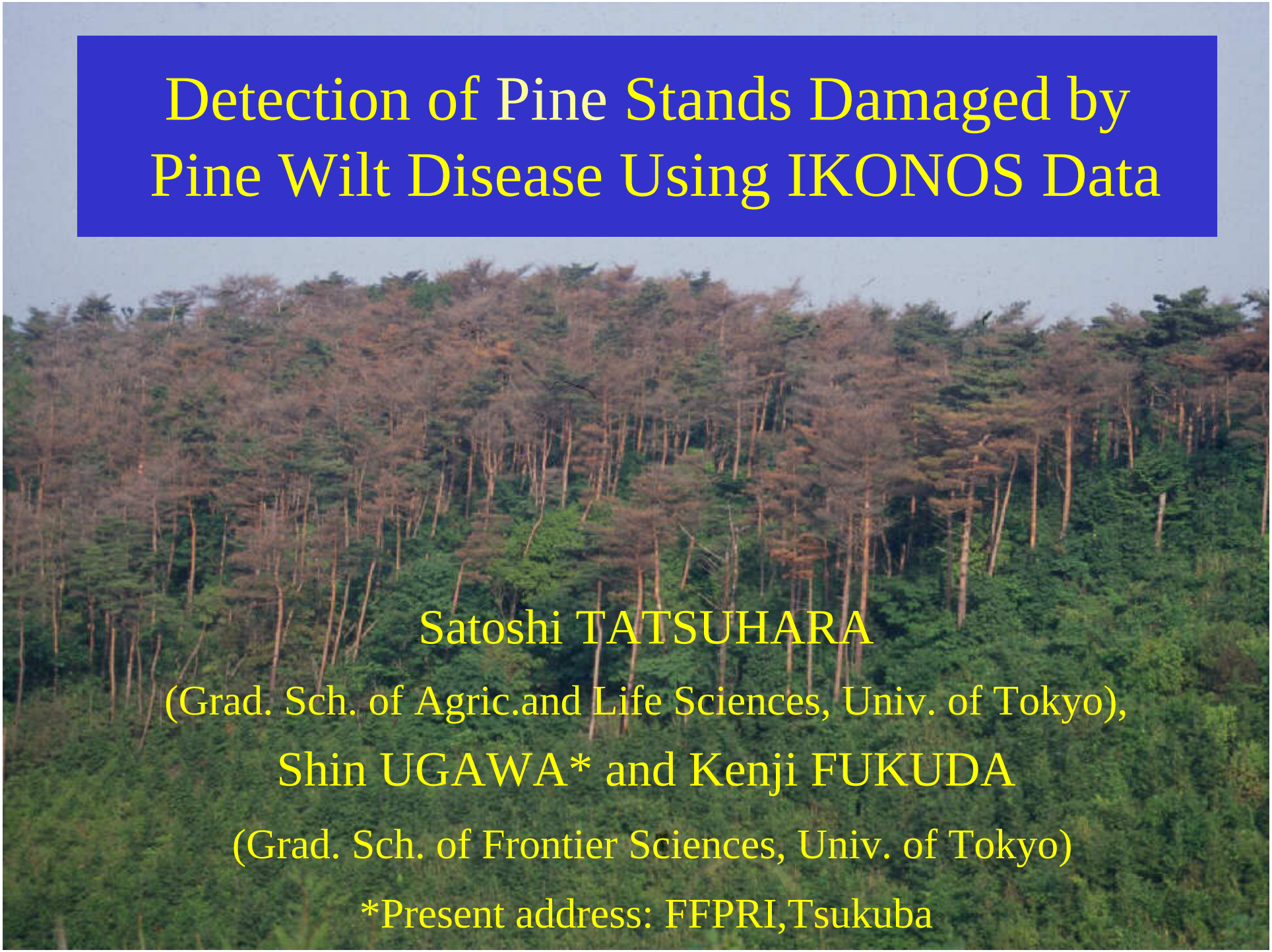
Detection of Pine Stands Damaged by Pine Wilt Disease Using IKONOS Data



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Background and objective

- Pine wilt disease has widely spread in Japan and now is spreading to East Asia and Portugal.
- The causal agent, the pinewood nematode (*Bursaphelenchus xylophilus*), is an **alien species** invaded from North America.
- Finding damaged pine stands at an early stage is essential to prevent its expansion to other pine forests.
- Damage survey by foresters is often difficult and inefficient.

Detection of damaged pine stands by using **high-resolution satellite imagery**

High resolution satellite imagery

IKONOS images

Date: Dec. 26, 2000

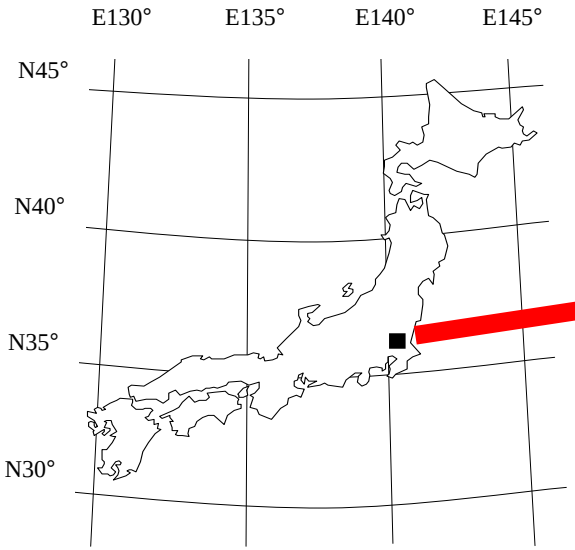
Spatial resolution:

