

Vegetation Changes of *Abies koreana* Forest in Yeongsil Area of Hallasan Mountain

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I. Introduction

The *Abies koreana* are among the key alpine plants scattered across the Korean Peninsula and are an indicator species for climate change. They are feared to become progressively fewer in their numbers due to climate change. *A. koreana* have already been classified as one of endangered species (EN) in the International Union for Conservation of Nature (IUCN)'s Red List, and as a rare plant by the Korea Forest Service, and as an indicator biospecies for national climate change by the Ministry of Environment. For this reason, there is an urgent need to continue conducting studies on *A. koreana* species.

According to a recent study, the growth and development of the *A. koreana* in Hallasan Mountain were found to be slowing down while in some areas, they are even rapidly withering to death. The damage in the areas near Yeongsil Trail was particularly severe both in scale and extent. This study's purpose was to provide basic data for the monitoring of ecological changes caused by change of vegetation structure of *A. koreana* forest in a study site susceptible to climatic change in Yeongsil area of Hallasan Mountain, Jeju Island.

II. Materials and Methods

2.1. Study area

A study was performed to track the changes in the ecosystem of the *A. koreana* forest over a long period. As *A. koreana* forests are distributed well throughout the summit of Hallasan Mountain, close to the temperate broad-leaved deciduous forest, a fixed survey/observation post was installed in an area in which changes in its vegetation structure are highly likely to happen in the near future. It was installed on Yeongsil area (Fig. 1).

2.2. Method of analysis

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Two surveys were conducted in 2009 and 2014, respectively, to identify the changes in the *A. koreana* forests. A total of 25 small quadrats (1 ha) each measuring 400 m² in area were established in the Yeongsil zone (elevation of 1,600 m), which is the largest among all the zones showing both high distribution and high number of dead trees. The survey targeted all the plants occurring within the survey zone. In case of the woody plant stratum (top stratum), whose diameter at breast height can be measured, the height, diameter at breast height, crown width, location within the quadrat, and stem shape were measured, while in case of the shrub stratum (bottom stratum), whose diameter at breast height cannot be measured, the height, crown width, location within the quadrat, and population size per tree species were measured. And in case of the herbaceous stratum, the tree cover rate by tree species, the population size per tree species and the initial height were measured after setting a total of five micro-sized quadrats measuring 100 m² in area each and positioned in five small quadrats. Based on the survey results, the change in the significance of the occurring species per stratum, the changes in the characteristics and stem shape by tree species, the changes in biodiversity, and the changes in the occurrence of dead trees were analyzed to quantify them.

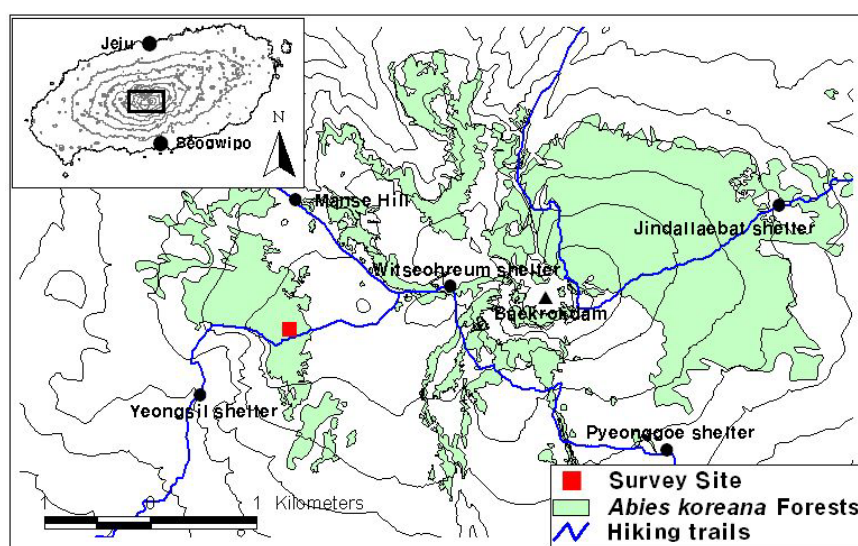


Fig. 1. Map of survey site of Yeongsil area in Hallasan Mountain.

III. Results and Discussions

3.1. Change in the population of each species

According to a survey on the density change of the species that have occurred and are still

alive in the *A. koreana* forests in Hallasan Mountain, the number of total species has increased by three species and 803 individual plants in the period from 2009 (16 species, 1,776 individual plants) to 19 species and 2,584 individual plants as of 2014. In particular, the ratio of *A. koreana* dropped by 14.4%, the largest reduction in population, while the yew trees increased by 10.5%, showing the largest increase in population (Table 1).

