# Effects of spatial resolution on digital image to detect pine trees damaged by pine wilt disease

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## ABSTRACT

This study was carried out to investigate the effects of spatial resolutions on digital image for detecting pine trees damaged by pine wilt disease. Color infrared images taken from PKNU-3 multispectral airborne photographing system with a spatial resolution of 50cm was used as a basic data. Further test images with spatial resolutions of 1m, 2m and 4m were made from the basic data to test the detecting capacity on each spatial resolution. The test was performed with visual interpretation both on mono and stereo modus and compared with field surveying data. It can be conclude that it needs less than 1m spational resolutions or 1m spatial resolutions with stereo pair in order to detect pine trees damaged by pine wilt disease.

**Keywords:** pine wilt disease, spatial resolution, simulated KOMPSAT-2 image

## INTRODUCTION

The pine tree is one of the Korean's favorite tree species, which is distributed widely throughout the entire Korean peninsula(Bae, 2003). In recent years pine wilt disease has been spread over rapidly in the southern part of Korean peninsula. It is called as "AIDS of Pine", because all of the affected trees will be blighted to death within few months. Nowadays it is a serious threat to pine forest.

Thus, to prevent the spreading of pine wilt disease in time it is very important to find out the damage front as possible as in early stage. But conventional ground surveys for data collection are labor cost and time consuming in a relatively huge and rugged mountain area. And the results of these surveys are often inconsistent and variable due to surveyor's bias and the subjectivity of visual discrimination of damage status (Reich and Price, 1998).

Remote sensing data is often regarded as a useful information source for such purposes. However, the use of space-borne remote sensing data has been limited by the relatively coarse spatial resolution. Up to now, forest managers have paid a little attention to the satellite data and still they have used aerial photographs solely and field survey in case of necessity. In fact, it is not easy to detect the damage area by pine wilt disease in low and/or medium resolution imagery, because in most cases the symptoms occurred in a tree level not in a stand level.

The new generation of high resolution satellite images like IKONOS and QuickBird is expected to overcome this matter, since the spatial resolutions are comparable with those of aerial photographs. Moreover it is also expected that the KOMPSAT-2 (Korean multipurpose satellite) MSC (Multispectral Camera) image data will contribute to enhance the application of high spatial resolution satellite image.

Therefore, the purpose of this study was to determine whether the pine trees damaged by pine wilt disease could be detected at the tree level using the IKONOS high spatial resolution satellite image. A further objective is aimed to detect its front area for effective control of the infected pine trees and for preventing its spread eventually.

## MATERIALS AND METHODS

### Pine Wilt Disease

The cause of pine wilt disease is infestation of pinewood nematode (*Bursaphelenchus xylopilus*). The nematode is blocking the tracheid of pine tree and dropping the efficiency of plant metabolism, which leads the pine tree blight to death. The pinewood nematode is not able to migrate from tree to tree on its own without any help. The main vector insect is sawyer beetle (*Monochamus alternatus*). The sawyer beetle is infected with the pine wood nematode while it transforms from the pupa to the adult in the wood of the damaged pine tree. Young pine wood nematodes enters into the spiracles of the adult. Once a beetle emerges and it flies to the healthy crown of pine tree for sufficient feeding from the new shoots of young branches. When the beetles are gnawing the new shoots, the nematodes invade into the wounds of the shoots. A beetle can holds about 270,000 worms of pine wood nematodes. They rapidly propagate to infest in the vascular tissues and in the sapwood.

This disease attacks individual trees, not the whole stand instead. Thus, once a pine tree is damaged, tree cutting follows as soon as possible to prevent the disease from spreading to neighboring trees. Therefore date of imaging is very important to detect the damaged trees using satellite image.

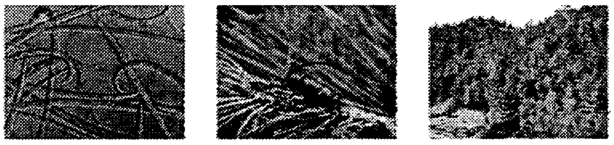

**Figure 1.** The Pinewood nematode (*Bursaphelenchus xylopilus*), sawyer beetle (*Monochamus alternatus*) and damaged pine trees by Pine Wilt Disease (from left to right).

## Study Site

The study site is located at Daebyun-ri, Gijang-gun, Busan Metropolitan City, Korea (Figure 2). Daebyun-ri is one of the infected areas by the pine wilt disease since 1998.