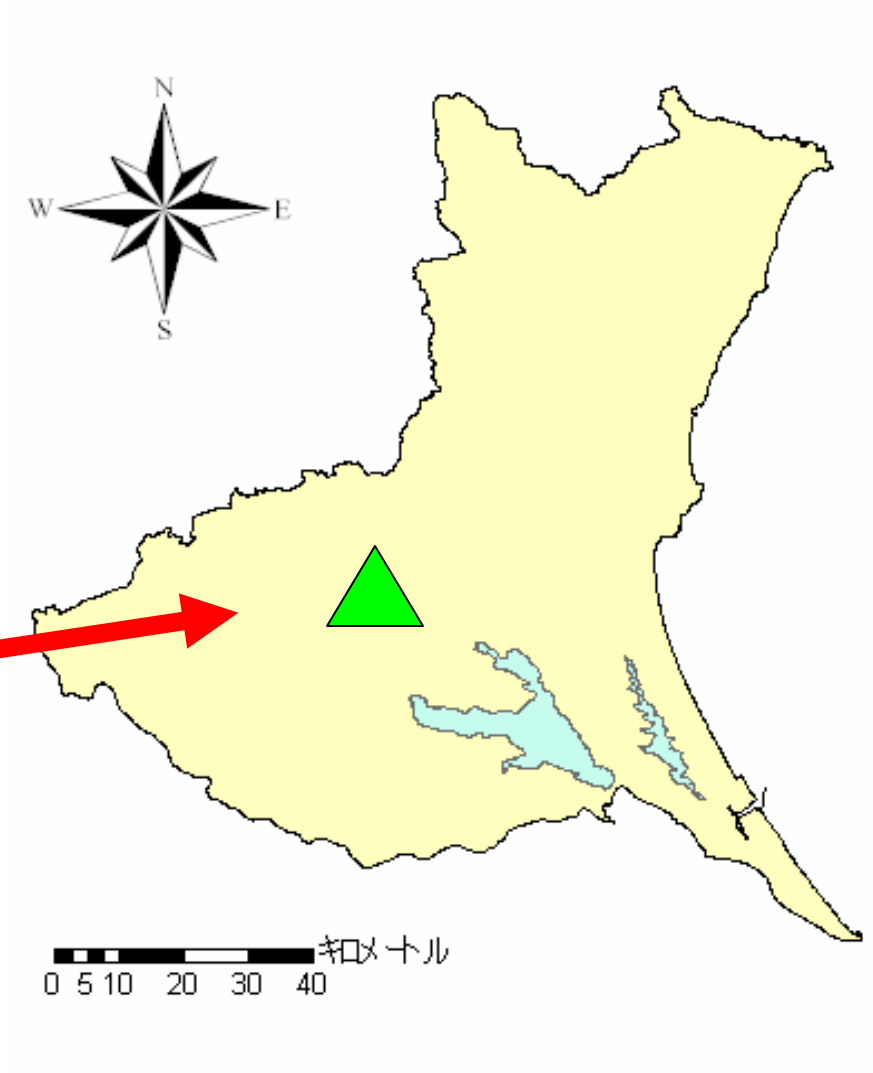
Panchromatic image: 1m

Multi-spectral image: 4m

Study area

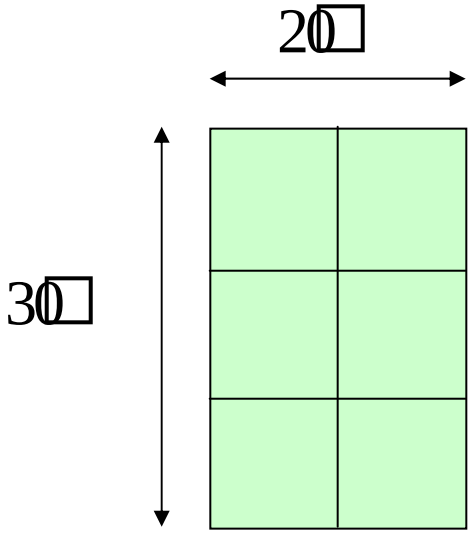
Mt. Tsukuba
Ibaraki Prefecture

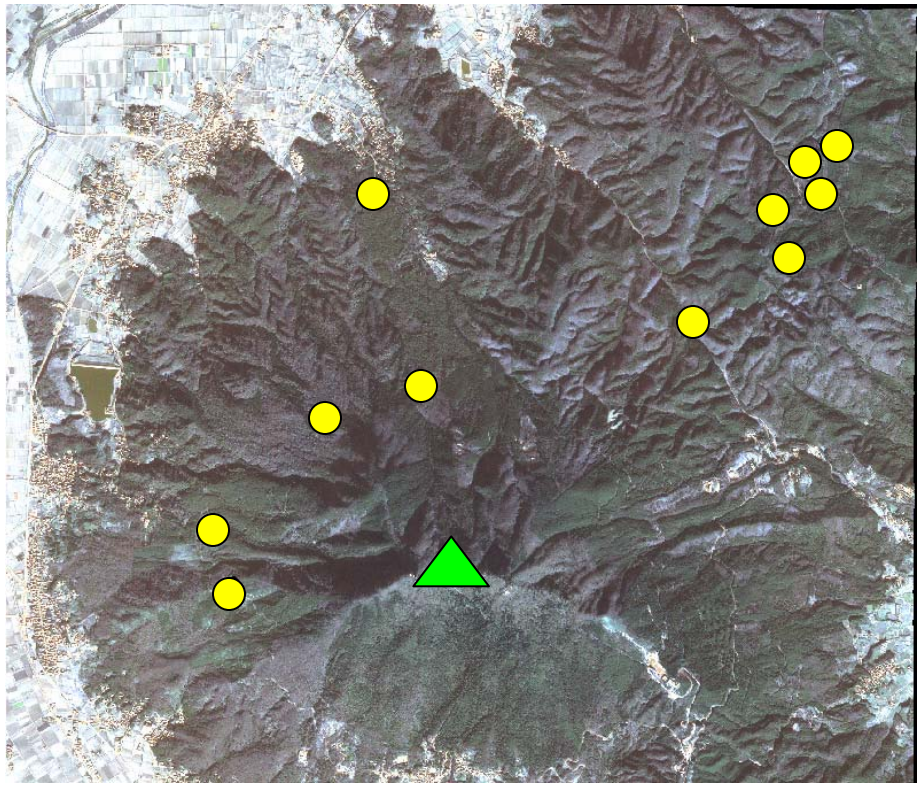




Study area

- Eleven 20m×30m plots
- Variety in severity of the damage (23 ~ 68%)
- Each plot was divided into sub-quadrats（10m×10m）
- The total number of quadrats: 66





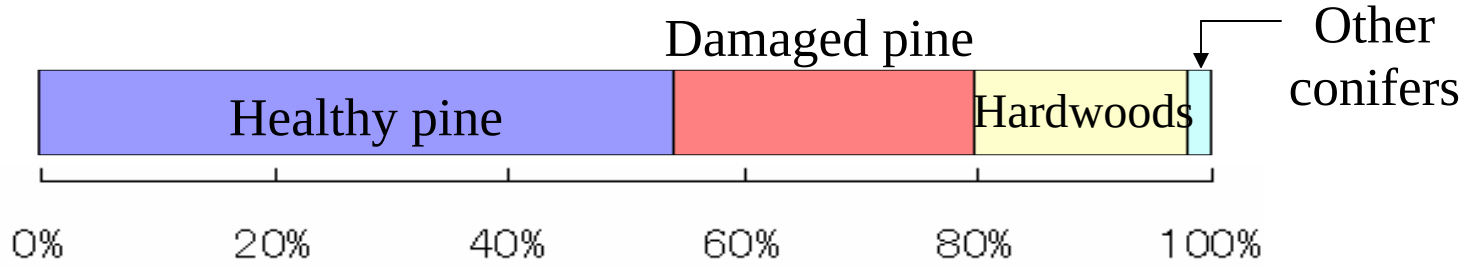
Field survey

- Species, DBH and condtion (healthy/damaged) were surveyed for all trees in the plots.
  - Damage Ratio

