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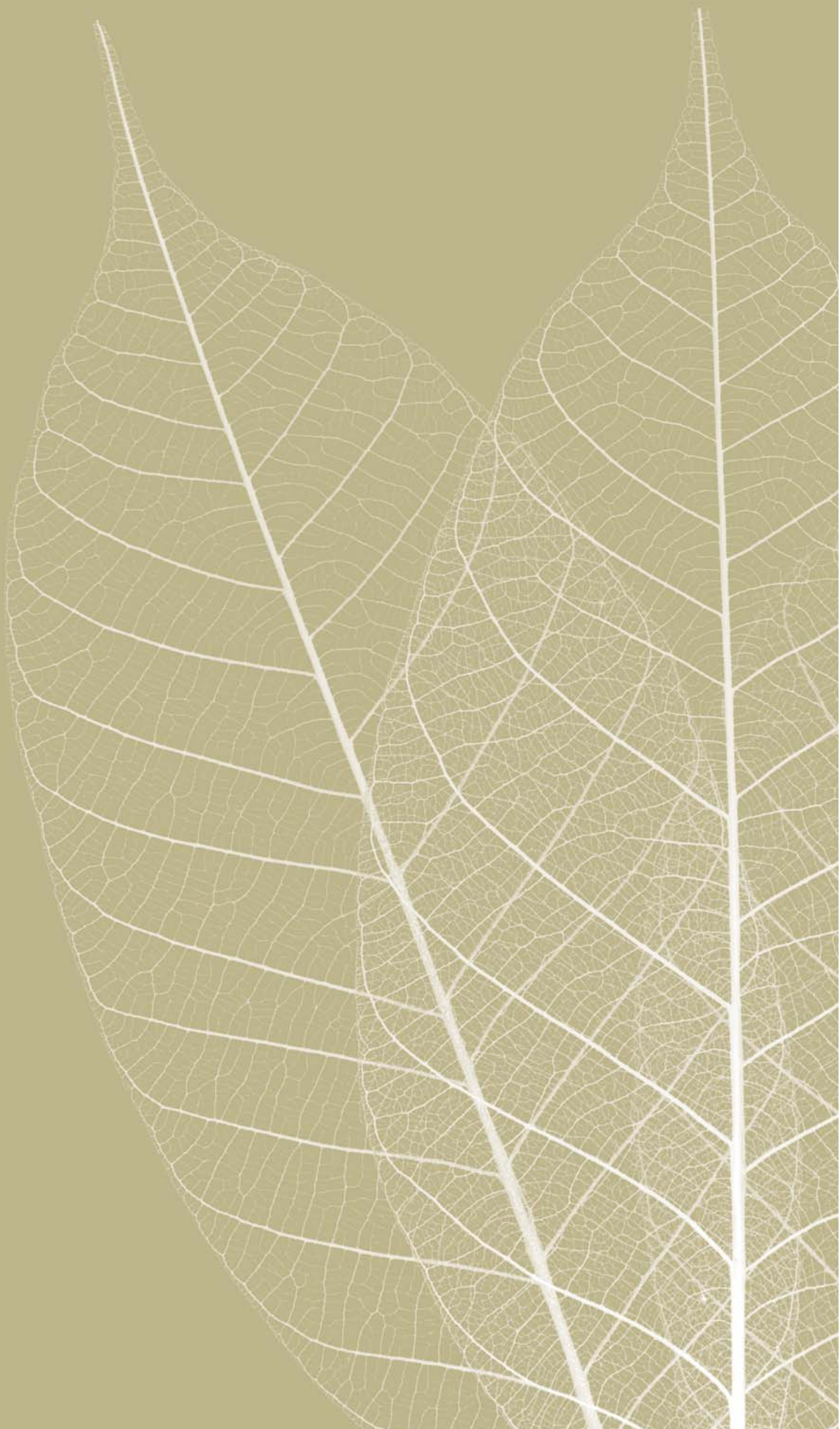
Forest Eco-Atlas of Korea

KOREA FOREST RESEARCH INSTITUTE

Forest Eco-Atlas of Korea



Preface

The mountains of Korea are gently curved and smooth due to old geological changes in the Korean peninsula. In this respect, the image of the mountains has something in common with the Koreans, a people who are easy-going and soft-hearted. The forests of Korea have long shared happiness and sorrow with the people. Only 60 years ago, these forests were completely devastated by the Korean War and the poverty that ensued. However, the Korean people strived to revive the economy from the ruins of war and make the woodlands green again. Their great reforestation efforts have come to fruition.

In the past, conifers dominated the forests in Korea, but deciduous trees gradually are replacing the pines. The local vegetation was changing. A variety of harmful pests such as pine caterpillar, pine needle gall midge, and pine wilt disease inflicted serious damage to the pine forest. These days, fortunately, the destruction was reduced thanks to the diversity of tree species. Nevertheless, landslides and forest fires still damage the forests. No doubt, these are effects of climate change. It is known that forests play a very important role in addressing climate change.

Within the forest, countless plants, animals, insects, and microorganisms live with each other in a harmonious tangled web of relationships. The forests provide humans with the necessities to survive, such as drinking water. The trees absorb carbon dioxide in the air. The woods also help reduce the impact of natural disasters. More importantly, these forests stimulate our interests, teach us many lessons, and enrich all our lives.

This book is published to introduce the forest ecosystem in Korea to the readers. In addition, it presents the Korean history, various living creatures, and the traditional view of nature, such as 'Maeul-soop' (Korean village forests) and the 'Baekdu-daegan' (traditional mountain system of Korea), and recent research achievements. To help our readers understand this book better, we have inserted as many drawings and pictures as possible by drafting ecological maps.

I would like to express my deep gratitude to researchers for dedicating themselves in publishing this book despite difficult circumstances. I hope this book will serve an invaluable role in promoting our culture, tradition, forest management, and view of nature.

August, 2010

Choi, Wan Yong ; Director General of the Korea Forest Research Institute Choi, Wan Yong

Forest Eco-Atlas of Korea

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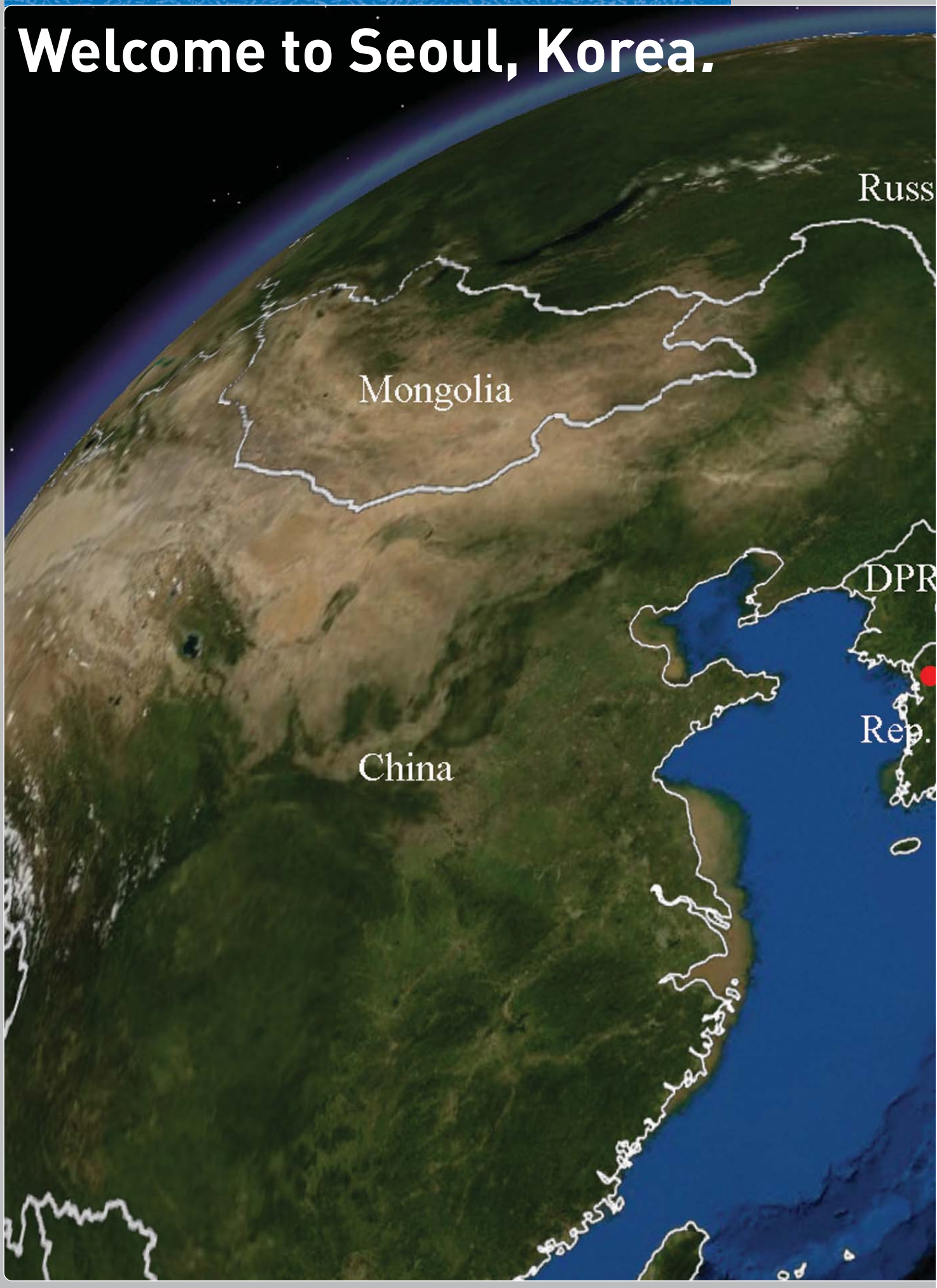
Welcome to Seoul, Korea.



Jung Hwa Chun

Sauce : ArcGlobe(ESRI)

Climate, Topography, and Soil in Korea

Climate

Korea is surrounded by the sea on three sides, marked by a wide gap of temperature, compared to the size of the land. Located on the temperate zone of the middle latitude, has a mild climate with four distinct seasons. However, the country is colder in winter and hotter in summer than other countries on the same latitude with the same seasonal distinction because it is situated on the east of the Asian continent and the west of the Pacific where periodic winds prevail. The annual range of temperatures in Korea is 20∼40℃, showing an extreme climate in both summer and winter. The climate is called a continental climate or the east coast climate. The temperatures of Seoul in the coldest day and hottest day show 25.88℉ (-3.4℃) in January and 77.72℉ (25.4℃) in August. The annual average temperature of the Korean Peninsular is lower than other countries on the same latitude. Hye-san-jin and Jeju Island show 37.40℉ (3℃) and more than 57.2℉ (14℃) of the annual average temperate respectively because northwesterly seasonal winds cause cold winter. Generally, the isothermal of the country is deep bent over the southern part from the mountainous areas centering on the ranges of Mt. Baekdu-daegan, except for the plateau called "Gaemagowon". On the eastern part of Baekdu-daegan mountain ranges, the isothermal stretches over the north and south. It indicates that inland provinces has lower temperature than coast provinces and East Coast provinces warmer climate than Western Coast provinces on the same latitude.

Korea's rainfall distribution is typical of a gradually decrease from south to north. As for precipitation, the southern coastal zone shows the largest amount of 1,500 ㎜ and the southeastern coastal zone of Mt. Baekdusan the smallest amount of 500∼600 ㎜. The southeastern coastal zone of Jeju Island has the highest precipitation of within 1,800 ㎜ nationwide. Such characteristics of Korea's climate shape a mixed climate (a peninsular climate) of a continental climate which can be seen in Manchuria and Mongolia and an oceanic climate in Japan. Thus, Korea is chilly and dry in winter, warm and humid in summer, showing a distinct difference of heat and cold and extreme temperatures in the hot and cold days. The extremely hot vapor in the country is likely to produce a barren soil.

Topography

Korea is geographically located at the eastern tip of the Asian continent as a peninsular, adjacent to Japan over East Sea to the east and the Straits of Korea to the south. Korea is neighboring China and Russia over the Amnokgang River and Dumangang River.

Mountains in Korea are leaning to the east so the eastern parts have steep slopes and the west shapes gentle slopes. Hills with gentle slopes and low sea levels gather around the mountain ranges. In the lower part of the hills, mountain streams run. When it comes to the distribution of the mountains

Im-Kyun Lee

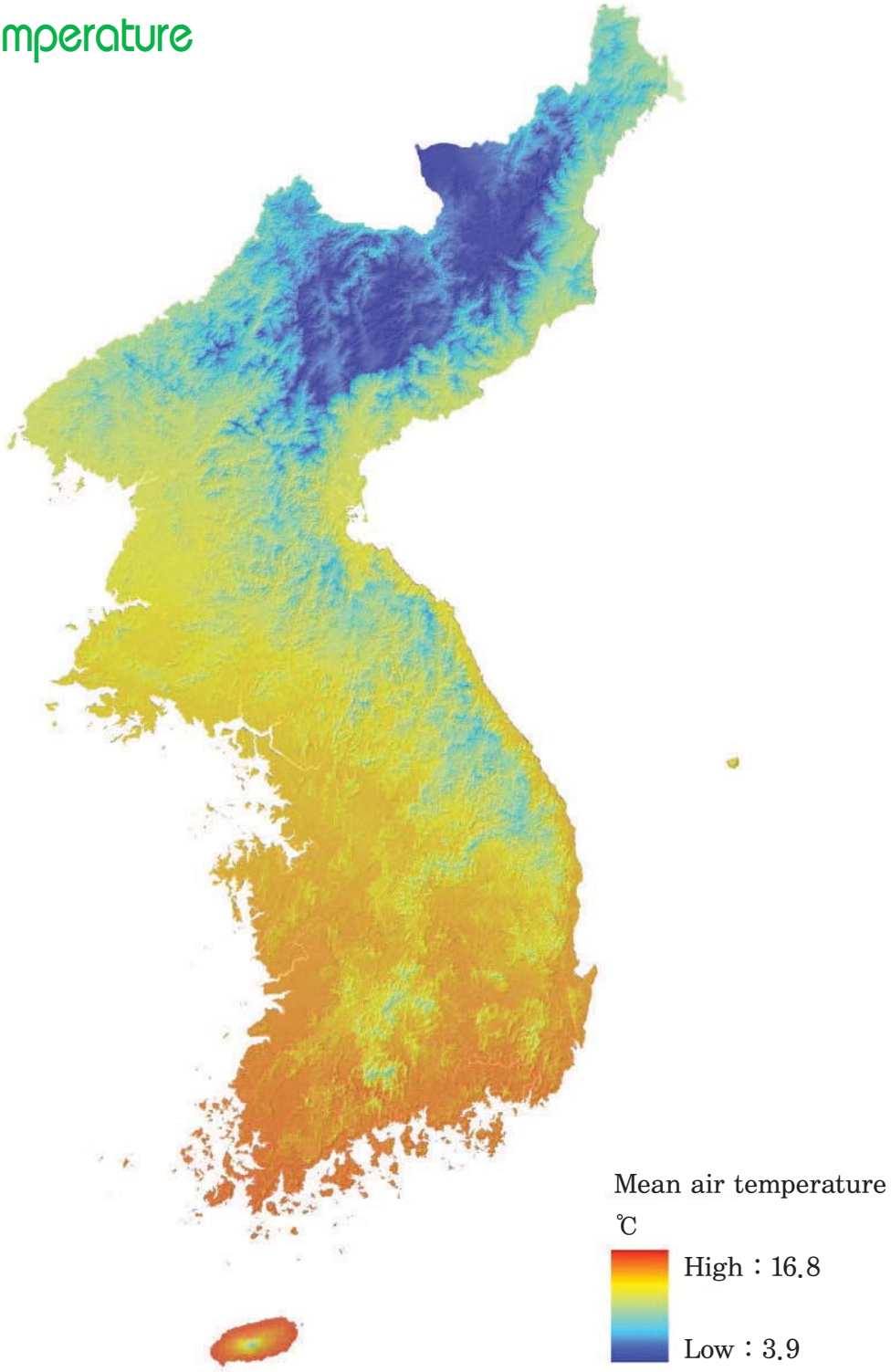
by latitude, high mountains of above 2,000 m are distributed in North Korea. Mt. Baekdusan, the highest peak of the Korean Peninsular, is 2,744 m and Mt. Hallasan, the highest peak of South Korea, is 1,950 m, followed by Mt. Jirisan of 1,915 m. Overall, the Korean Peninsular has within 500 m-or-less mountains, except for the 1,500 m-high Gaemagowon plateau, and 1,000 m-high Baekdu-daegan mountain ranges.

Geology & Soil

Half of the soil in Korea is composed of gneiss complex including granite, granite gneiss and granitic gneiss. This derives from the protuberance and denudation of granite interpenetrated from the rocks of the pre-Cenozoic era and its degenerated granitic gneiss since the Cretaceous period and the diastrophic period. The soil is classified by region into Gyeonggi metamorphic, Sobaeksan metamorphic complex, Jirisan metamorphic complex, etc.

On the soil of Korea, brown soil of mountains and forests, podzol soil, red soil and dark red soil are found due to the climate characteristics. Brown soil of mountains occurs in the middle provinces with a high temperature and precipitation in summer and in the southern provinces where deciduous broad-leaved forests are widely found. Podzol soil is seen in the cold environment with a high level of organisms. The Gaemagowon plateau where coniferous forests grow is well-known for consisting of podzol soil. Red soil is found markedly in the hills with low sea levels and gentle slopes on the foot of mountains in South Korea. The soil is reportedly produced under the past climate of a high level temperature and humidity, rather than a present climate. Korea has a much sandy soil weathered from granite and clay soil weathered from gneiss. Dark red soil ranges in the limestone zone found in South Pyongan Province and Hwanghae Province in North Korea; Gwangwon Province and its neighbors of North Chungcheong Province and North Gyeongsang Province in South Korea. Basaltic weathered soil and volcanic ash soil are seen in Jeju Island and Ullung Island both of which underwent the eruption of volcanos. In terms of the local environmental factors affecting the growth of the forest trees in Korea, for example larch is located by the following order of factors: climate, depth of soil, slope and topography. The growth of *Pinus densiflora* for. *erecta* is influenced by topography, shape of slope, and direction; pines of the Middle Province by topography, degree of dryness, moisture, depth of soil; oaks by topography, depth of soil, solidity and density of soil; black pines by depth of soil, degree of dryness, moisture, and topography.

Mean Temperature



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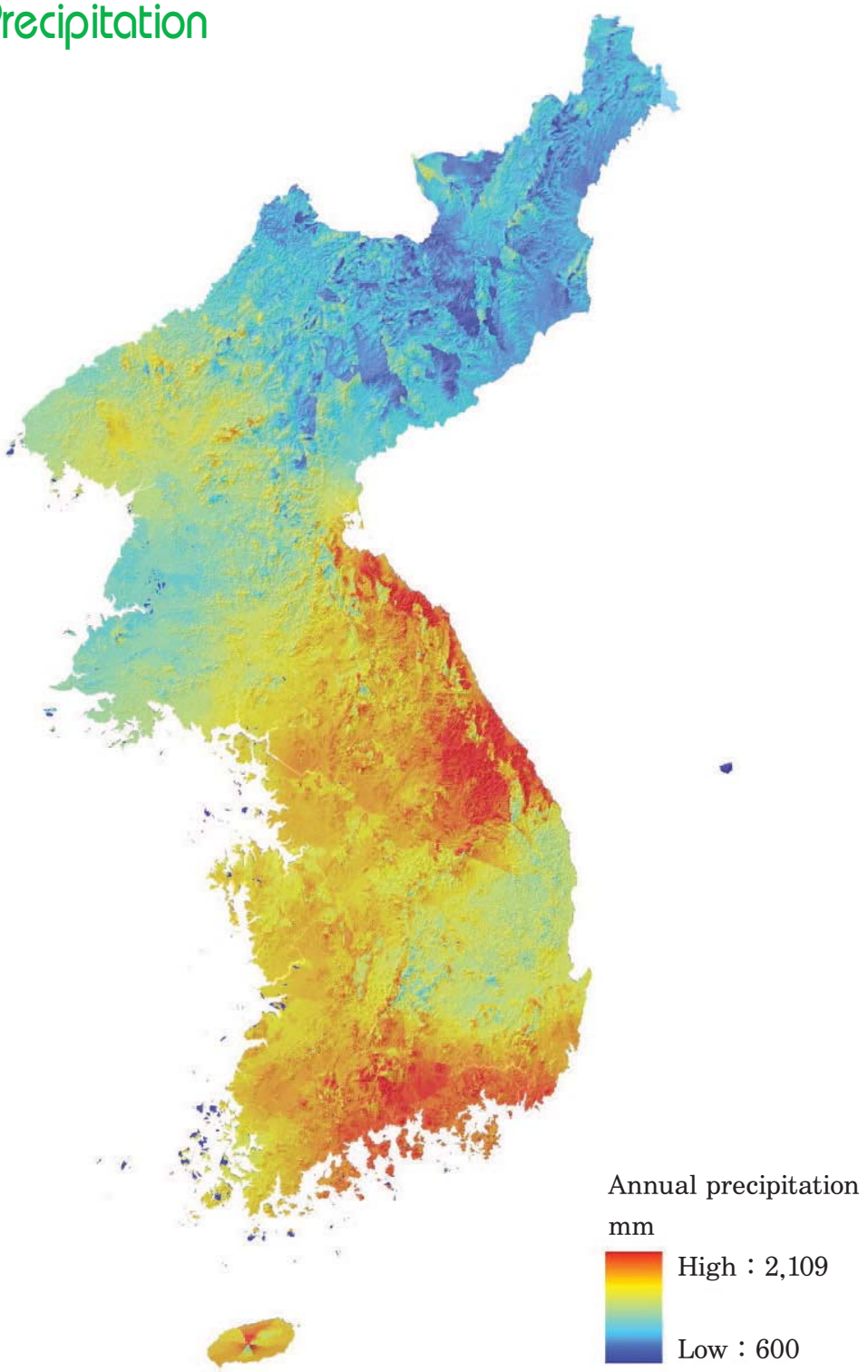
Annual Precipitation