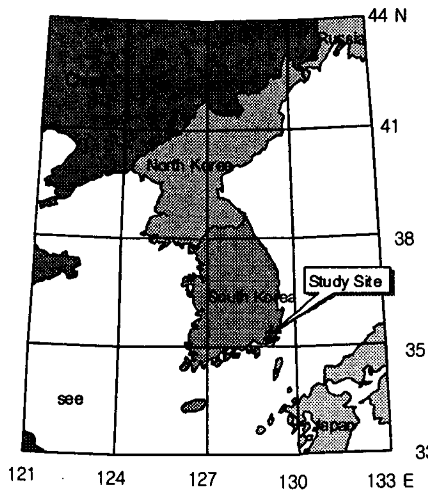


**Figure 2 Location map of study area**

## Field Measurements

In order to get a reference data, accurate tree positions were measured using Total Station. The measurements were performed on 0.1ha size circular plot, which has 35.7m diameters. The plots were selected randomly in natural pine forest regards on stands density. All trees larger than 6cm diameter were measured and recorded with its status such as sound, infected, dead and cut. The results were in Table 1.

**Table 1.** Result of field measurement. (S: Sound, I: Infected, D: Dead, C: Cut in year 2005)

| Plot | Status | | | | Stand Density (Nr./ha) |
|---|---|---|---|---|---|
| | S | I | D | C5 | |
| 1 | 54 | 7 | 43 | - | 1060 |
| 2 | 59 | - | 2 | 13 | 850 |
| 3 | 54 | - | 7 | - | 610 |

## PKNU3 Multispectral Airborne Data

The PKNU3 is a small size airborne photographing system developed by the Pukyong National University. The PKNU3 consists of a multi-spectral camera (REDLAKE MS4000) and a thermal infrared camera (Raytheon IRPro). The REDLAKE MS4000 sensor is a triple CCD camera that can take R, G, B, IR images simultaneously. The green and blue bands are detected on one CCD with a Bayer pattern consisting of rows of red-green-red-green and blue-green-blue-green pixels. A monochrome CCD sensor acquires the red plane at full resolution. It can produce RGB and CIR images with a resolution of 1600 × 1200 pixels. The pixel size is 7.4 $\mu$m. Figure 3 shows the spectral characteristic of MS4000 multispectral camera.

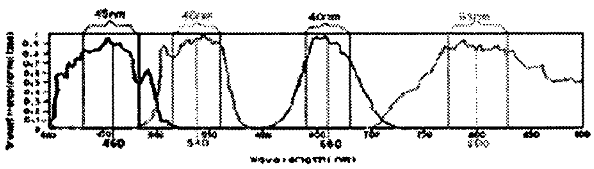

**Figure 3.** Spectral characteristic of MS4000 multispectral camera

Images used in this study were taken at 12. Jan. 2005. The flight was performed in height 1000m so the images have a GSD of 50cm. Used Images have 60% end-lap and 30% side-lap for the stereo analysis.

The images were oriented with Leica Photogrammetry Suite (LPS). Different from frame camera, digital images have no fiducial marks and all the parameters for the inner orientation were fixed. Parameters used in orientation was take from the result of Lee and Choi(2004), the developer of the camera systems. Beside the original images reduced spatial resolution of 1m, 2m and 4m were produced and also oriented for stereo interpretation.

After image orientation a orthophoto with spatial resolution of 50cm was produced. With cubic convolution resampling method further images with spatial resolution of 1m, 2m and 4m were derived from the orthophoto.

## RESULTS AND DISCUSSIONS

The analyses were carried out in stereo and mono modus with visual interpretation. All the trees within the plot were recorded with the attribute of damage status. Damaged trees appear more or less in white tone on a CIR image, whereas the sound and vital trees appear in red color. Therefore it was not so difficult to identify the damaged trees. More difficulties appear in dense pine stand, because the many tree crowns are closed and look like a one tree. This is a one of the well-known problem in aerial photographs.

Table 2 and Figure 4 show the interpretation results. In case of 50cm spatial resolution, it shows similar identifying result in both stereo and mono modus. In comparison with field measurement however ca. 50% of trees were identified. This largely depends on the stand characteristics. The stands are very dense and composed with relative small trees. If a tree located between a big trees, than the small tree could not find in aerial photos.

With a spatial resolution of 1m, they show different results between stereo interpretation and orthophoto interpretation. By the stereo interpretation it gives similler results in both 0.5m (total 104 trees) and 1m (total 99 trees) spatial resolution. However by the orthophoto interpretation the identified trees were reduced from 105 to 52. This indicates that, interpretation with stereoscopic view shows its advantages in this resolution.

