Land cover change by Normalized Difference Vegetation Index (NDVI) during 20 years

Torlarp Kamyo*[1] Dokrak Marod[1] and Sura Pattanakiat[2]

[1] Faculty of Forestry, Kasetsart University, Bangkok 10900, Thailand
[2] Faculty of Environment and Resource Studies, Mahidol University, Nakhonpathom 73170, Thailand
*Corresponding author; E-mail: torlarp66@yahoo.com

Abstract

The study on Land cover change by Normalized Difference Vegetation Index (NDVI) was carried out at Mae Klong Watershed Research Station (MKWRS). The objective aimed to clarify the changed of forest and non forest areas of a tropical seasonal forest in MKWRS during 1992-2011.

The Results showed the changes of non forest into forest areas were fluctuated and varied among years. The non forest area was originated from 22. 28 km^2 and rapidly changed to forest areas, especially in the first period, 1992 to 1996, about 61.33 % of total changed, then it declined in the later years. Indicating the natural succession in MKWRS is going well and may recovery into the forest areas within the intermediate of times, about 30 years since abandoned in 1982.

Key Word: land cover change, normalized difference vegetation index (NDVI), seasonal tropical forests, forest dynamics

Introduction

The increasing population growth rate recently brought significant effects to the rapidly decreasing forest areas. It encourages land use change by converting forest land into other land use types such as agricultural field, accommodation and industrial area. These activities carry out the pollution into the environment, particularly direct effect to human life and biodiversity loses.

Tropical forests are the majority source for biodiversity, almost 70% of living lives in the world was found in the tropical forest (Longman and Jenik 1987). In addition, the people believe that tropical forests are the main sources of carbon sequestration controlling point. It is an important cause of global warming. Thus, they are expecting the countries which are located in tropic zones to conserve the forest land in order to suspend the global warming problems. In addition, half of populations are relying on the natural resources. Indicating that the tropical ecosystem is facing on a critical situation, in fact, there are small numbers of forest databases in terms of forest dynamics monitoring, in particular, the consequence of global warming on tropical forest regeneration. Subsequently, the primary research on forest dynamics is very important to apply in the other aspects, such as carbon sequestration, the biodiversity management and forest resources management, etc.

Long-term ecological research was established in Mae Klong Watershed Research Station, MKWRS, since 1992. Many permanents plots were distributed from the abandoned to natural forest areas and tree monitoring was also done (Marod *et al*., 2004, 2010). However, the land cover changes, especially after prohibited the

recovery in abandoned areas since 1982 were less documented. Thus, this study aimed to clarify the land cover changes from abandoned areas, non forest, into forest areas from the past to present.

Study site and Methodology

The study was conducted in a seasonal tropical forest at MKWRS, Thong Pha Phoom District (14’ 30” to 14’ 45” N, 98’ 45” to 99’ E), Kanchanaburi Province, western Thailand. The watershed is 108.9 km^2 in area and ranges from 100 to 900 m above mean sea level. The climate is sub-tropical with a long wet season (May to October) alternating with a short cool dry season and the subsequent hot dry season (November to April). Mean, minimum, and maximum annual rainfall were 1,546, 1,243and 1,897 mm, respectively. Mean monthly temperature is 27.5°C with a maximum of 39.1°C in April and a minimum of 14.6°C in December. The soil is very dry during the dry season and the tension was too high for the measurement by using porous cup method (Marod *et al*. 2002). The parent materials are granite, limestone and shale. Phyllite and quartzite are also found in small patches of the watershed area (Suksawang**,** 1995). The prevailing forest type in this area is a mixed deciduous forest (MDF, Marod *et al*. 1999), with small areas of dry dipterocarp forest (DDF) on the mountain ridges, and dry evergreen forest (DEF) along the riparian areas. The dominant tree species were *Shorea siamensis*, *Dillenia parviflora*, *Xylia xylocarpa* var. *kerrii*, *Pterocarpus macrocarpus*, *Vitex peduncularis*, *Canarium susbulatum*, *Mangifera caloneura*, *Schleichera oleosa* (Marod *et al*. 1999). In the past, the local people created the upland rice fields in the watershed areas, recently, where were abandoned and let it into natural succession process. Within the area, forest fires have probably occurred repeatedly over the past several hundred years (Rundel and Boonpragob 1995).