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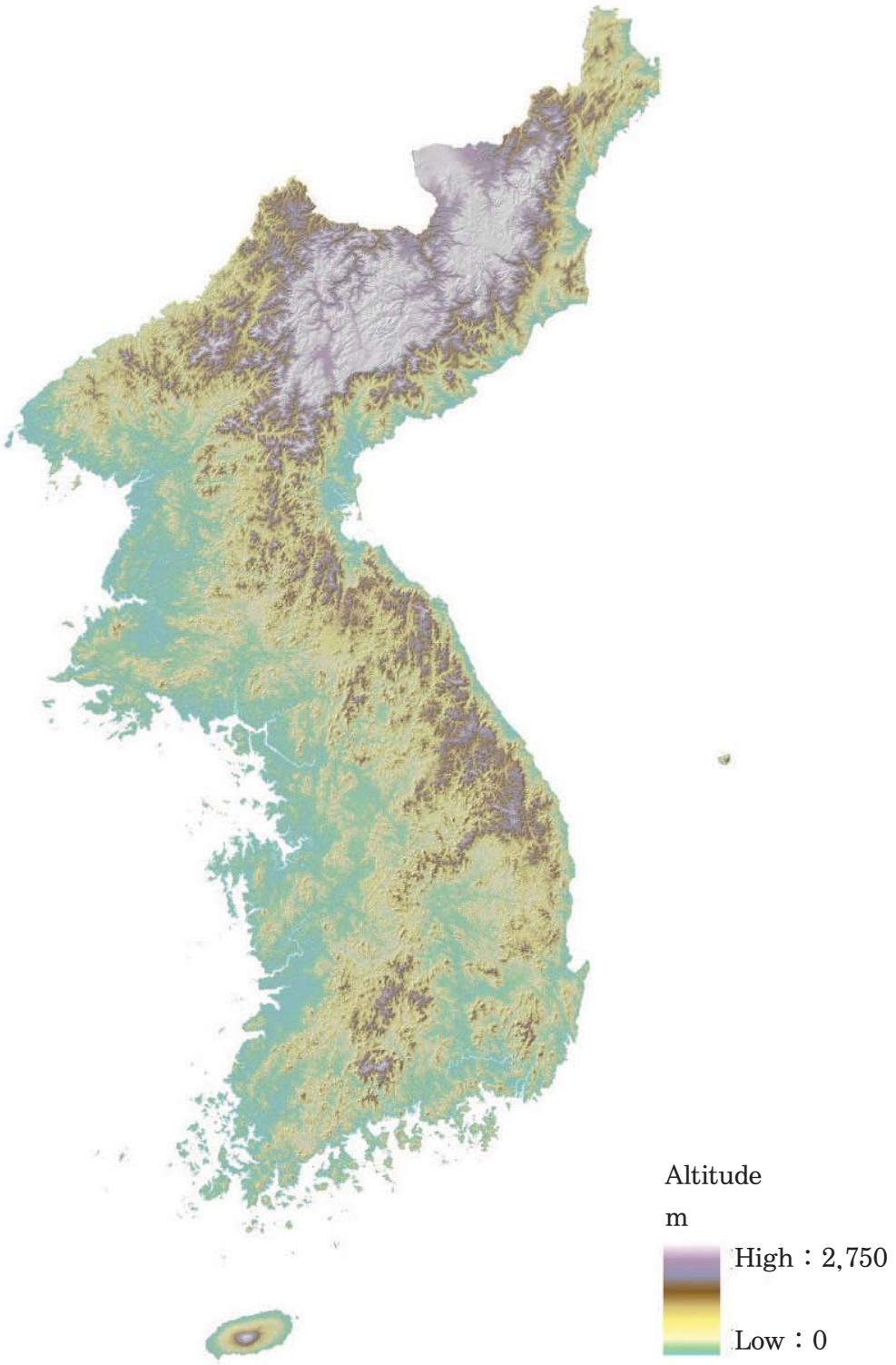
Altitude



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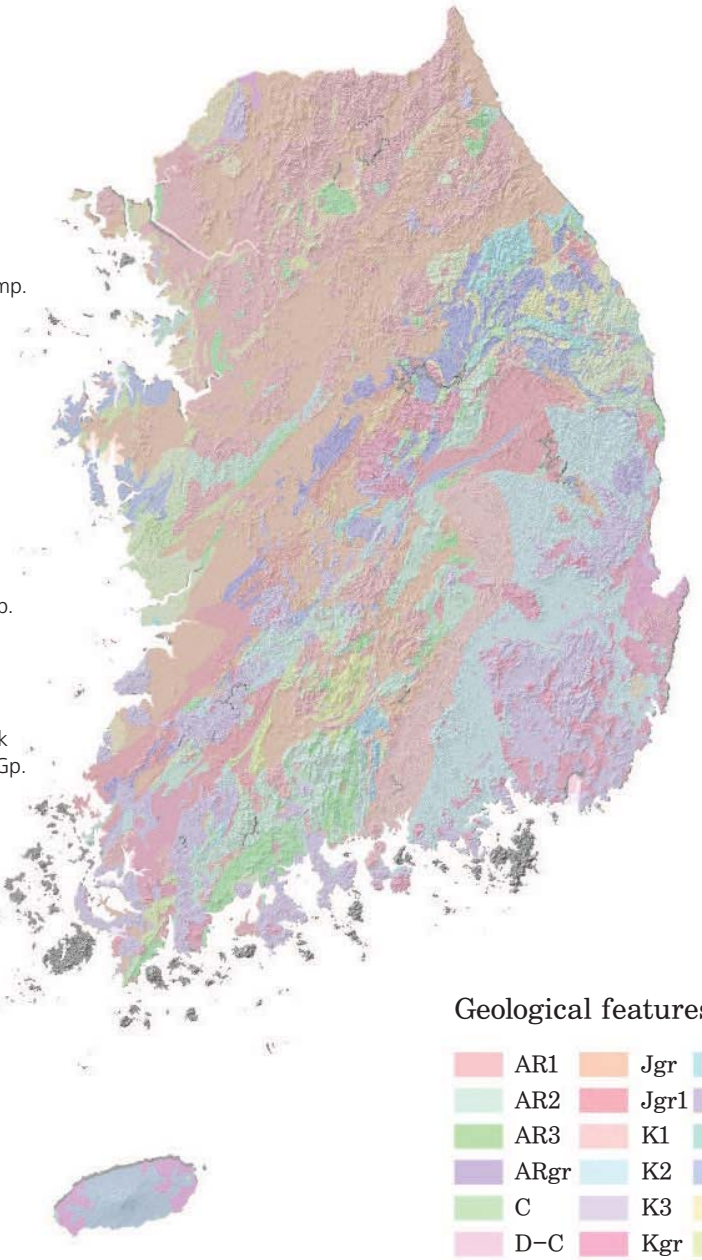
Geological Features

AR1 : Rangrim Gp., Gneiss, Migmatitic Gneiss
AR2 : Granitic Gneiss
AR3 : Porphyroblastic Gneiss
Argr : Rangrim Granite, Andol Comp., Ryonhwasan Comp.
D-C : Rimjin Gp.
J1: Daedong Gp.
J2 : Jasong Gp.
Jgr : Daebo Granite, Tanchon Comp.
Jgr1 : Foliated Granite
K1 : Sindong Gp., Hanbongsan Gp., Packchon Gp., Pongchonbong Gp., Seson Gp.
K2 : Hayang Gp., Ponghwasan Gp., Neungju Gp., Jinan Gp.
K3 : Yucheon Gp., Jaedok Gp.
Kgr : Amnokgang Comp., Bulgugsa Granite
N : Hamgyong Gp., Yeonil Gp.
O : Great Limestone Gp., Singok Gp., Mandal Gp., Sangsori Gp.
P : Tuman Gp.
PALgr : Namgang Comp., Chongjin Comp., Tumangang Comp.
PALv : paleozoic Basic Volcanic Rocks.

PR1 : Seosan Gp., Yulri Gp., Machollyong Gp., Musan Gp., Hwanghae Gp.
PR2 : Sangwon Gp. North Type, Jikhyon Gp., Sadangu Gp., Yeoncheon Gp., Janrak-Euiam Gp.
PR3 : Sangwon Gp. South Type, Jikhyon Gp., Sadangu Gp., Mukchon Gp., Kuhyon Gp., Taean Fm.
PRgr : Buncheon Granite, Hongjesa Granite, Sancheong Anorthosite(PRan), Riwon Comp., Sakju Comp., Pyoksong Comp., Ongin Comp., Seosan Cranite Gneiss, Yonsan Comp.
PRv : Proterozoic Basic Volcanic Rocks.
Pgr : Hangmusan Comp., Pongsan Comp., Namsan Granite
Q1 : basalt, Trachytes
Q2 : Basalt, Volcanic Rocks, Trachytes
Q3 : Pumice, Marine, Sediments
S : Koksan Fm., Wolyangri Fm., Hoedongri Fm.
Tgr : Hyesan Comp., Pyonggang Comp.



Geological features

AR1	Jgr	P–T	Pgr
AR2	Jgr1	PALr	Q1
AR3	K1	PALv	Q2
ARgr	K2	PR1	Q3
C	K3	PR2	S
D–C	Kgr	PR3	Tgr
E	N	PRan	og1
J1	O	PRgr	og2
J2	P	PRv	og3

N

0 50 100 Kilometers

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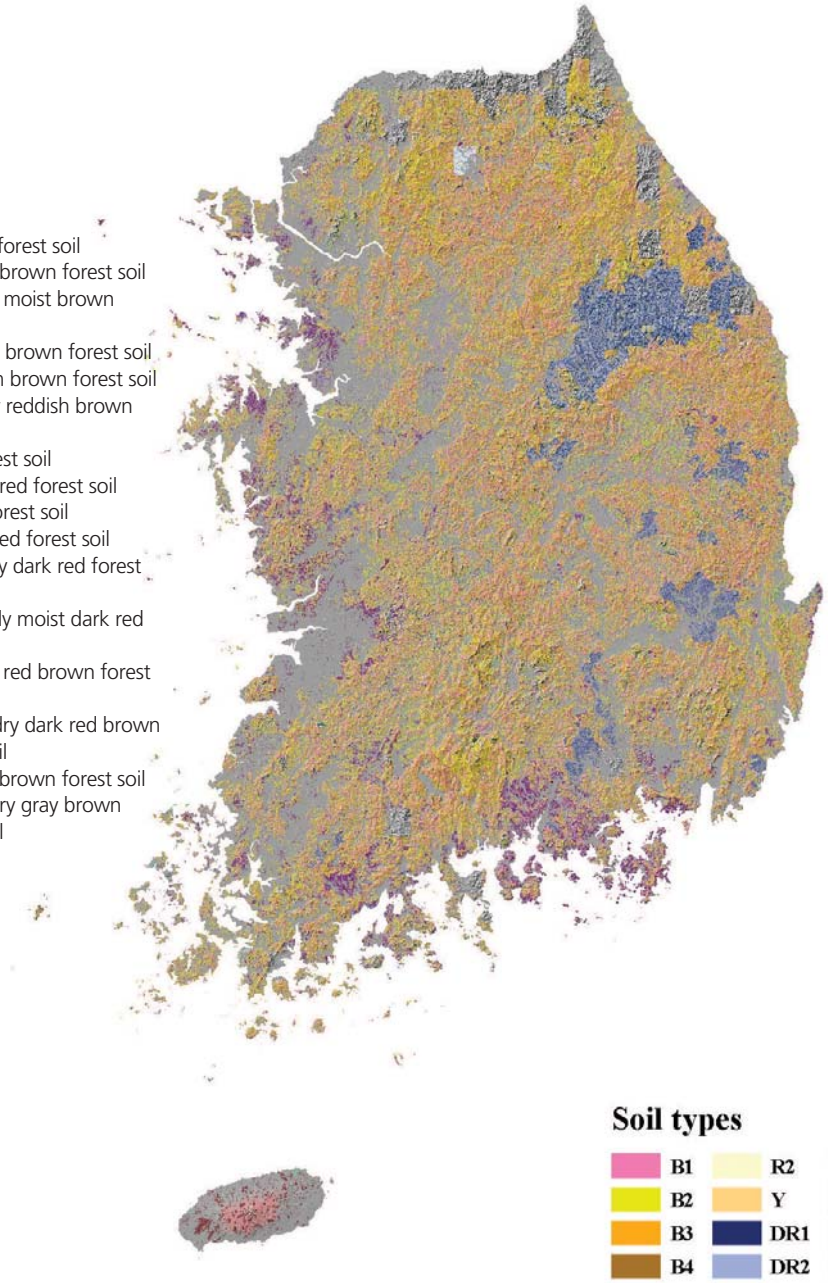
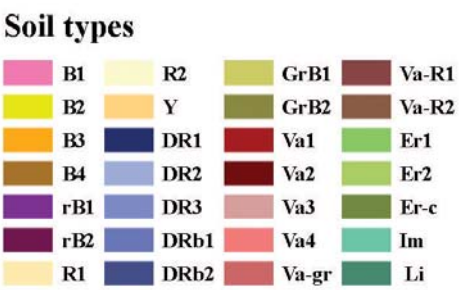
Soil Types

B1 : Dry brown forest soil
B2 : Slightly dry brown forest soil
B3 : Moderately moist brown forest soil
B4 : Slightly wet brown forest soil
rB1 : Dry reddish brown forest soil
rB2 : Slightly dry reddish brown forest soil
R1 : Dry red forest soil
R2 : Slightly dry red forest soil
Y : Dry yellow forest soil
DR1 : Dry dark red forest soil
DR2 : Slightly dry dark red forest soil
DR3 : Moderately moist dark red forest soil
DRb1 : Dry dark red brown forest soil
DRb2 : Slightly dry dark red brown forest soil
GrB1 : Dry gray brown forest soil
GrB2 : Slightly dry gray brown forest soil

Va1 : Dry volcanic ash forest soil
Va2 : Slightly dry volcanic ash forest soil
Va3 : Moderately moist volcanic ash forest soil
Va4 : Wet volcanic ash forest soil
Va-gr : Gravel volcanic ash forest soil
Va-R1 : Dry red volcanic ash forest soil
Va-R2 : Slightly dry red volcanic ash forest soil
Er1 : Slightly eroded soil
Er2 : Severely eroded soil
Er-c : Erosion controlled soil
Im : Immature soil
Li : Lithosol





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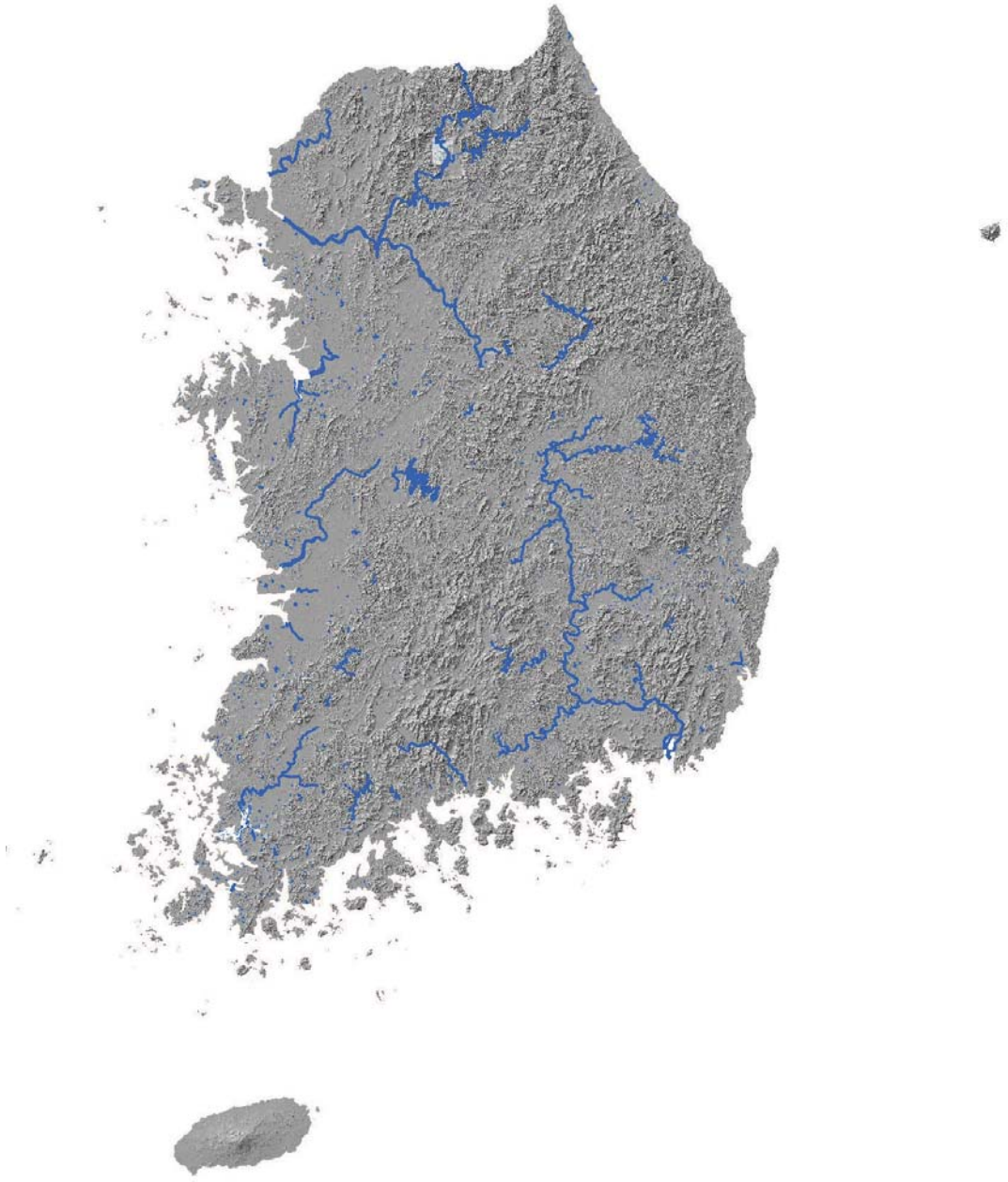
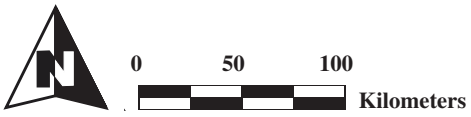
Water System



Major rivers and lakes



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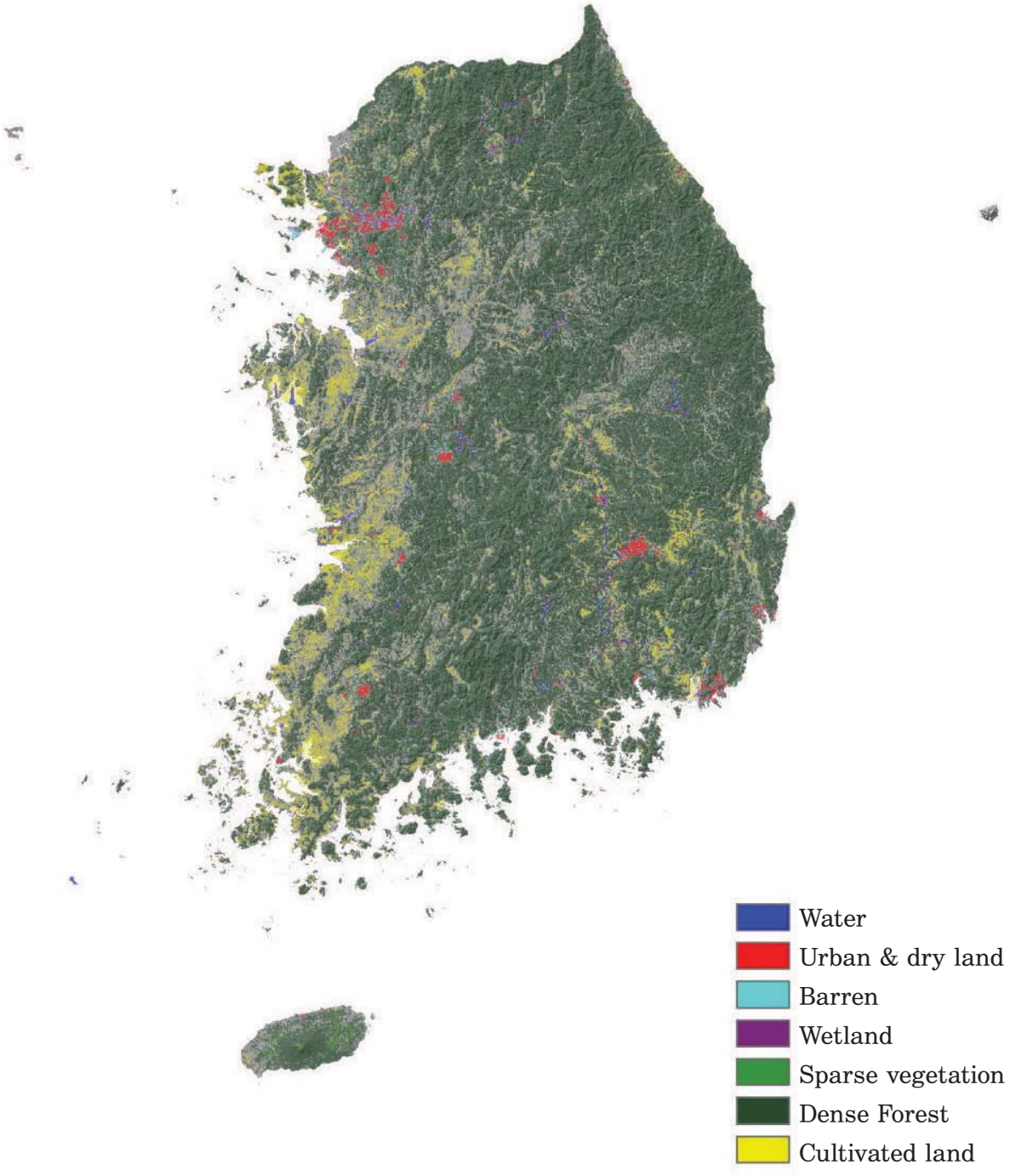
Land Cover



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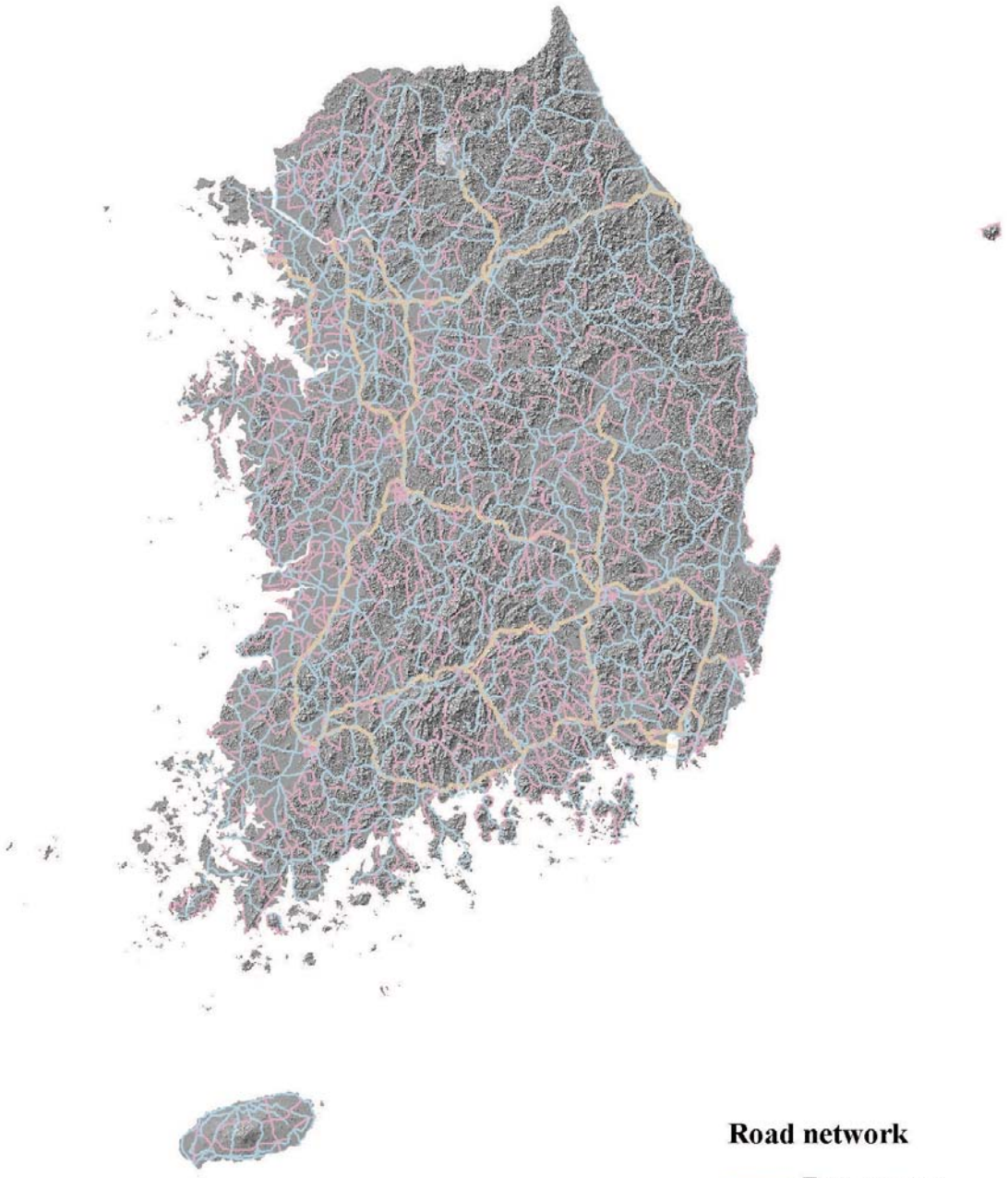
Road Network



