

Ecological Attributes by Forest Types in the Natural Forest of Mt. Odae

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Abstract

This study was conducted to evaluate the ecological attributes of forest types which were classified by cluster analysis in the natural forest of Mt. Odae on the basis of the vegetation data (232 sampling points) from the point-quarter sampling methods. For the classified types, the species composition was expressed by importance value to describe the stand structure and the species diversity was quantified using the Shannon's diversity index. Recognized forest types were 1) *Quercus mongolica*–*Pinus densiflora*–*Betula ermanii* forest type, 2) Mixed mesophytic forest type, 3) *Q. mongolica* forest type, 4) *B. ermanii* forest type. Species diversity indices of total and overstory were highest in the Mixed mesophytic forest type (3.465 and 2.942), and lowest in the *B. ermanii* forest type (0.118 and 0.832). In addition to that, *Q. mongolica*–*P. densiflora*–*B. ermanii* forest type was calculated as 3.226 and 2.565, and *Q. mongolica* forest type was calculated as 2.776 and 1.218 in total and overstory, respectively. It was considered that after the *P. densiflora* and *B. ermanii* first invaded and site condition became good, *Q. mongolica*–*P. densiflora*–*B. ermanii* forest type was dominated by *Q. mongolica*. Mixed mesophytic forest type showed the most stable stand structure with various species distributed uniformly. *Q. mongolica* forest type would preserve the present stand status for a while, and the *B. ermanii* in *B. ermanii* forest type would be pressed by other species over time.

Key Words: forest type, classification, importance value, species diversity, Mt. Odae

Introduction

Forests include all of the ecological attributes, including structure, function, complexity, interrelationship, dynamics, etc. (Kimmins 1994). The properties of these forest types can be used not only as information on certain biological components of forest ecosystems but also as information on the phenomena and causes related to other biological components and the physical environment. Vegetation is determined by climate, topography, and soil, but changes in appearance by biological influences and human activities lead to actual vegetation (Otto 1994). Since the vegetation

distribution conditions in the forest type are very complicated and variously intertwined, it is difficult to fully grasp the distribution and growth situation by some ecological characteristics of the forest, but it is meaningful to understand the ecological characteristics close to such conditions (Kim 1999).

Large amount of the Korea's forestland area is covered with deciduous forests which are ecologically complex but form valuable resources (Korea Forest Service 2016). Deciduous forests have complex structures and functions due to variations in internal and environmental factors. In particular, the forests in Korea are more complex than the for-

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ests in Europe and have a wide variety of species in terms of species composition (Lee et al. 2004). Because ecological forest management plans for sustainable conservation & management of forest ecosystems, and the classification of basic vegetation units to determine the objective unit of practices is essential, the forest cover type classification which identify physiognomy is mostly used (Jo et al. 2004; Lee et al. 2014).

The classification of forest types is an attempt to group relatively homogeneous forest communities or groupings of vegetation classes that are repeatedly differentiated from other vegetation units into the same group (Lee et al. 1996; Chung and Kim 2012; Lee 2014). Forest cover type classification is based on the species composition of the overstory and these have been widely used by both professional and scientific societies as the standardized description of forests (Kimmins 2004). The definition of forest cover type in this paper was adapted from Eyre (1980) as “a descriptive classification of forestland based on present occupancy of an area by tree species”. Those are characterized by the trees presently occupying the area, which convey no information as to whether they are temporary or permanent. Furthermore, it is a group of stands with similar composition that develops in the same way in response to given ecological factors (Kimmins 2004).

The previous studies on Mt. Odae have mainly focused on specific areas such as peak, vicinity of Buddhist temples, valleys, and etc. or studies on populations (Choi et al. 1996; Kim et al. 1996; Lee et al. 1996; Lee et al. 2008; Chun et al. 2011; Choi et al. 2014; Kim et al. 2014; Kim et al. 2015b; Kang et al. 2016). Although there were studies across the entire area of Mt. Odae, the study of Park et al. (1996) analyzed interspecific correlation with the elevation of valleys, and the study of Kim et al. (2015a) classified the study area as broad-leaved forest, coniferous forest, mixed forest, rock vegetation and miscellaneous one, and comparisons were made between large and small scale vegetation map. The other study by Lee et al. (1998) has been carried out on the interspecific association and ordination of the forests of Mt. Odae, but there has been no report on the forest type classification and ecological characteristics. Therefore, this study carried out to classify forest types of the natural forest of Mt. Odae and to evaluate ecological attributes for each classified forest type.