To detect the land cover changes, the satellite images of Landsat 5 TM were used from 1992 to 2011 which divided into 4 years interval. Contemporary with the Landsat 5 TM image scanning, the classification was divided into 2 types, non forest and forest areas, by using NDVI (Normalized Difference Vegetation Index) of remote sensing technique. The NDVI is a measurement of the balance between energy received and energy emitted by objects on earth. When applied to plant communities, this index establishes a value for how green the area is, that is, the quantity of vegetation present in a given area and its state of health or vigour of growth. The NDVI is a dimensionless index, so its values range from –1 to +1. In a practical sense, the values that are below 0.1 correspond to bodies of water and bare ground, while higher values are indicators of high photosynthetic activity linked to scrub land, temperate forest, rain forest and agricultural activity (Meneses-Tovar, 2011).

NDVI is calculated from these individual measurements as follows:

$$NDVI = (NIR – RED)/ (NIR+ RED)$$

NIR and RED are the reflectance of the near-infrared and red bands; in the particular case of Landsat images, it corresponds to bands 4 and 3.

NDVI of dense vegetation canopy will tend to positive values (say 0.3 to 0.8). It was used to classified the non forest and forest areas, < 0.3 and > 0.3, respectively.

Creating NDVI difference image (DNDVI) through the subtraction of the NDVI image of one date from that on another date (Cakir *et al.*2006). In this study, the NDVI (year $_{after}$) image was subtracted from the NDVI (year $_{before}$) image as shown in the equation:

$$DNDVI = NDVI\ (year_{after}) - NDVI\ (year_{before})$$

To identify the changed areas in a different date image, a threshold technique based on differencing image histogram was selected. In this method, the significant changes were found in the tails of the histogram distribution while pixels showing no significant change had a tendency to be clustered around the means (Singh, 1989). The first step was to select the threshold, where zero is considered non-change area while values bigger or smaller than zero are considered as area of change. Finally, a change/no change map was created between period as 1992 -1996, 1996-2000, 2000-2004, 2004-2008 and 2008-2011.

Results and discussion

Land cover change

In 1992, the covered areas of non forest and forest areas originated from 22.28 and 88.30 km^2, respectively. After abandoned since 1982, the natural recovery from non forest into forest areas was rapidly succeed and varied among years (Figure 1). The mean of changed through the study period was 3.81±5.62 km^2. However, the highest recovery was found in the first phase (1992 to 1996), about 13.66 km^2 (61.33 % of total changes), then, it declined in the later period (Table 1).

Table 1 Forest and non forest areas in MKWRS 1992 to 2011.

Year	Non forest area (Km^2)	Changed from non forest into forest (%)	Forest area (Km^2)
1992	22.28	-	88.30
1996	8.62	61.33	101.98
2000	5.74	12.89	104.85
2004	3.82	8.61	106.78
2008	3.38	2.01	107.23
2011	3.25	0.58	107.36

According to perform a differential analysis on the two NDVI results, the differences between the forest area and non forest area can be clearly seen in Figure 2. It showed the same trended that the mean of changed through the study period from non forest into forest was 8.14±6.84 km^2 and the mean of changed from forest into non forest was 4.2±1.27 km^2. While, the highest change was found in the first phase (1992 to 1996) changed from non forest into forest was 19.93 km^2, then, it declined in the later period (Table 2).