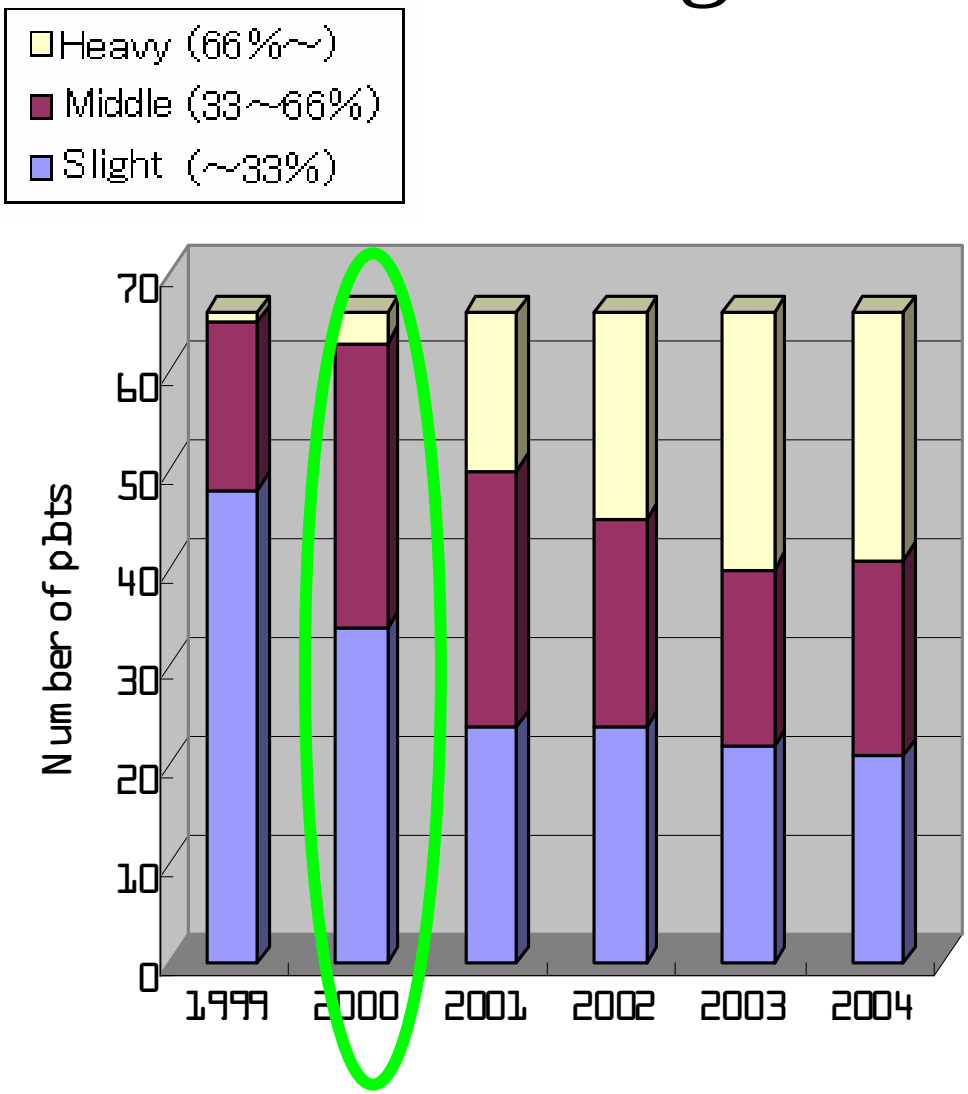
    = (BA of damaged pine trees) / (BA of all pine trees)
  - Ratio of healthy pine trees

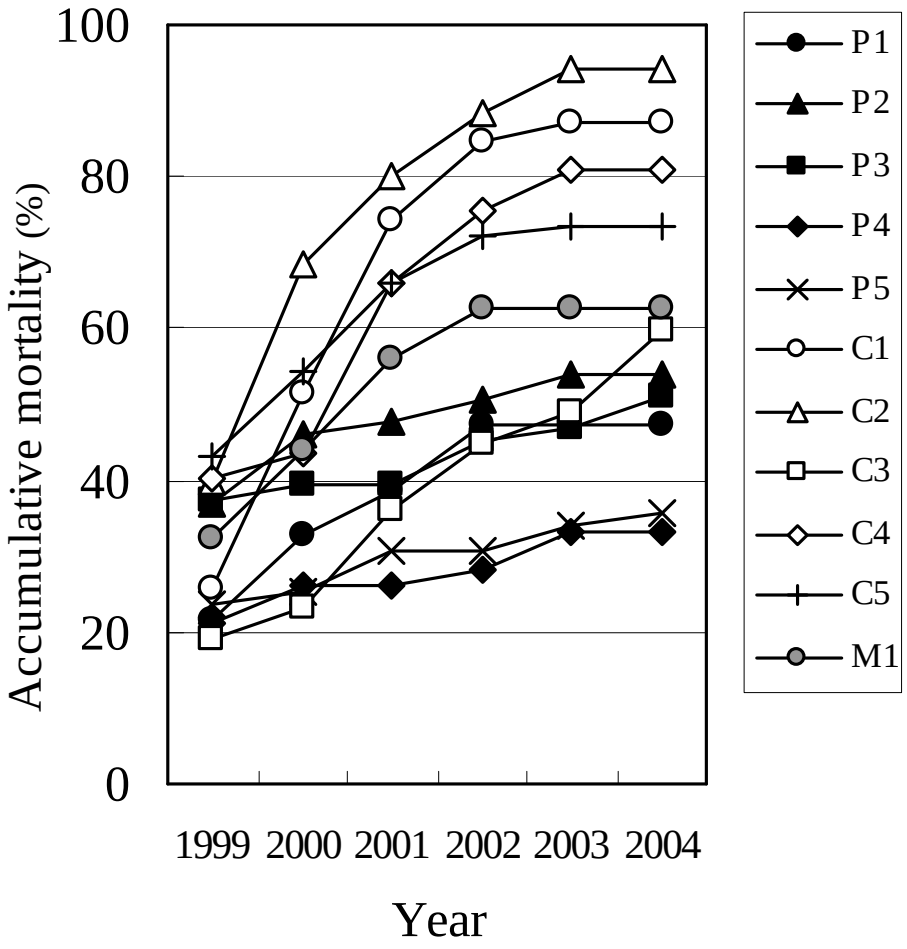
    = (BA of healthy pine trees) / (Total BA of the stand)
  - Ratio of hardwood trees

    = (BA of hardwood trees) / (Total BA of the stand)