Data and Methods

Study area

The study was conducted in the area of Mt. Odae, located in the course of Baekdudaegan. Odaesan national park designated as the 11th national park in Korea in 1975 is divided by Baekdudaegan into the Woljeongsa (vicinity of Buddhist temple) and Sogeu-gang (valley) district. Mt. Odae is spread out across Gangneung-si, Hongcheon-gun, and Pyeongchang-gun in Gangwon-do over a total area of 303.929 km², and based around the highest peak Birobong which stands at 1,563 m above sea level, Mt. Dongdae (1,434 m), Durobong (1,422 m), Sangwangbong (1,491 m), and Horyeongbong (1,561 m) stand together like a giant folding screen (Korea National Park 2016). The summit of its five peaks is Birobong and they stand to the south of Mt. Seorak along the Baekdudaegan, the mountain range as known the symbolic spine of the Korean Peninsula (Korea National Park 2016). This study carried out in 232 points, moving total of 12.0 km throughout Mt. Dongdae, Durobong, and Noinbong (Fig. 1).

Collection of data

The vegetation survey was conducted based on the point quarter sampling method from August to September 2013, and data were collected from a total of 232 sampling points. The method was used to collect vegetation data like the height, DBH and distance from center point to tallied tree (Fig. 2). This method saves labor and time but not sacrifices the information and accuracy obtainable from plot or line sampling methods (Brower and Zar 1977). At each point, the closest tree from the point was tallied by three vertical strata (overstory, midstory, and understory) and then, the species was identified using a Coloured Flora of Korea (Lee 2003). The distance of between points was apart from 30-50 m and the areas of gap and forest plantations were excluded to eliminate biased vegetation data.

The total of 232 sampling points were established in the study area and presented as a curve to verify the valid amounts of sampling points. The species curve for the collected vegetation data was shown in Fig. 3. The species curve by number of sampling points was portrayed to evaluate that whether the size of sample plots were enough to represent the study area. Any species appeared no more at

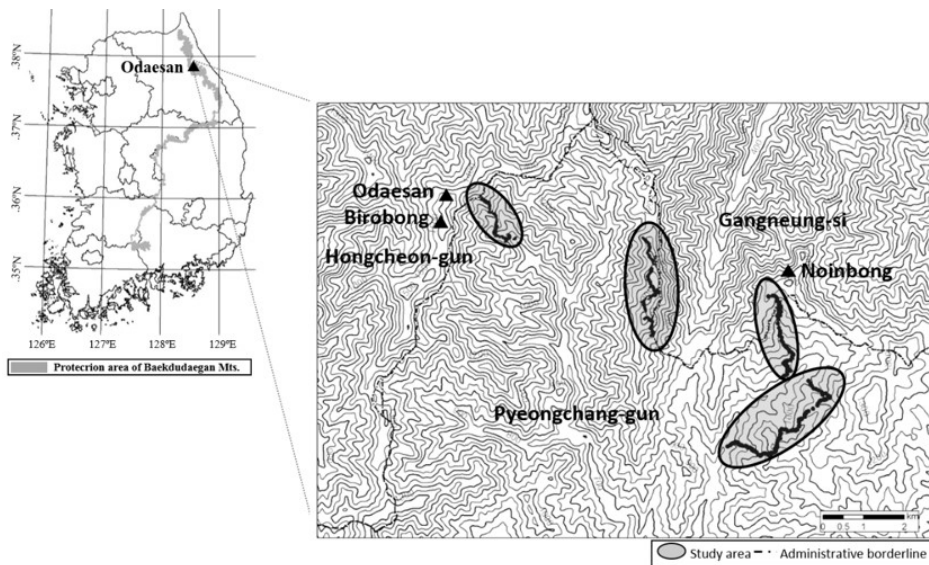


Fig. 1. The location of study area and sampling point.