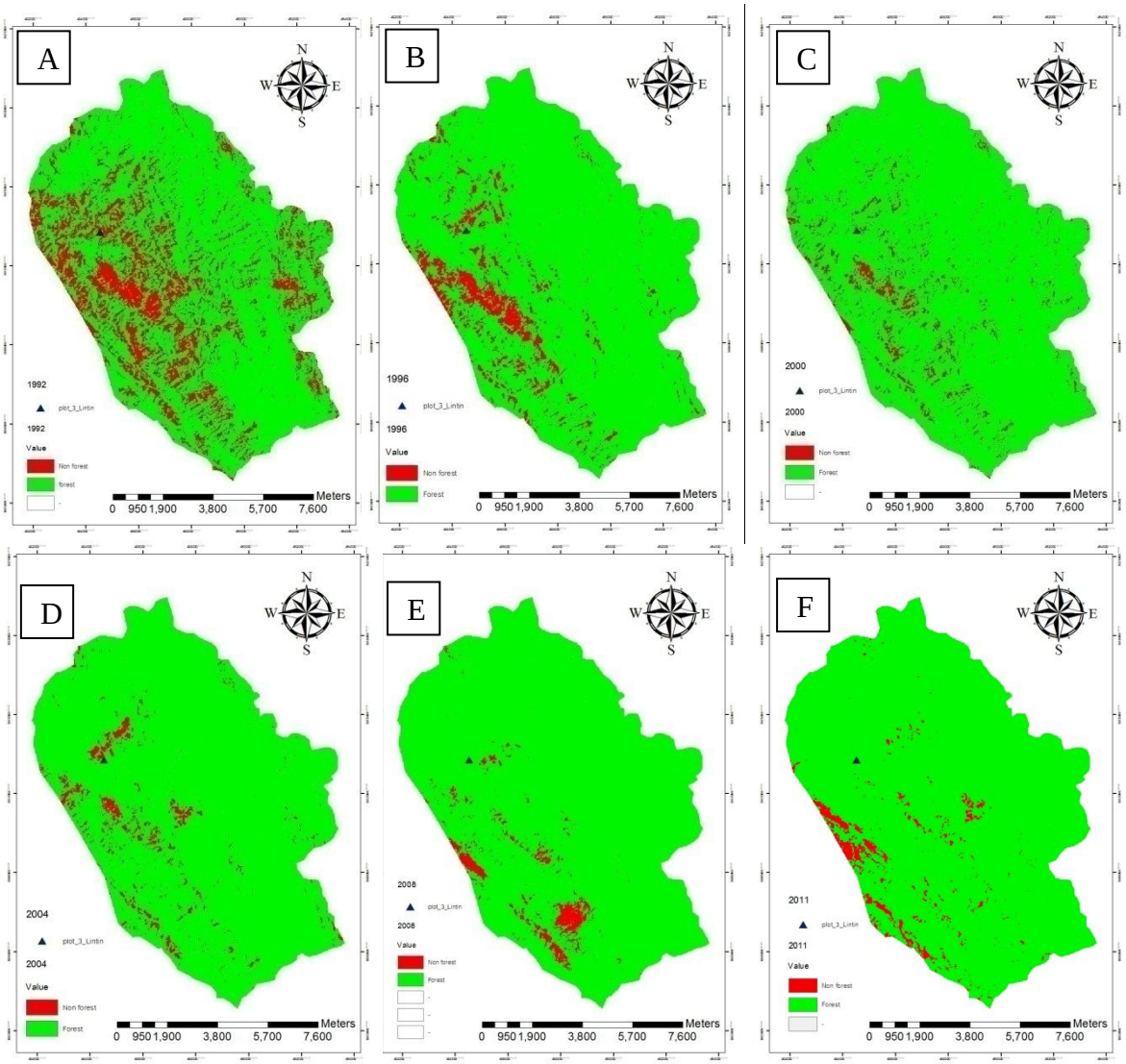

Figure 1 The changes of forest area, green color, and non forest area, red color, in the different year; A) 1992, B) 1996, C) 2000, D) 2004, E) 2008 and F) 2010.

Table 2 Forest area changed during 1992 and 2011.

	1992-1996	1996-2000	2000-2004	2004-2008	2008-2011
Changed from forest into non forest (km^2)	5.79	5.36	3.52	3.31	3.02
Non Changed (km^2)	84.89	97.30	101.28	103.38	104.48
Changed from non forest into forest (km^2)	19.93	7.95	5.81	3.92	3.12