**Table 2.** Identification of individual trees in stereo and single modus on various spatial resolution images

(Unit: Number of Trees)

| Plot | Status | Stereo | | | Ortho | | |
|---|---|---|---|---|---|---|---|
| | | 0.5m | 1m | 2m | 0.5m | 1m | 2m |
| 1 | Dead | 15 | 14 | 5 | 11 | 5 | 3 |
| | Sound | 26 | 27 | 12 | 32 | 13 | 4 |
| 2 | Dead | 7 | 5 | 3 | 4 | 3 | 2 |
| | Sound | 32 | 28 | 8 | 34 | 12 | 7 |
| 3 | Dead | 1 | 1 | 1 | 1 | 1 | 1 |
| | Sound | 23 | 24 | 9 | 23 | 18 | 7 |
| Sum | Dead | 23 | 20 | 9 | 16 | 9 | 6 |
| | Sound | 81 | 79 | 29 | 89 | 43 | 18 |

In the images with spatial resolution of 2m, it becomes difficult to recognise the individual tree crowns. Thus the possiblility to identify the individual tree are fall rapidly. This could be observed in both stereo and orthophoto modus. With the stereo interpretation only 38% of the trees interprted in 0.5m image were identified and only 24% of the trees with orthophotos.

With a 4m spatial resolution, it was impossible to identify individual trees without any prior information, although in the stereo modus one can recognise the crown in the rough. It was possible to separate the forest and nonforest area. Thus it was not performed to identify the individual trees.

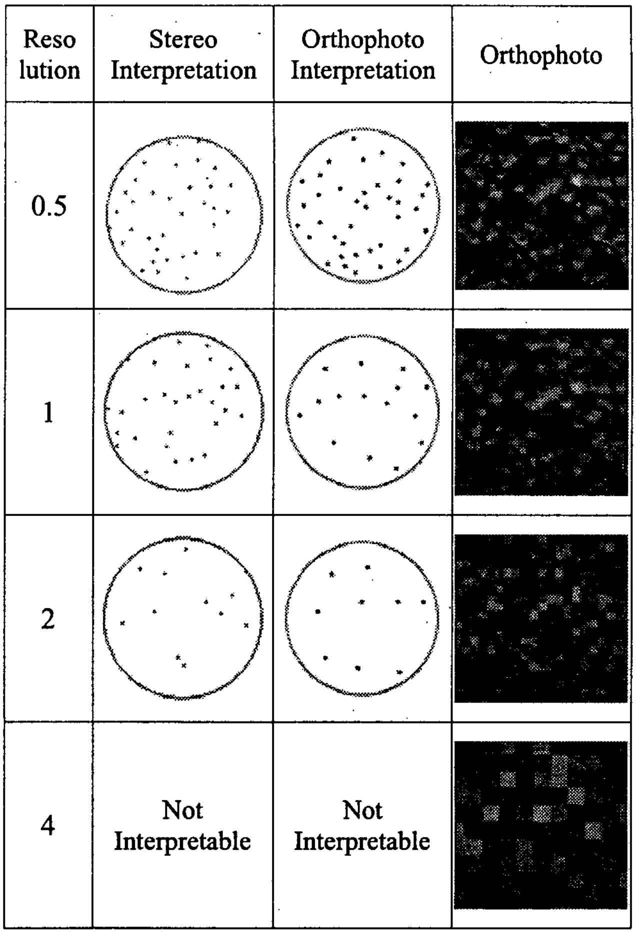


**Figure 4.** Identified trees on various spatial resolutions and stereo and orhtophotos (Plot 2).

## CONCLUSION

This study was carried out to investigate the effects of spatial resolutions on digital image for detecting pine trees damaged by pine wilt disease. Color infrared images taken from PKNU-3 multispectral airborne photographing system with a spatial resolution of 50cm was used as a basic data. Further test images with spatial resolutions of 1m, 2m and 4m were made from the basic data to test the detecting capacity on each spatial resolution. The test was performed with visual interpretation both on mono and stereo modus and compared with field surveying data.

It can be conclude that using aerial photographs it can be identified only ca. 50% trees in dense forest with small trees. In stereo interpretation the differences between 50cm and 1m resolution images were disregardable. But in mono interpretation the differences were considerable. These indicate that it needs less than 1m spational resolutions or 1m spatial resolutions with stereo pair in order to detect pine trees damaged by pine wilt disease.

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