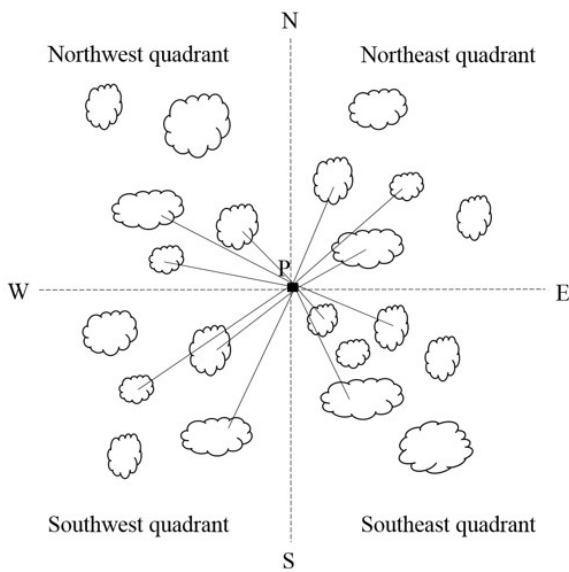


Fig. 2. The diagram of point-centered quarter sampling method.

171th with 57 species, consequently it was adequate to represent the study area.

Arrangement and analysis of data

The cluster analysis was conducted for vegetation data in the study area in order to classify similar sampling points and to make groups according to the species composition in overstory. The sampling points were classified by Ward’s method which also known as Minimum variance clustering.

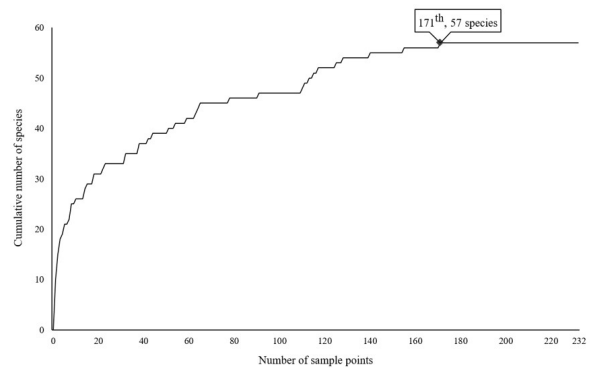


Fig. 3. Species curve by number of sampling points in study area.

This has widely used by ecologists for grouping purpose (Everitt 1974; Hartigan 1975; Orloci 1967). This method is intuitive because it is based on the simple underlying principle that the variance within clusters is minimized with respect to the variance between clusters at each stage of clustering (Ludwig and Reynolds 1988). The SPSS Statistics 20.0 software was used for the analysis.

A forest type is composed of various species, so species composition plays an important role in describing and analyzing the forest type (Kim 2002). The species composition was expressed by importance value proposed by Curtis and McIntosh (1951). The importance value provides an overall estimate of the importance or influence of a plant species within the each type (Brower and Zar 1977). The value is

the sum of relative density (RD), relative frequency (RF), and relative coverage (RC), then divided by the three factors to express percentage.

$$\text{Importance value} = (\text{RD} + \text{RF} + \text{RC}) / 3$$

Species diversity can provide useful information to account for various structural characteristics of forest types. A forest type consisting of a large number of species has diverse species interaction thus, the forest type with high species diversity would be structurally complex (Kim 2002). Shannon-Wiener diversity index which affected more by richness and less by evenness is appropriate index for the forest of which two or three species are dominant such as in the natural forest of South Korea (Kim et al. 2011). The species diversity is quantified by species richness (the number of species present in samples of a specific type) and species evenness (the relative abundance of different species) (Brower and Zar 1977).

Results

Classification of forest types

Forest types were classified by cluster analysis used to make immethodical forests into similar vegetation group on the basis of overstory species (Fig. 4). The 232 sampling points were classified into four forest types. The recognized forest types were *Q. mongolica* forest type, *B. ermanii* forest type, Mixed mesophytic forest type, and *Q. mongolica*-*P. koraiensis*-*B. ermanii* forest type. The determination of the number of forest type and nomenclature were referred to

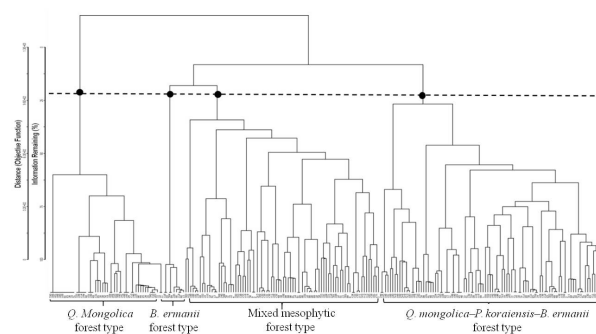


Fig. 4. The dendrogram yielded by minimum variance method (Ward's method) in study area.

the thesis of Lee (2013).