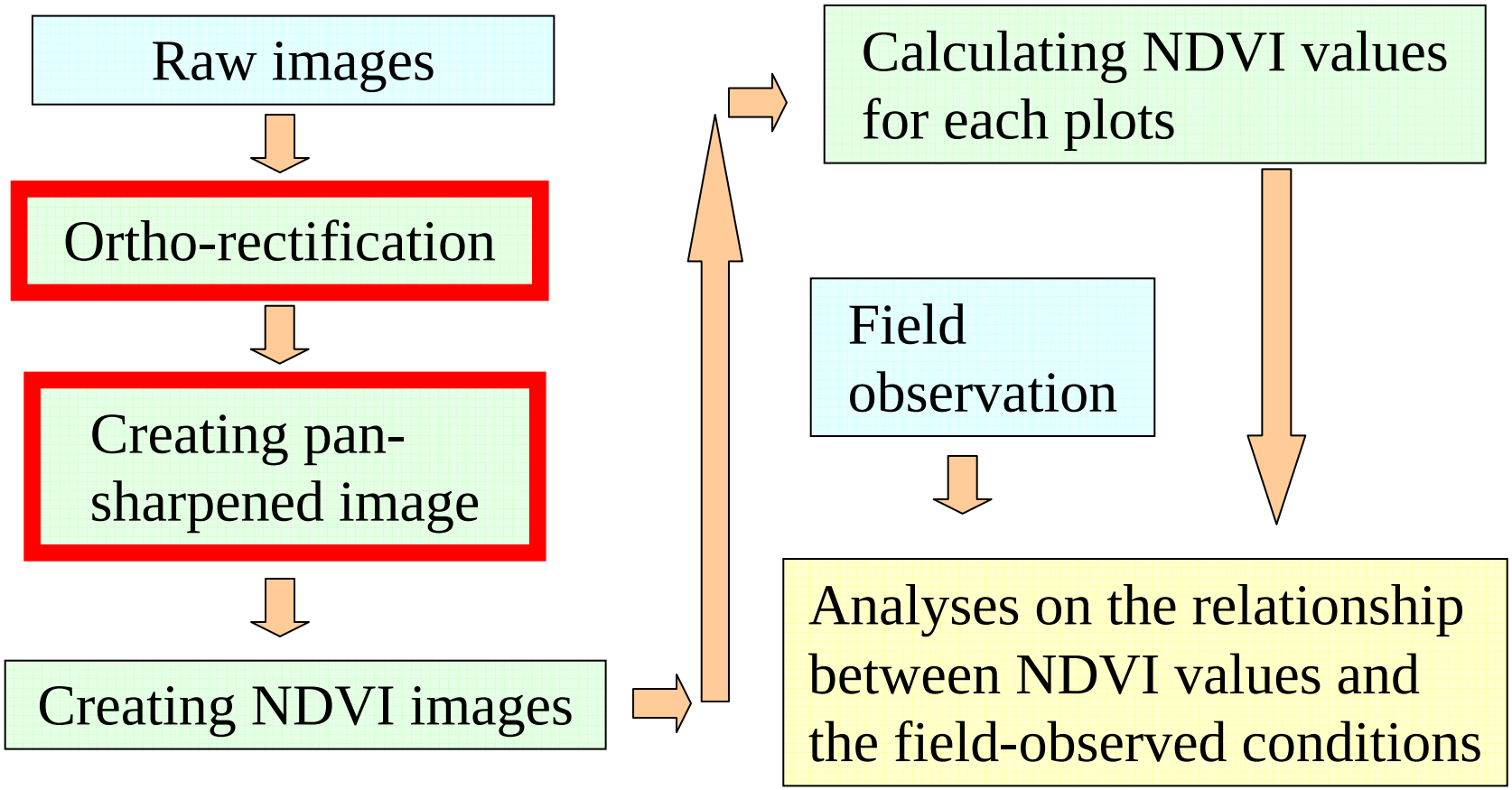
Damage severity in plots





The most severely damaged plot (C2)

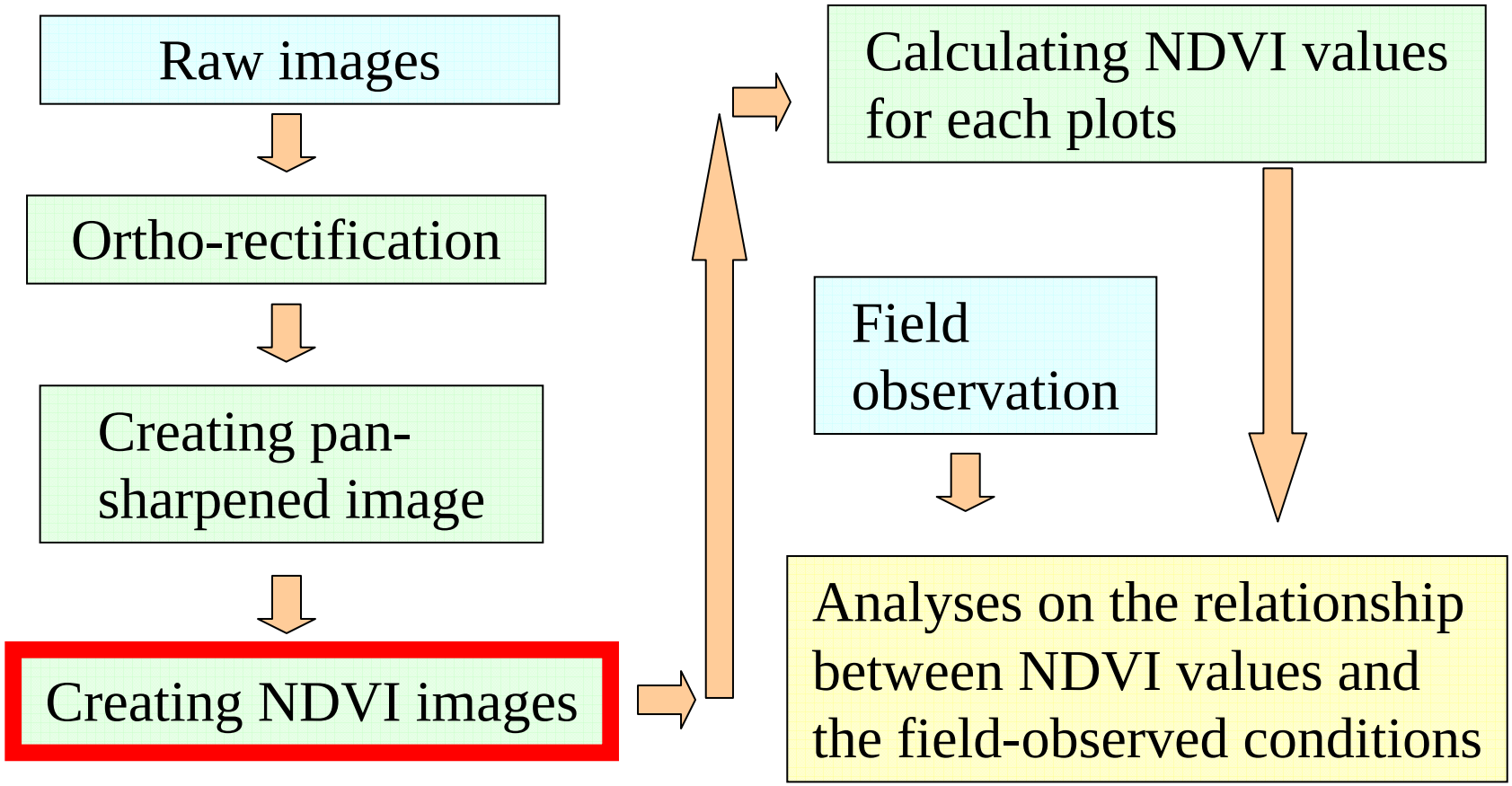
Methods


Raw images
Ortho-rectification
Creating pan-sharpened image
Creating NDVI images
Calculating NDVI values for each plots
Field observation
Analyses on the relationship between NDVI values and the field-observed conditions

Pan-sharpened image

1m-resolution color image created from panchromatic image and multi-spectral image

Methods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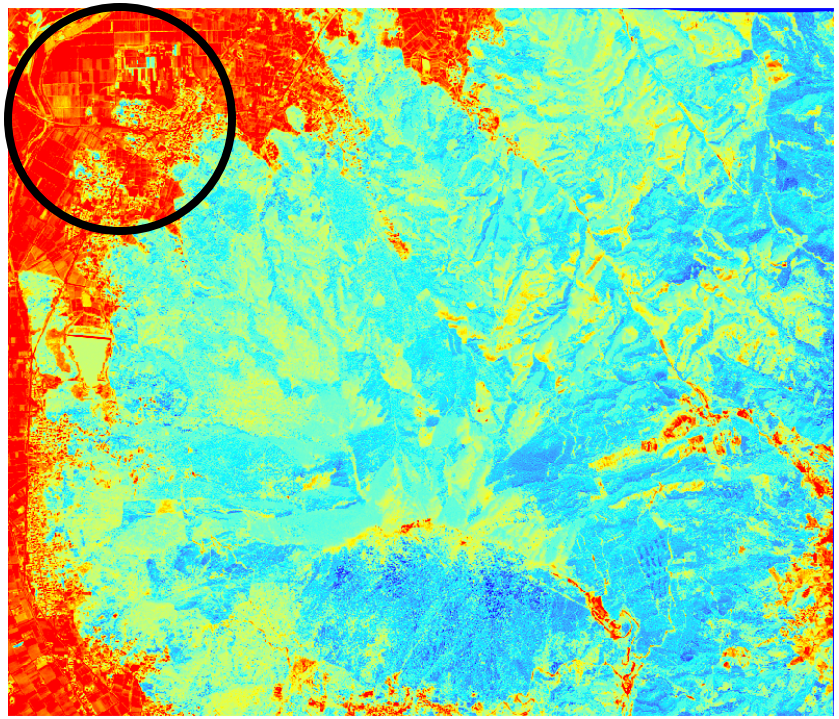
NDVI (normalized difference vegetation index)

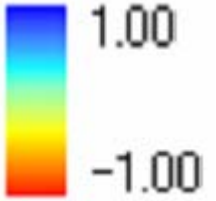
- The value of NDVI: -1 ~ +1.
- Vegetation yield positive values.
- For IKONOS, band 3 is red-band and band 4 is near-infrared-band.

