insects may lead to highly reliable results. Second, clinical intensity is also very important variable (Maggi, 2002), so it may be able to be used as an important prediction variable. Third, the resolution according to the size of study area shall be taken into account. The lower the resolution, the lower the effect of direction and slope. Therefore, the effect of a slope with high correlation may be reduced, so the effect shall be considered. In addition, the correlation with weather variables which are considered to have significant correlation with the growth and migration of vectors of blight and harmful insects shall be analyzed and spreading prediction based on the analysis results is required. By taking into account these variables, it's expected to have high accuracy spreading prediction model.

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