Species composition

The species composition was expressed as the importance value of canopy layer species for the four forest types (Fig. 5). The results showed that inhabited species and compositional rates were temperamentally different from one another, depending on the forest type which was formed by a number of similar vegetation sampling points.

Species diversity

Species diversity is a method of expressing the structural attributes of forest types. This is one of the basic concepts of ecology that has been used to characterize forest types and ecosystems (Brower and Zar 1997). The species diversity could provide useful information to understand various types of attributes of forest type. High species diversity indicated a highly complex forest type because it enabled interaction of a wide variety of species. The species diversity could play an important role in measuring the stability and maturity of the forest types would be increased as forest succession proceeds (Kim 2002). In this study, Shannon-Wiener's species diversity index was calculated in four forest types for total and overstory woody plants in Table 1. Species diver-

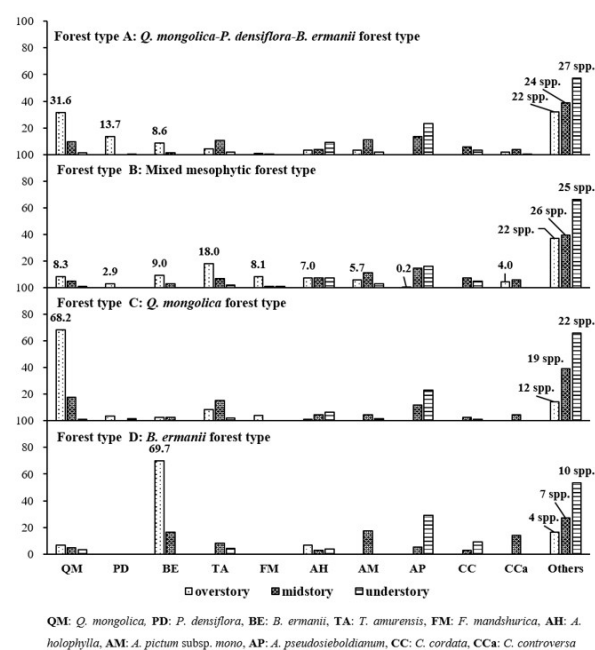


Fig. 5. Species composition of canopy layer for each forest type.

Table 1. Indices of species diversity of each forest type

		**QM-PD-BE	MM	QM	BE
*R	Total	53	52	47	23
	Overstory	30	31	18	7
<i>H'</i>	Total	3.226	3.465	2.776	0.118
	Overstory	2.565	2.942	1.218	0.832
<i>H max'</i>	Total	3.970	3.951	3.850	3.135
	Overstory	3.401	3.433	2.890	1.946
<i>J'</i>	Total	0.812	0.877	0.721	0.038
	Overstory	0.754	0.857	0.421	0.428
1- <i>J'</i>	Total	0.188	0.123	0.279	0.962
	Overstory	0.246	0.143	0.579	0.572

*R, Number of species speared in each forest type (species richness); *H'*, Species diversity; *Hmax'*, Maximum species diversity; *J'*, Species evenness; 1-*J'*, Species dominance; **QM, *Quercus mongolica*; PD, *Pinus densiflora*; BE, *Betula ermanii*; MM, Mixed mesophytic.

sity indices (*H'*) of total and overstory were highest in the Mixed mesophytic forest type (3.465 and 2.942), and lowest in the *B. ermanii* forest type (0.118 and 0.832). In addition to, *Q. mongolica*-*P. densiflora*-*B. ermanii* forest type was calculated as 3.226 and 2.565, and *Q. mongolica* forest type was calculated as 2.776 and 1.218 in total and overstory, respectively. Comparison of species diversity among the forest types cannot be made by using the species diversity index only (Kim 1999). Species diversity index should be judged by making comparison of species diversity index with evenness index and maximum species diversity index.

Discussion: Ecological Attributes of Forest types

Q. mongolica-*P. densiflora*-*B. ermanii* forest type

Ninety three sampling points out of 232 (40.1%) came under the *Q. mongolica*-*P. densiflora*-*B. ermanii* forest type (Fig. 5). In overstory species composition, *Q. mongolica* followed by *P. densiflora* and *B. ermanii*. *P. densiflora* and *B. ermanii* were the key species in this forest type. *P. densiflora* was shade-intolerant species. Once the pine tree stand came to maturity and improved the site condition, the species were often replaced by the more shade tolerant species of deciduous trees such as oaks or other deciduous species, which regenerate more easily in the understory of the pine tree stand (Lee et al. 2010). In addition to that, *B. ermanii* also was shade intolerant species, often colonizing bared areas after disturbance such as severe fires or soil dis-

turbances (Lim and Kim 2015). It was observed that it often preceded its associates by invading disturbed soils that had been logged or cleared by fire.

