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Flora of a Cool Temperate Forest Around Restoration Center for Endangered Species, Yeongyang

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ABSTRACT

The present study aimed to clarify flora living at the area of Restoration Center for Endangered Species in Yeongyang, Gyeongbuk Province. In May, August, and September 2019 and in May and July 2020, all of vascular plants were recorded, and endangered, Korea endemic, and exotic plant species were further identified. The study site contained a total of 418 floral taxa (98 families, 261 genera, 384 species, 4 subspecies, 27 variations, and 3 formations), in which Magnoliophyta accounted for larger proportion (95.2%) than Pteridophyta (3.6%) and Pinophyta (1.2%). In addition, 1 endangered (*Cypripedium macranthos* Sw.) and 5 Korea endemic species (*Aconitum pseudolaeve* Nakai, *Eleutherococcus divaricatus* var. *chiisanensis* [Nakai] C.H. Kim & B.-Y. Sun, *Lonicera subsessilis* Rehder, *Paulownia coreana* Uyeki, and *Weigela subsessilis* [Nakai] L.H. Bailey) were detected. The number of exotic species was 33, consisting of 4 invasive-exotic, 4 potentially invasive-exotic, and 25 non-invasive species. Compared to a previous assessment before the establishment of the center (in 2014), there were increases in total floral taxa (from 361 to 418), endangered species (from 0 to 1), and exotic species (from 26 to 33). These results possibly reflect temporal changes in floral community, which should be confirmed through subsequent long term monitoring.

Keywords: Anthropogenic disturbance, Biodiversity, Floral composition, Gyeongbuk Province

Introduction

Flora is the undoubtedly important component in terrestrial ecosystems. It mediates various ecosystem processes, such as pedogenesis (Shanmugam & Kingery, 2018), carbon sequestration (Chapin *et al*., 2009), and nutrition cycle (Wurzburger & Hendrick, 2009). Floral diversity also governs ecosystem structure by controlling the environment around fauna and microbes, although flora accounts for only 17% of global number of species (Mora *et al*., 2011). From the phytosociological perspective, distribution and composition of plant community can exhibit the integrated information regarding climatic and geological history on a landscape over a long time period (Pott, 2011).

Studying flora species composition has been prioritized in terms of the terrestrial ecosystem research and conservation/restoration ecology. For example, plans for landscape protection and land use change generally require a thorough structural monitoring of flora (Korean Ministry of Environment, 2014a; Oh *et al*., 2015). Assessments following anthropogenic or natural disturbances also frequently include it as a key index revealing health and sustainability of a target site (Lee *et al*., 2018; Onaindia

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et al., 2004). Sometimes, floral data are utilized to quantify the degree of urbanization and naturalization as well (Beon *et al*., 2005; Oh *et al*., 2011).

Yeongyang in Gyeongbuk Province is one of the least urbanized peninsular regions in South Korea, and retains diverse forest types (Lee *et al*., 2006) and vascular plant species (Chung *et al*., 2007; 2008; Oh *et al*., 2015). In 2018, a land use change occurred by the establishment of Restoration Center for Endangered Species, which possibly shifted the local floral community. However, there is no information on the flora throughout the area of Restoration Center for Endangered Species, despite an environmental risk assessment before the construction (Korean Ministry of Environment, 2014a).

The present study explored flora living at the area of Restoration Center for Endangered Species in Yeongyang. Our study primarily focused on the identification of vascular plants, and the associated analyses of endangered, endemic, and exotic species based on the Korean classification. Furthermore, comparisons with a previous assessment to the same area (Korean Ministry of Environment, 2014a) were made so that potential floral changes after the establishment of the center could be elucidated.

