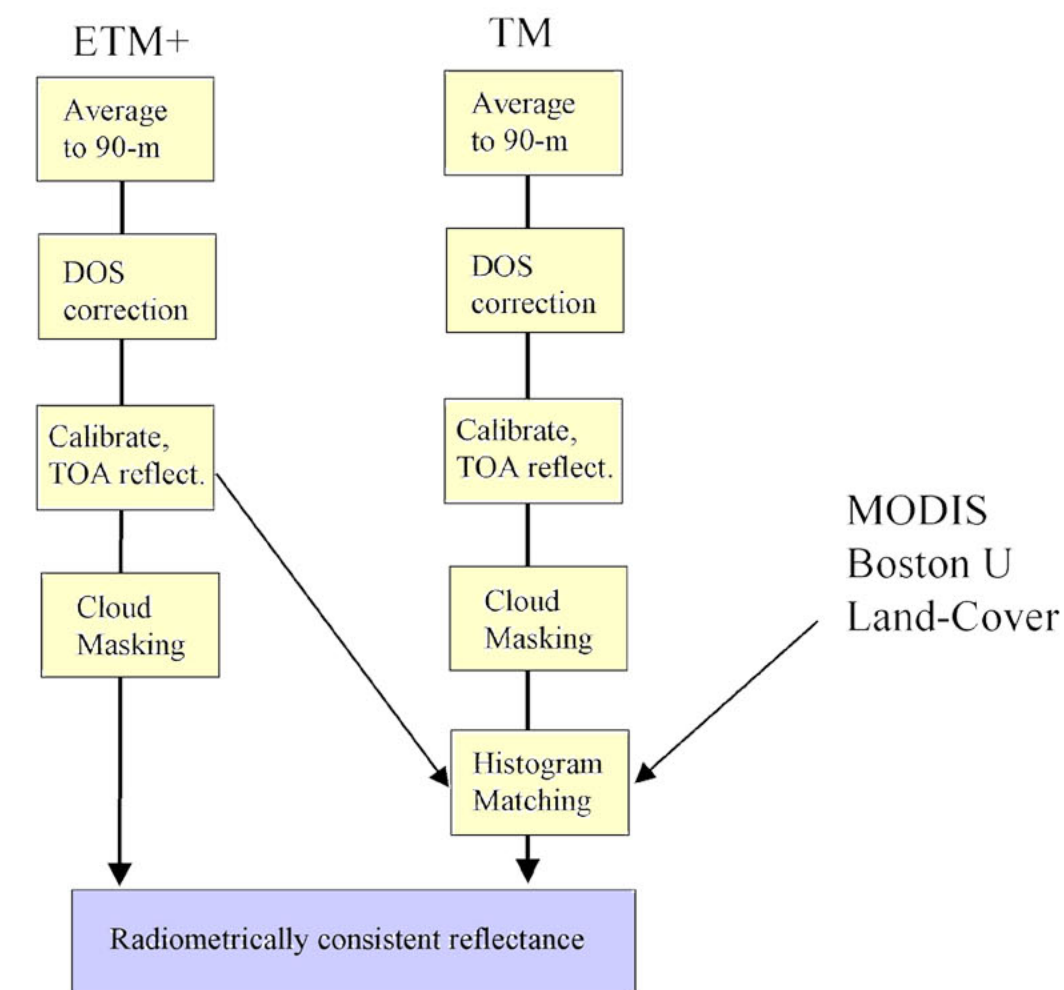# Part 2: Forest Change Mapping

Overview

The forests of Northern and Northeastern China have been part of a larger national reforestation program for the last two decades. At the same time, considerable pressure exists to convert forested land to agricultural use, and to harvest forest resources. As part of our GOFC-GOLD project, we have begun to systematically map the balance between forest clearing (due to both natural and anthropogenic causes) and forest gain or regrowth using Landsat-5 TM and Landsat-7 ETM+ imagery. The sections below describe the remote sensing methodology used, and give preliminary results for two regions: the Changbai, and Khingan regions.
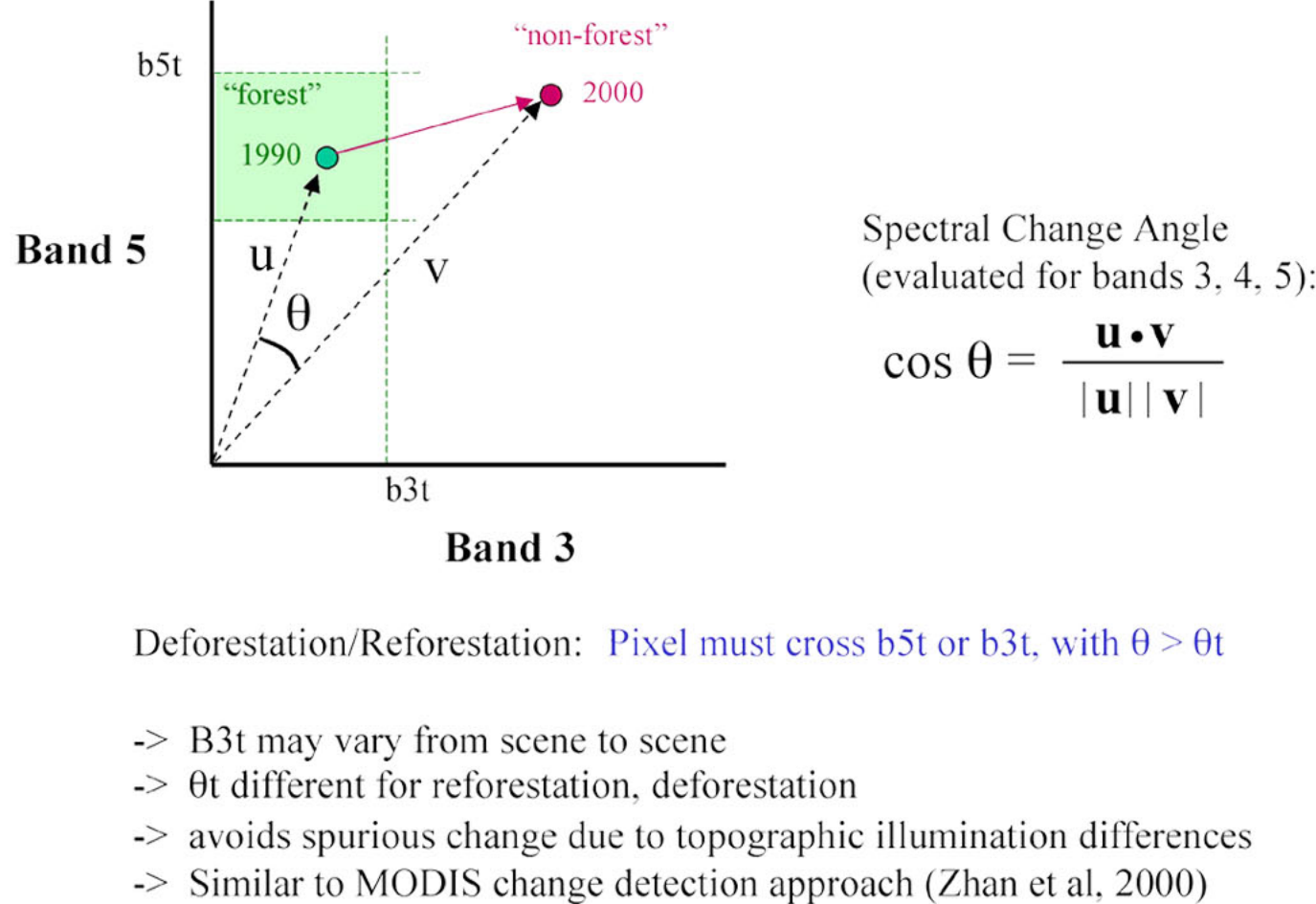
Change Detection Approach

Accurately establishing the balance between forest loss and gain requires accounting for both deforestation and regrowth. The latter is more difficult, since in slowly growing northern forests, a given image pixel may be mapped as regrowth for two or more decades, resulting in a tendency to overestimate regrowth area.   To avoid this problem we establish spectral thresholds (equivalent to forest structural thresholds) and only map forests as regrowth when they cross these thresholds.