Kim et al. (2015) reported that, as years went by with no additional major disturbances, eventually, the abundance of shade-intolerant species such as *P. densiflora* or *B. ermanii* would be decreased and those of hardwood species would be increased through natural invasion (Kim et al. 2015). In this forest type, consequently, *Q. mongolica* predominate followed by *P. densiflora* and *B. ermanii*.

Mixed mesophytic forest type

Mixed mesophytic forest type ranked next to the *Q. mongolica*-*P. densiflora*-*B. ermanii* forest type in measure of sample area with eighty two sampling points out of 232 (35.3%). No absolute dominance was found and importance values were shared by a number of species in this forest type. Widespread dominants included *T. amurensis*, *B. ermanii*, *Q. mongolica*, *F. madshurica*, *A. holophylla*, and etc.. This forest type presented the highest species diversity index resulted from the evenness which express 0.8 or more. It was a typical characteristics of Mixed mesophytic forest type composed of various species. Several studies (Hwang et al. 2012; Chung and Kim 2013; Lee et al. 2014; Lim and Kim 2015) in Korean natural forests have reported the existence of Mixed mesophytic forest, typified by diversity and complexity.

Even though the forest type was primarily characterized by the canopy layer, the lower layers also had distinctive

features. To a large number of canopy species must have been added lower trees that seldom or never attain canopy position as *A. pseudosieboldium*, *Magnolia sieboldii*, *Syringa reticulata* var. *mandshurica*, *A. mandshuricum*, and *Salix caprea*. Among the shrubs, *Rhododendron schlippenbachii*, *Philadelphus schrenkii*, *Symplocos chinensis*, *Deutzia glabrata*, and *Callicarpa japonica* were most generally present and abundant.

In such regions of Appalachian Mountains in the United States where the term of this forest type was derived, even though the species were different, trees of same genera showed very similar ecological characteristics and physiognomy to those of this forest type (Lim and Kim 2015). The forest type has been regarded as the oldest and most complex association of the temperate deciduous forest formation (Braun 1950; Vankat 1979; Barbour and Billings 1988). Even in Europe (European Environment Agency 2006), it has been recognized the Mixed mesophytic forest types, suggested the characteristics of structure and diversified species composition.

Q. mongolica forest type

Q. mongolica forest type ranked next to the Mixed mesophytic forest type in measure of sample area with 48 sampling points out of 232 (20.7%). *Q. mongolica* is a deciduous oak species that dominantly and widely distributes in Korean deciduous forests (Korea Forest Service 2016). As mentioned before, when stand of *P. densiflora* was cut or destroyed by fire, the oak vigorously invaded and became dominant through constant sprouting with the failure of pine trees to regenerate themselves under the stand (Kim et al. 2015).

Q. mongolica, with the importance value of 68.2%, was associated with 17 tree species including *T. amurensis* and *A. pseudosieboldium* in the canopy (Fig. 5), and common in ridges and mid-slopes. In the midstory, *Q. mongolica*, *T. amurensis*, and *A. pseudosieboldium* were dominant. *A. pseudosieboldium*, however, was a sub-tree species with a maximum height of 8 m which no reach to the overstory inherently (Korea Biodiversity Information Service 2016). *T. amurensis* was a deciduous tree species that grows up to 20 m in height, but had a characteristic of growing mainly in a valley or mid-slope. The distribution percentage of *Q. mongolica* in the over- and midstory and the growth pattern of *A. pseudosieboldium* and *T. amurensis* suggested that the domi-

nance of *Q. mongolica* would continue for a considerably long time. In some previous studies, it has been reported that the stand structure was shifted toward that *Q. mongolica* was maintained or predominant, and some ecologists estimated it as a late succession species (Byun et al. 1998; Cho and Choi 2002; Choi and Oh 2003; Kim 2010).