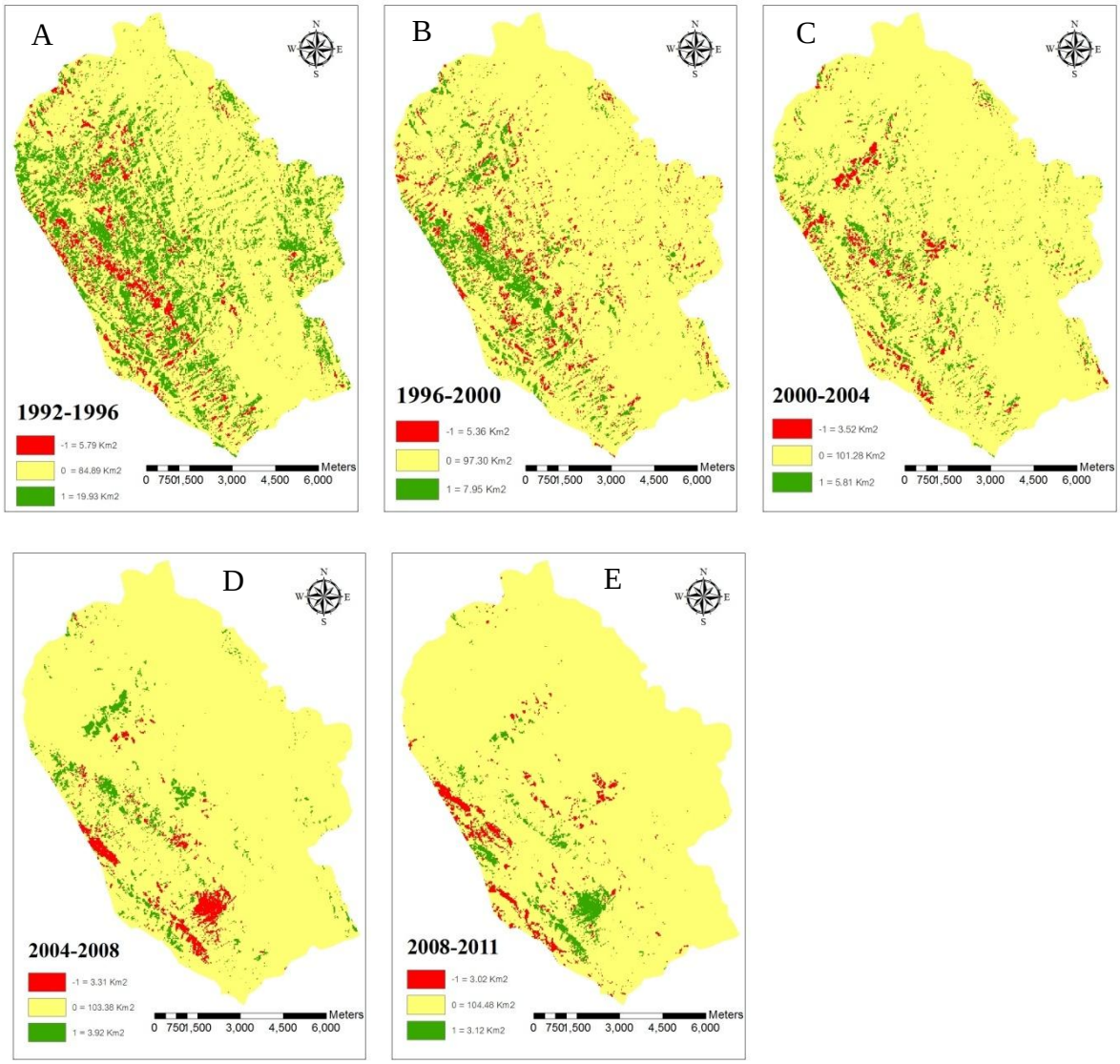

Figure 2 The change / no change of forest area map between study periods; (A) 1992-1996, (B) 1996-2000, (C) 2000-2004, (D) 2004-2008 and (E) 2008-2011. The red and green colors indicated the loss and gain areas of forest, respectively, while the yellow color represented that it had no changed.

References

Cakir H.I., Khorram S. and Nelson S.A.C. 2006. Correspondence Analysis for Detecting Land Cover Change, Remote Sensing Environmental. 102 : 306-317.

Marod, D., K. Utis, Y. Chanchai, T. Hiroshi and T. Nakashizuka T. 1999. Structural dynamics of the natural mixed deciduous forest in western Thailand. Journal of Vegetation Science 10: 777-786.

Meneses-Tovar, C.L. 2011. NDVI as indicator of degradation. Unasylva 238 : 39-46.

Rundel, P. W. and K. Boonpragob. 1995. Dry forest ecosystems of Thailand. In: S.H. Bullock, H. Mooney & E. Medina eds. "*Seasonal Dry Tropical Forests*," pp. 93-123. Cambridge University Press, New York.

Singh A.1989, Digital Change Detection Techniques using Remotely-Sensed Data, International Journal Remote Sensing 10: 989-1003.