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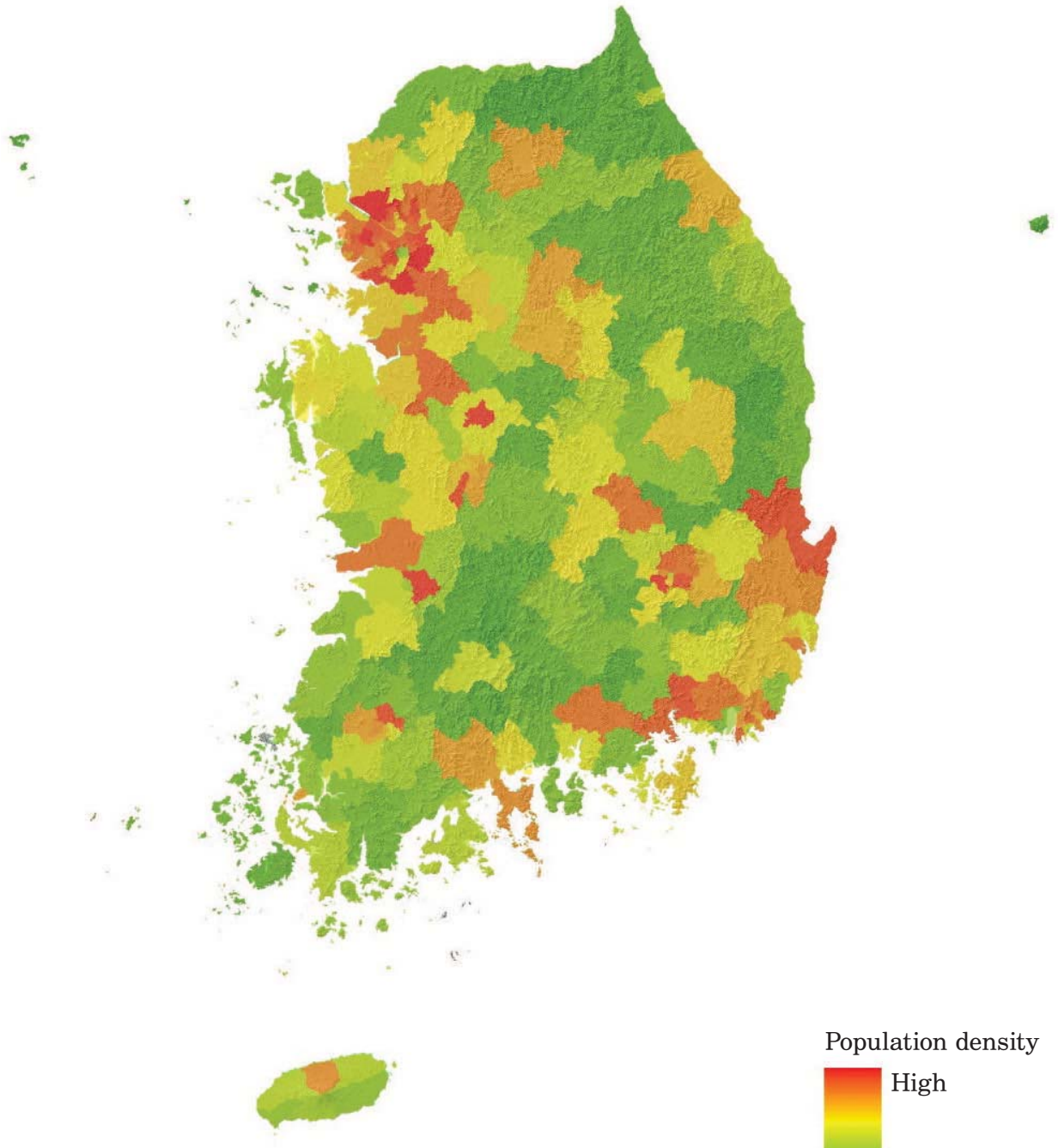
Population Density



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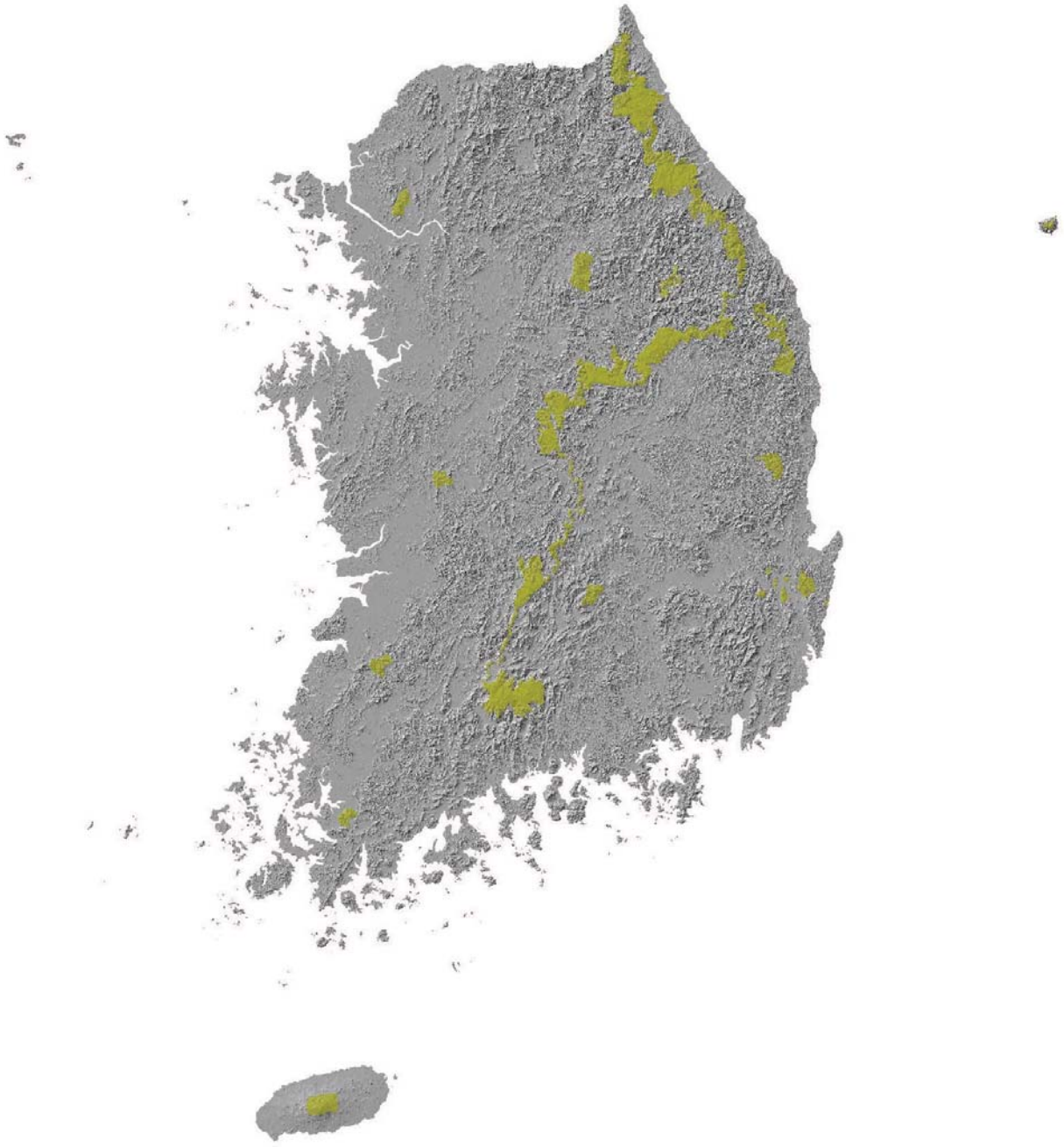
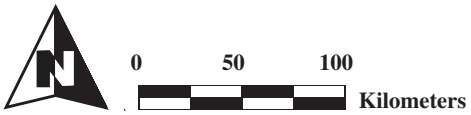
Protected Forests





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Vegetation Changes and Disturbances in Korea

About 18,000 years ago, the Korean peninsula faced the Ice Age, and it was linked to Japan and Taiwan. Most of the areas on the Korean peninsula were the tundra vegetation zone, where the growth of plants and trees was restricted by cold weather, while shrubs, herbaceous plants, and lichens were dominating.

As climate got warmer, most of the areas on the Korean peninsula became the temperate zone. Boreal forests remain in North Korea and in high mountains of South Korea. Warm-temperate forest zone where evergreen trees are dominating is scattered in the southern coastal region and the low-lying areas in Jeju Island.

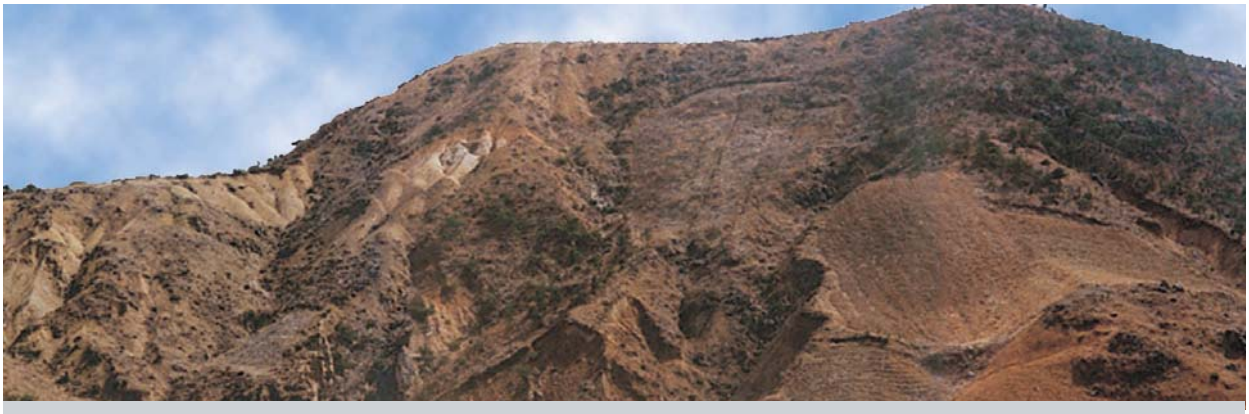
The world's first rain gauge was invented in 1,442 (the Joseon dynasty). We have precipitation data of Seoul from the late 18th century to today. Based on the data, it is found that there were very severe droughts in the middle and late 18th century, and between in the late 19th century and the early 20th century. It seems that the amount of precipitation showed big differences every year.

From the late 19th century to the middle 20th century, there were Japanese occupation period and the Korean War, in addition to terrible drought. As the agricultural and economic conditions deteriorated, Korean heavily relied on forest which provides a source of fuel, timber and food. As a result, forest was extremely deteriorated, and the volume of forest growing stock in the 1960s was less than 10 m^3/ha.

Most of the forests and mountains were denuded. When heavy rain fell, soil erosion was severe. Also, Korean red pine (*Pinus densiflora*) which is a pioneer species become dominant in new forests, which accounted for 60% of the total forest land area in South Korea. Due to the low diversity of forest ecosystem, they fell victim to various insects, such as pine caterpillar, pine needle gall midge, and black pine bast scale. Over the recent 20 years, pine wilt disease has also caused great damage to pine trees. Since the 1980s, there has been less damage done by insects. Meanwhile, pests that eat away deciduous tree species are gradually on the rise. Consequently, the damaged areas increases.

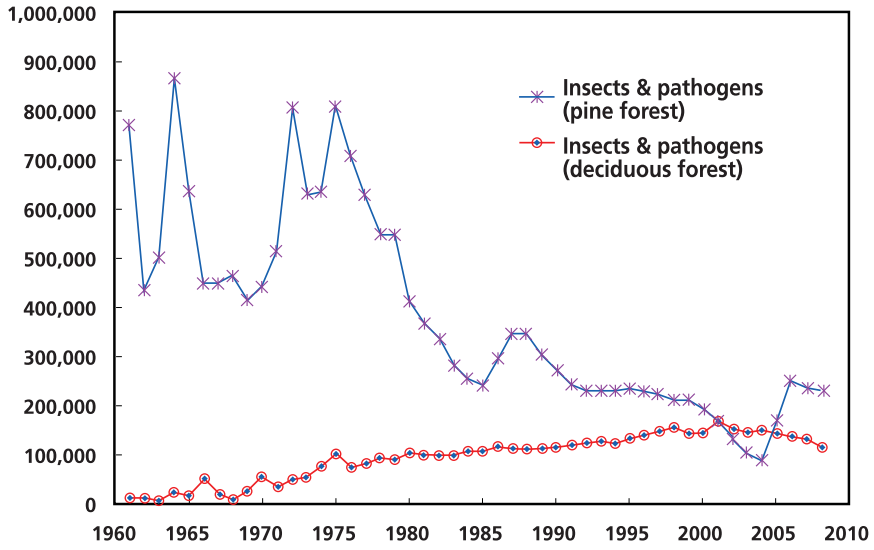
Forest has been fairly recovered due to the efforts to protect forest and replace woody fuels with other sauces, in addition to the success of forestation in the 1970s. At the end of 2007, the volume of forest growing stock reached at 97.8 m^3/ha. Oak forest is gradually replacing the once-dominant Korean red pine forest due to the natural vegetation development and pests. At the end of 2007, oak forest accounts for 27%, which is higher than 23% of Korean red pine forest.

Jong-Hwan Lim



Before reforestation

After reforestation

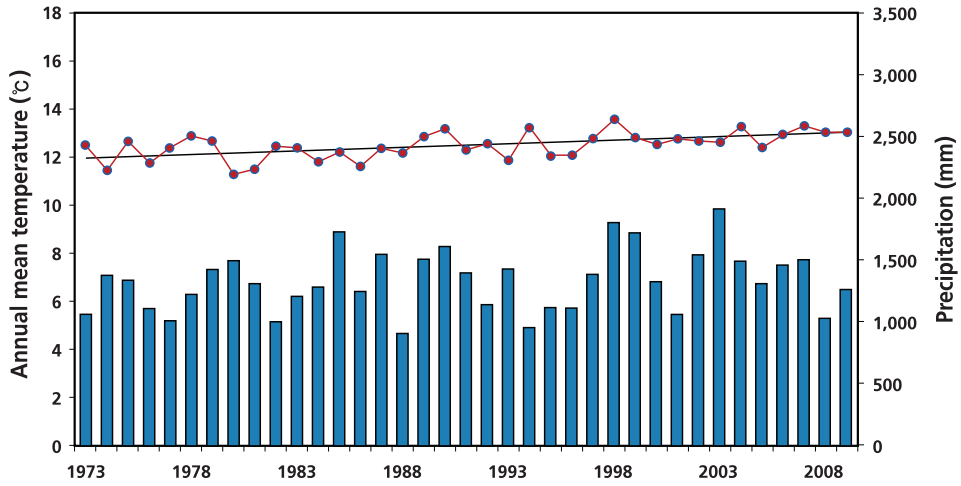


The changes of the damaged land caused by forest pests in South Korea.
[Source: Korea Forest Service (Every year) Statistical Yearbook of Forestry]

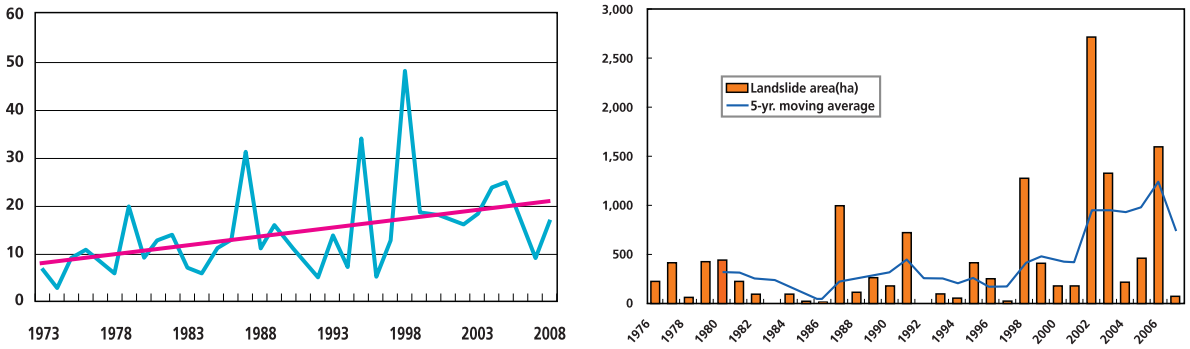
From the 1970s to 1980s, forest had been partially destroyed due to urbanization and industrialization, and suffered from air pollution. Since the 1990s, however, the efforts to make forest greener have been made, such as environment protection campaign, implementation of sustainable forest management, conservation of forest ecosystem, and restoration of devastated forests. According to the data from 61 weather stations in South Korea, the annual average temperature has risen by 1˚C over the past 36 years due to climate change and urbanization effect. The average winter temperature (from November to February) has grown by 1.87˚C, which is the fastest seasonal temperature rise. Also, the number of torrential rain days has increased, and rainfall of over 50 mm per hour increases. Under these circumstances, it is likely that extreme weather events will occur more frequently than ever, leading to the increase in damage.

Due to climate change, it is expected that the vegetation range will shift from low to high latitude and from low-lying to high lands. According to the climate change scenario, most of the temperate areas will become warm-temperate zone. Warm-temperate zone will become subtropical areas. However, trees will have difficulties in catching up the rapid change of climate, so some populations of them will be reduced. As a result, it is expected that the genetic diversity of some tree species will be decreased. The vegetation in the subalpine zone and the following tree species – yezo spruce, Korean fir and Korean yew (*Taxus cuspidata*) - are usually grown in high mountains. Therefore, these tree species and vegetations are expected to be significantly decreased because they will have to survive fierce competitions with other tree species which move up from low altitudes. In addition, the unsuitable climate change in the future is another factor in reducing such tree species

Yezo spruce (*Picea jezoensis*) forest in Gangwon-do province, Korea

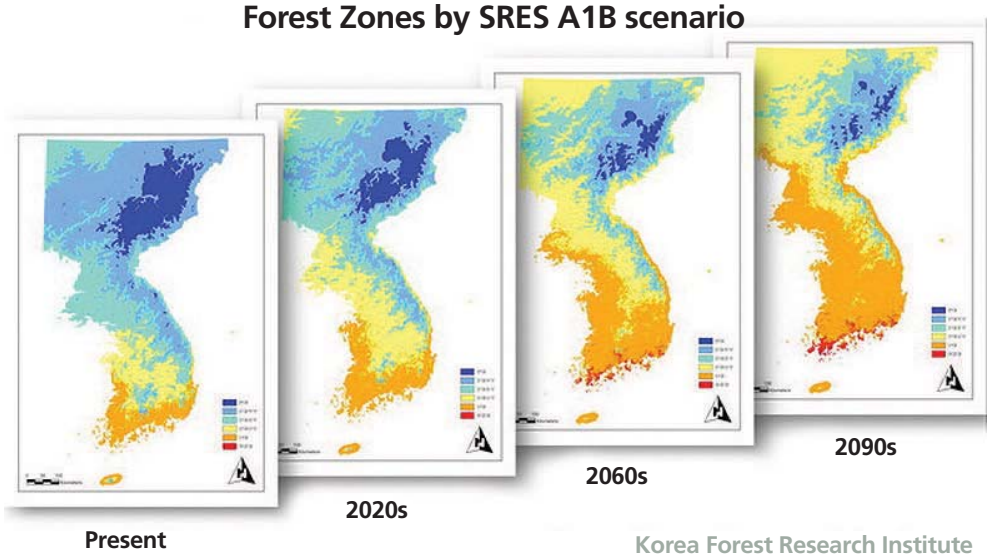


Changes of annual mean temperature and precipitation based on 61 meteorological stations in Korea. [Source: KMA (Korea Meteorological Administration)]



Changes of the number of annual heavy rainfall events higher than 50 mm per hour(left) [KMA 2009] and landslide area (right). [Source: Internal data of Korea Forest Service. 2008]

Predicted Changes of the Major Climatic Zones matching with Forest Zones by SRES A1B scenario



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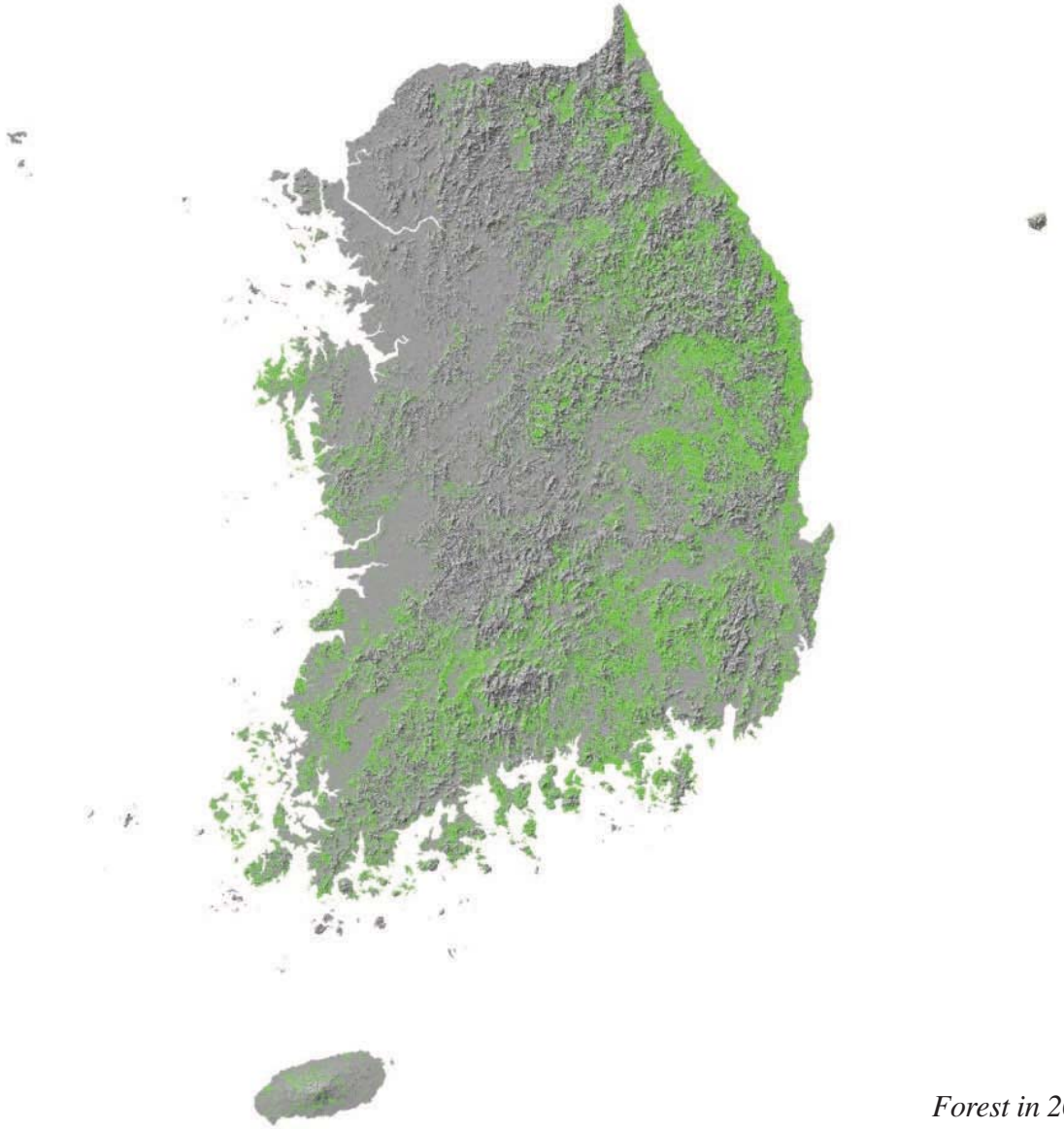
Pine Forest (*Pinus densiflora, P. thunbergii*)

Pine forests of South Korea have two types of *Pinus densilora* and *P. thunbergii*. The latter is found in the coastal mountains and forests. The size of the land of pines in South Korea is on a decreasing phase. In 1974, the size of the land accounted for 49% (3,230,000 ha) of the entire forests. However, in 2007, the size declined to 23% (1,470,000 ha) of the entire forests.