B. ermanii forest type

This forest type was characteristically distributed in limited small areas of the study area. *B. ermanii* occupied the large portion in overstory as about 69.7%. *B. ermanii* was a pioneer species and intolerant species, showing a high composition rate in the overstory, while the composition rate was gradually decreasing in the midstory and understory. Associated species showed low variability, and included *Q. mongolica*, *A. holophylla*, *Phellodendron amurense* (others), *A. nephrolepis* (others). The species diversity index was calculated as 0.118 for all vegetation and 0.832 in the overstory.

As mentioned before, *B. ermanii* was thought to be a pioneer species and has adapted to regenerating areas after severe disturbances. It has been observed that this species precedes its associates by invading disturbed area. After reaching the mature stand would continue without additional major disturbances, the density of *B. ermanii* decreased while those of other coniferous and deciduous species increased (Kim et al. 2015). Eventually, *B. ermanii* would disappear sooner than other species and this forest type would not be able to be maintained.

References

- Barbour MG, Billings WD. 1988. North American terrestrial vegetation. Cambridge University Press, pp 434.
- Braun EL. 1950. Deciduous forest of eastern North America. Blakiston, Philadelphia, pp 596.
- Brower JE, Zar JH. 1977. Field and laboratory methods for general ecology. W. C. Brown Company Publishers, Dubuque, Iowa, USA, pp 73.
- Byun DW, Lee HJ, Kim CH. 1998. Vegetation pattern and successional sere in the forest of Mt. Odae. Korean J Ecol 21: 283-290.
- Cho HS, Choi SH. 2002. Plant community structure of the Baekcheon valley in Taebaeksan area, the Baekdudaegan. Korean J Environ Ecol 15: 368-377.
- Choi SH, Kwon JO, Min SH. 1996. Plant community structure analysis in Noinbong area of Odaesan national park. Korean J