Materials and Methods

Study site

Study site covered overall area of Restoration Center for Endangered Species (255 ha) in Yeongyang (N36°38'10.30 E129°09'13.69), which was located at the northeastern part of Gyeongbuk Province (Fig. 1). Topographically, approximately 77% of the site area were mountainous (slope >15°), but there were plain and stream inside as well. The altitude ranged from 235 m to 568 m (376 m on average). The soil was classified as inceptisols in the USDA soil taxonomy, and as a brown forest soil type with a sandy loam to loamy sand texture in the Korean forest soil nomenclature. The climate was cool temperate with a hot humid summer and a cold dry winter. The concentrated precipitation event generally occurred in the middle of summer. The average air temperature, precipitation, relative humidity, and wind speed were 13.3°C, 1,032.6 mm, 63.0%, and 2.9 $m \cdot s^{-1}$ during the last 10 years, respectively. The highest and lowest air temperature was 37.7 and −15.0°C throughout a year.

Floral data collection and analysis

Vascular plants were investigated in May, August, and September 2019 and in May and July 2020. The field survey was based on the line transect method (Braun-Blanquet, 1964), which targeted on the area of Restoration Center for Endangered Species. Any vascular plants were identified in the field using the characteristics of organs (e.g., leaves, flowers, and stems) according to Lee (2003) unless further specification was required with a microscope in detail.

The nomenclature for each taxon followed the national species list from National Institute of Biological Resources. The enforcement regulations by Korean Ministry of Environment were applied to specify the legally protected (endangered or Korea endemic) and exotic plant species. In terms of exotic species, further classification was conducted by the possibility of invasion to the native ecosystems (invasive-exotic, potentially invasive-exotic, and non-invasive) according to a previous assessment by Korean Ministry of Environment (2014b). Urbanization and naturalization indices were calculated with the equations purposed by Yim and Jeon (1980), Numata and Kotaki (1975). Meanwhile, floral data before the establishment of the center (Korean Ministry of Environment, 2014a) was cited and restructured to make a direct comparison with data from the present study. In particular, the classification and the lists of legally protected or exotic species were adjusted to the same versions for those of the present study.

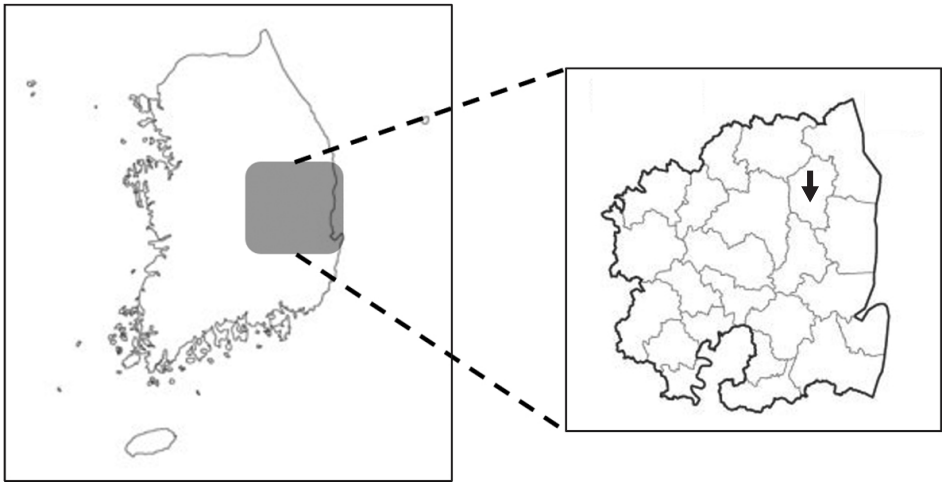

Fig. 1. Location of the study site (black arrow).

Results and Discussion

Total floral taxa

There were 418 floral taxa (98 families, 261 genera, 384 species, 4 subspecies, 27 variations, and 3 formations) in the study site (Table 1). Magnoliophyta occupied the largest proportion (95.2%) of the floral taxa, followed by Pteridophyta (3.6%) and Pinophyta (1.2%). The dominant families within Magnoliophyta were Asteraceae (51 taxa), Fabaceae (25 taxa), Rosaceae (25 taxa), Poaceae (24 taxa), Liliaceae (17 taxa), and Lamiaceae (16 taxa), while the dominant genera within Magnoliophyta were *Artemisia* (9 taxa), *Carex* (8 taxa), *Persicaria* (8 taxa), *Viola* (8 taxa), *Dioscorea* (6 taxa), and *Quercus* (6 taxa). On the other hand, the dominant family and genus within Pinophyta were Pinaceae (4 taxa) and *Pinus* (2 taxa), whereas those within Pteridophyta were *Dryopteridaceae* (4 taxa) and Dryopteris (4 taxa). Full list for the floral taxa in the study site was provided in Supplementary Table 1.