[Source: Korea Forest Service. 2009. Statistical Yearbook of Forestry No. 39]



Forest in 2005

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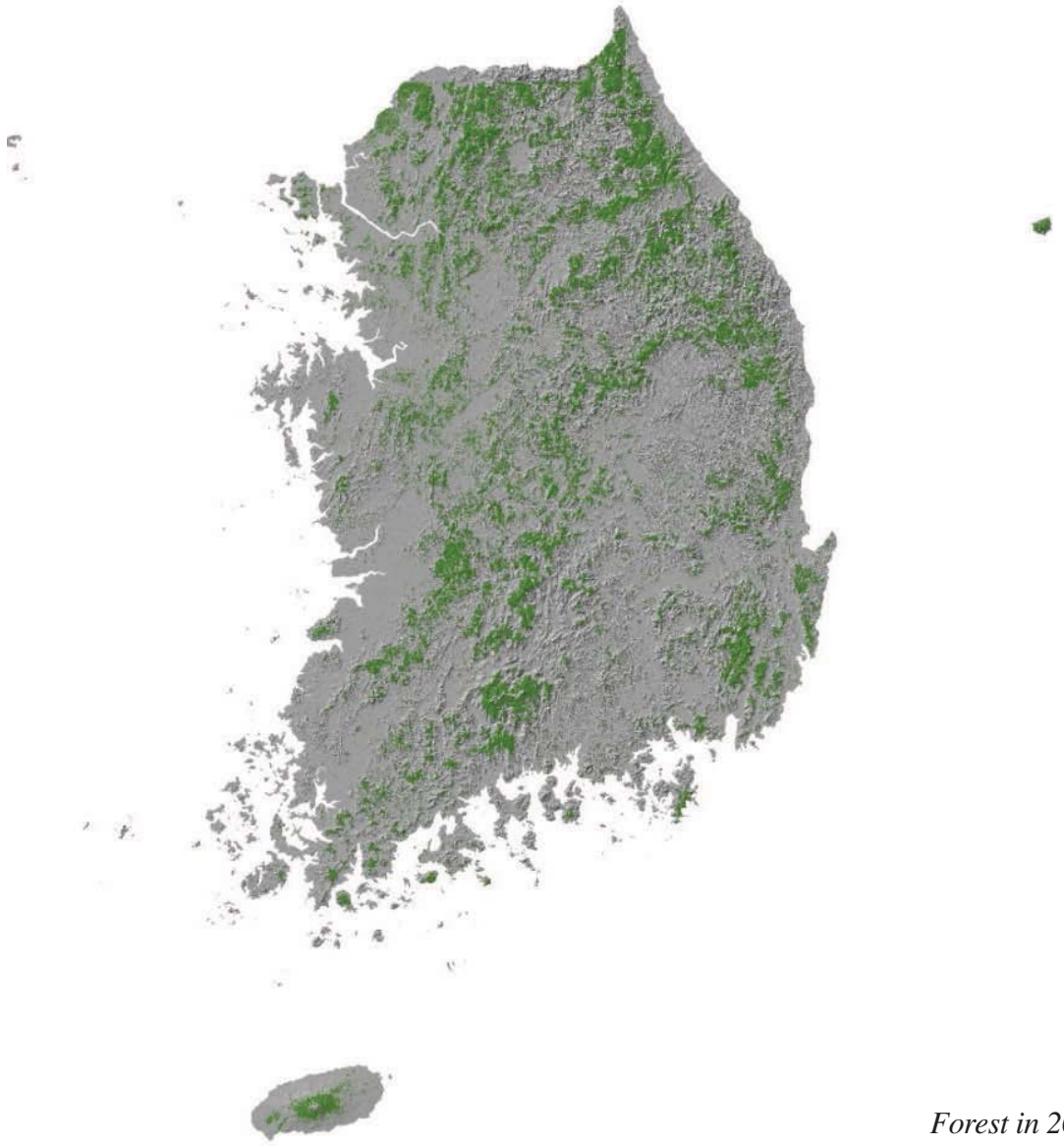
Deciduous Forest (*Quercus* spp.)

Pine forests in South Korea are decreasing and deciduous forests are increasing. *Quercus* spp. is the most noticeable type of deciduous forests. South Korea has 6 kinds of *Quercus* species. In particular, *Quercus mongolica, Q. serrata, Q. aliena and Q. dentata* are widely found in South Korea. The current size of the land of deciduous forests stands at 1,660,000ha.

[Source: Korea Forest Service. 2009. Statistical Yearbook of Forestry No. 39]



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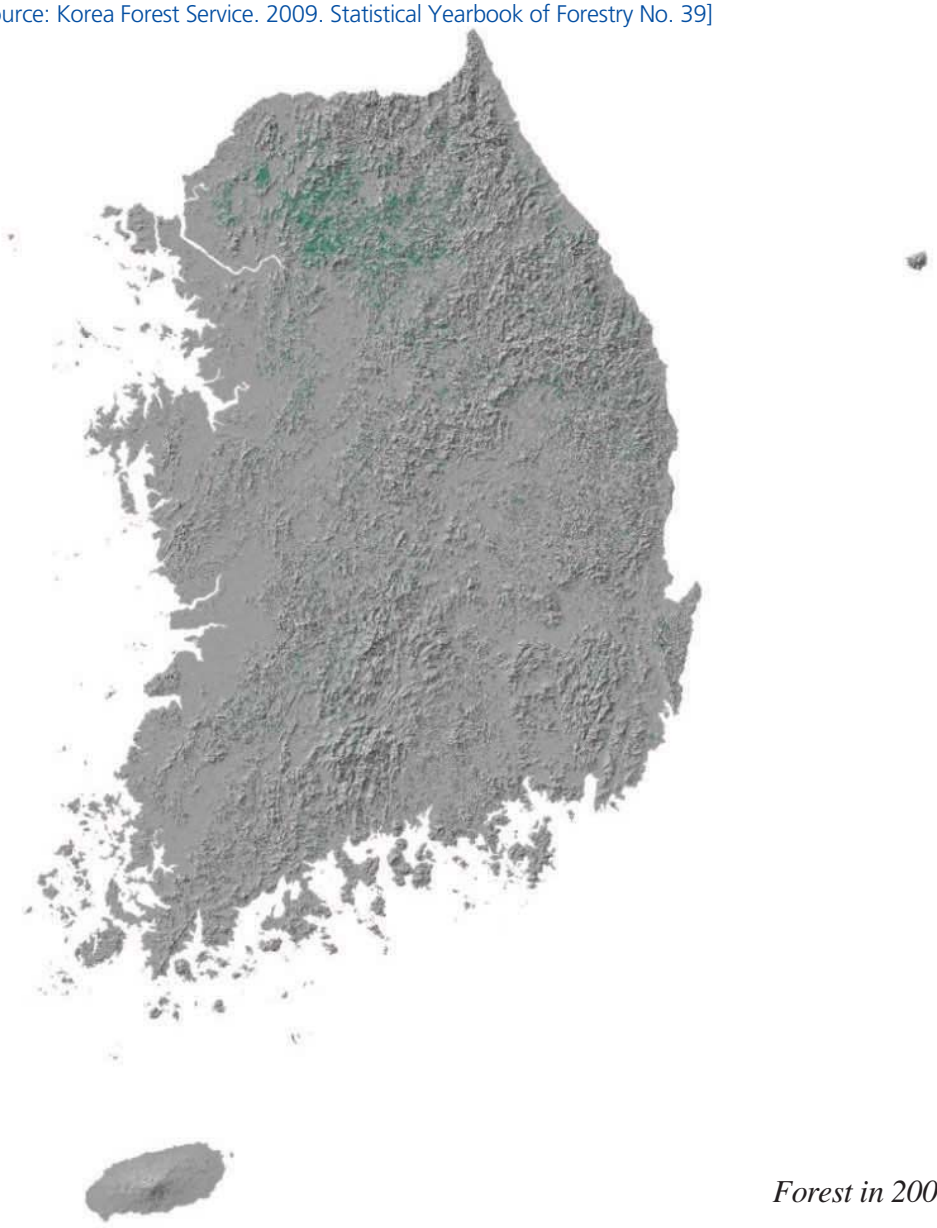
Planation (*Pinus koraiensis*)

Pinus koraiensis is endemic species of northeast Asia. The natural locations of the tree range from North Korea and Northeastern part of China to the farthest section of Russia. In South Korea, natural types of *Pinus koraiensis* are found along high mountains, but most *P. koraiensis* in Korea was planted. Currently, South Korea has 230,000 ha-sized plantations of *P. koraiensis*, mostly in the middle western part of Korea. [Source: Korea Forest Service. 2009. Statistical Yearbook of Forestry No. 39]



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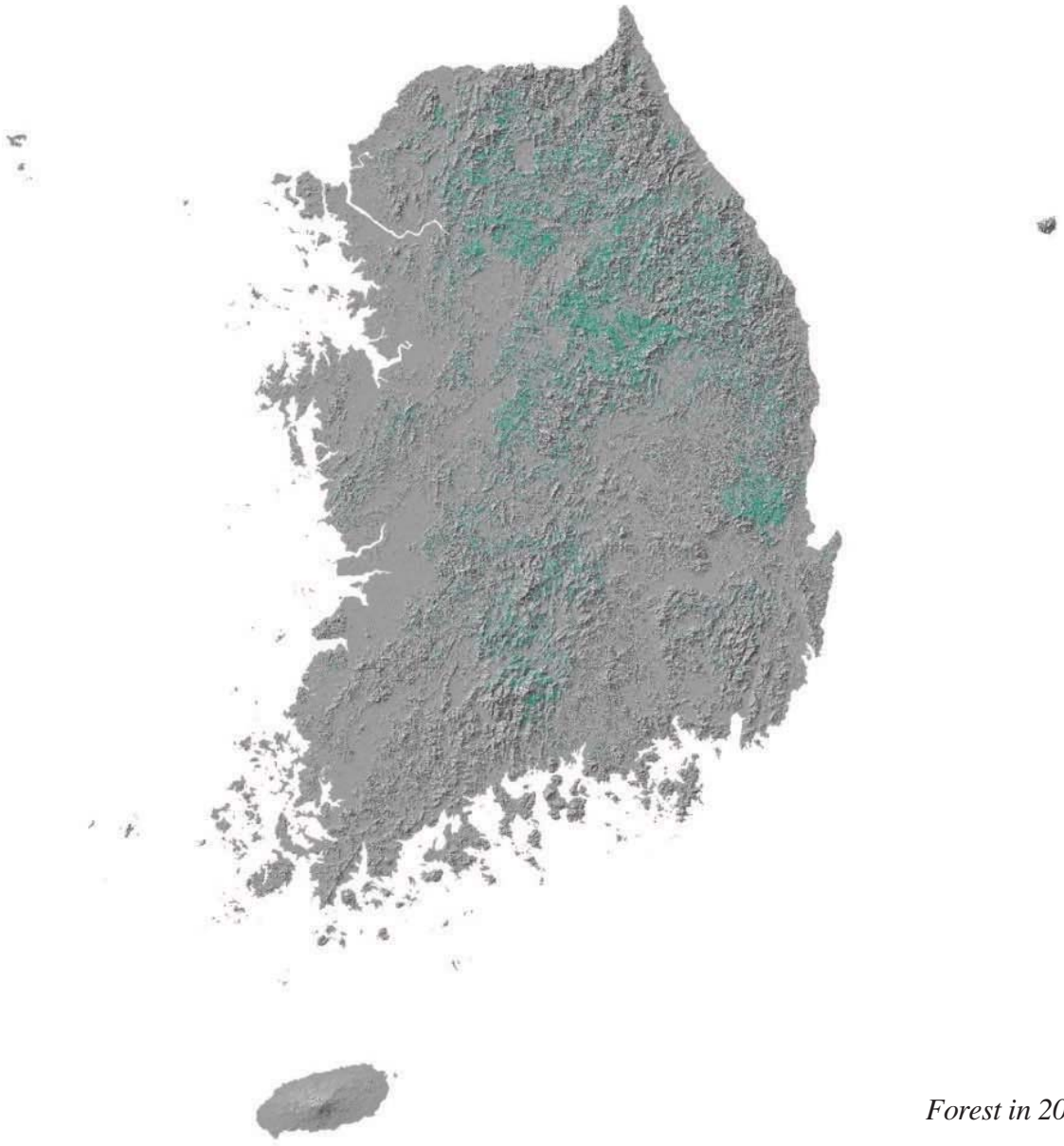
Plantation (*Larix kaempferi*)

Larix kaempferi is a species planted most in South Korea. Currently, this type of trees is planted in 460,000 ha-sized land.

[Source: Korea Forest Service. 2009. Statistical Yearbook of Forestry No. 39]



Forest in 2005

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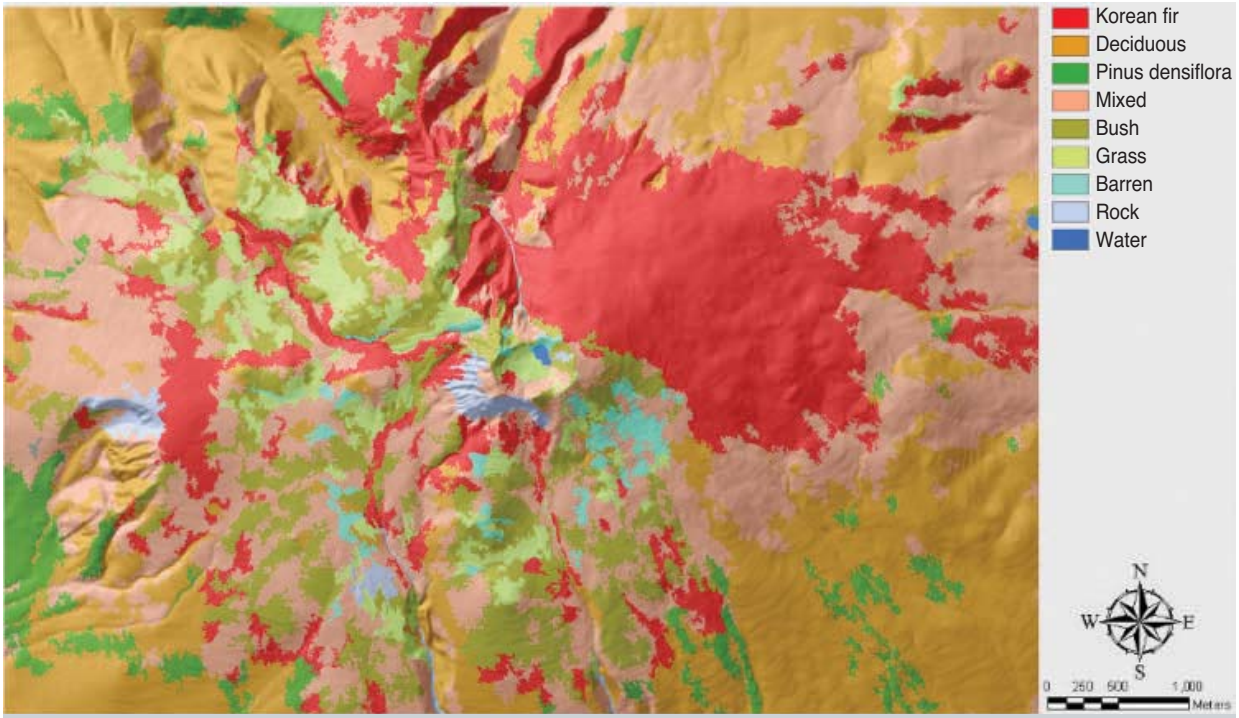
The Decline of Korean Fir Forests Due to Climate Change

Korean fir (*Abies koreana*) grows naturally in high mountains in South Korea, such as Mt. Deogyusan, Jirisan, and Hallasan. Also, Korean fir is a rare endemic tree species, so it is registered on the IUCN red list. In addition, it is used for landscape architecture due to its beauty. Korean fir forest is the densest at the top of Mt. Hallasan. Since the 1990s, however, this forest has been gradually losing ground. The cause of this problem is now being investigated.

According to the recent global warming, increases in temperatures and in the frequency, duration and/or severity of drought and heat waves could have affected on forest structure, composition, and even biogeography. Korean fir (*Abies koreana*) which is rare and endemic, is distributed on high mountains in Korea. To understand the spatial differences and speed of declining, we set permanent plots and air temperature/humidity sensors on three locations in 2003. Then, we draw stem-maps and measured mortality every year, leaf conditions, e.g. leaf length, leaf folding symptoms, and in-situ physiological responses to air temperature. Using Landsat TM and IKONOS images, we made the vegetation map and assessed the changes in NDVI from 1994 to 2003. While populations on north-eastern slope showed vigorous growth, those on south/west were sparse and declining.

These healthy Korean fir trees grow on fertile soil

Jong-Hwan Lim



Vegetation distribution map around the top of Mt. Hallasan. Korean fir forest is dyed with a red color (by J.H. Chun)

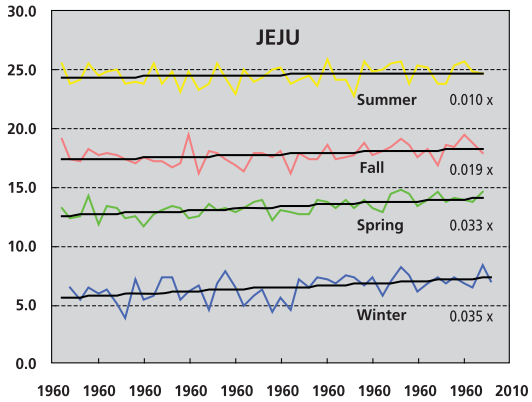
Korean fir forests on the southern and western slopes are declining rapidly from late 1990s

NDVI on southern and western slope was significantly decreased during the period, while no changes on north- eastern slope detected. Tree mortality was increased linearly according to the rise in previous winter temperature in two plots on southern and southwestern parts of the peak. Physiological measurement data including net photosynthetic rates, showed that higher temperature than 15℃ in June is stressful to Korean fir trees. Consequently, the recent Korean fir forest decline in Mt. Hallasan especially on southern and western slope where solar energy input is higher than north-eastern slope has been accelerated by water stress due to the imbalance between water requirement and supply from roots in winter and spring. This hypothesis was supported by the result of the mortality was linearly increased by the increase of air temperature in winter.

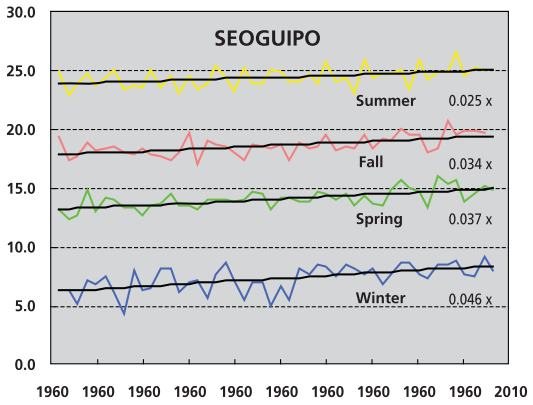
According to the climate change scenario, air temperature will be increased much higher in winter season than summer while precipitation in winter will not be increased significantly. Thus declining of Korean fir forests in Mt. Hallasan is expected to be proceeded faster in the future due to warming, and the speed of declining of the forests on southern/western slope will be faster than north-eastern slope. Shrinkage of the population size will result in loss of genetic diversity.

This Korean fir withers after loss of leaves and decoloration

Air temperature increase during the last 45 years



Annual mean temp. 1.24℃,
and winter temp. 1.57℃ increased



Annual mean temp. 1.68℃,
and winter temp. 2.05℃ increased

The Korean fir forest is located at the top of Mt. Hallasan

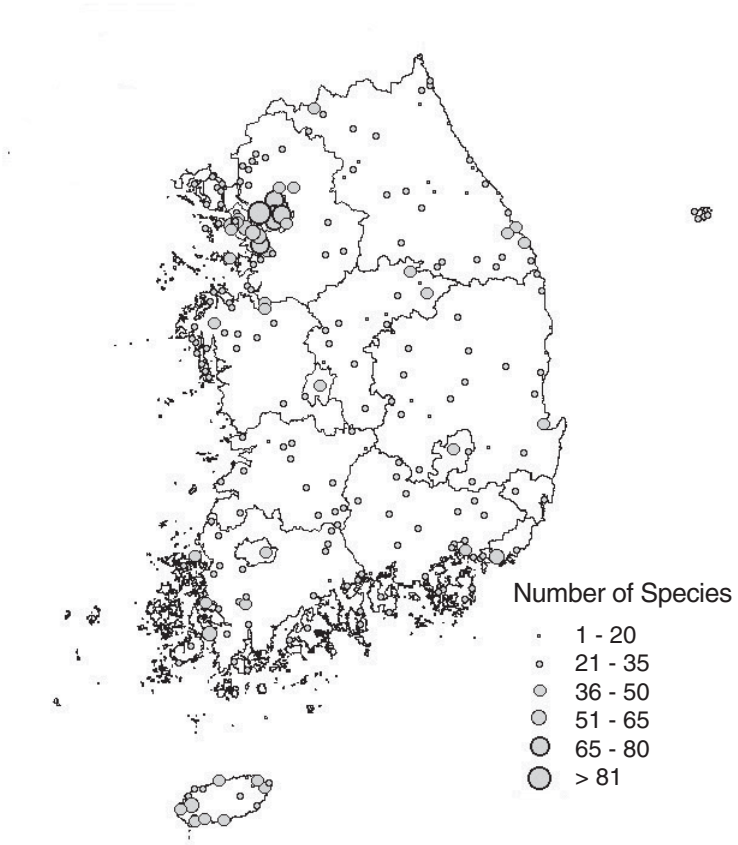
Naturalization and Invasion of Alien Plants

The Korea Forest Research Institute had investigated the distribution of naturalized plants in 257 forests from 1997 to 2001. The Institute found that 37 family and 271 species were found (Park *et al*. 2002). Since then, the species of naturalized alien plants may have been on the increas. Most of them grow especially in open fields or disturbed areas. According to the classification standard by administrative district, 150 species are distributed in Gyeonggi Province, 147 species in Seoul, 132 species in Jeju Island, and 128 species in Incheon. Many species are found in Jeju Island. This is possible because there is a lot of pasture in the island.

More specifically, the Compositae family has 63 species, the Gramineae family has 43 species, the Cruciferae family has 26 species, and the Leguminosae family has 19 species. When it comes to origin of country, 112 species are from Europe, 64 from North America, 29 from Tropical America, and 28 from Eurasia. Twenty seven species, including *Rumex crispus, Erigeron canadensis, Erigeron annuus*, *Taraxcum officinale*, *Lactuca serriola*, and *Poa pratensis* are distributed in a wide range of areas and belong to the highest grade 'five' of degree of naturalization. White snakeroot (*Ageratina altissima*) was first found in Seoul and spreads to Gyeonggi Province. This alien plant species even invades forest, and cause damage to the forest ecosystem.