- Environ Ecol 9: 156-165.
- Choi SH, Oh KK. 2003. Vegetation structure of mountain ridge from Jeongryeongchi to Bokseongijae in the Baekdudaegan. Korean J Environ Ecol 16: 421-432.
- Choi YE, Kim CH, Oh JG, Lee NS. 2014. Community distribution on mountain forest Vegetation of the Birobong area in the Odaesan national park, Korea. Korean J Ecol Environ 47: 91-102.
- Chun YM, Ahn JK, Hong MP, Shin JT, Won HJ, Lee SH. 2011. Structure and dynamics of *Abies nephrolepis* community in Odaesan national park. The Geographical Journal of Korea 45: 559-570.
- Chung SH, Kim JH. 2012. The classification of forest types by factor analysis in natural forests of Dutasan. Journal of Agriculture & Life Sciences 46: 21-30.
- Chung SH, Kim JH. 2013. The classification of forest cover types by consecutive application of multivariate statistical analysis in the natural forest of western Mt. Jiri. J Korean For Soc 102: 407-414.
- Curtis JT, McIntosh RP. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology 32: 476-496.
- European Environment Agency. 2006. European forest types: Categories and types for sustainable forest management reporting and policy. Office for Official Publications of the European Communities, Luxembourg, pp 111.
- Everitt B. 1974. Cluster analysis. John Wiley & Sons Inc., New York, USA.
- Eyre FH. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington DC, pp 148.
- Hartigan JA. 1975. Clustering algorithms. John Wiley & Sons Inc., New York, USA.
- Hwang KM, Lee JM, Kim JH. 2012. Community classification and successional trends in the natural forest of Baekdudaegan in Gangwon province - focused on Hyangrobong, Odaesan, Seokbyeongsan, Dutasan, Deokhangsan and Hambaeksan-. Journal of Agriculture & Life Science 46: 41-55.
- Jo HJ, Lee BC, Shin JH. 2004. Forest vegetation structure and species composition of the Baekdudaegan mountain range in South Korea. J Korean For Soc 93: 331-338.
- Kang SC, Han BH, Park SC, Choi JW. 2016. Plant community structure of the Soguemgang valley in Odaesan national park. J Korean Env Res Tech 19: 29-44.
- Kim CH, Oh JG, Kang EO, Choi YE. 2014. Community distribution on mountain forest vegetation of the Noinbong area in the Odaesan national park, Korea. Korean J Ecol Environ 47: 103-115.
- Kim CH, Oh JG, Lee NS, Choi YE, Song MJ. 2015a. A study on the forest vegetation of Odaesan national park, Korea. Korean J Ecol Environ 48: 61-67.
- Kim DW, Han BH, Kim JY, Yeum JH. 2015b. Plant community structure of *Abies holophylla* community from Sinseonganm to Jungdaesa in Odaesan national park. Korean J Environ Ecol 29: 805-906.
- Kim GT, Choo GC, Um TW. 1996. Studies on the structure of forest community at Sangwonsa, Pirobong, Horyongbong area in Odaesan national park. Korean J Environ Ecol 10: 151-159.
- Kim HD. 2010. Studies on community dynamics of vegetation and successive dynamics in Bukhansan national park. Ph.D. Dissertation. Changwon National University, pp 161.
- Kim JH, Guangze Jin, Chung SH. 2015. Stand development patterns of forest cover types in the natural forests of northern Baekdudaegan in South Korea. J For Res 26: 381-390.
- Kim JH, Lee HS, Hwang GM. 2011. Ecological attributes of species composition by topographical positions in the natural deciduous forest. Journal of Forest Science (Institute of Forest Science. Kangwon National University) 27: 17-22.
- Kim JH. 1999. Forest ecology; attributions and analysis of forest community. HayangMoonSa, Seoul, Korea, pp 208.
- Kim JH. 2002. Community ecological view of the natural deciduous forest in Korea. In: Ecology of Korea. Bunwoo Publishing Company, Seoul, Korea, pp 93-104.
- Kim KT. 2002. The analysis of ecological structure and dynamics for community types in the natural deciduous forest of Mt. Chumbong area. Ph.D. Dissertation. Kangwon National University.
- Kimmins JP. 2004. Forest ecology - A foundation for sustainable forest management and environmental ethics in forestry. 3rd ed. Printes Hall Pub. Co., Upper Saddle River, NJ, pp 611.
- Korea Biodiversity Information System. 2016. <http://www.nature.go.kr/ekbi/Subindex.do>.
- Korea Forest Service. 2016. Statistical Yearbook of Forestry, pp 414.
- Korea National Park Service. 2016. <http://english.knps.or.kr/Knp/Odaesan/Intro/Introduction.aspx?MenuNum=1&Submenu=Npp>
- Lee DG, Kwon KW, Kim JH, Kim GT. 2010. Silviculture (in Korean). Hyangmoonsa, Seoul, Korea, pp 334.
- Lee DG, Um TW, Chun JH, Jung MH. 2001. Plant classification and characteristics in natural deciduous forest of Mt. Joongwang province. Korean Forest Society 0: 161-163.
- Lee HJ, Byun DW, Kim CH. 1998. Analysis of interspecific association and ordination on the forest vegetation of Mt. Odae. Korean J Ecol Environ 21: 291-300.
- Lee JM, Hwang GM, Kim JH. 2014. The classification of forest by cluster analysis in the natural forest of the southern region of Baekdudaegan mountains. J Korean For Soc 103: 12-22.
- Lee JM. 2013. The classification of forest communities and the evaluation of species diversity in natural forests of six Mts. in Gangwon-do Baekdudaegan. Master dissertation. Kangwon National university.
- Lee KJ, Cho W, Han BH. 1996. Plant community structure of *Pinus densiflora* forests in Odaesan national park. Korean J Environ Ecol 9: 115-125.

- Lee KJ, Kim JS, Choi JW, Han BH. 2008. Vegetation structure of *Abies Holophylla* forest near Woljeong temple in Odaesan national park. Korean J Env Eco 22: 173-183.
- Lee CB. 2003. Coloured flora of Korea. Hyangmoonsa, Seoul, Korea, pp 916.
- Lim SM, Kim JH. 2015. The ecological characteristics of classified forest cover types in the natural forest of Sobaeksan. J For Env Sci 31: 126-135.
- Ludwig JA, Reynolds JF. 1988. Statistical ecology. John Wiley & Sons Inc., New York, USA, pp 125-144.
- Orloci L. 1967. An agglomerative methods for classification of plant communities. J Ecol 55: 193-206.
- Otto HJ. 1994. Waldökologie. E. Ulmer, Stuttgart, pp 391.
- Park IH, Ryu SB, Kim RH. 1996. Forest structure in relation to altitude and part of slope in a valley forest at Odaesan national park. Korean J Ecol Environ 9: 126-132.
- Vankat JL. 1979. The natural vegetation of North America. John Wiley & Sons, New York, pp 261.
- Yang HM, Kang SK, Kim JH. 2001. Selection of desirable species and estimation of composition ratio in a natural deciduous forest. J Korean For Soc 90: 465-475.