In a quantitative manner, our result differed from previous studies investigating the other mountainous areas in Yeongyang. For instance, Chung *et al*. (2007) found 513 floral taxa (91 families, 318 genera, 424 species, 3 subspecies, 73 variations, and 13 formations) in Geomma-san, while Chung *et al*. (2008) observed 437 taxa (88 families, 267 genera, 384 species, 4 subspecies, 43 variations, and 6 formations) in Podo-san. Oh *et al*. (2015) also reported 582 taxa (94 families, 307 genera, 508 species, 4 subspecies, 61 variations, and 9 formations) in Ilwol-san. Such difference between the present and previous studies might occurred because the study site has undergone anthropogenic disturbances such as agriculture (Korean Ministry of Environment, 2014a), in contrast to Geomma-san, Podo-san, and Ilwol-san. The presence of agricultural fruit trees (e.g., *Diospyros kaki* Thunb. and *Ziziphus jujuba* Mill.) in the study site possibly supports this explanation (Supplementary Table 1). Relatively low altitude of the study site (study site: 376 m; Geomma-san: 1,017 m; Podo-san: 748 m; Ilwol-san: 1,219 m) might also contribute to such differences in floral taxa (Yirga *et al*., 2019).

The total number of floral taxa from the present study was larger than that of a study for the same site before the establishment of Restoration Center for Endangered Species (102 families, 331 species, 4 subspecies, 25 variations, and 1 formation) (Korean Ministry of Environment, 2014a). Such increase in floral taxa was remarkable in Magnoliophyta (from 344 to 398 taxa). On the contrary, the number of family was lower in the present study than in Korean Ministry of Environment (2014a) as a result of the disappearance of 5 families (Eucommiaceae, Ginkgoaceae, Grossulariaceae, Malvaceae, and Orobanchaceae) and the new appearance of 1 family (Juncaceae). These changes might reflect the potential reorganization in plant niche and vegetation composition after the anthropogenic event due to the construction (De Martis *et al*., 2016). Given that the present study covered a relatively short period of time, this aspect should be confirmed through further monitoring in the long-term.

Legally protected species

A total of 6 legally protected species were detected in the study site (Table 2). Of them, the endangered species included *Cypripedium macranthos* Sw. (grade II by Korean Ministry of Environment). The endemic species consisted of *Aconitum pseudolaeve* Nakai, *Eleutherococcus divaricatus* var. *chiisanensis* (Nakai) C.H. Kim & B.-Y. Sun, *Lonicera subsessilis* Rehder, *Paulownia coreana* Uyeki, and *Weigela subsessilis* (Nakai) L.H. Bailey.

One result deserving highlight is that the detected endangered species, *C. macranthos*, did not occur in the previous study on the same site, while the number of endemic species remained unchanged (Korean Ministry of Environment, 2014a). This new inclusion might result from either seed disposal from the outside of the study site or simple unidentification during the previous study.

Table 2. List of legally protected plant species found in the study site

Type	Scientific name
Endangered species	*Cypripedium macranthos* Sw.
Endemic species	*Aconitum pseudolaeve* Nakai
	Eleutherococcus divaricatus var. *chiisanensis* (Nakai) C.H. Kim & B.-Y. Sun
	Lonicera subsessilis Rehder
	Paulownia coreana Uyeki
	Weigela subsessilis (Nakai) L.H. Bailey

Table 1. Number of floral taxa found in the study site

Phylum	Family	Genus	Species	Subsp.	Var.	For.	Subtotal
Magnoliophyta	87	247	365	4	26	3	398
Pinophyta	2	4	5	0	0	0	5
Pteridophyta	9	10	14	0	1	0	15
Total	98	261	384	4	27	3	418