White snakeroot invaded the pine forest in Mt. Namsan, Seoul

Jong-Hwan Lim



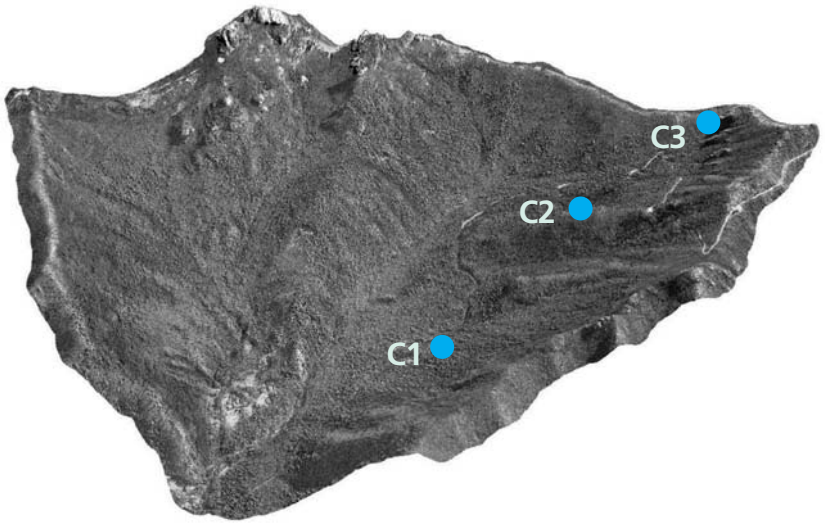
Distribution of the number of naturalized alien plant species. Size of the circles represent the number of species. There is a tendency of the number of naturalized alien plants is closely related with the degree of urbanization and transportation.

Erigeron annuus (left) and *Ambrosia artemisiifolia* (right) are distributed nationwide

[Reference: Park, S.H., J.H. Shin, Y.M. Lee, J.H. Lim, J.S. Moon. 2002. Distributions of Naturalized Alien Plants in Korea. KFRI Research Bulletin No. 193. Korea Forest Research Institute/Korea National Arboretum, Ukgo Press, Seoul. 184p.]

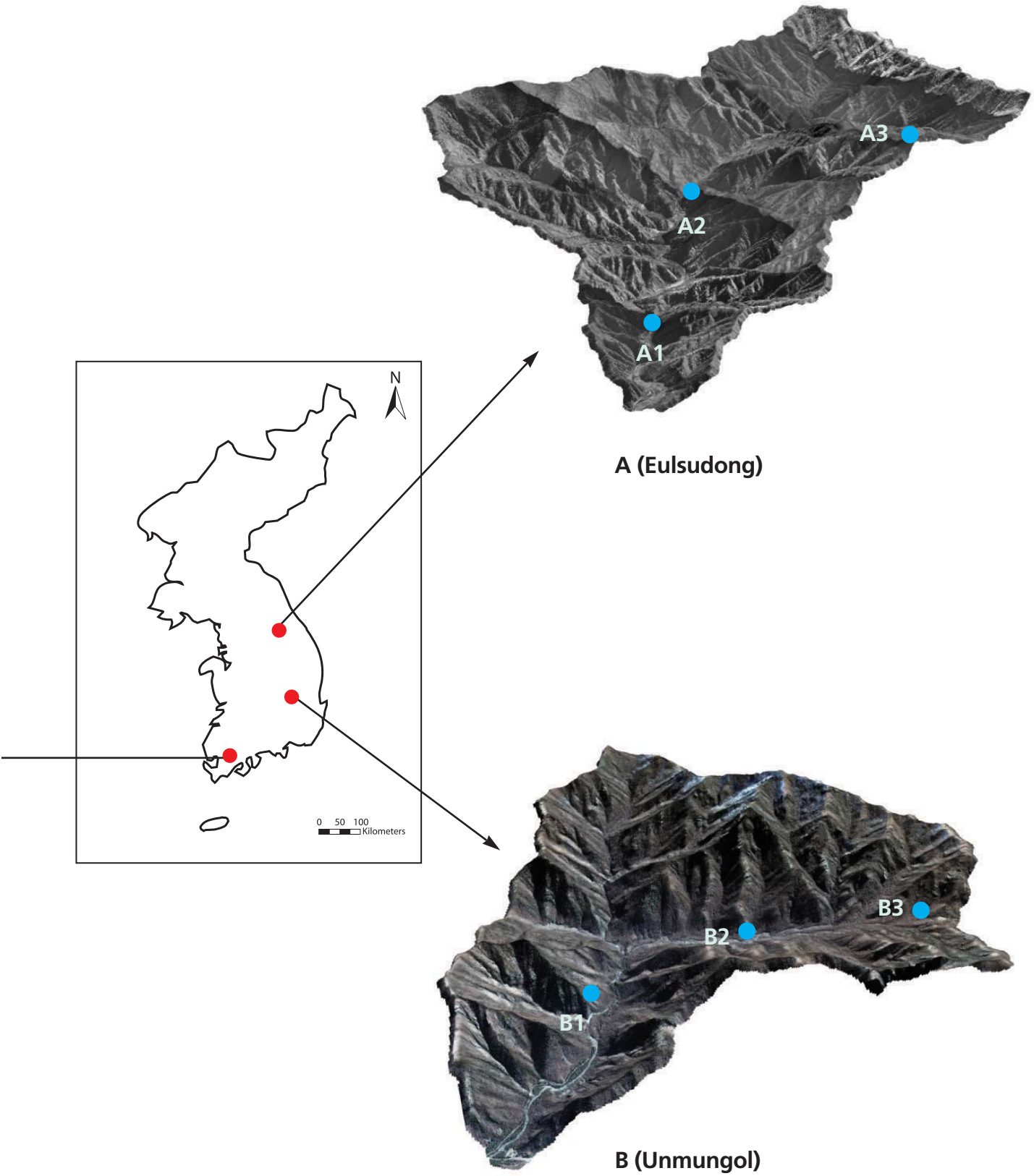
Vegetation profiles

A survey for which 3 major forest areas were selected, was conducted for 3 years, in order to figure out vegetation profiles of forests in South Korea. Area A refers to the basin of Eulsudong where Mt. Odaesan and Mt. Gyebangsan meet. This area belongs to the cold region so deciduous forests of the temperate zone are found here. Area B refers to the basin of Unmungol where Mt. Gajisan and Mt. Unmunsan, the core of Youngnam-alps (greatest moutain range in Youngnam region) are included. This area adopts a rest-year-system for restoration of nature and gives limits on the number of visitors so the nature of this area is kept in good preservation, showing a marked number of deciduous tree species. In the lower part of Area B, there is Unmunsa Temple, a college for Buddhists nuns. Area C refers to the basin where Mt. Duryunsan and Mt. Daedunsan are included. In this area, evergreen deciduous tree species are most developed in South Korea. Around the downstream of this area, evergreen deciduous tree species are easily found, but deciduous forests are widely seen, nearing the upper stream. Therefore, deciduous tree species are mostly found around the top part of the area.



C (Duryunsan)

Hee Moon Yang, Jung Hwa Chun, Tae-Sung Kwon



A (Eulsudong)

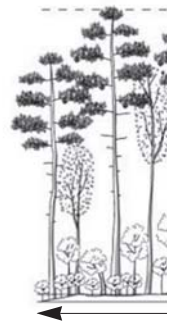
B (Unmungol)

Vegetation Profiles (A)

We found a total of 417 species in A. Here are the details: Pteridophyta (21 species), Gymnospermae (8 species), Monocotyledoneae (51 species), Cholipetalae (222 species) and Sympetalae (115 species). There are a total of 13 rare plant species, including *Patrinia saniculaefolia* and *Syringa patula* var.*kamibayshii*. Most of them are distributed in the upper reaches of streams or in subalpine zones 1,000 m above sea level. In addition, there are 28 species of

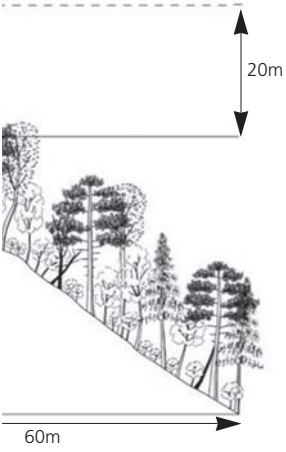
A1: From the southern slope of the mountainside to the ridgeline, there is a pure forest where the biggest *Pinus densiflora* which are 18 m in height, and 80 cm in DBH are dominant in the upper layer of the forest. In the middle of the mountainside, *P. densiflora* are dominant, but *Larix kaempferi* and *Ulmus davidiana* var. *japonica* are also found in the upper layer of the forest. However, there is *L. Kaempferi* forest at the bottom of the mountainside. *Fraxinus rhynchophylla, Betula davurica*, and *Quercus mongolica* are dominant in the middle layer of the forest. From the valley near the northern slope to the bottom of the mountainside, *P. densiflora* are dominant, but *Cornus controversa* and *Tilia amurensis* are prevalent in the middle and upper layer of the forest. From the middle to the top of the mountainside, *T. amurensis*, *B. davurica, Q. serrata, C. controversa, F. rhynchophylla* are dominant in the upper and middle layer of the forest. There is pure pine forest on the ridgeline, but 9 species of broad-leaved trees are mixed in the middle layer of the forest.

A2: From the western slope of the ridgeline to the top of the mountainside, *Pinus densiflora* and *Quercus mongolica* grow. In the middle of the mountainside, *Q. mongolica*, *Tilia amurensis*, and *Betula schmidtii* are dominant. At the bottom of the mountainside, there are many age-old *Abies holophylla* which is up to 56 cm in DBH. It is assumed that these trees were artificially planted. Abandoned farming fields and vegetable filtering strips exist from the ridgeline to the valley. *Q. mongolica, Ulmus davidiana, Acer mono* and *Juglans mandshurica* are dominant in vegetable filtering strips where stand density and living ground cover are low. Meanwhile, herbaceous plants are thriving in abandoned farming fields. *P. densiflora* and *Populus maximowiczii* are dominant in low-lying areas near the stream on the eastern slope. *A. holophylla, Populus davidiana*, and *Q. mongolica* grow at the bottom of the mountainside. *A. holophylla, Maackia amurensis*, and *Q. mongolica* are dominant in the middle of the steep mountainside. *A. holophylla* does not exist from the top of the mountainside to the ridgeline. Instead, *P. densiflora* is dominant there.



A3: In the subalpine zone 1,300 m above sea level, *Picea jezoensis* which is up to 24 m in height is dominant. *Taxus cuspidata, Acer mandshuricum*, and *A. pictum* subsp. *mono* are dominant in the middle and upper layer canopy. *A. ukurunduense*, *Sorbus commixta*, and *Prunus padus* for. *padus* are mainly found in the middle and lower layer of the forest. A rare plant, *Syringa wolfii* usually grows in high mountains. The habitat of this plant was found here.

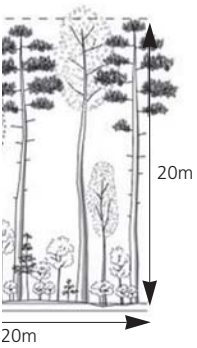
endemic plants, such as *Eleutherococcus sessiliflorus* and *Betula ermanii*. In the case of naturalized plants, only 2 species are found – *Erigeron annuus* and *Oenothera biennis.*



T1 : 16~19m (70%)
Pinus densiflora, Larix kaempferi, Ulmus davidiana var. *japonica*

T2 : 9~13m (60%)
Fraxinus rhynchophylla

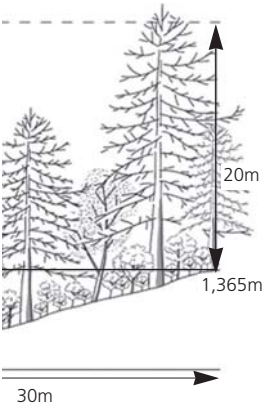
Staphylea bumalda, Lindera obtusiloba var. *obtusiloba, Morus bombycis* var. *bombycis*
Tripterygium regelii, Smilax sieboldii for. *sieboldii, Corydalis ochotensis*



T1 : 13~15m (80%)
Pinus densiflora, Populus maximowiczii

T2 : 6~8m (40%)
Syringa reticulata var. *mandshurica, Fraxinus rhynchophylla*

Carpinus cordata, Lindera obtusiloba var. *obtusiloba, Acer pictum* subsp. *mono*
Osmorhiza aristata, Astilbe rubra var. *rubra, Tripterygium regelii*



T1 : 18~24m (40%)
Picea jezoensis

T2 : 13~15m (70%)
Taxus cuspidata, Picea jezoensis, Acer mandshuricum

T3 : 6~10m (50%)
A. ukurunduense, Sorbus commixta, Prunus padus for. *glauca*

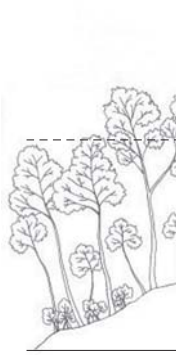
Tilia manshurica, A. komarovii
Ligularia fischeri, Sorbaria sorbifolia var. *stellipila, Ribes mandshuricum* for. *mandshuricum*

Vegetation Profiles (B)

According to the investigation in B, there are 41 order, 86 family, 216 genus, 391 species, including 80 variety, 19 forma, and 2 subspecies. There are 21 Pteridophyta species, 7 Gymnospermae species, 66 Monocotyledoneae species, 202 Cholipetalae species, and 95 Sympetalae species. 10 rare plant species, including *Lilium cernuum* and *Viola albida*, and 15 species of endemic plants in the Korean peninsula, such as *Clematis trichotoma* and *Stewartia*

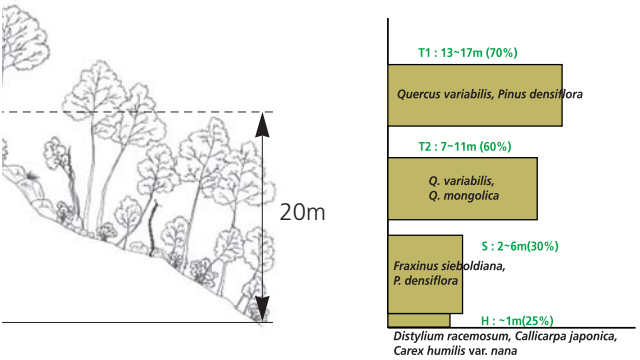
B1: The investigation area is located at the lower reaches of the valley where the Shim-shimi Valley and Doo-shimi Valley meets. On the Southwest slope, *Quercus variabilis* accounts for 60 to 80 percent of the upper layer canopy, which stretches from near the valley to the ridgeline. *Pinus densiflora* exists only at the bottom of the valley and the middle of the mountainside, but it is a small community. *P. densiflora* does not exist in the upper layer canopy and the ridgeline. A few stumps of *Q. mongolica* in *Q. variabilis* form a forest on the ridgeline. On the northeast slope of B1, a variety of tree species appears on the upper layer canopy, *Q. serrata* is dominant at the bottom of the mountainside. *Carpinus laxiflora* var. *laxiflora* and *Q. mongolica* are dominant in the middle of the mountainside. *Q. variabilis* and *Q. mongolica* are prevalent on the top of the mountainside, and *P. densiflora* is dominant on the ridgeline.

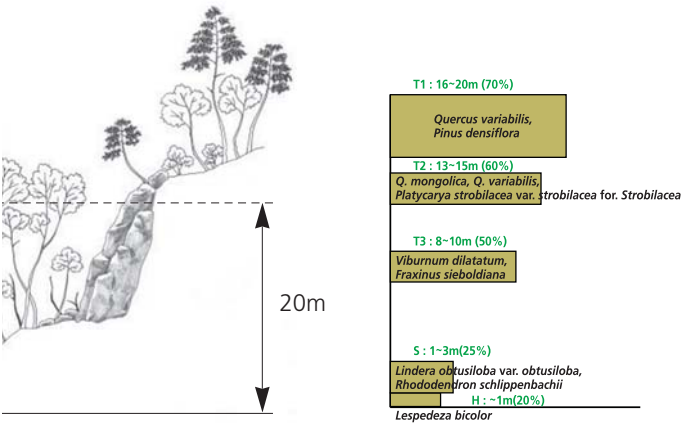
B2: *Quercus serrata* and *Carpinus laxiflora* var. *laxiflora* are the domininant species on the western slope. These tree species dominate the upper layer of the canopy except for the ridgeline. The number of *Cornus controversa* is relatively high near the valley and at the bottom of the mountainside. *Q. mongolica* and *Q. serrata* dominate the upper layer canopy in the middle of the mountainside. *Q. mongolica* is dominant at the top of the mountainside and near the ridgeline. *Pinus densiflora* appears on the ridgeline, but it is a small community. *Q. aliena* are dominant at the bottom and in the middle of the eastern slope on the mountainside. However, *Q. aliena* is not dominant except for these areas. *Q. variabilis* is dominant from the middle of the mountainside, and *P. densiflora* is prevalent from the top of the mountainside to the ridgeline. However *Q. mongolica* appears in the form of the upper tree on the ridgeline, but it is not dominant.

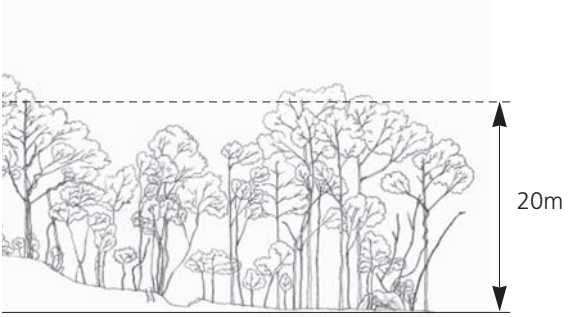


B3: Streams do not exist, but humidity is high. It is about 100 m distance to the main ridgeline which leads to Mt. Unmunsan. There are lush forests where *Fraxinus rhynchophylla*, *Quercus variabilis, Prunus serrulata* and other tree species which do not appear in the investigation area B1 and B2 dominate the upper layer of the forest. B3 features a variety of plant species per area unit, where rare plants, such as *Monotropa uniflora* and *Aristolochia manshuriensis* grow.

pseudocamellia, were also found. In particular, *Lilium cernuum* and *Viola albida* are listed as the second grade protected species according to the wild animal and plant protection law. There are 4 species of naturalized plants, such as *Fallopia dumetorum* and *Amorpha fruticosa*, but there are no species disrupting the ecosystem.



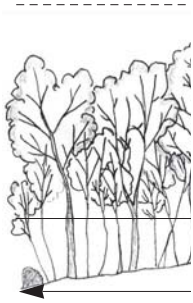




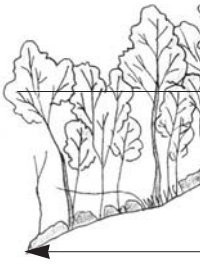
Vegetation Profiles (C)

According to the investigation in C, there are 34 order, 76 family, 140 genus, 213 species, including 32 variety, 15 forma, and 2 subspecies. More specificially, Pteridophyta has 19 species, Gymnospermae has 6 species, Monocotyledoneae has 25 species, Cholipetalae has 118 species, and Sympetalae has 45 species. There are 3 rare plant species, such as *Arisaema heterophyllum, Paeonia japonica*, and *Viola albida* and 2 species of endemic plants

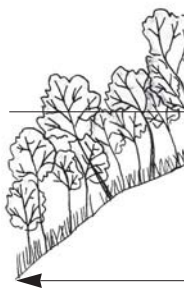
C1: Subtropical tree species, such as *Idesia polycarpa, Quercus acuta* for. *acuta, Dendropanax morbifera*, are dominant. The number of *Camellia japonica* is high in the lower layer of the forest. The vegetation cover of the tree layer and subtree layer is 90%, while the vegetation cover of the lower layer, such as a shrub layer and herb layer, is 20% and 30%, respectively. *Carpinus laxiflora* var. *laxiflora* is the dominant species in the middle of the mountainside where a variety of tree species exists, such as *Fraxinus sieboldiana, Platycarya strobilacea* var. *strobilacea* for. *strobilacea, Celtis jessoensis*, and *Machilus japonica*. The vegetation cover of tree layer is 95%. *Q. serrata* and C. *laxiflora* var. *laxiflora* are dominant at the top of the mountainside, but the height of canopy is less 12 m. The subtree layer is denser than the tree layer. *Q. serrata* appear only both at the top of the mountainside and on the ridgeline in the investigation area C1, where *Sasa borealis* is densely grown in the lower layer of the forest.



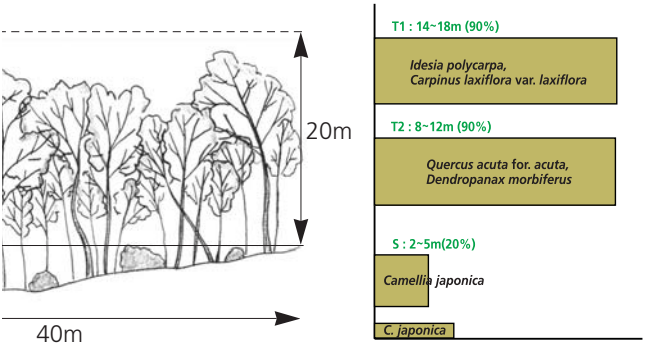
C2: Depending on the types of the dominant species, a variety of forest types appear. The investigation area C2 is located in the middle and at the top of the mountainside. It is assumed that slope directions and environmental factors affect the differences between dominant species. In particular, there are big exposed rocks in C2. The region is classified into 3 forest types by dominant species. The first type is dominated by various temperate broad- leaved tree species, such as *Carpinus tschonoskii* var. *tschonoskii*, *Quercus serrata*. The second type is dominanted by subtropical broad-leaved tree species, such as *Q. acuta* for. *acuta* and *Camellia japonica*. The third type is dominanted by *Q. serrata*. The height of the canopy is about 18 m. The tree layer is dense, while the shrub layer is less thick. *Sasa borealis* is densely grown in this area. All crown layers are dense in areas where subtropical broad-leaved trees are dominant. The area where *Q. serrata* is dominant has the following features – the tree layer is less thick, while the subtree layer is dense.