Table 1. Number of major species of trees occurring in the survey sites in Hallasan Mountain

Korean name (Scientific name)	2009	Ratio	2014	Ratio	Ratio change (%)
<i>Abies koreana</i>	803	45.21	796	30.80	-14.4
<i>Taxus cuspidata</i>	272	15.32	666	25.77	10.5
<i>Prunus maximowiczii</i>	427	24.04	540	20.90	-3.1
<i>Quercus mongolica</i>	177	9.97	189	7.31	-2.7
<i>Rhododendron mucronulatum</i> var. <i>ciliatum</i>	3	0.17	155	6.00	5.8
The other species : 14 species	94	5.3	238	9.23	4.0
Total	1,776	100	2,584	100	-

3.2. Change in size (tree height and diameter at breast height) of each species

Average diameter at breast height and height of those species occurring in the survey sites were measured. The largest diameter at breast height of *A. koreana* was shown to shrink from 34.0 cm in 2009 to 31.4 cm in 2014, while the average diameter at breast height has increased by 0.2 cm to 10.2 cm. A survey on the height of the *A. koreana* showed that the average tree height has increased by 0.13~3.03 m while that of the largest individual tree has increased by 0.1~5.9 m. In addition, the average height of *Taxus cuspidata* was shown to decrease by 0.3~1.86 m but that of the largest individual tree showed no significant change. A survey on the changes in the composition ratio of the populations of key tree species according to their diameter at breast height showed that *A. koreana* showed a decrease across all levels of the diameter at breast height, with the population with a diameter larger than 5cm and smaller than 10 cm having decreased most significantly (Table 2).

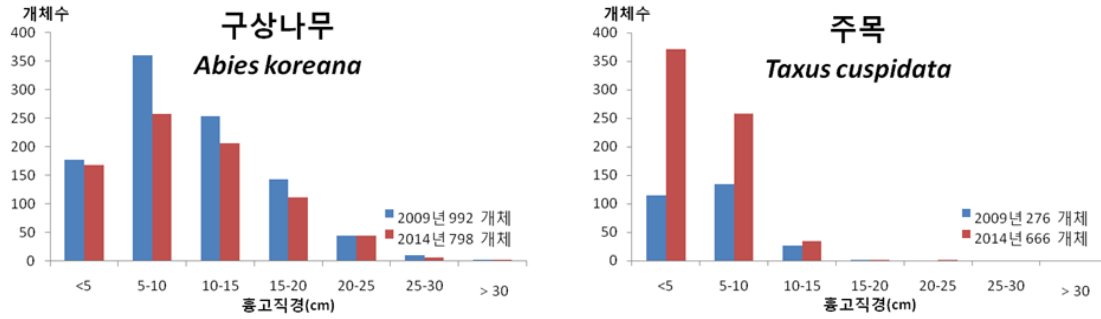


Fig. 2. Changes in the tree population by varying diameter at breast height of major species of trees occurring in the survey sites in Hallasan Mountain.

Table 2. Changes in the diameter at breast height and height of the major species of trees occurring in the survey sites in Hallasan Mountain

Korean name (Scientific name)	DBH (cm)				Height (m)			
	Average		Maximum		Average		Maximum	
	2009	2014	2009	2014	2009	2014	2009	2014
<i>Abies koreana</i>	10.0	10.2	34.0	31.4	2.90	3.03	5.80	5.90
<i>Taxus cuspidata</i>	5.7	5.2	19.5	20.5	2.17	1.86	4.45	4.45
<i>Prunus maximowiczii</i>	5.0	5.6	33.0	14.5	2.44	2.47	5.40	4.40
<i>Quercus mongolica</i>	7.9	8.6	25.0	25.2	2.85	3.04	4.83	6.00
<i>Rhododendron mucronulatum</i> var. <i>ciliatum</i>	1.9	2.7	2.4	5.0	1.63	1.44	1.86	2.00

3.3. Changes in the importance indices

According to a survey on the importance value of the key species occurring along the different strata of the *A. koreana* forests in Yeongsil region, in the tree stratum, *A. koreana* was the species showing highest importance value. In 2009, the order of importance value was *Prunus maximowiczii*, *Quercus mongolica* and *T. cuspidata*, but it changed in 2014 to the order of *T. cuspidata*, *P. maximowiczii* and *Q. mongolica*. Such change is considered to occur as a result of a rapid increase in the density of the *A. koreana* as well as in the occurrence of a relatively larger number of dead *P. maximowiczii* and *Q. mongolica*, thereby significantly altering the importance value of the composition species (Table 3).

Table 3. Changes in the importance value of the major species of trees in the tree stratum of the survey site in Hallasan Mountain

Scientific name	Korean name	Importance value	
		2009	2014
<i>Abies koreana</i>	구상나무	106.2	105.4
<i>Taxus cuspidata</i>	주목	40.9	51.3
<i>Prunus maximowiczii</i>	산개벚치나무	56.7	45.6
<i>Quercus mongolica</i>	신갈나무	45.2	29.0
<i>Rhododendron mucronulatum</i> var. <i>ciliatum</i>	털진달래	2.5	13.6
The other species (14 species)	기타	48.5	55.1
Total		300	300

3.4. Changes in the species biodiversity indices

The species biodiversity index in relation to the maximum species diversity index increased in all species, showing no significant difference among them, but the species biodiversity showed an increase in the shrubby forest. In case of the herbaceous stratum, no significant difference was found in the maximum species biodiversity, but the species biodiversity has dropped rapidly, suggesting that the change in habitats caused by an increase of *Sasa palmata* and dead-trees as well as the momentary reduction in the number of herbaceous species may have contributed to the decrease in the species biodiversity of the herbaceous stratum (Table 4).

Table 4. Changes in the species biodiversity by stratum of the *A. koreana* forests in Hallasan Mountain

Layer	Year	The number of species	Diversity index (H')	Maximum diversity index (H'max)	Evenness index (J')
Upper layer	2009	15	0.645	1.176	0.549
	2014	19	0.787	1.279	0.615
Lower layer	2009	17	0.817	1.230	0.664
	2014	15	0.865	1.176	0.736
Herbal layer	2009	44	0.708	1.643	0.431
	2014	41	0.275	1.613	0.170

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