The presence of the endangered species was comparable to previous studies in Yeongyang, which revealed several endangered species (grade II by Korean Ministry of Environment) such as *C. macranthos* in Geomma-san (Chung *et al*., 2007) and *Eleutherococcus senticosus* (Rupr. & Maxim.) Maxim. and *Paeonia obovata* Maxim. in Podo-san (Chung *et al*., 2008); however, no endangered species was found in Ilwol-san (Oh *et al*., 2015). As *C. macranthos* has been unreported around the study site until the present study, detailed investigations should be necessary to ensure whether that species habituate in the surrounding area of Restoration Center for Endangered Species.

Exotic species

The number of exotic species was 33, comprising 4 invasive-exotic, 4 potentially invasive-exotic, and 25 non-invasive species (Table 3). The invasive-exotic species consisted of 3 North American species (*Ambrosia artemisiifolia* L., *Ambrosia trifida* L., and *Aster pilosus* Willd.) and 1 European species (*Lactuca scariola* L.). The potentially invasive-exotic species contained 2 North American species (*Amorpha fruticosa* L. and *Bidens frondosa* L.), 1 European species (*Festuca arundinacea* Schreb.), and 1 Eurasian species (*Rumex obtusifolius* L.). These species were either herbaceous weeds living along road- and stream-side (*A. artemisiifolia*, *A. trifida*, *A. pilosus*, *L. scariola*, *B. frondosa*, *F. arundinacea*, and *R. obtusifolius*) or plantation shrubs (*A. fruticosa*). Meanwhile, the non-invasive species were comprised of 9 North American species (*Conyza canadensis* (L.) Cronquist, *Coreopsis lanceolata* L., *Cuscuta campestris* Yunck., *Erigeron annuus* (L.) Pers., *Euphorbia maculata* L., *Geranium carolinianum* L., *Helianthus tuberosus* L., *Oenothera biennis* L., and *Robinia pseudoacacia* L.), 9 European species (*Cerastium glomeratum* Thuill., *Fallopia dumetorum* (L.) Holub, *Medicago sativa* L., *Poa pratensis* L., *Rumex crispus* L., *Taraxacum officinale* F.H. Wigg., *Thlaspi arvense* L., *Trifolium pratense* L., and *Trifolium repens* L.), 3 Eurasian species (*Avena fatua* L., *Carduus crispus* L., and *Dactylis glomerata* L.), 2 Tropical American species (*Amaranthus retroflexus* L. and *Galinsoga quadriradiata* Ruiz & Pav.), 1 South American species (*Bidens pilosa* L.), and 1 Asian species (*Melilotus suaveolens* Ledeb.).

Urbanization (proportion of exotic floral taxa in the study site to that in the entire country) and naturalization (proportion of exotic floral taxa to total floral taxa in the study site) indices were 9.9 and 7.9%. These values slightly exceeded the findings from Chung *et al*. (2005; 2007; 2008) in Yeongyang (urbanization index: 6.3-9.7%; naturalization index: 3.6-4.1%) as well as the indices prior to the establishment of the center (urbanization index: 7.8%; naturalization index: 7.2%) (Korean Ministry of Environment, 2014a). Moreover, the proportion of both invasive-exotic and potentially invasive-exotic species increased 1.5-fold, comparing it to that before the establishment of the center (Fig. 2). These results demonstrate that the study site might have been subjected to the anthropogenic disturbances like agriculture and the construction of the center, as suggested by the total floral taxa data (see total floral taxa subsection). Considering that the newly appeared exotic species (e.g. *L. scariola*) are generally tolerant and invasive to the unvegetated bare environments (Kim *et al*., 2013), the increasing trend in invasive species