Our change detection algorithm uses the concept of spectral change angle, evaluated for Landsat bands 3, 4, and 5 for two successive dates. Compared to other metrics (e.g. the magnitude of the change vector itself) the spectral angle is relatively insensitive to variations in illumination condition. Images are first orthorectified, coregistered, and atmospherically corrected to surface reflectance. Radiometric change detection is performed at 90-m resolution to avoid errors due to residual misregistration. Deforestation and regrowth categories are mapped as those exhibiting (i) high spectral change angles, and (ii) crossing spectral thresholds in bands 3 and 5.

Change Detection Philosophy

What are we trying to measure?
1) Area of Deforestation (mature forest to non-forest)
2) Area of Reforestation (from young regrowth to mature forest)
3) The net balance between the two, evaluated regionally

1. Radiometric Image Preprocessing

2. Spectral Angle Change Detection Algorithm

Spectral Change Angle
(evaluated for bands 3, 4, 5):

$$\cos\theta = \frac{\mathbf{u}\cdot\mathbf{v}}{|\mathbf{u}||\mathbf{v}|}$$

Deforestation/Reforestation: Pixel must cross b5t or b3t, with θ > θt

-> B3t may vary from scene to scene
-> θt different for reforestation, deforestation
-> avoids spurious change due to topographic illumination differences
-> Similar to MODIS change detection approach (Zhan et al, 2000)