NDVI=(band 4-band 3)/(band 4+band 3)

Pan-sharpened image

NDVI image





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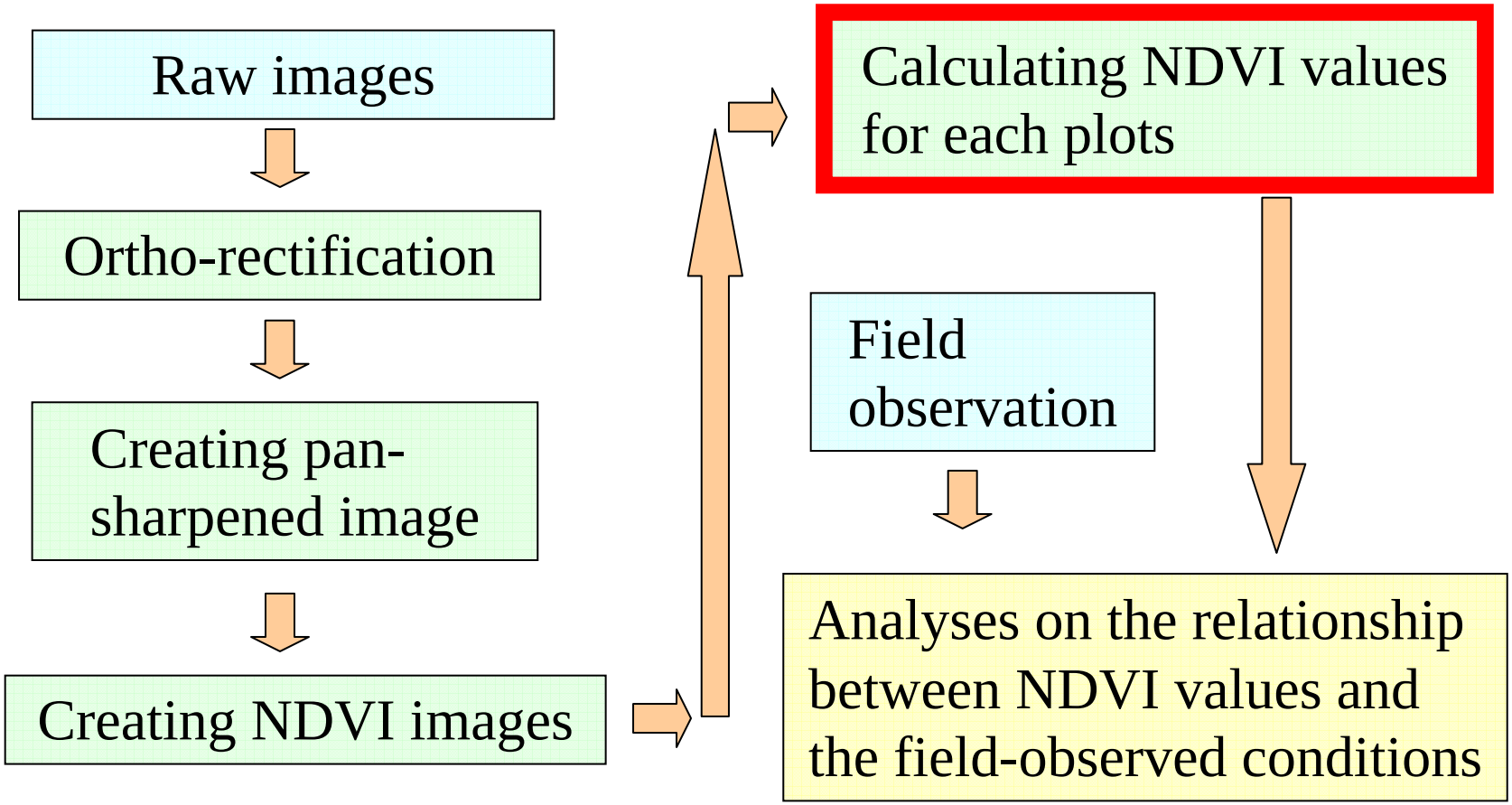
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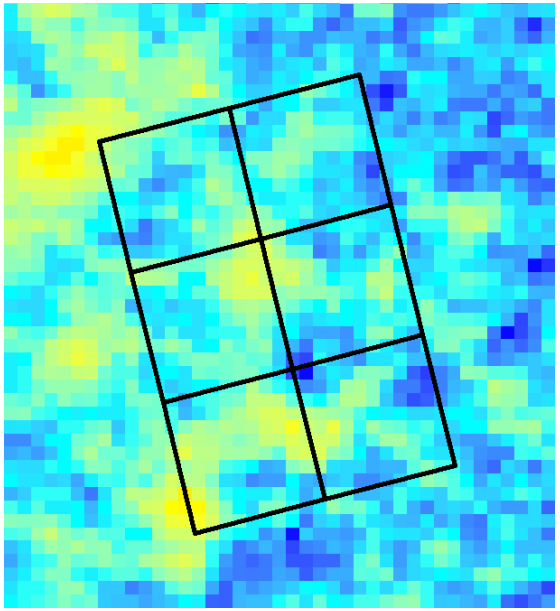
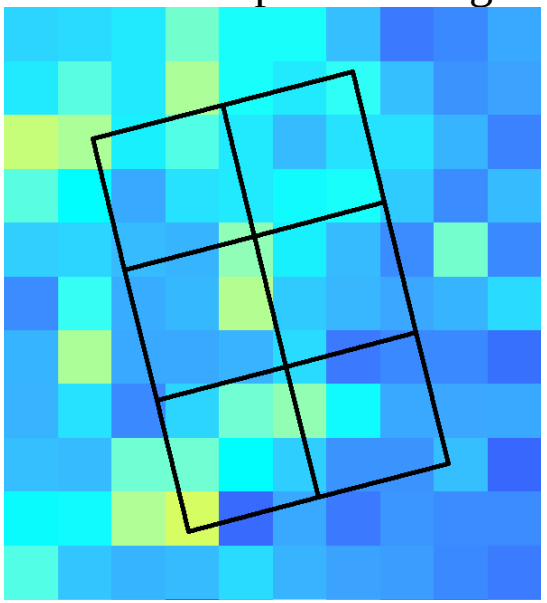
Calculating NDVI value for each plot

- Averaging NDVI values of pixels in each plot for pan-sharpened image
- Resampling 4m×4 m pixels into 1m×1m pixels and averaging NDVI values of pixels in each plot for multi-spectral image
- One plot contained almost 100 pixels.