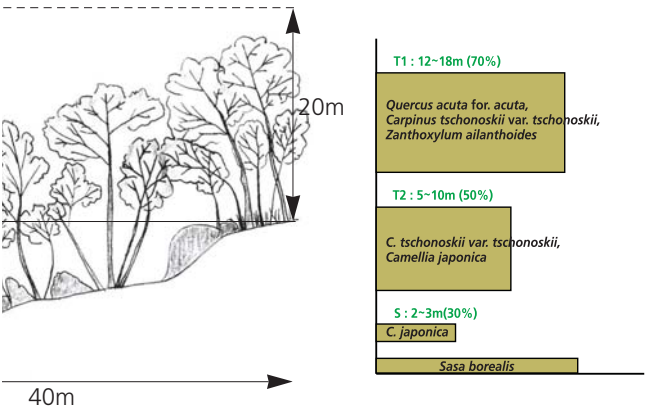


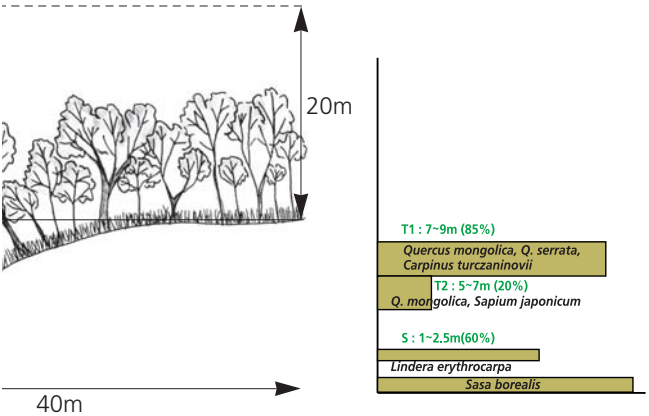
C3 is located on the northern slope more than 500 m above sea level. *Quercus mongolica* is dominant. Areas located closer to the ridgeline feature the dominance of *Q. mongolica*. *Sasa borealis* that dominates the lower layer of the forest floor gets less dense, but its height increases when it becomes further away from the main ridgeline. Due to the thickness of *S. borealis*, the vegetation in the lower layer is not lush.



in the Korea peninsula, such as *Weigela subsessilis* and *Stewartia pseudo-camellia.* The striking feature of "C" is that the vegetation distribution is mixed with subtropical broad-leaved trees, such as *Idesia polycarpa, Dendropanax morbifera*, and *Quercus acuta* for. *acuta*. and temperate broad-leaved trees, such as *Quercus serrata* and *Carpinus laxiflora* var. *laxiflora.*



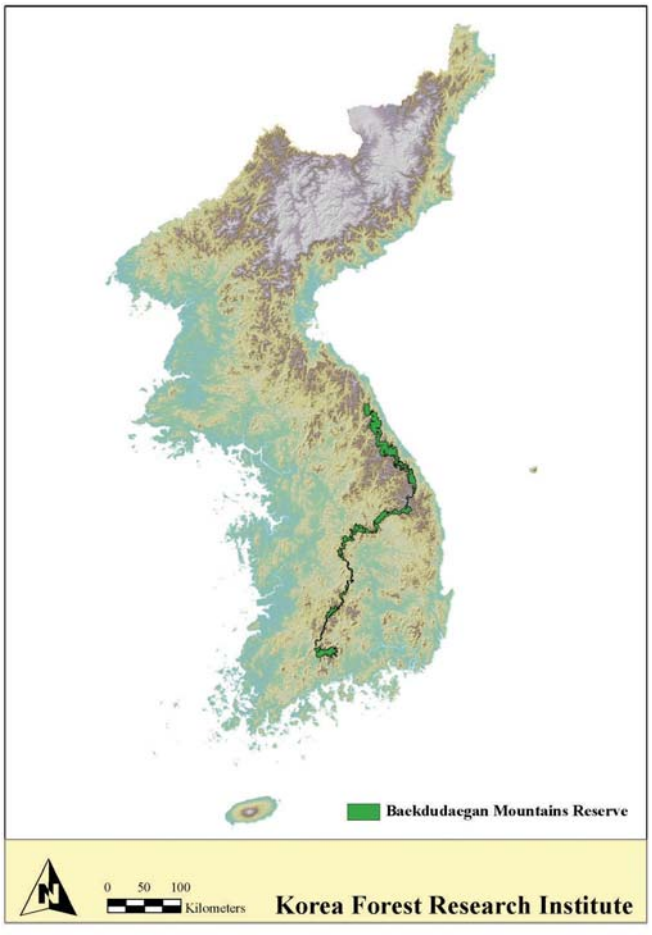




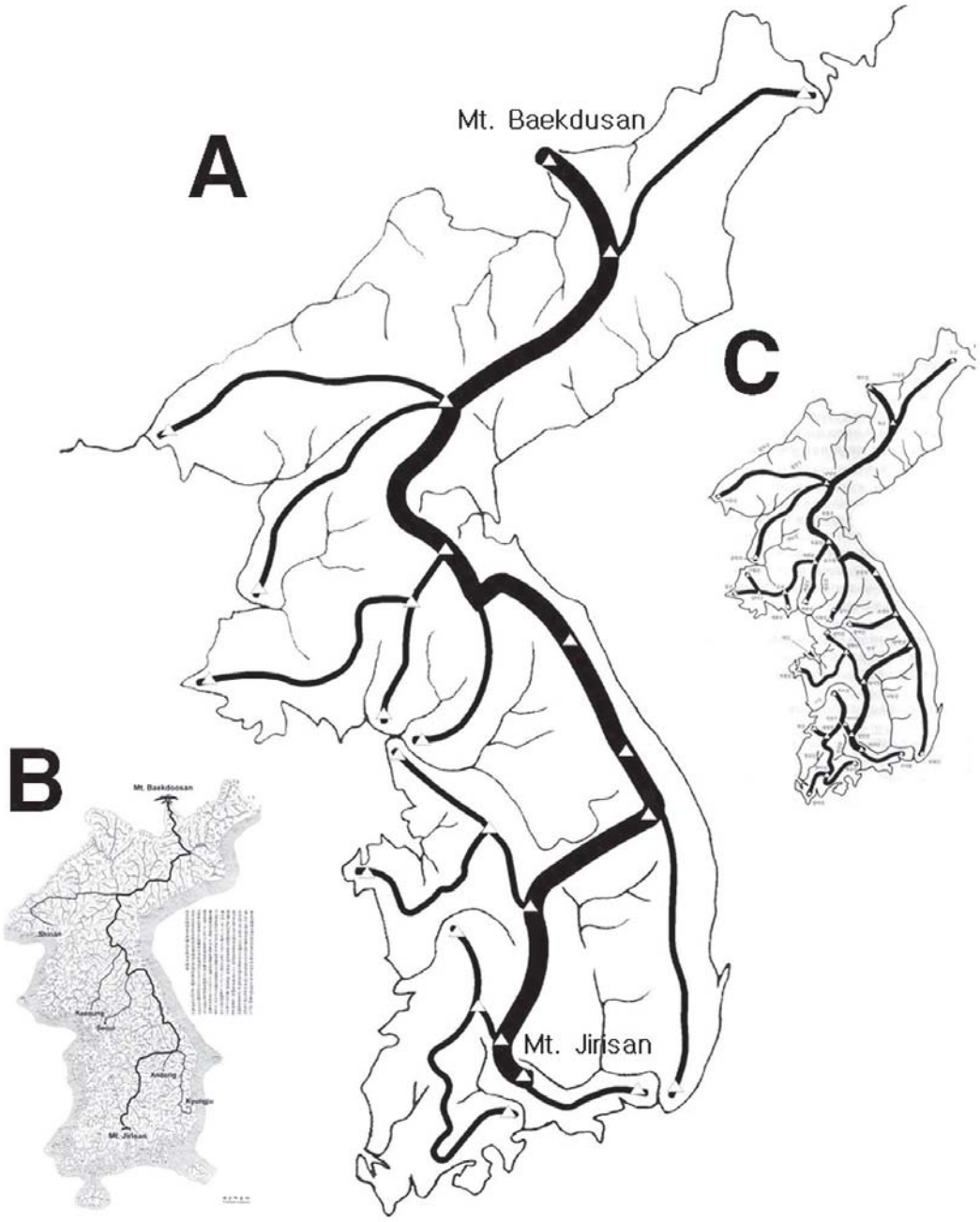
Korean View to Nature, 'Baekdu-daegan'

The mountain system of Korea is hierarchically organized from large to small mountain ranges. Mt. Baekdusan, is the highest mountain on the Korean peninsula, and is latitudinally located on the almost northern tip of the Korean peninsula. Mt. Hallasan is the highest mountain in South Korea, and is latitudinally situated on the most southern tip of Korea. Also, Mt. Jirisan is the highest inland mountain in South Korea. Our ancestors defined the Baekdu-daegan in the following way. The Baedu-daedan is a mountain range and watershed-crest-line which runs through most of the length of the Korean peninsula, from Mt. Baekdusan in the north to Jirisan in the south. The Baekdu-daegan's sub-system is categorized into Jeonggan (long mountain range) and Jeongmaek (mountain range). This mountain system constitutes an axis of symmetry with waterway network, and surrounds the Korean peninsula in a systematic way. This is why our ancestors firmly believed that rivers and mountains protected the Korean peninsula. When the king 'Wang Geon' founded the Goryeo dynasty, this belief made people think that both Mt. Baekdusan and Jirisan safeguarded him against dangers.

The concept of the Baekdu-daegan was born in this way, and it took root at the end of the Goryeo dynasty. As the geography was systematically developed in the Joseon dynasty, the definition of Baekdu-daegan, one Jeonggan and 13 Jeongmaek was systematically established, leading to the birth of the San-gyeong-pyo (C), and Daedong Yeojido (B). The former was a hierarchical relationship chart book of mountains in Korea. The latter was the most accurate map of the Korean peninsula in the Joseon dynasty. Therefore, the Baekdu-daegan is both the axis of natural geography and the pillar of the spirit of humanity. Also, it serves as the flag for promoting Korea around the world.



Joon Hwan Shin



A. Map of traditional major mountain ranges by hierarchical relationship chart of mountains in Korea.
B. The route (bold and thick line) from hometown through Baedu-daegan to Mt. Baekdusan in old map.
C. Outline map of mountains by the traditional idea of Korea.

Traditional Forest Management 'Maeul-soop'

A. This village forest is located in Boryong, Yangpyeong-gun, Gyeonggi Province. The view from the outside of the village

B. The view from the inside of the village (The opposite direction of A)

Joon Hwan Shin

'Maeul-soop' traditional village forests in Korea are based on native religion. The village forests were combined with Buddhism, Feng-Shui, or Confucianism according to the needs of the times. Therefore, they were sometimes artificially planted, or protected and conserved. Based on this traditional spirit, our ancestors found the site for building a village where their children could live a sustainable life. In this process, our forefathers relied on the mountain system, including the Baekdu-daegan and Jeongmaek. Then, they established a forest to make up for topographical disadvantages. This is the process of how traditional village forests came into existence.

The most favorite site for building a village must be found in front of a majestic mountain originated from the Baekdu-daegan or Jeongmaek. Also, a village should be built between a mountain in the back and a river flowing in the front. In addition, it should be surrounded by mountains (A). The village should face the south to ensure that sunshine streams in from everywhere. On the center of the village, two mountain ranges serve the role of blocking strong winds and circulating soft winds, respectively. The mountain ranges need to be not only low enough to let sunshine come in from all directions but also high enough to block strong winds. In reality, it is hard to find this perfect place. Therefore, forests were planted to compensate for topographical disadvantages. These kinds of forests are called "Bibo-soop". Most traditional village forests are Bibo-soop. When Koreans established Bibo-soop, they focused on seeking harmony with the topography of surrounding forests, which is akin to classical western weaving techniques (A, B).

As Korean traditional village forests have been conserved in its unique natural environment, they retain the characteristics of mixed woven fabric, meaning that nature and people culture have affected each other. This is why Bibo-soop located at the entrance of a village are much more in Korea compared to China and Japan, even though there are also religion forests, windbreak forests (C), flood prevention forests (D), and scenic forests in Korea.

C. This village forest is located in Yongmun, Yecheon-gun, Gyeongbuk Province

D. This village forest is located in Damyang-gun, Chonnam Province

Ecoregion in South Korea

Biodiversity differs from place to place according to its scale. Therefore, it is not possible to map out a conservation plan in a uniform way. Also, it is not a realistic way of managing the ecosystem because its boundaries are not actually drawn. This is why we created the national classification system concerning the ecosystem, which is divided into "Ecoprovince", "Eccoregion" and "Ecodistrict"

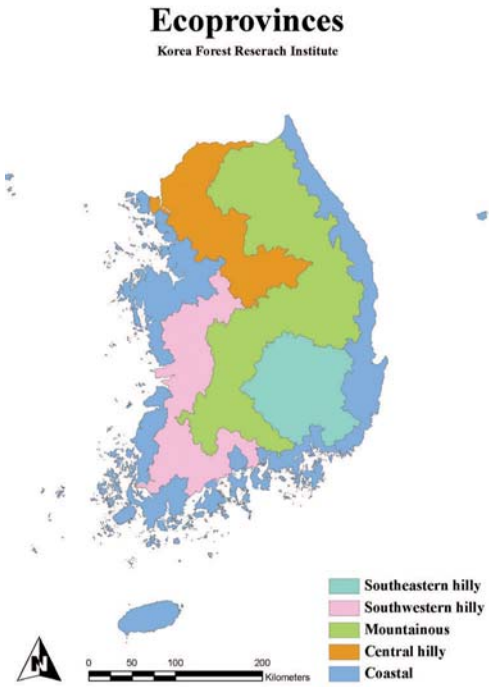
Hierarchical System of Ecological Unit

Criteria	Ecological Unit*	Use
Climate	Ecozone (62,500 km^2)	Worldwide planning (formation)
Ecological Connectivity Cultural Homogeneity	Ecoprovince (10,000-62,500 km^2)	Strategic planning and assessment
Regional Climate by Physiography	Ecoregion (100-10,000 km^2)	Broad applicability for modeling and sampling environmental management
Geomorphological Process	Ecodistrict (1,000-10,000 km^2)	Nutrient cycling, Pollution, Acid rain, Watershed analysis and management
Vegetation Process	Ecoseries (1.5-1,000 ha)	Project and management area planning and analysis
Biophysicochemic al Homogeneity	Ecotope (0.25-1.5 ha)	Forest stand technique (very detailed project planning)

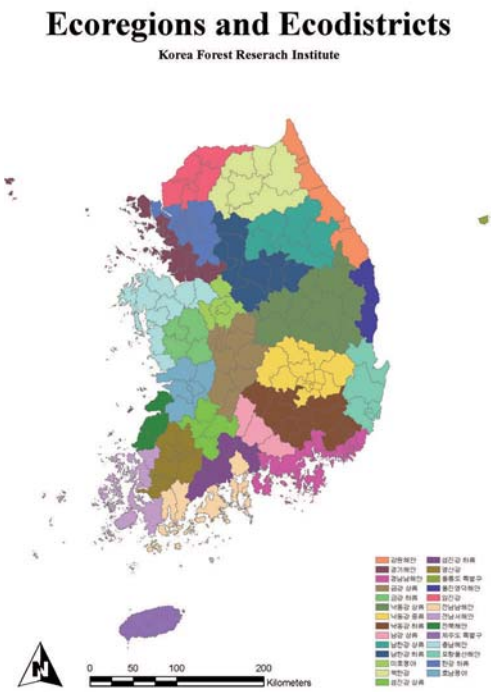
*[Reference : Klijin, F 1994. Ecosystem classification for environmental management. Kluwer Academic Publishers]

Joon Hwan Shin

Ecoprovince is based on ecological connection and cultural homogeneity, which clearly shows both the distribution of rare mammals and wide basins.



Ecoregion is based on the clustering of climate factors, which explains both the number of big forest fires and the distribution of pine mushroom. Ecodistricts are marked in each Ecoregion, and they are useful for understanding the distribution of indigenous species and the topography in the scale of landscape.



Ecoregion: The scope is marked with the same color

Ecodistrict: It is distinguishable by line in Ecoregion

Korean History

Recent genetic studies show that the Korean people might be regarded as a group of Mongolian people who interbred with humans from the South. The Mongolian people had lived in the cold climate of North Asia for several ten thousand years. In contrast, the Southern humans moved out of Africa 60,000 years ago and are widely scattered around hot tropic zones such as South India, South Asia, and Australia. The two groups met in the Korean peninsula, and formed the Korean people as like most Asian peoples (Wells, 2002). Hence, the Korean people feel at ease in cold climate as well as in hot climate.

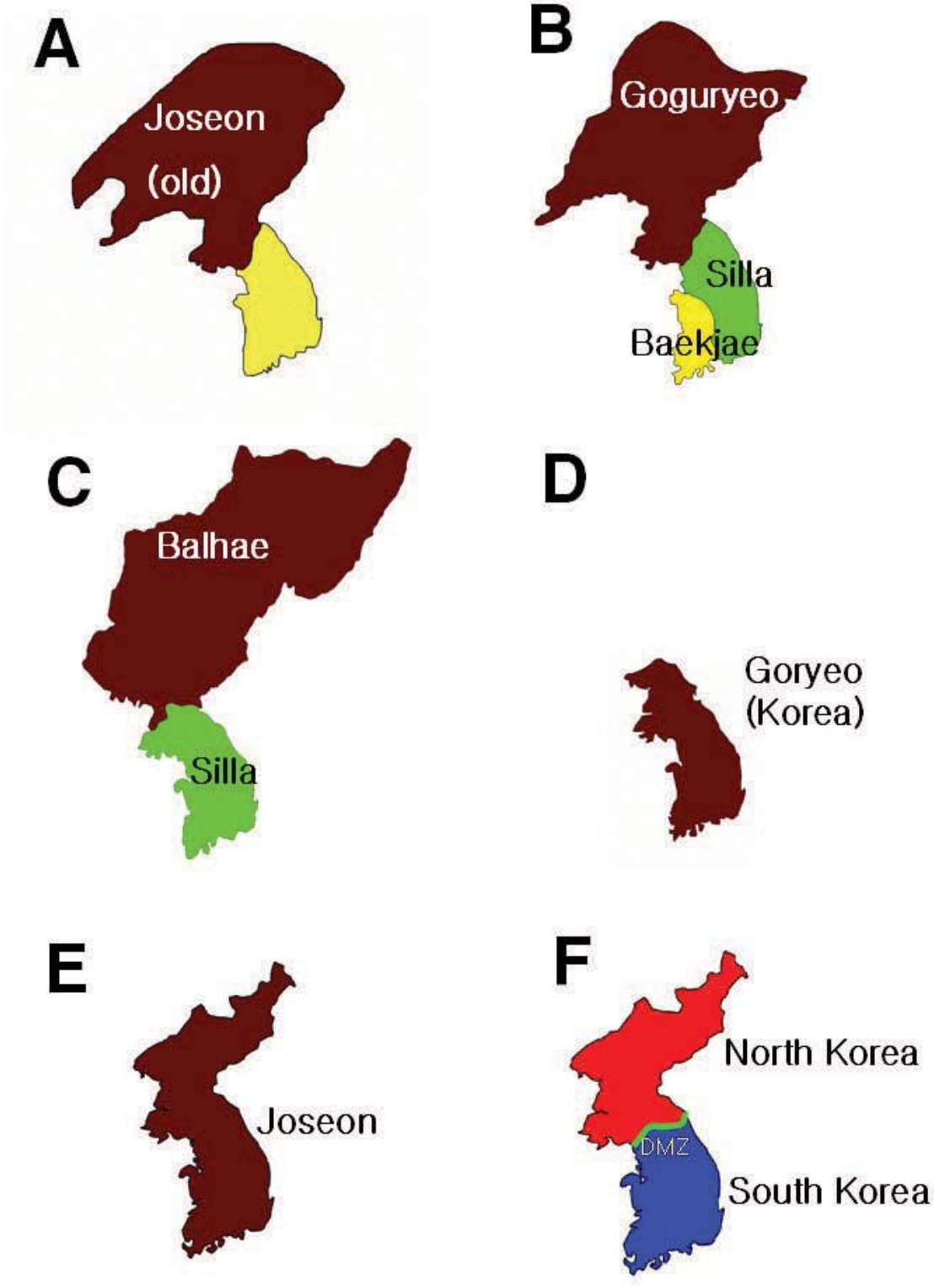
The Korean language derived from the Ural Altaic language group. Joseon (old) was the first Korean kingdom, which had existed from 2,333 BC to 108 BC, but was destroyed by the Han dynasty in China. Bronze tools were mainly used in the early Joseon kingdom, and iron tools were used in the late Joseon kingdom. Central area of the Joseon was transferred from Manchuria close to Amrokgang River to the middle-northern part of the Korean peninsula (A). At that time, many tribal countries sprung up in the south of the Korean peninsula.

After the fall of Joseon, the three kingdoms of Goguryeo, Baekje, and Silla divided the Korean peninsula. The three kingdoms were in fierce competitions to take control of the power (B). Silla destroyed Goguryeo and Baekje, and finally united the Korean peninsula in AD 668 by joining forces with the Dang dynasty in China. After the fall of Baekje, many people escaped to Japan. Dae Jo-Yeong, a former Goguryeo general, established Balhae (AD 698 to 926). The United Silla maintained the peaceful relationship with Balhae (C), but it collapsed in 935.

The Korean peninsula was divided into the three kingdoms again at the end of the United Silla, but it was united (AD 900 to 936). Then, the Goryeo (Korea) dynasty was born. The Mongolian army invaded Korea in 1,231, and the Goryeo dynasty finally raised the white flag and surrendered in 1,270. The Goryeo dynasty lasted 452 years, but finally collapsed due to the coup of a General Lee Seong-Gye, who later established the Joseon dynasty in 1,392. He chose Seoul as the capital of the Joseon dynasty. The border with China was finally established in the middle of the 15th century (E). The Joseon dynasty embraced Confucianism as the national religion. Hangul, the Korean character, was also created in the Joseon period. High-ranking officials were recruited through the national exam 'Gwageo'. After Toyotomi Hideyoshi united Japan, he sent 200,000 soldiers and invaded Joseon in 1,592. The 7-year war between Japan and Joseon did not bring any benefit to both countries. Later, the Japan-Korea Annexation Treaty was signed in 1905.

After Japan's surrender in the second world war, Korea won the independence, but unfortunately, the country was divided into two: the Republic of Korea (South Korea) and the Democratic People's Republic of Korea (North Korea). In 1950, North Korea suddenly attacked South Korea. This was the start of the three-year Korean War, claiming 3,286,393 lives. After the Korean War ended, the Military Demarcation Line (MDL) divided the Korean peninsula, and the Demilitarjzed Zone (DMZ) was established. South Korea is an industrialized country and a member of OECD. Meanwhile, North Korea is an underdeveloped country, and many people suffer from famine.

Tae-Sung Kwon



[Reference: Wells, S. 2002. The journey of man: a genetic Odyssey. Korean Version by S-T. Hwang. ScientificBooks Co. (in Korean)]

DMZ (The Demilitarized Zone) Ecosystem

After the Second World War, North and South Korea were under the military rule of Soviet Union and the United States, respectively. The ideological conflict between the democracy and communism gave rise to the division of South and North Korea. Consequently, the Korean War broke out in 1950, and ended in 1953. About more than 3 million people were dead during the war. The Korean peninsula was completely destroyed. Since the Armistice Treaty was signed, the Military Demarcation Line (MDL) has divided the North and South Korea. The DMZ is a kind of military buffer zone, which is a 2 km wide area along the borders of North and South Korea on the center of the Military Demarcation Line.

In South Korea, there is the Civilian Control Zone, an area extending about 10 to 20 km, south of DMZ. Civilians are severely restricted to enter this area, except for some farmers. This means that both the DMZ and CCZ have been no man's land after the end of the Korean War. There is nowhere in the world where the access of civilians has been highly restricted for a long time.

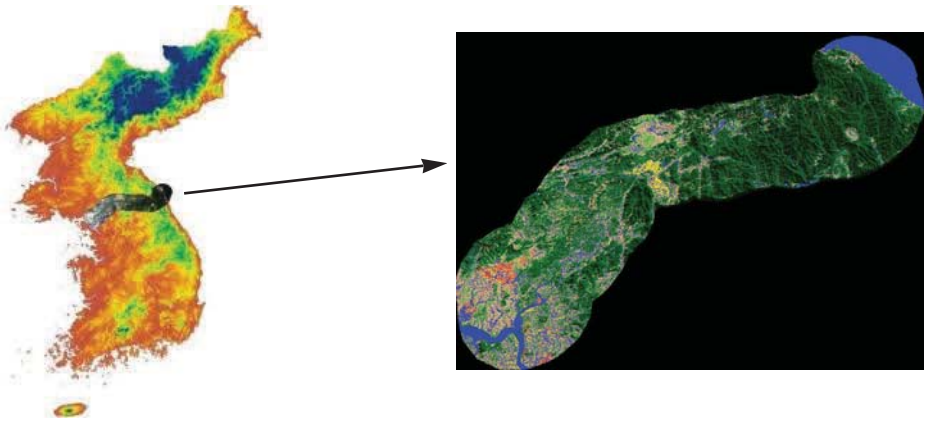
DMZ line across the middle part of the Korea peninsula, which is located between the biggest continent and the largest ocean in the world. It includes west Sea Islands and coastal areas which feature salt wetlands and hills, the central-western inland areas which contain the upper reaches of Hantan river and a lava plateau, the central-eastern mountain areas which feature mountainous areas and high moors, and the east coast region which feature lagoons, wetlands and cliffs. Therefore, DMZ has a variety of bio-geographical features. Topographical differences exist in the DMZ, which results in the distribution variation of plants and animals, making it possible to clearly define the ecosystem in the DMZ.