Study Area

Initial study regions for Landsat change detection analysis: Changbai and Khingan regions. These regions form part of the forested, mountainous perimeter around the predominately agricultural valleys of the Sungari and Liao He Rivers. The Changbai area includes a mixture of well managed plantation forests and natural preserves. Selective cutting is balanced by regeneration. In contrast, the Khingan region has experienced a wave of migration from Southern China during the last two decades. This population pressure has made forest management difficult in the region.
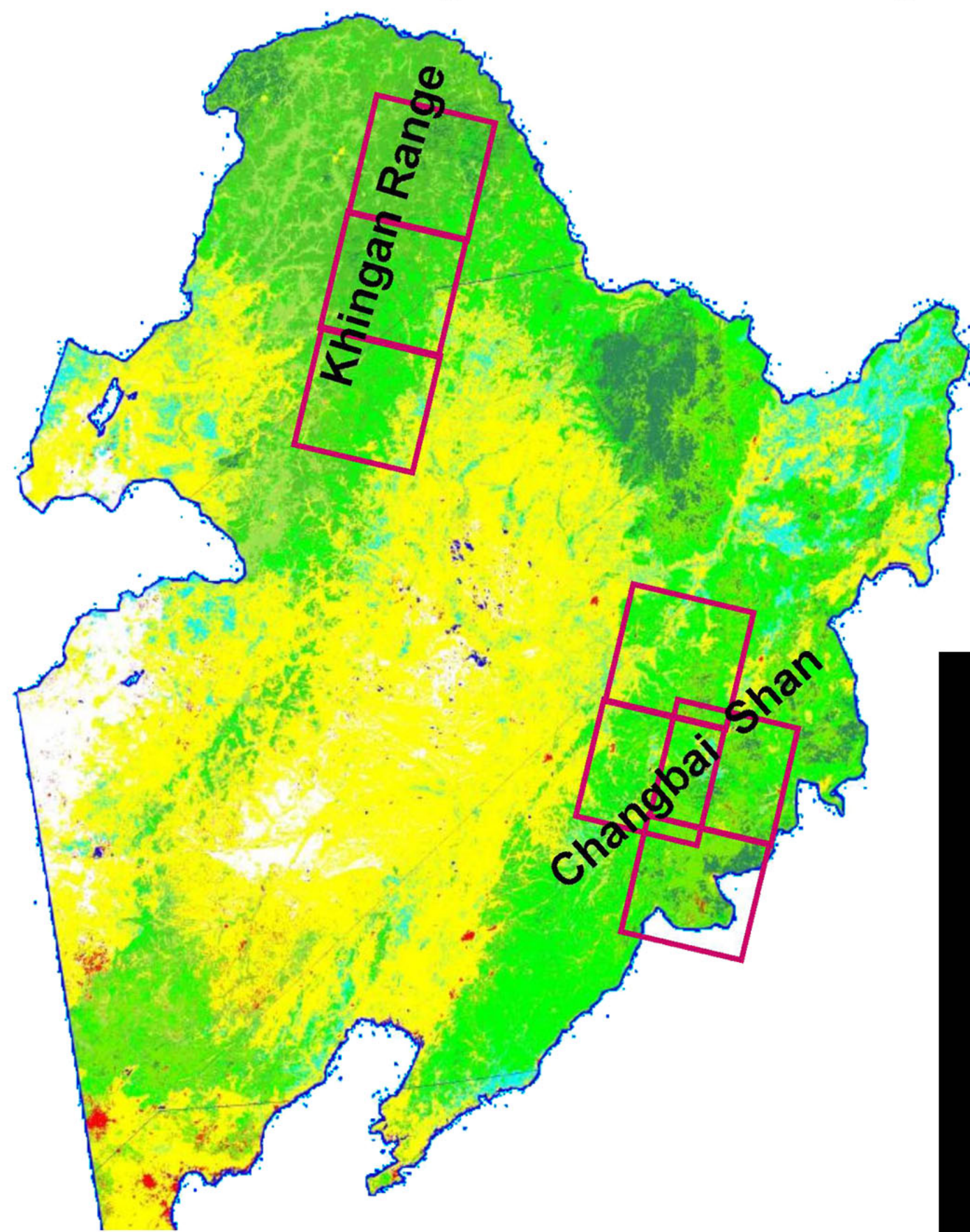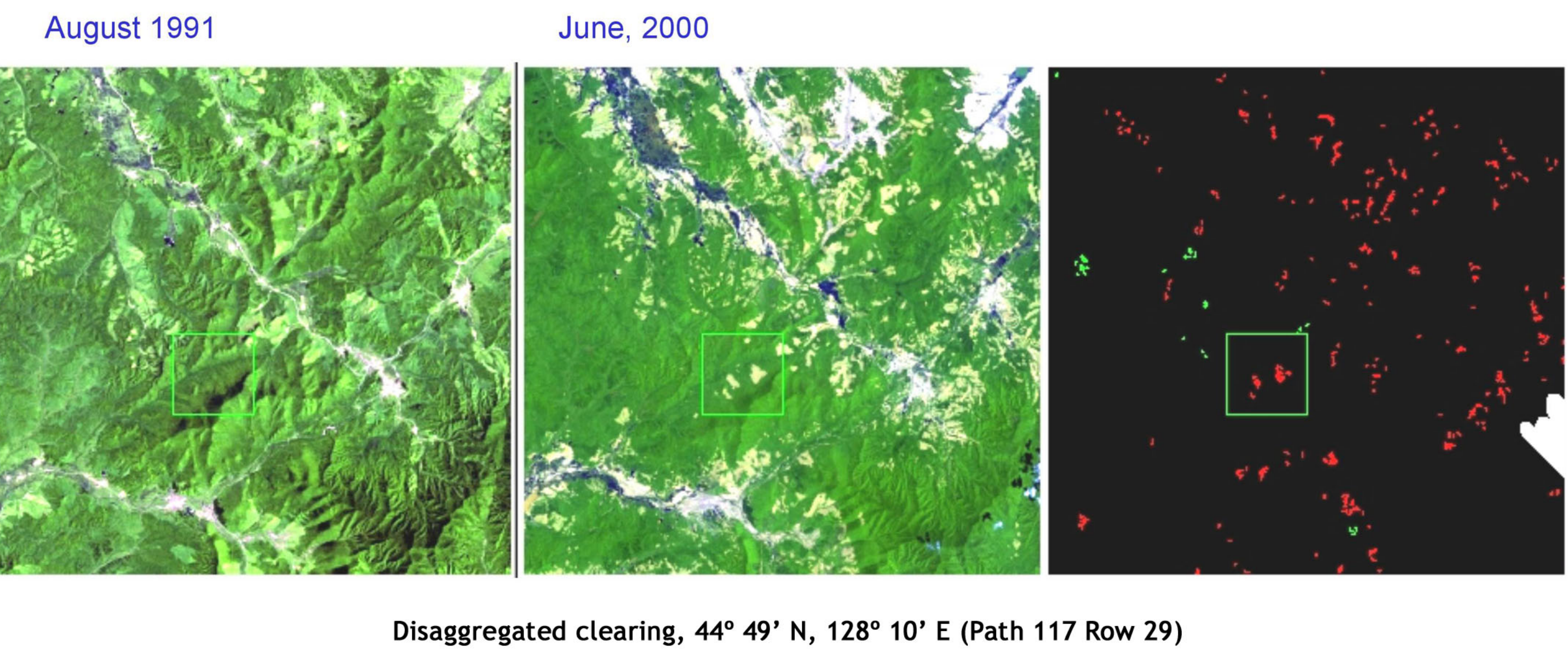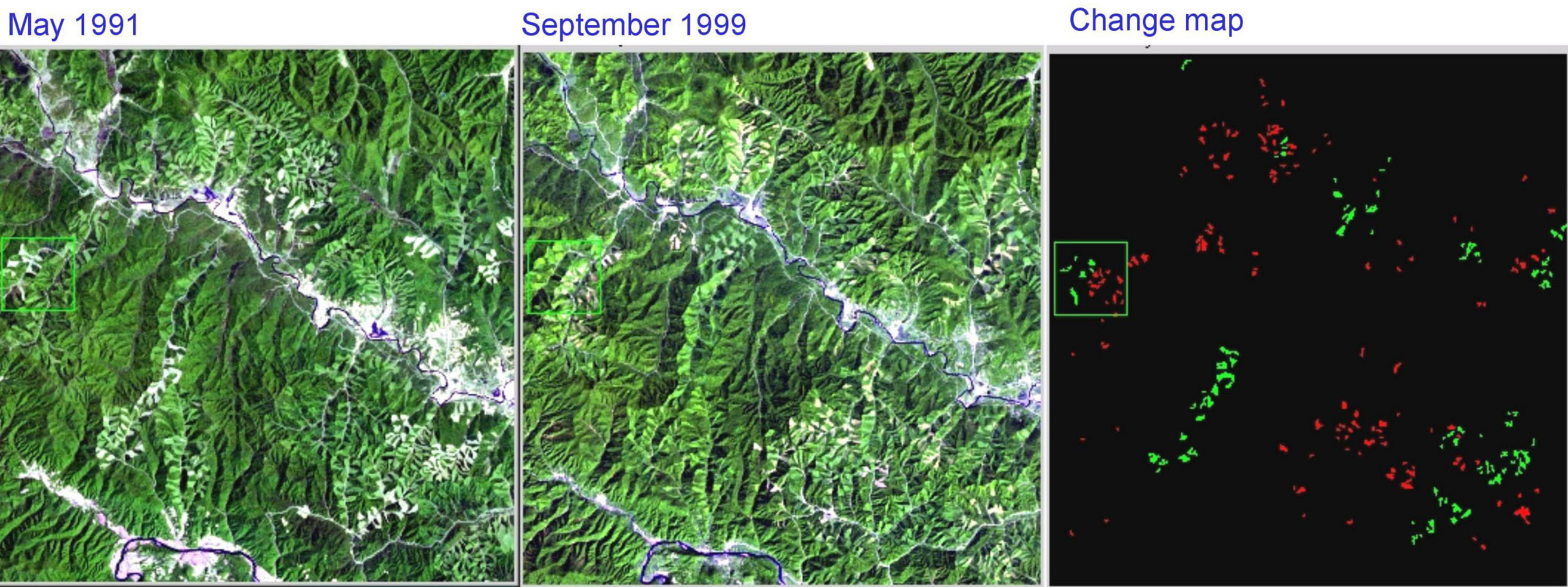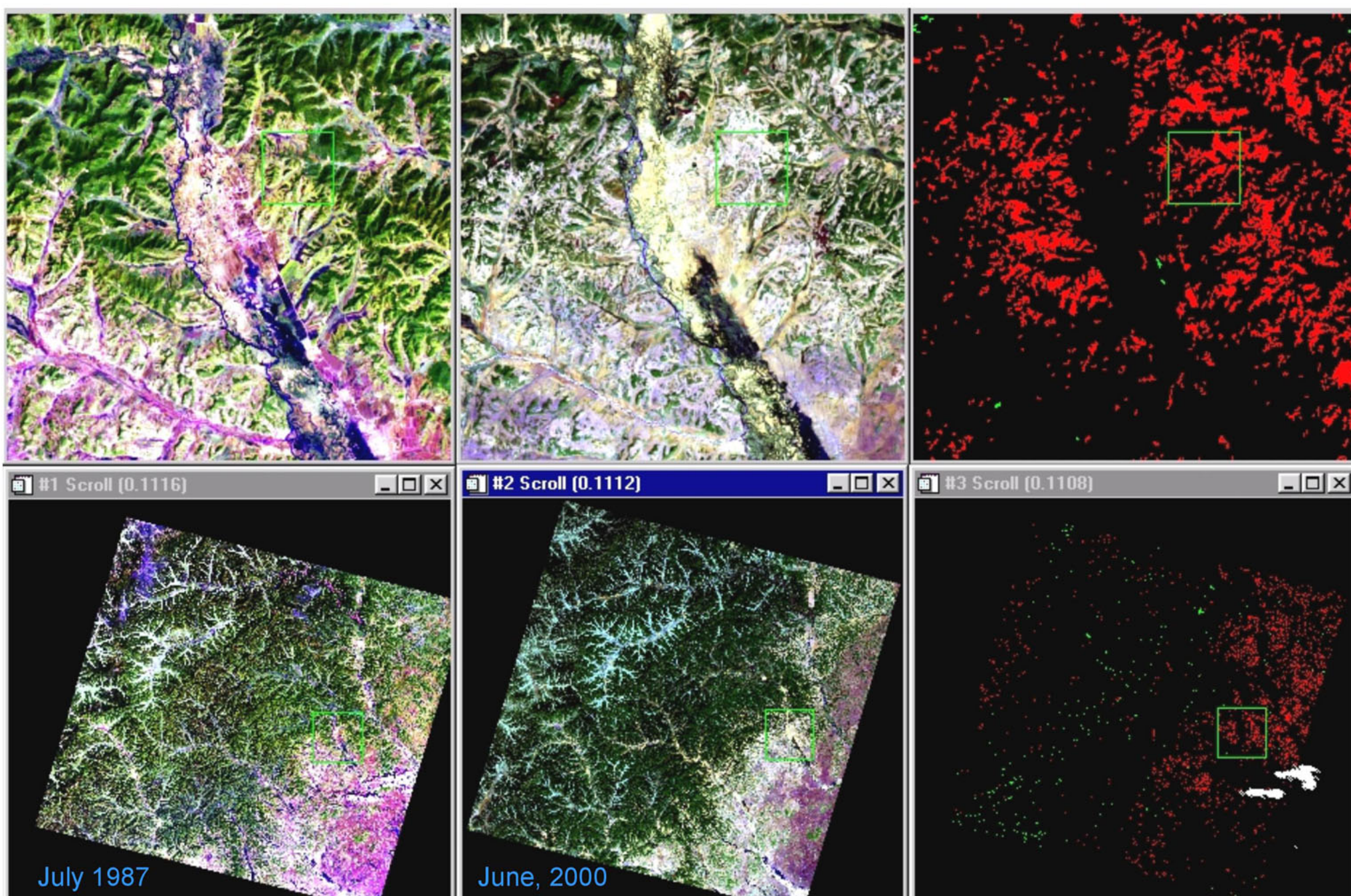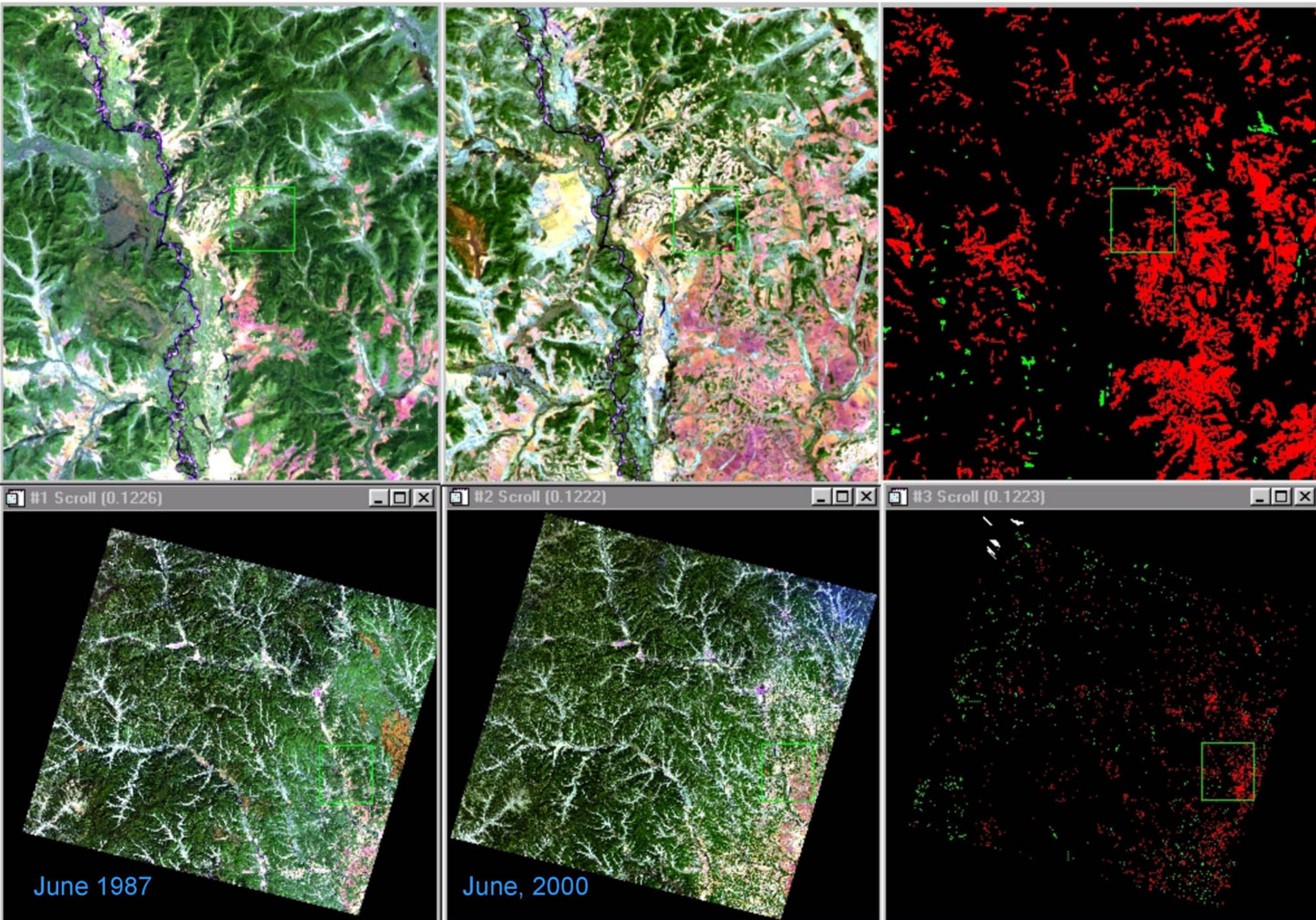