Table 3. List of exotic plant species found in the study site

Type	Scientific name
Invasive-exotic	*Ambrosia artemisiifolia* L.
	Ambrosia trifida L.
	Aster pilosus Willd.
	Lactuca scariola L.
Potentially invasive-exotic	*Amorpha fruticosa* L.
	Bidens frondosa L.
	Festuca arundinacea Schreb.
	Rumex obtusifolius L.
Non-invasive	*Amaranthus retroflexus* L.
	Avena fatua L.
	Bidens pilosa L.
	Carduus crispus L.
	Cerastium glomeratum Thuill.
	Conyza canadensis (L.) Cronquist
	Coreopsis lanceolata L.
	Cuscuta campestris Yunck.
	Dactylis glomerata L.
	Erigeron annuus (L.) Pers.
	Euphorbia maculata L.
	Fallopia dumetorum (L.) Holub
	Galinsoga quadriradiata Ruiz & Pav.
	Geranium carolinianum L.
	Helianthus tuberosus L.
	Medicago sativa L.
	Melilotus suaveolens Ledeb.
	Oenothera biennis L.
	Poa pratensis L.
	Robinia pseudoacacia L.
	Rumex crispus L.
	Taraxacum officinale F.H. Wigg.
	Thlaspi arvense L.
	Trifolium pratense L.
	Trifolium repens L.

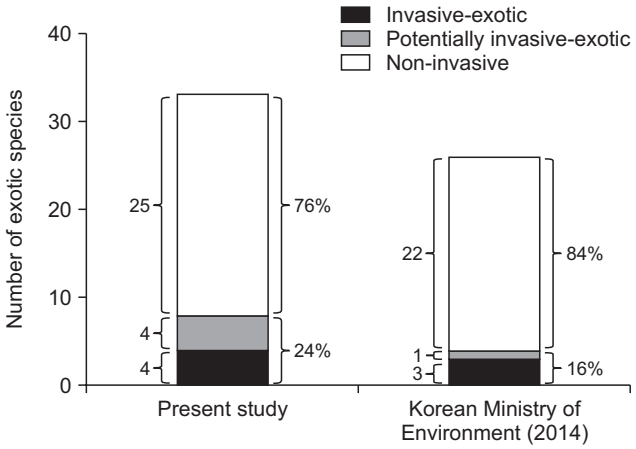

Fig. 2. Number of exotic plant species. Values beside each bar indicate the species number (left) and the proportion (right) for the corresponding classes.

might be closely related to the recent construction of infrastructure, such as parking lots and roads across the study site.

Concluding remarks

The present study exhibits a total of 418 floral taxa (98 families, 261 genera, 384 species, 4 subspecies, 27 variations, and 3 formations) around the area of Restoration Center for Endangered Species in Yeongyang, Gyeongbuk Province. The flora in the study site particularly contained 1 endangered species and 5 Korea endemic species as well as 33 exotic species consisting of 4 invasive-exotic, 4 potentially invasive-exotic, and 25 non-invasive.

Several changes were detected relative to the data before the establishment of the center. In particular, the total number of floral taxa increased by 16%, although several floral families (Eucommiaceae, Ginkogoaceae, Grossulariaceae, Malvaceae, and Orobanchaceae) were faded out in the present study. Additionally, 1 endangered species (*C. macranthos*) newly occurred, and the proportion of invasive and potentially invasive species was 1.5-fold elevated. Overall results imply potential alterations in floral community, which might be related to the recent establishment of the center at the study site. Subsequent studies should be required to confirm and track the potential floral changes in the future.

Conflict of Interest

The authors declare that they have no competing interests.

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References

Beon, M.S., Oh, H.K., Kim, Y.H., and Kim, Y. (2005). Vascular plants and urbanization index in the Jeoniu stream area. *Korean Journal of Environment and Ecology*, 19, 231-245.

Braun-Blanquet, J. (1964). [*Pflanzensoziologie*: *grundzüge der Vegetationskunde*], 3rd ed. Vienna: Springer. German.

Chapin, F., McFarland, J., McGuire, A., Euskirchen, E., Ruess, R., and Kielland, K. (2009). The changing global carbon cycle: linking plant-soil carbon dynamics to global consequences. *Journal of Ecology*, 97, 840-850.

Chung, G.Y., Jeong, H.J., Nam, G.H., and Park, J.H. (2005). Flora of vascular plants in Irwolsan of Gyeongbuk. *Korean Journal of Plant Resources*, 18, 131-147.