Over the past half-century, civilians have not been allowed to access the DMZ, which is why the natural environment still remains intact. In particular, the mountainous areas in the DMZ are hard to access because of its steep terrain, which brings about creating the proper condition for the growth of various animals and plants. Buried landmines are also another factor that denied people's access to the DMZ. However, the original vegetation and the natural ecosystem are seriously destroyed in military operation areas. For example, soldiers intentionally set fire to the fields of the DMZ to clear any obstacles. Natural vegetation cannot be almost found in the West coast. However, there are no farming activities in some areas where landmines are buried in soil, leading to the creation of small reservoirs or ponds. This is the best environment where marshes can be created. In this ecological environment, the aquatic ecosystem exists where a variety of vegetation, amphibians, reptiles, and spiders can live. In particular, big moist forests serve as habitat and movement routes for big mammals like Chinese water deer. The 'Yong Marsh' in Mt. Daeamsan which is located 1,280 m above sea level in the middle and eastern mountain areas is first designated as the Ramsar conservation list in South Korea. This region records a below-zero temperature (°C) for more than half a year, and is covered with fog. This is why dead trees or big trees which are rooted under the moors have been alive for more than 500 years.

It is reported that there are 1,597 species of plants, 98 species of birds, 11 species of mammals, 100 species of fishes, 602 species of insects, 186 species of spiders, 282 species of mushrooms and wood

Hee Moon Yang

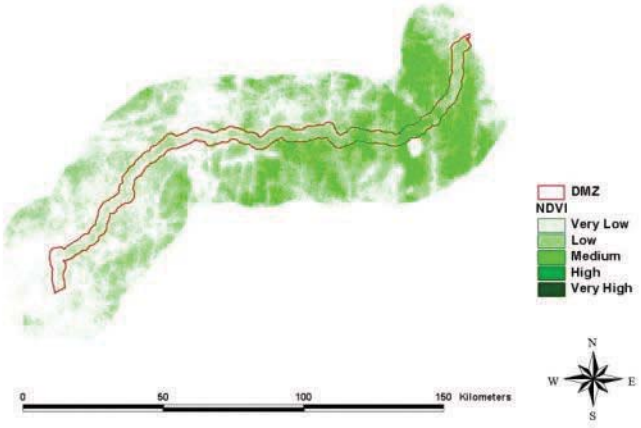
rotting fungus, and 113 species of lichens. The gross area of the DMZ and CCZ is 9,791 km^2. The forest area has seen a decline from 74% in the 1980s to 71% in the 2000s. It is also reported that the volume of forest growing stock is being reduced. According to the analysis of Normalized Difference Vegetation Index (NDVI), the volume of forest growing stock is higher in the east than the west of the DMZ. In addition, it is reported that the DMZ is covered in more lush green vegetation than the CCZ.



Location of DMZ in the Korean peninsula

The swampy place where landmines are buried, and *Hydropotes inermis*

The Yong marsh located in Mt. Daeamsan (Ramsar Conservation List)



The results of the NDVI analysis of the DMZ and CZZ

Rare Species in DMZ Ecosystems

Iris dichotoma

Rana plancyi

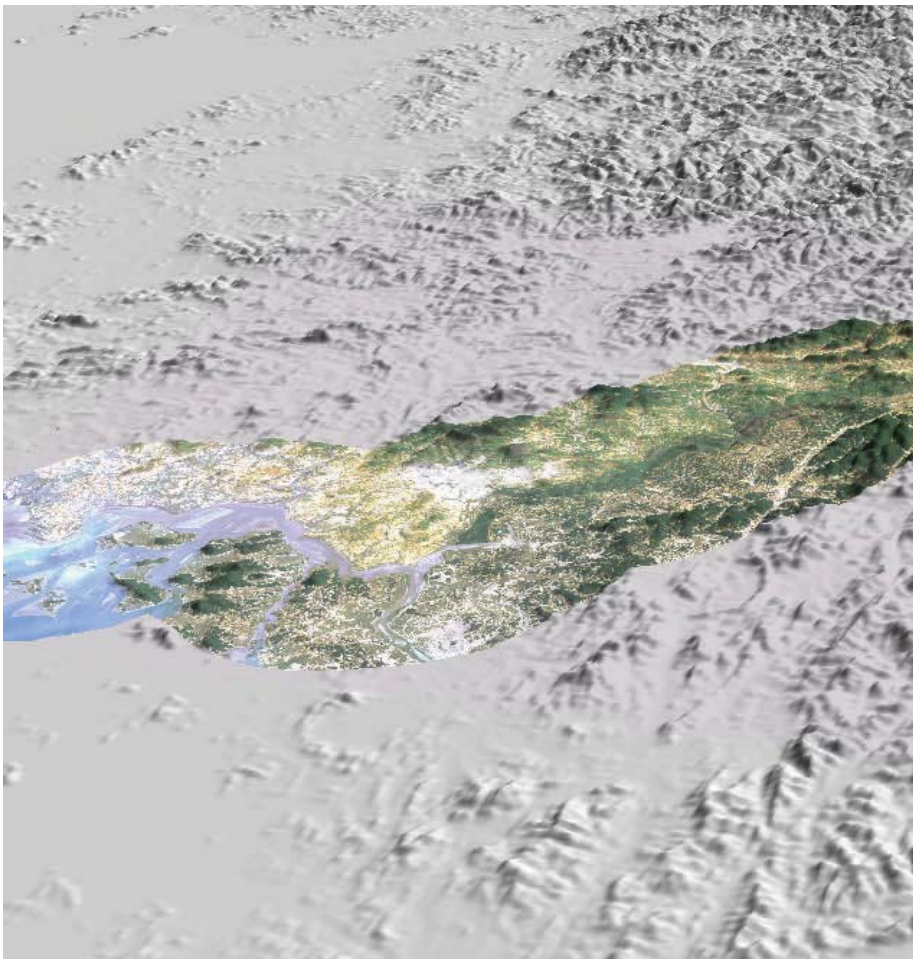
Platalea minor

Macrolepiota koreana

Phoca vithlina

Pteromys volans

Brachymystax lenok



Hanabusaya asiatica

Bufo stejnegeri

Astraeus koreana

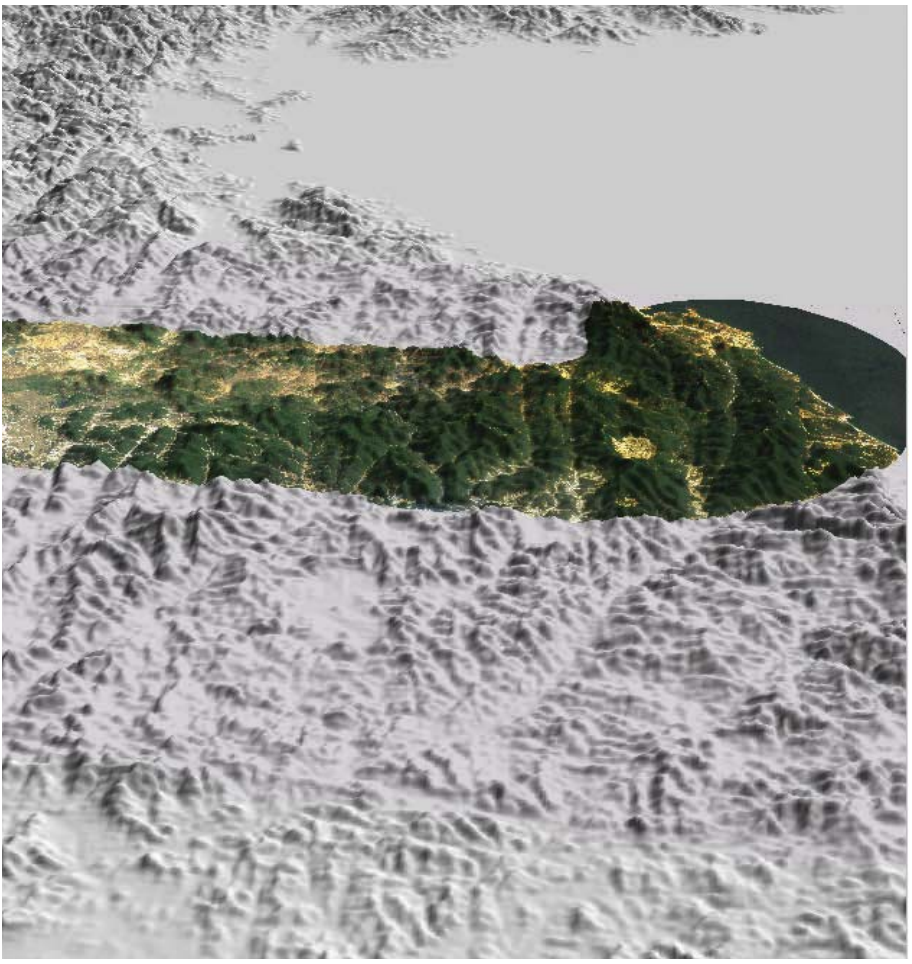
Takeoa n

Epimedium koreanum

Grus vipio

Argyroneta aquatica

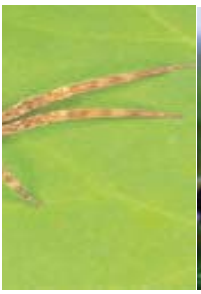
Grus japonensis



Dictyophora indusiata f. *lutea*

Vitex rotundifolia

Cygnus olor



ishimurai

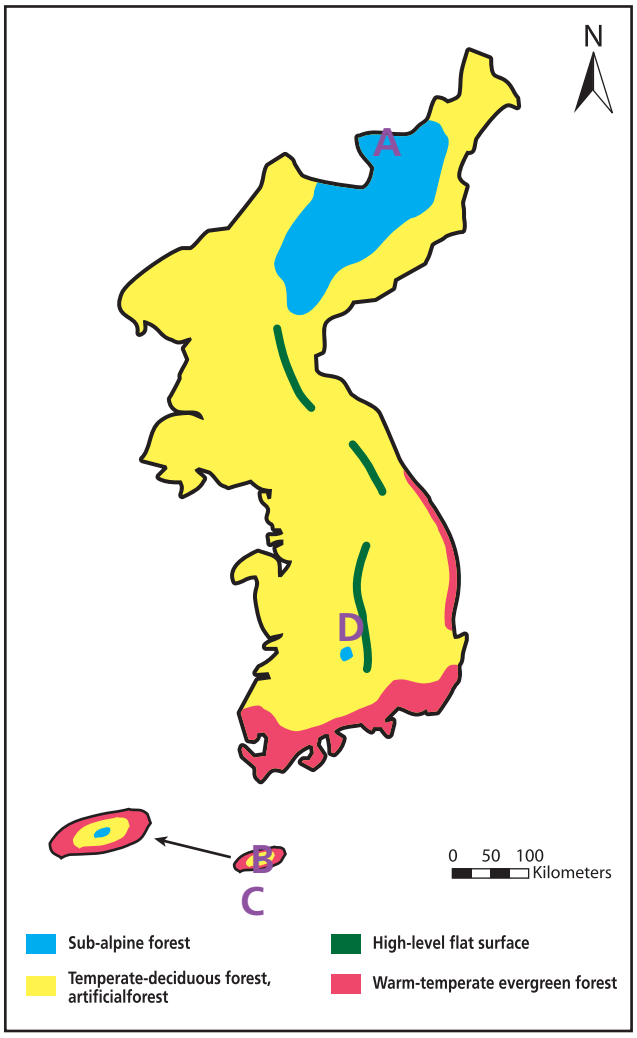
Iris setosa

Naemorhedus caudatus

Lampetra reissneri

Wildlife Habitats of Korea

The Baekdu-daegan is the longest mountain range in the Korean peninsula, meaning that it rules forest. The Korean forest looks simple, but exists in many varieties, such as caldera, crater lake, the subalpine forest and sub-tropical forest. *Nucifraga caryocatactes* lives in the *Pinus pumila* forest in Mt. Seoraksan, and the *Abies koreana* forest in Mt. Jirisan. *Bonasa bonasia* is a northern species and lives in the Baekdu-daegan. *Pitta nympha* is a southern species and lives mainly in the sub-tropical evergreen tree forest, even they are found in the south coast. Depending on the type of species, forest can be classified into the coniferous forest and deciduous forest. According to wild animal habitats, forest can be categorized into the subalpine forest, the temperate deciduous forest, high level flat surfaces, the artificial forest, and the sub-tropical evergreen forest. Marado located at the most southern-part of Korea do play an importent role for stopover sites to migrating birds.



Dryocopus martius

Nucifraga caryocatactes

Pitta nympha

Chan-Ryul Park

A: Heaven Lake on Mt. Baekdusan, caldera

B: Baengnok Lake on Mt. Hallasan, crater lake

C: Marado Island, seacoast cliff

D: The Mountain Range of Mt. Jirisan, subalpine

Representative Wildlife in each Habitat

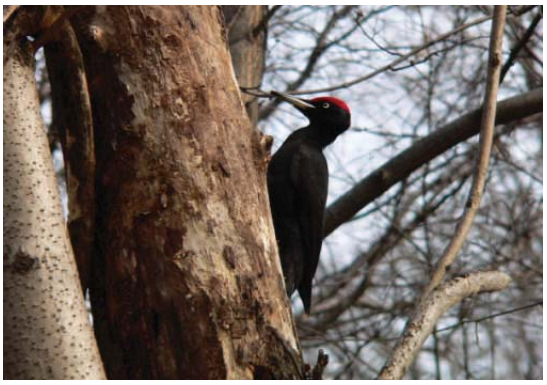
Type	Habitat type	Threat factors
Forests	Subalpine forest	Eco-tourism
	Temperate deciduous forest	Forest harvesting, Fragmentation
	High level flat surface	Habitat change for crop production
	Plantation	Forest tending
	Warm-temperate evergreen forests	Timber harvesting, Fragmentation
Ocean	Seacoast Cliff	Fishing, Eco-tourism, Ocean contamination
	Uninhabited island	
Wetlands	Riparian Forests	Channelization Habitat change
	Forest wetlands	Eco-tourism
Settlement Areas	Country village	Habitat change
	Urban	Urbanization
Demilitarized Zones		

	Representative wildlife
	Whistling Hare (*Ochotona hyperborea*), Amur Goral (*Nemorhaedus goral raddeanus*), Black Grouse (*Tetrao tetrix*), Nutcracker (*Nucifera caryocatactes*), Siberian Rubythroat (*Erithacus calliope*), Rosy Finch (*Leucosticte arctoa*), White-rumped Swift (*Chaetura caudacuta*)
	Black bear (*Ursus thibetanus ussuricus*), Wild boar (*Sus scrofa*), Leopard Cat (*Felis bengalensis*), Siberian Flying Squirrel (*Pteromys volcans*), European Water Shrew (*Neomys fodiens orientalis*), Blue-and-White Flycatcher (*Cyanoptila cyanomelana*), Woodpeckers, Owls, Tits, Warblers
	Buntings, Bush Warbler (*Cettia diphone*)
	Red Squirrel (*Sciurus vulgaris coreae*), Tits, Finches
	Roe Deers (*Capreolus capreolus*), Fairy Pitta (*Pitta nympha*), Black Paradise Flycatcher (*Terpsiphone atrocaudata*)
	White-tailed Eagle (*Haliaeetus albicilla*), Peregrine Falcon (*Falco peregrinus*)
	Styan's grasshopper warbler (*Locustella pleskei*)
	Ducks, Herons
	Common Kingfisher (*Alcedo atthis*), Striated Heron (*Butorides striatus*)
	Korean Water Deer, Weasels, Rufous turtle doves, Swallows, Sparrows, Rat Snakes (*Elaphe schrenckii*), Scops owl (*Otus scops*), Mandarian Ducks (*Aix galericulata*), Starlings (*Sturnus cineraceus*), Orioles (*Oriolus chinensis*)
	Sparrow, Magpie, Kestrel, Tits, Domestic doves
	Korean Water Deers, Cranes, Martens

Subalpine Forests

There are a few subalpine forests in South Korea, including Mt. Seoraksan and Hallasan. In general, subalpine forests are found in areas above the timberline. But, strictly speaking, there are only a few subalpine forests. *Nucifraga caryocatactes, Tetrao tetrix*, and *Leucosticte arctoa* can be observed in subalpine forests. *Ochotona hyperborea* and *Hirundapus caudacutus* can be observed in North Korea.

Nutcrackers (*Nucifraga caryocatactes*)



Black Woodpeckers (*Dryocopus martius*)

Evergreen tree forests

Evergreen trees are the ideal place to avoid predators because they have always leaves. Also, evergreen trees provide rich foods. The coastal cliffs of the south and west coast islands serve as a breeding ground for *Falco peregrinus, Haliaeetus alicilla, Haliaeetus pelagicus, Phalacrocorax* spp., *Larus crassirostris*, and *Monticola solitarius*. Evergreen forest is dominant in these areas. Coastal cliffs of uninhabited island also provide abundant preys. Viewed in this light, the coastal cliffs of Ulleung Island and the south coast islands are one of the important breeding grounds for sea birds and birds of prey. Also, *Locustella pleskei* and *Cisticola juncidis* breed in bushy evergreen forests.

Distribution sites of Black Woodpeckers

Peregrine Falcons (*Falco peregrinus*)

Temperate Deciduous Tree Forests

Temperate deciduous tree forests are abundant with big trees where Woodpeckers, Owls, and *Phylloscopus* spp. are living, indicating the typical association of forest bird species. Due to the differential erosion of granite, *Aquila chrysaetos* is breeding on some cliffs at the top of the mountain. *Falco peregrinus* is breeding on the cliffs near the coast. However, bird species which cannot be easily found in farming fields and cities are sometimes breeding in the secondary forest. Why? The secondary forest is located in low altitudes, and is artificially affected a lot. *Hypsipetes amaurotis, Stereptopelia orientalis, Parus* spp., and *Sitta europaea* are easily observed. The population density of birds is highest in temperate deciduous tree forests in Korea.

Eastern Crowned Willow Warbler (*Phylloscopus coronatus*)

Eagle Owls (*Bubo bubo*)

High level flat surfaces

The high level flat sufaces are found between Baekdu-daegan ridgelines which are located above high sea level. There are several high level flat sufaces, including Daegwallyeong, in South Korea. Due to strong winds, bushes and herbaceous plants dominate. *Cettia diphone* and *Emberiza* spp. are also common. Birds, such as *Emberiza fucata* and *Saxicola torquata*, are breeding on high level flat sufaces because they usually live in open and flat land. Due to artificial development, there are only a few high level flat sufaces between Baekdu-daegan ridgelines.

Distribution sites of Eagle Owls

Stonechats (*Saxicola torquata*)

Forest Wetlands

The representative forest wetlands include the "Yong" marsh which is located in Mt. Daeamsan in Yanggu, Gangwon Province, and the Mujechi marsh which is located in Ulsan. Although the area of forest wetlands is small, they maintain biodiversity and serve the role of biogeochemical functions in the forest ecosystem. Forest wetlands serve as an important spawning ground for amphibians and reptiles. They also provide water for birds and mammals.

Jeju Salamanders (*Hynobius quelpartensis*) at forest wetlands

River Wetlands

River wetlands filter out polluted waters which flow into the river from forests and farming fields, or slow down the water flow. River wetlands also serve as an important channel and a habitat for plants and animals. *Aix galericulata, Anas poecilorhyncha, Lutra lutra*, and Herons can be observed in the river wetlands with *Salix koreensis*. Also, *Cinclus pallasii*, kingfishers, wagtails, and *Charadrius dubius* can be seen.

A pair of mandarian ducks (*Aix galericulata*) at paddy

Natural riparian areas at meandering rivers

Common Kingfishers (*Alcedo atthis*)

Habitat around human-settlement

The village where *Hydropotes inermis* and *Mustela sibirica coreana* are inhabited, contains the highest biodiversity. *Gallicrex cinerea* and *Porzana fusca* breed in the marshlands of rice fields or rivers. *Ninox scutulata, Otus scops, Aix galericulata, Eurystomus orientalis, Halcyon pileata, Upupa epops, Oriolus chinensis, Emberiza cioides, Streptopelia orientalis, Alauda arvensis, Galerida cristata*, wagtails, *Lanius bucephalus*, and herons eat loaches and fishes living in rice fields.

Barn Swallow (*Hirundo rustica*)

Brown Hawk Owl (*Ninox scutulata*)

Mulgunri Maeul-soop

Songmal Maeul-soop

The number of bird species is low in cities. As the area of forest in cities get smaller, the number of bird species is dramatically reduced. *Hypsipetes amaurotis, Parus major, Domestic pigeon, Passer montanus, Oriolus chinensis, Streptopelia orientalis, Garrulus glandarius* are living in cities. *Falco tinnunculus* sometimes builds a nest on an artificial structure.

Tree sparrow (*Passer montanus*)

Squirrel (*Tamias vulgaris*)

Domestic Doves (*Columba livia*)

Urban forests at Daegu City

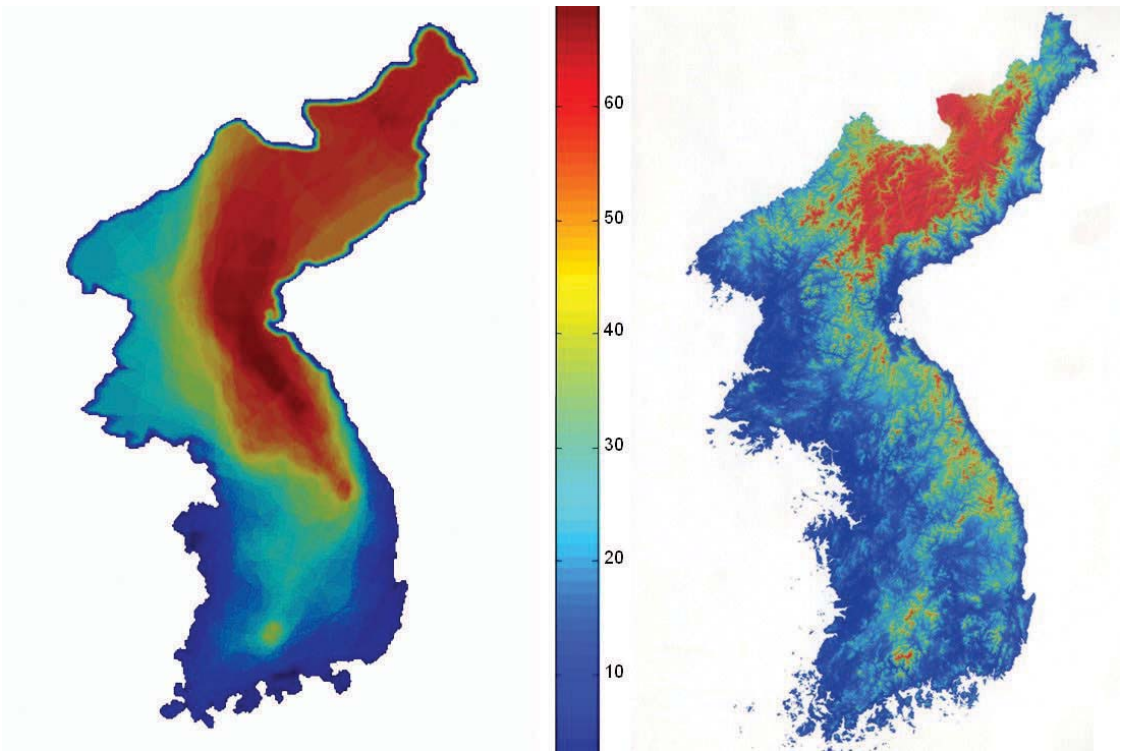
Urban forests at Seoul City

Butterflies in Korea

There are 265 species of butterflies in the Korean peninsula, and 212 species of them have been found in South Korea . The combined territories of South and North Korea are similar in size of Britain. Considering that about 60 species of butterflies exist in Britain, there are many species of butterflies in the Korean peninsula. Why? Korea has distinctive four seasons. Although the total area of the Korean peninsula is small, climate variability is huge. In addition, the Korean peninsula has many mountainous areas and rough terrain, which provide diverse habitats and foods for butterflies.