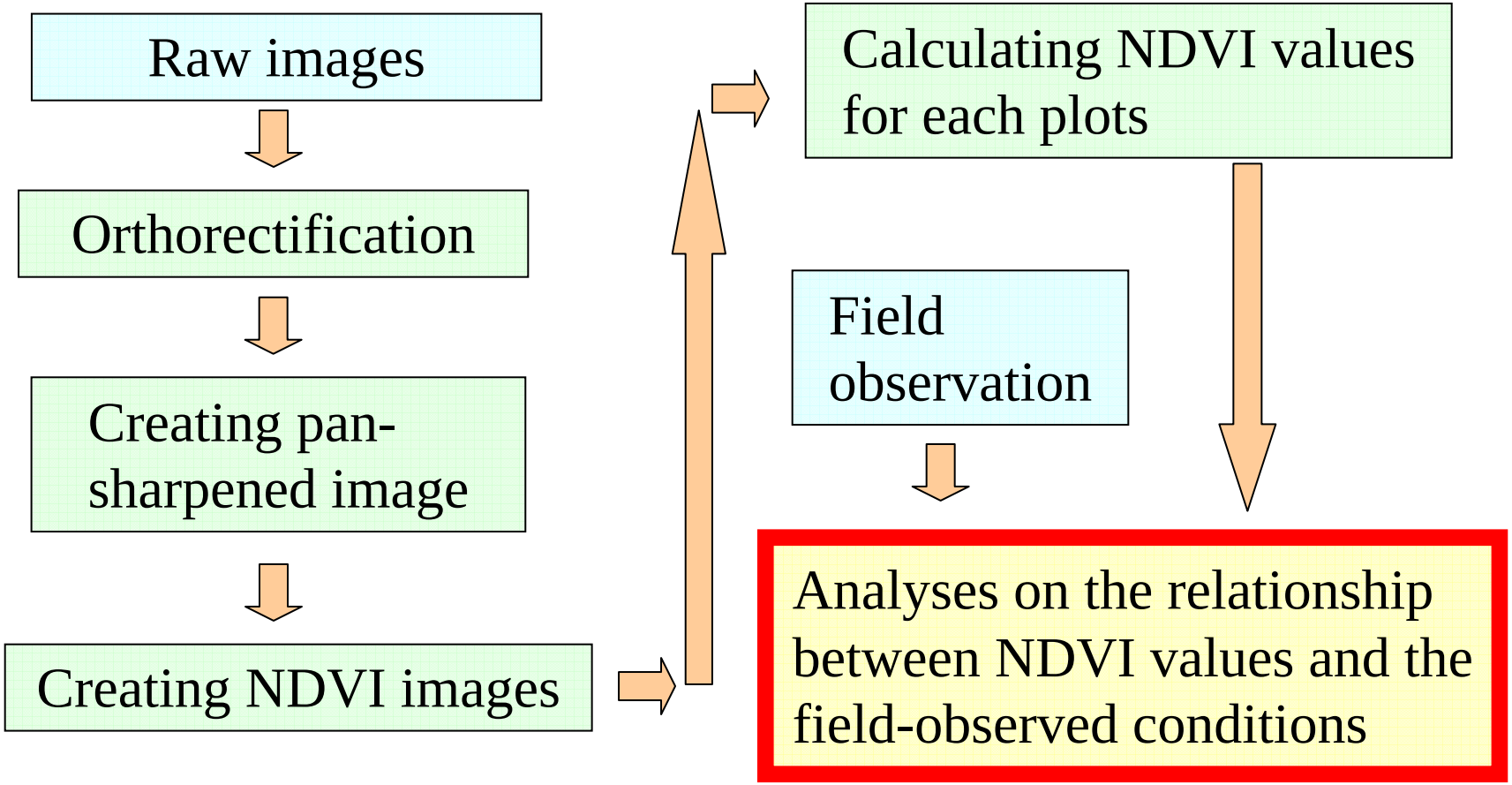
From pan-sharpened image



From multi-spectral image



Methods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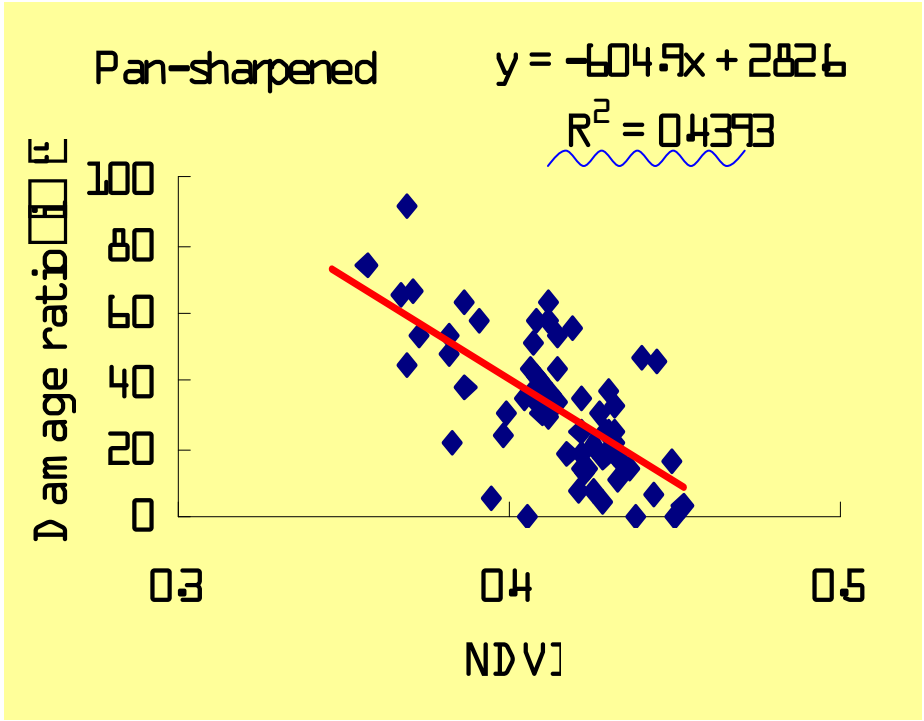
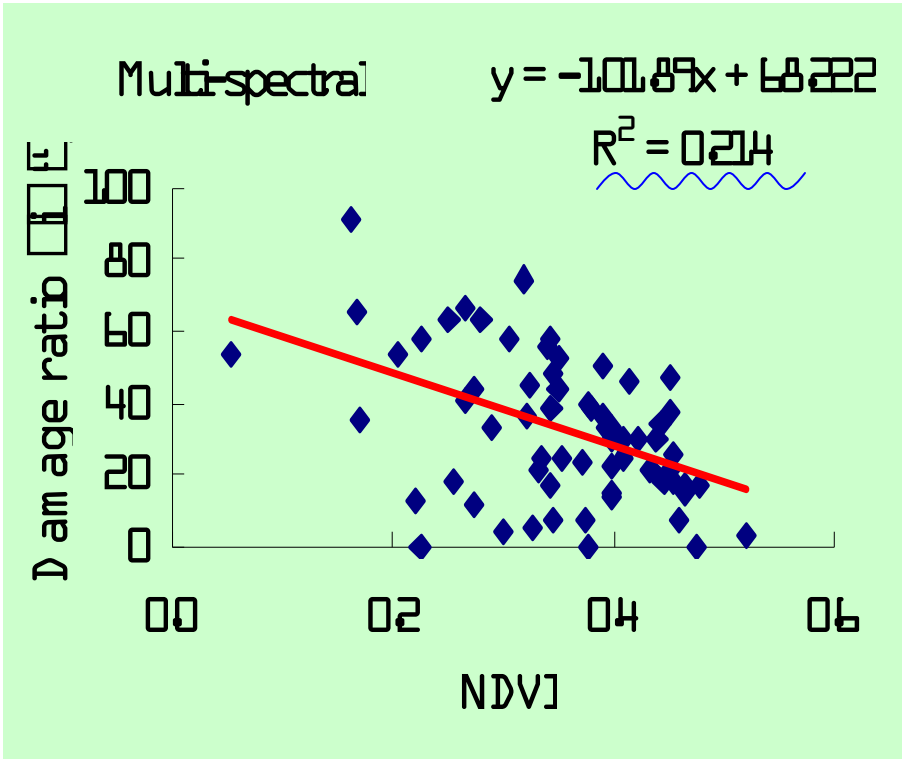
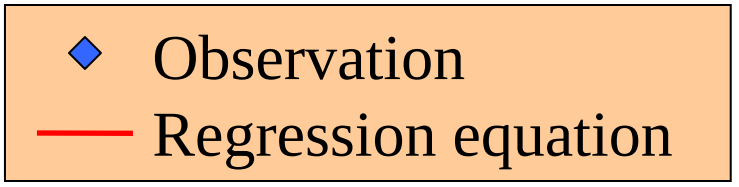
Results