Chung, G.Y., Yu, B.C., Jeong, H.J., Park, M.S., Lee, S.H., Choi, H.N., *et al*. (2007). Distribution of vascular plants in Geommasan (Yeongyang, Gyeongbuk). *Korean Journal of Plant Resources*, 20, 281-291.

Chung, G.Y., Park, M.S., Jung, S.Y., Lee, S.H., Choi, H.N., Nam, B.M., *et al*. (2008). Distribution of vascular plants in Podosan (Yeongyang, Gyeongbuk). *Korean Journal of Plant Resources*, 21, 281-291.

De Martis, G., Mulas, B., Malavasi, V., and Marignani, M. (2016). Can artificial ecosystems enhance local biodiversity? The case of a constructed wetland in a Mediterranean urban context. *Environmental Management*, 57, 1088-1097.

Kim, Y.H., Kil, J.H., Hwang, S.M., and Lee, C.W. (2013). Spreading and distribution of Lactuca scariola, invasive alien plant, by habitat types in Korea. *Weed & Turfgrass Science*, 2, 138-151.

Korean Ministry of Environment. (2014a). *Environmental risk assessment for the construction of the national Restoration Center for Endangered Species*, Sejong: Ministry of Environment.

Korean Ministry of Environment. (2014b). *A study on long-term management of exotic species*, Sejong: Ministry of Environment.

Lee, C.B. (2003). *Coloured flora of Korea*, Seoul: Hyangmunsa.

Lee, J.H., Bae, K.H., and Cho, H.J. (2006). Forest vegetation classification and species composition of Mt. Ilwol, Yeongyang-Gun, Korea. *Korean Journal of Agricultural and Forest Meteorology*, 8, 132-140.

Lee, S.H., Kim, S., and Kim, H.J. (2018). Effects of thinning intensity on understory vegetation in Chamaecyparis obtusa stands in South Korea. *Forest Science and Technology*, 14, 7-15.

Mora, C., Tittensor, D.P., Adl, S., Simpson, A.G., and Worm, B. (2011). How many species are there on Earth and in the ocean? *PLoS Biology*, 9, e1001127.

Numata, M., and Kotaki, O. (1975). [*Naturalized plants*], Tokyo: Japan Society of Library. Japanese.

Oh, H.K., Sagong, J.H., and You, J.H. (2011). Analysis on environmental indices and naturalized plants distributed in Gyeryong-si, Korea. *Korean Journal of Environment and Ecology*, 25, 479-489.

Oh, H.K., Son, B.Y., and You, J.H. (2015). Vascular plants and characteristics by type in Mt. Ilwolsan (Yeongyang, Gyeong-

buk) for designating an ecological and landscape conservation area. *Journal of the Korean Society of Environmental Restoration Technology*, 18, 43-62.

Onaindia, M., Dominguez, I., Albizu, I., Garbisu, C., and Amezaga, I. (2004). Vegetation diversity and vertical structure as indicators of forest disturbance. *Forest Ecology and Management*, 195, 341-354.

Pott, R. (2011). Phytosociology: a modern geobotanical method. *Plant Biosystems*, 145 Suppl 1, 9-18.

Shanmugam, S.G., and Kingery, W.L. (2018). Changes in soil microbial community structure in relation to plant succession and soil properties during 4000 years of pedogenesis. *European Journal of Soil Biology*, 88, 80-88.

Wurzburger, N., and Hendrick, R.L. (2009). Plant litter chemistry and mycorrhizal roots promote a nitrogen feedback in a temperate forest. *Journal of Ecology*, 97, 528-536.

Yim, Y.J., and Jeon, E.S. (1980). Distribution of naturalized plants in the Korean Peninsula. *Korean Journal of Botany*, 23, 69-83.

Yirga, F., Marie, M., Kassa, S., and Haile, M. (2019). Impact of altitude and anthropogenic disturbance on plant species composition, diversity, and structure at the Wof-Washa highlands of Ethiopia. *Heliyon*, 5, e02284.