Landsat mosaic of two study areas.
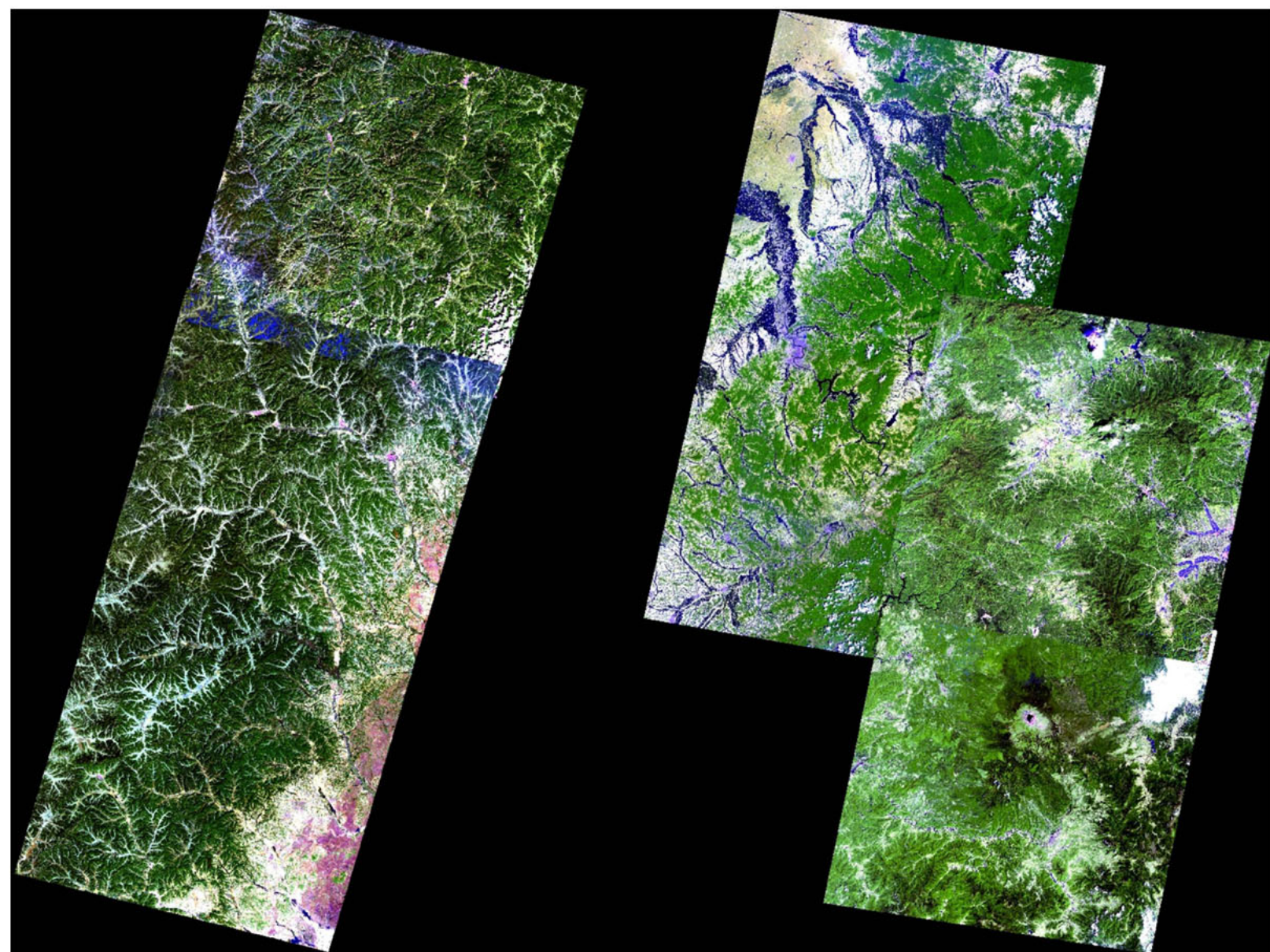
Changbai-Shan Region