Relationship between NDVI and the damage ratio

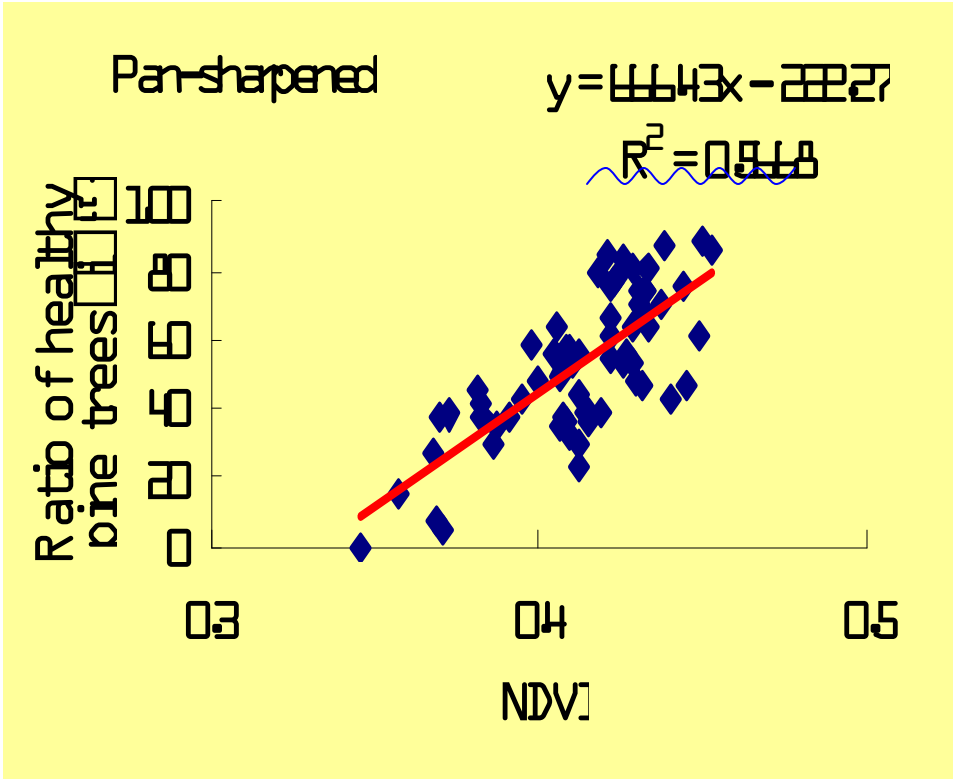


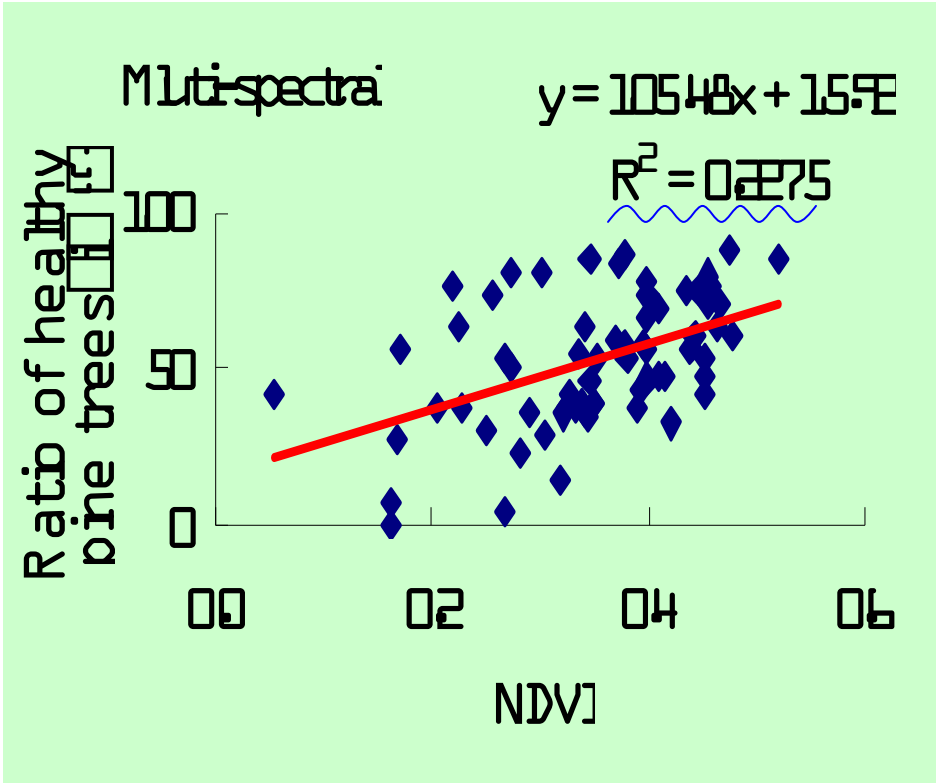




Results

Relationship between NDVI and the ratio of healthy trees



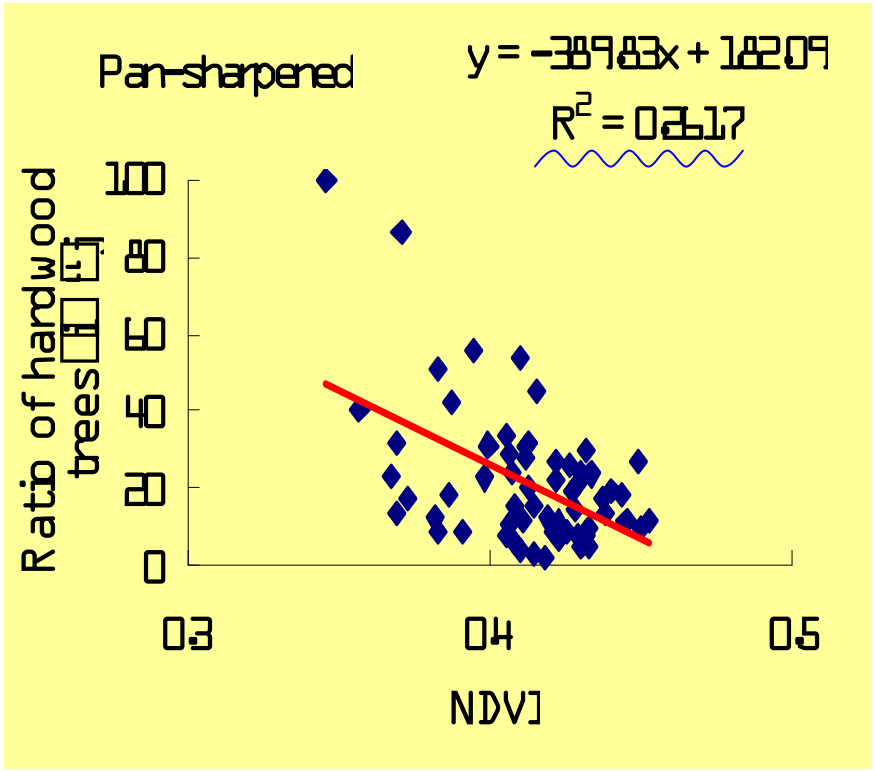


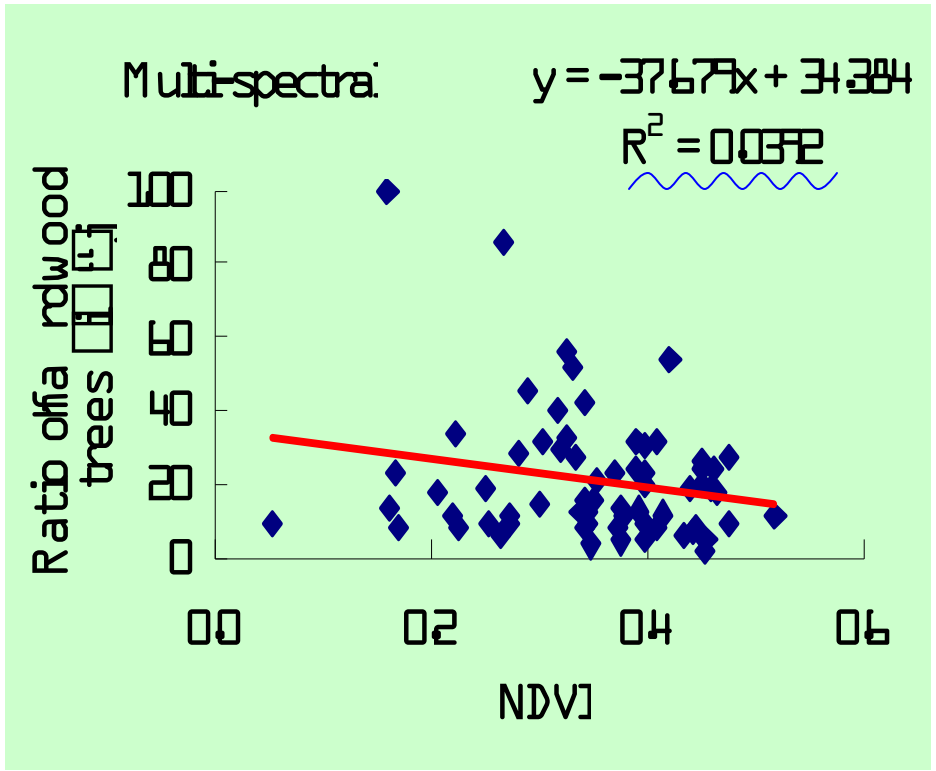
◆ Observation

— Regression equation

Results

Relationship between NDVI and the ratio of hardwood trees





◆ Observation

— Regression equation

Accuracy test

- The 66 sample plots were numbered in order of establishment, and the data set of the sample plots was split into two: odd numbered sample plots (**odd data set**) and even numbered sample plots (**even data set**).
- Regression equations were derived from the odd data set.
- They were applied to the even data set.

The root mean square errors (RMSEs) were calculated from observations and estimates of the even data set using:

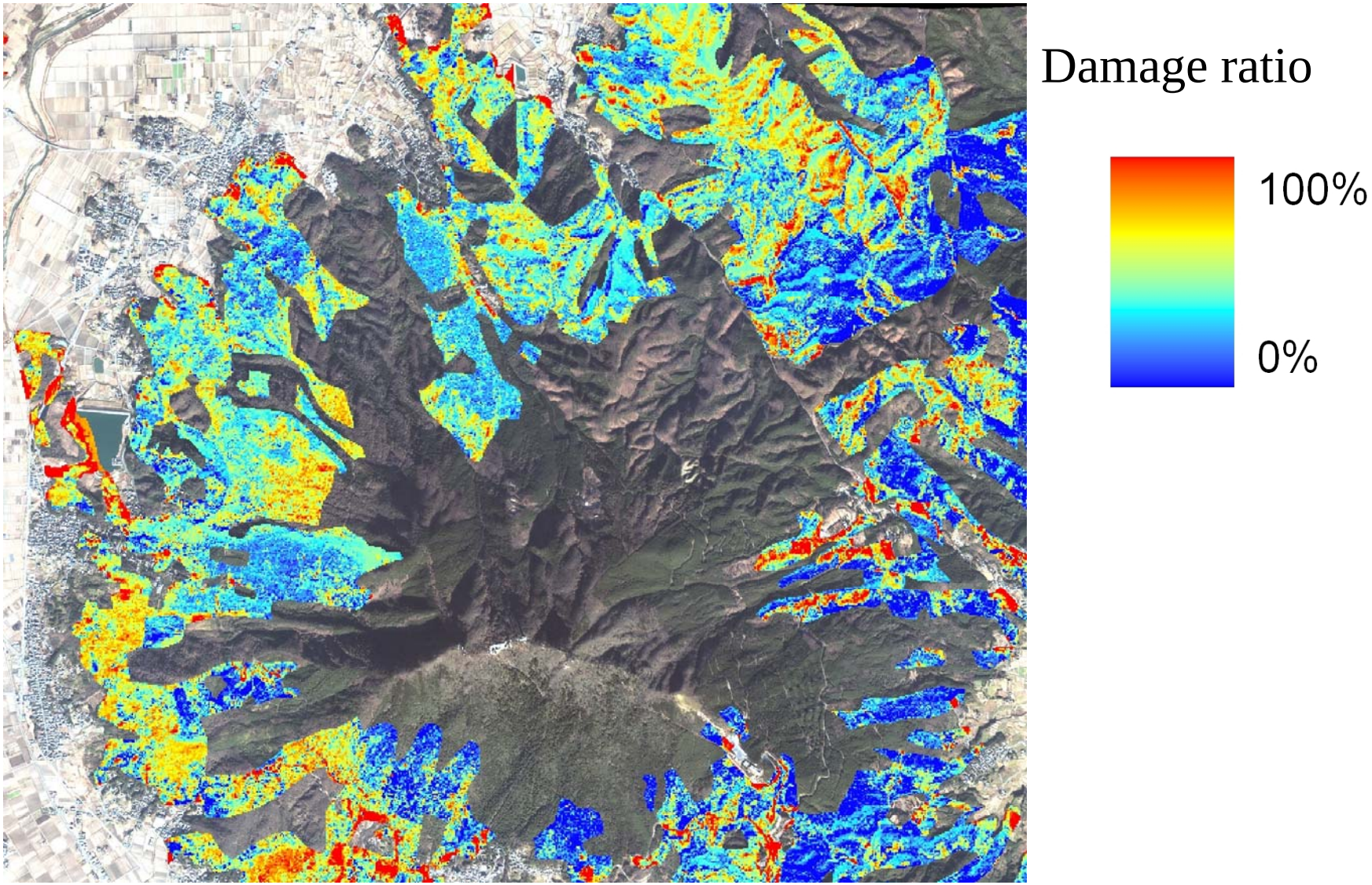
$$RMSE \quad \sqrt{\frac{1}{N}\sum_{i=1}^{N} \mathrm{i}X_i \quad |X'_i{}^2\mathrm{j}}$$

Xi=observation, Xi'=estimate, N=number of even plots

Results

	Pan-sharpened	Multi-spectral
Damage ratio	0.146	0.173
Ratio of healthy pine	0.121	0.169

Estimation of damage ratio by pan-sharpened image of IKONOS



Conclusions

- The pan-sharpened color imagery could effectively estimate the damage ratio in pine stands in a fine scale of 10m×10m basis.

But,□□□

- A mixture of deciduous hardwood trees in the study area increased the prediction error because the NDVI calculated from imagery in winter could not separate hardwood trees and damaged pine trees.

→use summer images

Next step

- Detection of pine wilt damage in **a single tree level**

- Comparison of satellite images in different years→ Estimation of damage progress

- Coupling with GIS data (elevation, slope direction, soil type, etc.)

  →Estimation of stand susceptibility

  Simulation of damage progress