The below picture shows the diversity map of butterfly on the Korean peninsula (by Park, Y.S.). But, the species which are distributed nationwide are not displayed on the map. The darker the red color is on the map, the more various butterfly species are. Compared to the topographic map on the right, diversity pattern of butterfly (A) is similar to topographical pattern (B).

A No. of Species **B**



Tae-Sung Kwon

Northern grassland species vulnerable to global warming

Mellicta britomartis

Neptis rivularis

Coenonympha oedippues

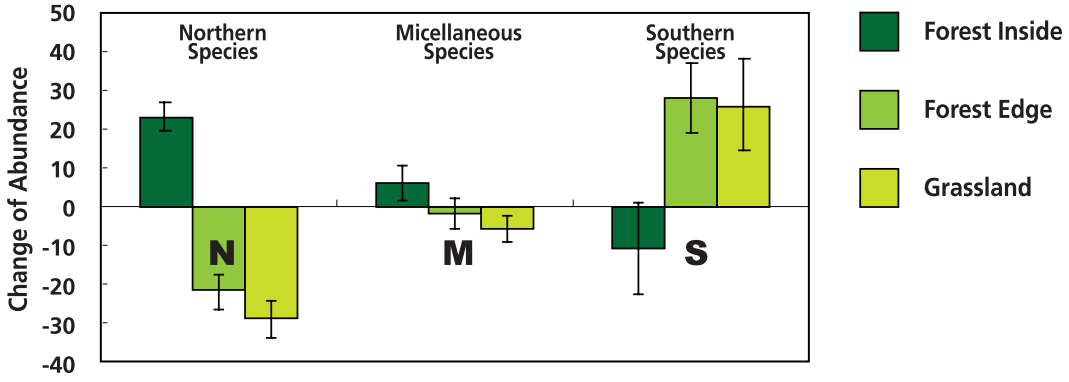
Southern species showing increase of abundance

Pseudozizeeria maha

Mycalesis francisca

Pieris canidia

South Korea is the only country which succeeded in reforestation of the denuded mountains in the world. Consequently, the area of grassland has become further reduced. Instead, the area of planted forest has increased. Due to the impact of global warming, the temperature of the Korean peninsula has increased about 1.5°C over the past century. The climate and vegetation change are affecting butterflies. Abundance of northern grassland butterfly species is on the decline due to synergistic interaction of climate change and the decline of habitat (The picture below, Kwon et al. 2010). Meanwhile, the number of southern butterfly is on the rise despite the reduction of the grassland area.



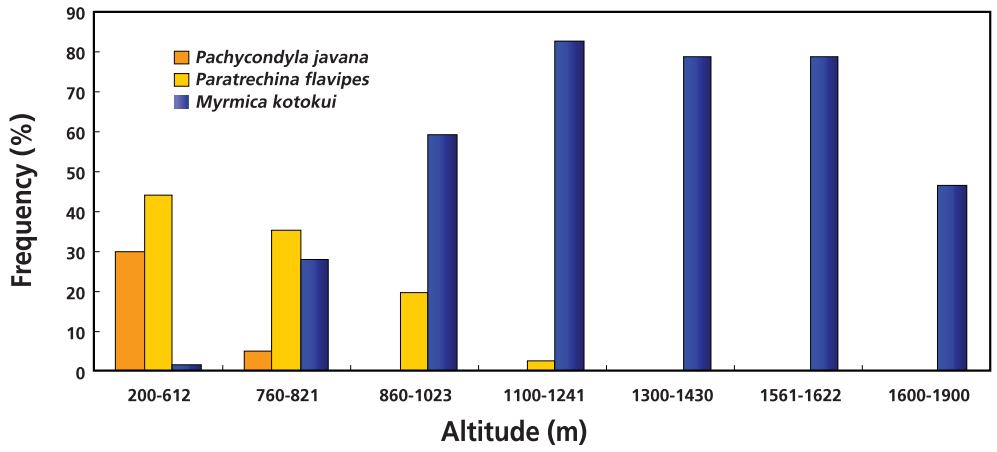
[Reference : Kwon T.S., S.S. Kim, J.H. Chun, B.K. Byun, J.H. Lim, J.H. Shin. 2010. Changes in butterfly abundance in response to global warming and reforestation. Environ. Entomol. 39:337-345]

Ants in Korea

About 120 species of ants exist in South Korea. Ants eat insects or nutrients from plants while living in soil, leaf litter, or dead branches. Ants play a critical role not only in circulating the materials in the ecosystem, but also with enhancing the productivity of forest by making the soil fertile. Many organisms live in ant colonies, which contribute to improving biodiversity. The ants below are the most common species that can be observed in forests in South Korea.

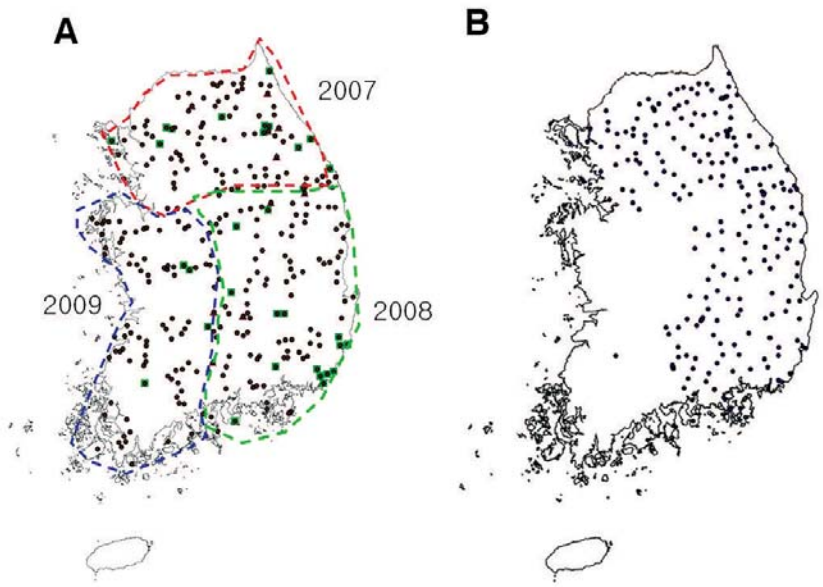
Paratrechina flavipes *Pheidole fervida* *Pristomyrmex pungens* *Lasius japonicus*

Ant Distribution and Temperature

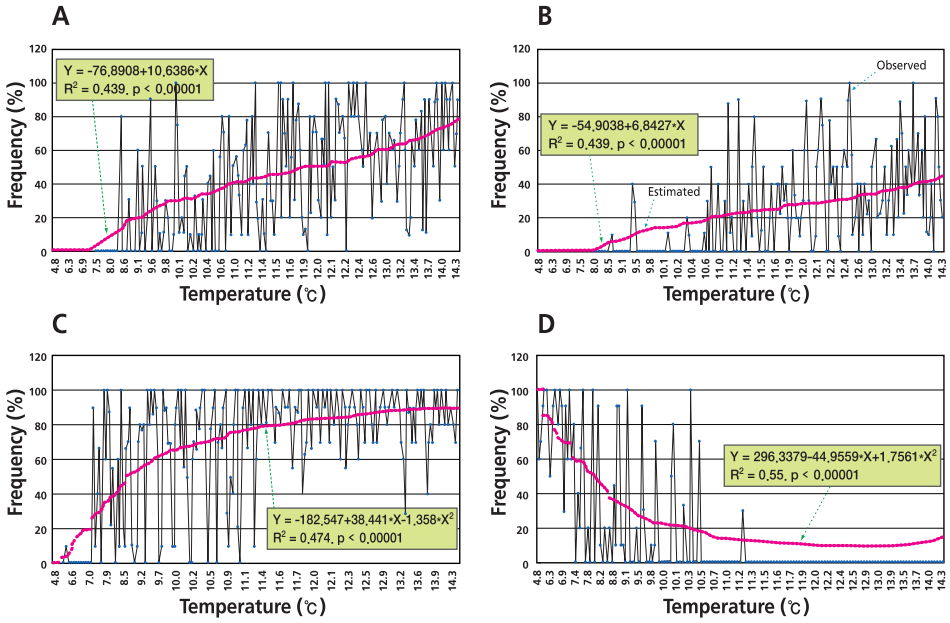


According to the research on ants in high mountains in South Korea, ant species are distributed vertically (above figure). Temperature falls as altitude increases at the rate of about 0.5 to 0.6˚C per 100 m. Therefore, the vertical distribution of ants indicates that temperatures are a critical factor in determining the distribution of ants. If this is true, it will be possible to predict the distribution of ants or the changes of ant distribution by referring to temperatures.

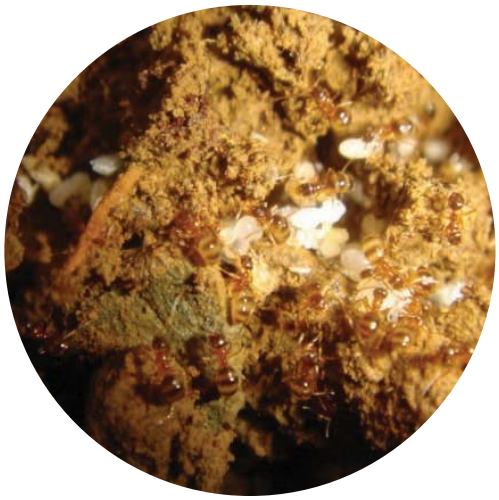
Tae-Sung Kwon



Since 2007, I had investigated about 300 sites (A) to create the distribution model of ants for the past three years, including 12 high mountain areas. I completed an analysis on 234 sites (B).

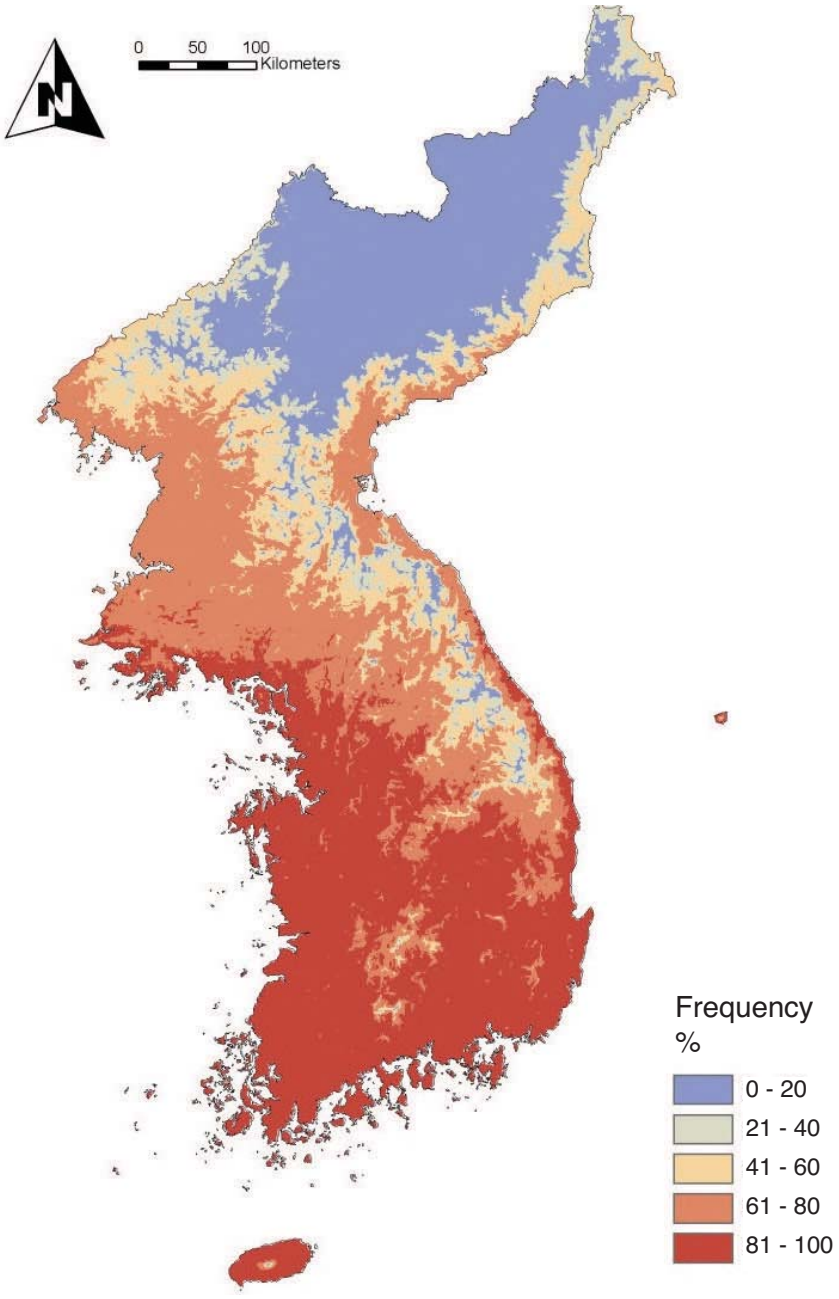


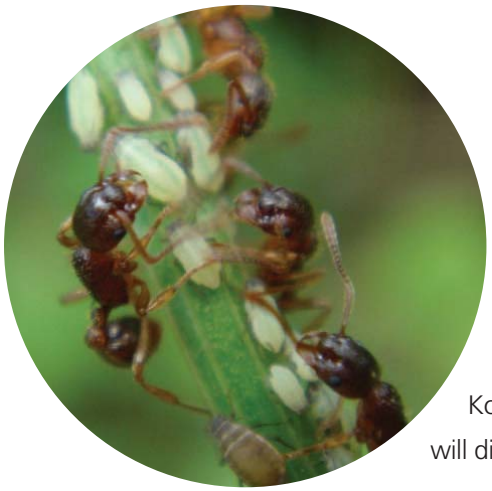
I selected 17 species, which were collected at more than 10% of the sites. According to the analysis, the distribution of 11 species is most affected by temperatures. Among them, more than 30 percent variation of the four species distribution (A: *Pachycondyla javana*, B: *Pristomyrmex pungens*, C: *Paratrechina flavipes*, D: *Myrmica kotokui*) is explained by temperature. The density of P*achycondyla javana, Paratrechina flavipes*, and *Pristomyrmex pungens* in South Korea gets higher as temperature increases, while the density of *Myrmica kotokui* gets higher as temperature drops. Based on this analysis, it is expected that *Pachycondyla javana, Paratrechina flavipes*, and *Pristomyrmex pungens* will increase in abundance if temperature goes up. Meanwhile, *Myrmica kotokui* will decrease in abundance.



Paratrechina flavipes

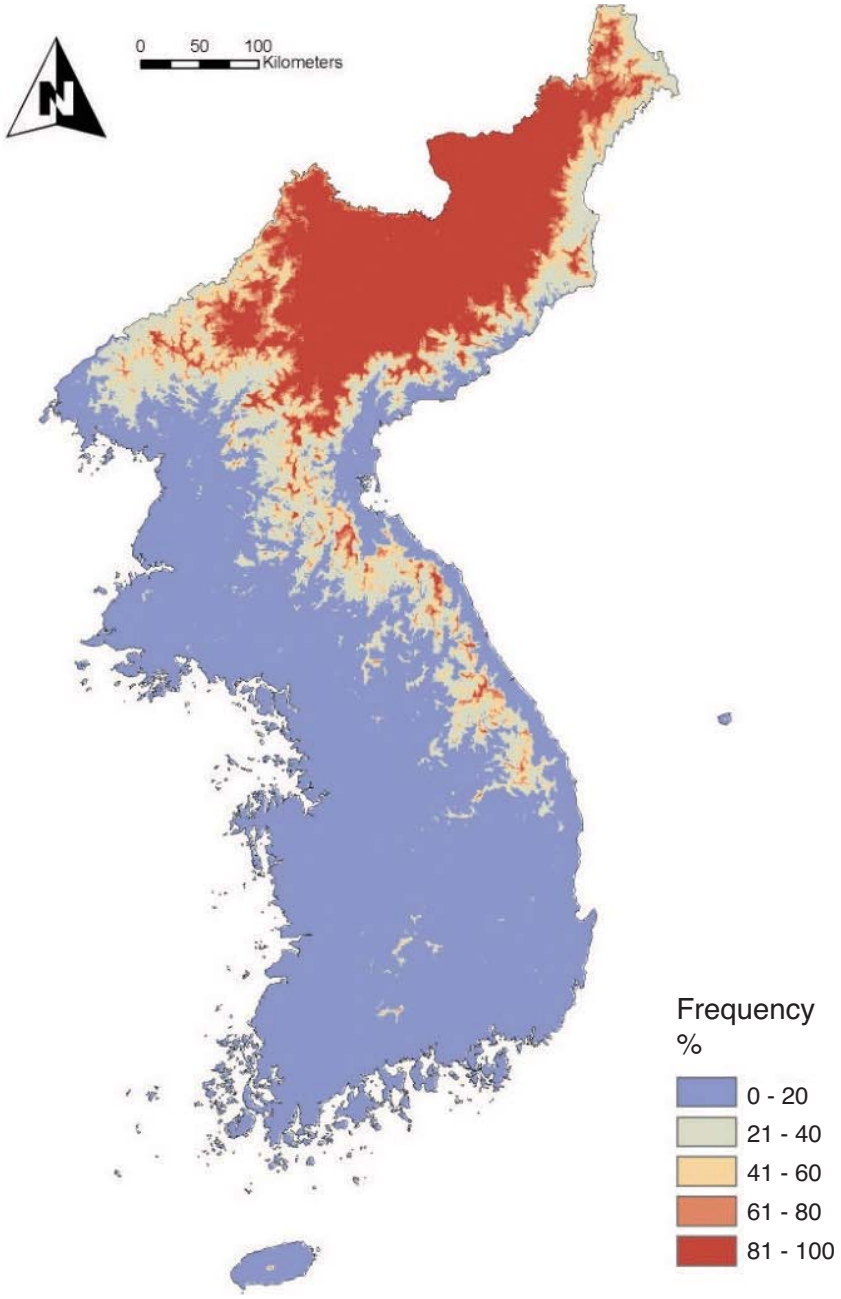
Paratrechina flavipes is abundant in forests in most regions of South Korea, especially in southern part. This small ant species is monogynous species and is endemic to north-eastern Asia. They live in forest and grassland in small colonies.





Myrmica kotokui

The density of *Myrmica kotokui* will get higher in areas with low temperatures, such as high mountain areas. According to the distribution model, however, it is expected that the density of *Myrmica kotokui* will be very high in the northern parts of North Korea. If temperature rises due to global warming, *Myrmica kotokui* will disappear in most existent areas in South Korea.



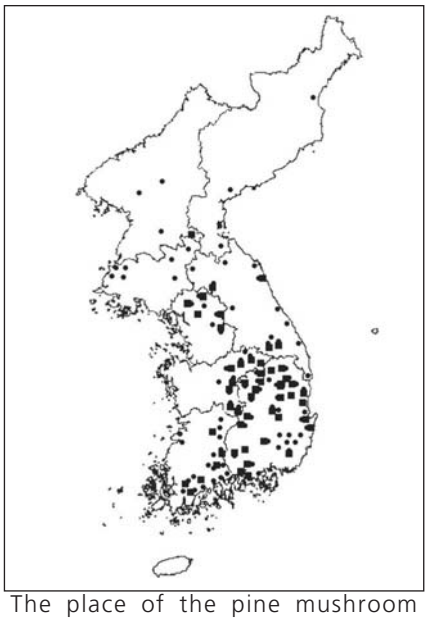
Mushrooms in Korea

Edible Mushrooms

It is known that about 1,600 species of mushroom are found in Korea. About 200,000 tons of edible mushrooms were produced in 2008. Here are representative edible mushrooms which are commercially cultivated: *Lentinula edodes, Pleurotus ostreatus, Flammulina velutipes, Pleurotus eryngi, Agaricus bisporus, Hypsizigus marmoreus, Hericium erinaceum, Grifola frondosa*, and *Agrocybe cylindracea*. *Ganoderma lucidum, Wolfiporia extensa, Sparassis crispa,* and *Phellinus* spp. are cultivated for treating diseases.

Pine mushroom, *Tricholoma matsutake*

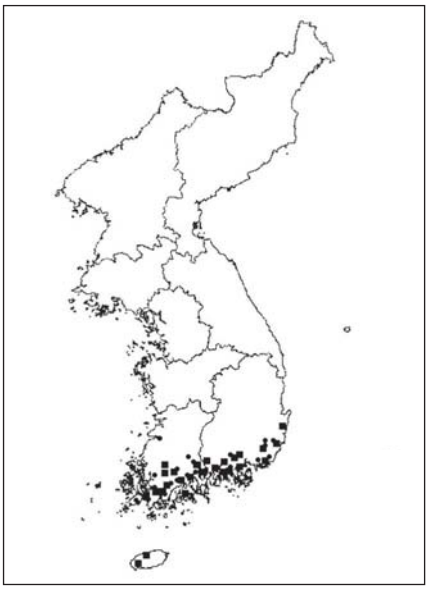
The pine mushroom grows in pine tree forests in Korea. Pine mushroom usually appears in the rainy season between at the end of June and the beginning of July, and during the autumn months of September and October. More than 90 percent of mushroom is produced in the autumn. The host plant of pine mushroom is *Pinus densiflora*. Rarely does *Pinus rigida* serve as a host plant (Park et al., 2004). Pine mushroom was evenly distributed across the country in the Joseon dynasty. Currently, it is distributed along the Taebaek, Chanyeong, and Noryeong mountain ranges (Bae et al., 2004). More than 80 percent of pine mushroom is produced in Gyeongsang Province. The pine mushroom production reached the peak in 1985, when 1,313 tons of pine mushroom were produced. Since then, the amount of production has been on the decline. From 1999 to 2008, an average of 412 tons of pine mushroom has been produced every year. An average of 193 tons of pine mushroom is exported to Japan, and an average of 274 tons of pine mushroom is imported from China and North Korea. This means that South Korea was a net exporting country, but is now a net importing country (Ka, 2009). Pine mushroom cannot be artificially produced, so it is harvested in nature. The study on the artificial production of the pine mushroom has made great progress. By the year of 2010, it will be possible to artificially produce pine mushroom (Ka et al., 2010).



The place of the pine mushroom production (In the first half of the Joseon period)

Kang-Hyeon Ka

Oak mushroom, *Lentinula edodes*



The place of the oak mushroom production (In the second half of the Joseon period)

The ancient documents of Sejong Sillok Jiriji (1454) and Sinjeung Donggukyeojiseungram(1528 to 1532) were published in the first half of the Joseon dynasty. They say that the oak mushroom was mainly produced in Gyeongsang and Jeolla Province (Bae et al., 2004). Based on these ancient documents, it seems that the oak mushroom was cultivated in the first half of the Joseon dynasty or even before. The phrase "*Sarcodon aspratus* is the best, the oak mushroom is the best second, and the pine mushroom is the best third" has been passed on from generation to generation (Jeong, 1966). Viewed in this light, it seems that the oak mushroom was very popular at that time. In the 1960s, the oak mushroom was mainly cultivated in Jeju Island, Wonju, Yeongdong, Geumneung, Jinan, and Gongju.

In the 1990s, the oak mushroom was mainly produced in Jangheung, Gongju, Yeongdong, Cheongyang, Geoje, and Jinan. It is now grown in Gimje, Gijang, Sangju, Buyeo, Yangpyeong, Gimpo, Hwaseong, Hongcheon, and Goseong, in addition to the six areas mentioned above (Bae et al., 2006). This means that the oak mushroom is cultivated across the nation. In 2007, the oak mushroom was one of the most produced mushroom species in the world. South Korea produced 39,556 tons of oak mushroom, Japan produced 92,117 tons of oak mushroom, and China produced 2,884,769 tons of oak mushroom. In the case of South Korea, the production of the oak mushroom is gradually on the rise. The country had produced an average of 36,849 tons of oak mushroom every year from 1999 to 2008. