NATIONAL FOREST CHANGE MONITORING SYSTEM IN SOUTH KOREA: AN ANALYSIS OF FOREST TREE SPECIES DISTRIBUTION SHIFTS

Eun-Sook Kim, Cheol-Min Kim, Jisun Lee and Jong-Su Yim

Abstract—Since 1971, South Korea has implemented national forest inventory (NFI) in pursuance of understanding current state and change trend of national forest resources. NFI1 (1971~1975), NFI2 (1978~1981), NFI3 (1986~1992) and NFI4 (1996~2005) were implemented in order to produce national forest resources statistics. However, since the early 1990s, international conventions and organizations started to require diverse forest information for the sustainable forest management and periodic monitoring of forest resources. Following these requirement, South Korea reformed total national forest inventory system. Starting from NFI5 (2006~2010), national forest resources inventory was implemented on the basis of the new system. These time series NFI data can be used to understand the long-term transition of forest and predict the future of forest condition in national scale.

In this study, two analyses were performed to identify forest distribution change using the long-term NFI data. First, area change and distribution change by forest types (coniferous forest, mixed forest, deciduous forest) were compared using time series forest type maps. Second, density change of *Pinus densiflora* and *Quercus* spp. using time series NFI data. As results, coniferous forest were reduced overall, but deciduous forests show evident increasing trend. The change of tree density appeared differently based on the topographic characteristics. While tree density of *Pinus densiflora* has rapidly decreased in regions with low altitude and gentle slope, tree density of *Quercus* spp. has sharply increased in regions with high altitude and steep slope. As for the tree density of *Pinus densiflora*, the northern slope showed more decreasing trend than southern slope. Time series National Forest Inventory data is the most extensive forest survey information in South Korea. We could analyze the long-term changing trend of forest stand based on these data.

Keywords: national forest inventory, forest change monitoring, distribution shifts

INTRODUCTION

Since 1971, South Korea has periodically conducted national forest inventory (NFI) to calculate the statistics of national forest resource. NFI was carried out with field surveys on sampling plots placed throughout the country in parallel with the production of forest type maps to classify and to map forest types using aerial photographs. In addition, starting in the fifth NFI, the forest monitoring system has been reformed with the aim of sustainable forest management and production of forest statistics at international standard (Table 1). Especially since the fifth NFI, sampling plots placed throughout the country became permanent and repeated survey has been conducted. Therefore, the base for monitoring changes in the same plots has been provided, and monitoring survey is now being conducted as the sixth NFI (2011~2015).

[1] Korea Forest Research Institute, Seoul 130-712, South Korea, Tel: +82-2-961-2893 / E-mail: drummer12@korea.kr

Table 1. National Forest Inventory system for plot survey and forest type map

Phase	Years	Sample Design	Number of plots	Plot form	Forest Type Map production
NFI1	1971~1975	Stratified Systemic Sampling	7,051	Circular sample plot (0.01ha)	First Forest Type Map (1:25,000)
NFI2	1978~1981		4,839		Second Forest Type Map (1:25,000)
NFI3	1986~1992		14,474	Cluster plot (0.05ha)	Third Forest Type Map (1:25,000)
NFI4	1996~2005		2,788		Fourth Forest Type Map (1:25,000)
NFI5	2006~2010	Systematic Sampling	14,164	Cluster and multiplex circular plots (0.04ha, basic plot)	1:5,000 Forest Type Map (Separate from NFI)

These data can be used to understand the transition of forest and predict the future of forest condition in national scale. Hernandez et al.(2014) studied the change of spatial distribution for *Pinus sylverstris* and *Fagus sylvatica* using time series NFI data. Bechage et al.(2008) analyzed the distribution shifts of hardwood-boreal ecotone from 1964 to 2004 based on elevation transect survey. The aims of this study are to understand the entirely changing trends of forest type and to draw main factors of distribution shifts for *Pinus densiflora* and *Quercus* spp.

STUDY SITE AND DATA

In this study, an analysis on a pilot area was conducted using the long-term National Forest Inventory (NFI) data to develop an analysis method for forest distribution change. Study areas are located in the temperate Midwest region of South Korea and cover the Chungcheongnam-do, Chungcheongbuk-do and Daejeon Metropolitan City with the total area of 1,660,000 hectare. The study area consists of forest area of 964 hectare which is 58% of the total land. Within the Chungcheong region, as Chungcheongnam-do is adjoined the Yellow Sea and Chungcheongbuk-do includes forested areas with east high and west low characteristics, showing different forest characteristics. For forest distribution change analysis, time series forest type maps and NFI data created over 40 years were used. Forest type maps used for analysis were the first forest type map (1972~1974), the third forest type map (1991), and 1:5,000 forest type map (2009), and NFI data used in this study are the first NFI (1975, 889 plots), the third NFI (in 1991, 1,493 plots), and the fifth NFI (2006~2010, 1,662 plots).

METHODS

Two analyses were performed to identify forest distribution change using the long-term NFI data. First, area change and distribution change by forest types (coniferous forest, mixed forest, deciduous forest) were compared using time series forest type maps. Second, density change of *Pinus densiflora* and *Quercus* spp. using time series NFI data. For each sampling plot, the number of *Pinus densiflora* and *Quercus* spp. (*Quercus mongolica*, *Quercus acutissima*, *Quercus serrata*, *Quercus variabilis, Quercus aliena*, *Quercus dentata*) per hectare were calculated to obtain tree density of each sampling plot. And, we compared the time series changes of tree density and topographic factors (elevation, slope, and aspect). Tree density analysis of *Pinus densiflora* and *Quercus* spp. were carried out only on natural forest sampling plots.

RESULTS

In the analysis of area changes of forest types using the time series forest type maps, coniferous forest and mixed forest were reduced overall, but deciduous forests show evident increasing trend. In comparing the data of 1970s and today, the area of coniferous forest has declined 35% and mixed forest 68%. Whereas, deciduous forest has significantly increased from 41,109 ha to 453,596 ha, and the increasing trend is mainly found in Chungcheongbuk-do region (eastern part of study area).

Table 2. Area changes of forest types by year (hectare)

Forest type	1972~1974	1991	2009
Total	884,088	893,712	885,270
Coniferous Forest	493,048	378,930	320,654
Mixed Forest	349,931	246,308	111,020
Deciduous Forest	41,109	268,474	453,596

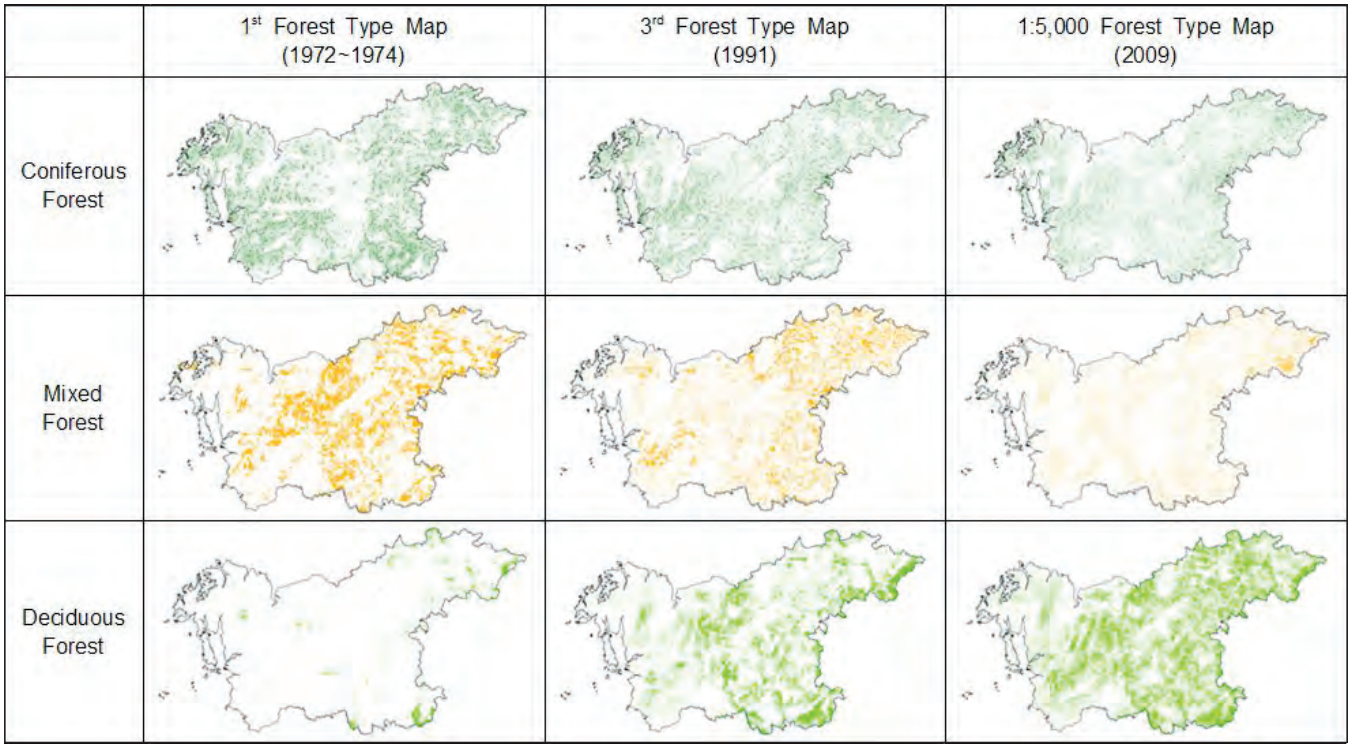

Figure 1—Forest type distribution change based on time series forest type maps

When comparing the natural change of tree density by tree species using the survey data of time series NFI sample plots, density of *Pinus densiflora* has reduced overall and particularly a notable decrease is found in the Chungcheongnam-do (western part of study area) region. Also, the tree density of *Quercus* spp. has rapidly rose entering the fifth NFI, and a significant increase was observed in the mountainous region of Chungcheongbuk-do (eastern part of study area).