Plantation forestry in the Changbai Mountains, adjacent to the Changbai forest preserve. Both new (red) and reforesting (green) clear-cuts are visible.

May 1991   September 1999   Change map

Plantation Forestry, 42° 56' N, 127° 49' E (Path 116 Row 30)

10 km

August 1991   June, 2000

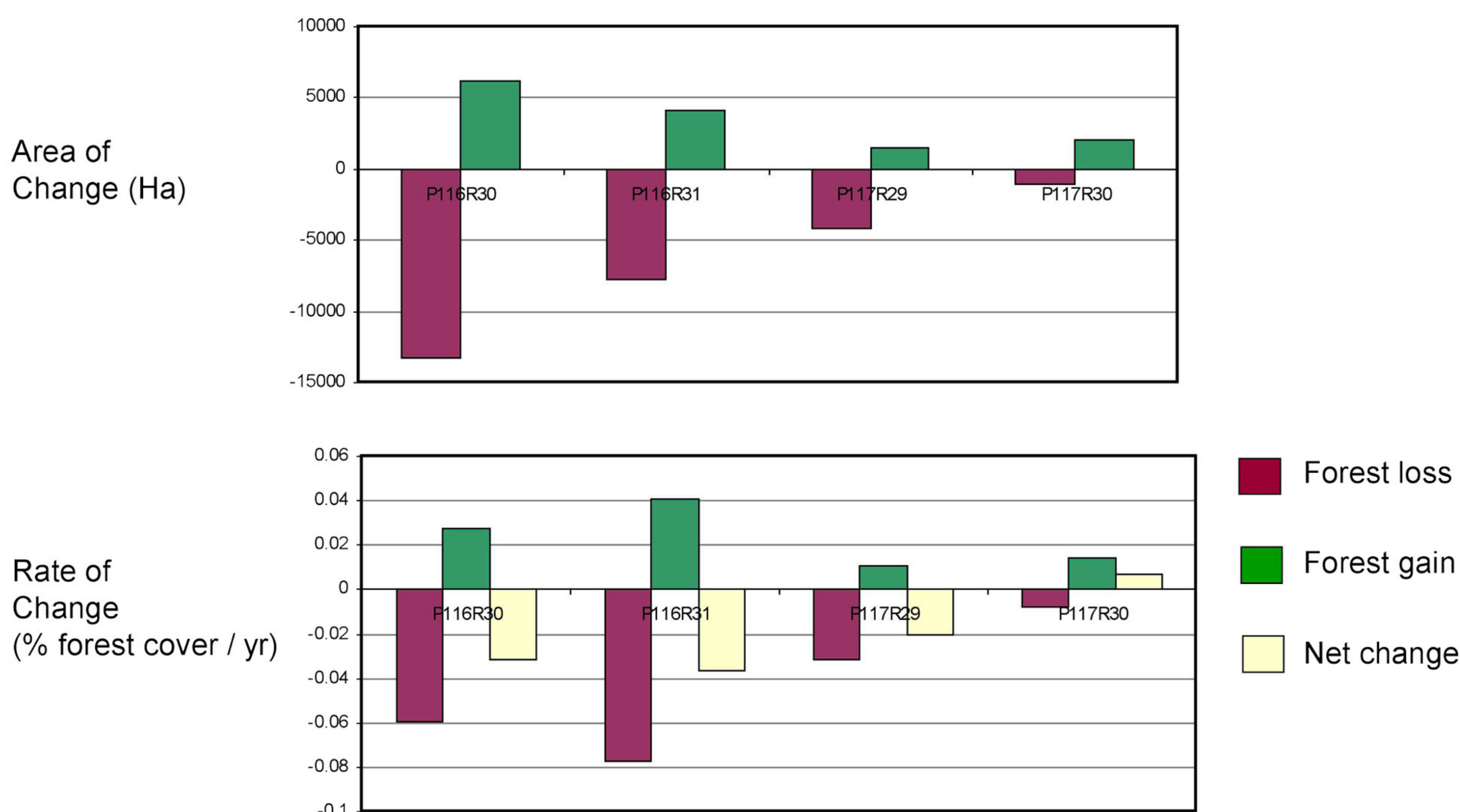Disaggregated clearing, 44° 49' N, 128° 10' E (Path 117 Row 29)
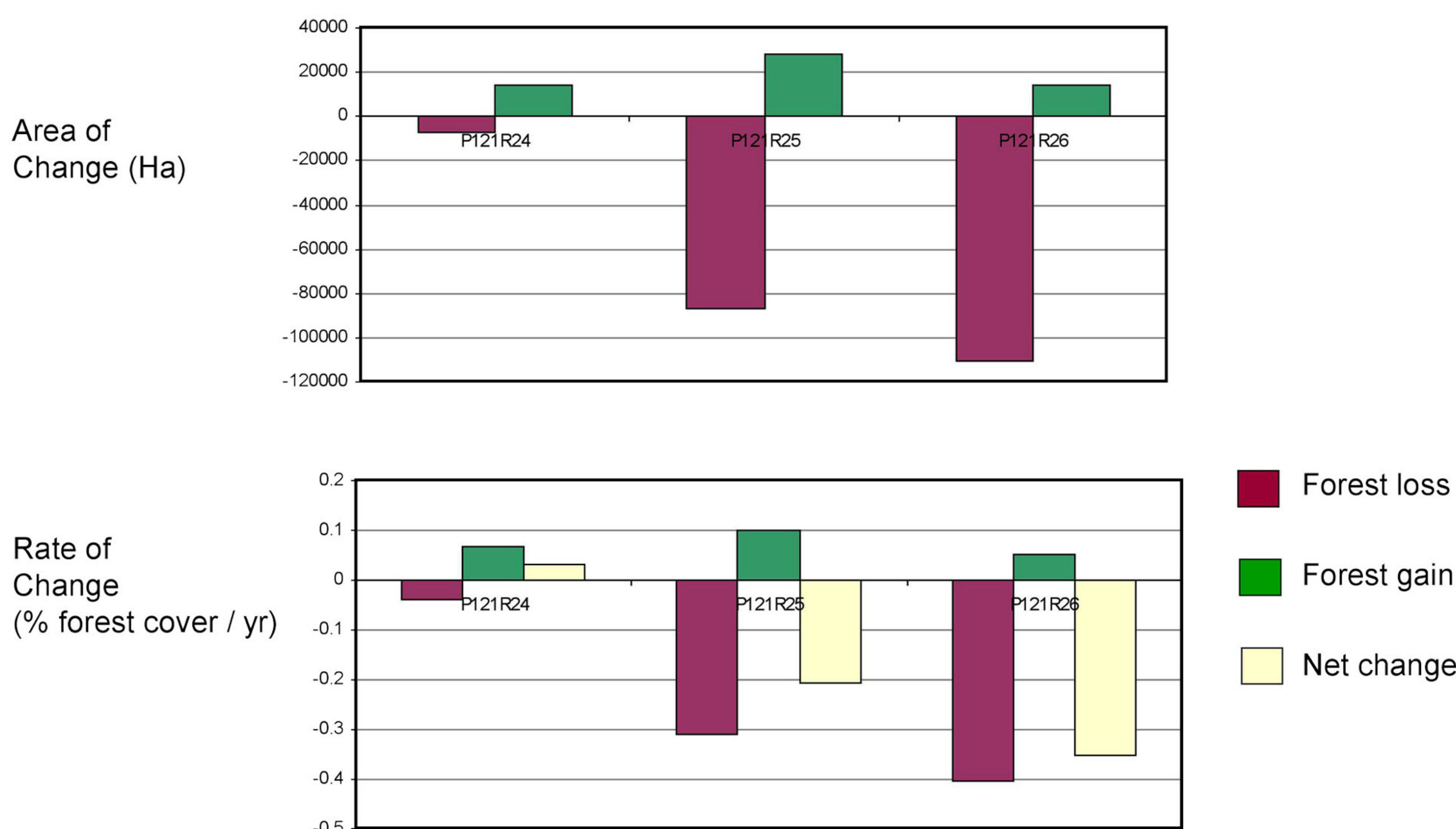
Khingan Region

Major forest clearing, Khingan Region: In contrast to the small-scale harvesting observed in the Changbai mountains, substantial clearing is observed in the Eastern Khingan region, adjacent to populated agricultural regions.

Major Clearing, Khingan Region - (Path 121 Row 25)

June 1987   June, 2000

Major Clearing, Khingan Region - (Path 121 Row 28)

July 1987   June, 2000

Preliminary Forest Change Statistics: Changbai Shan Region

Area of Change (Ha)

Rate of Change (% forest cover / yr)

Forest loss
Forest gain
Net change

Preliminary Forest Change Statistics: Greater Khingan Region

Area of Change (Ha)

Rate of Change (% forest cover / yr)

Forest loss
Forest gain
Net change

Preliminary Results

Forest-cover gains and losses have been tallied for each Landsat scene (identified by path row), and normalized to an annual rate of percent forest change, to adjust for differing intervals between individual scene pairs. The results suggest little net change in the Chaingbai region, but significant forest-cover losses for the Khingan region of some 3-4% per decade. Across both regions, the average net loss is less than 1% per decade.

Net rate of forest-cover change

% change of forest area per year

Changbai   Khingan