The change of tree density appeared differently based on the topographic characteristics. While tree density of *Pinus densiflora* has rapidly decreased in regions with low altitude and gentle slope, tree density of *Quercus* spp. has sharply increased in regions with high altitude and steep slope. As for the tree density of *Pinus densiflora*, the northern slope showed more decreasing trend than southern slope.

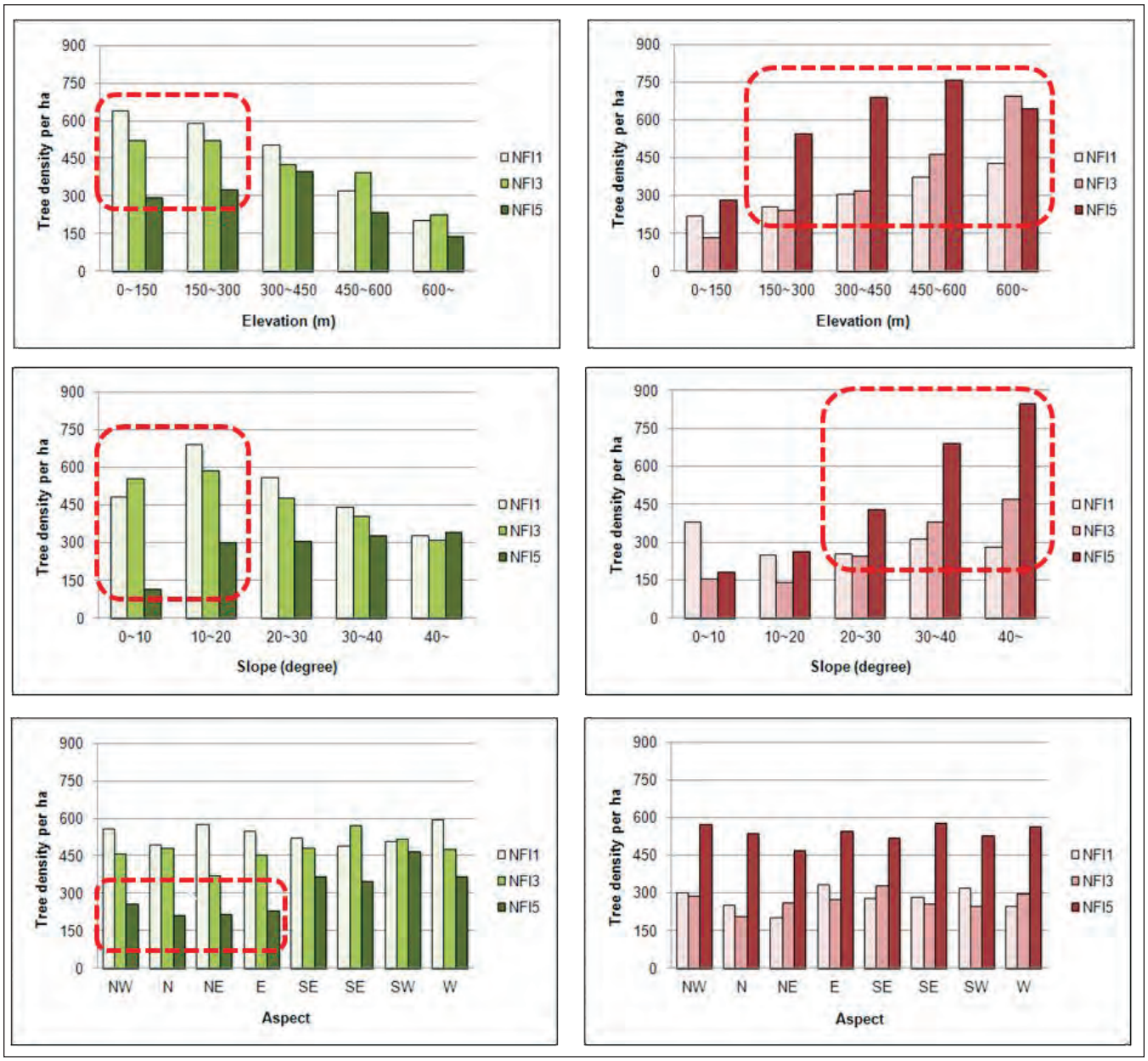

Figure 2—Change analysis in tree density of *Pinus densiflora* and *Quercus* spp. depending on the terrain conditions using time series NFI data

DISCUSSION

In this study, coniferous forest were reduced overall, but deciduous forests showed evident increasing trend. Similarly, tree density of *Pinus densiflora* has reduced and that of *Quercus* spp. has increased. This phenomenon can be understood as the general trends caused by temperature increase of climate change. Tree density of *Pinus densiflora* has rapidly decreased in regions with low altitude and gentle slope and these results shows that optimal habitat region of this species is changing. Also, decline trends of *Pinus densiflora* in northern slope region contained the good moisture conditions is the result of completion between other tree species.

Time series National Forest Inventory data is the most extensive forest survey information in South Korea. We could analyze the long-term changing trend of forest stand based on these data. We have the plans of an intensive analysis for interrelationships of climate change and forest change using NFI data and long-term climate data.

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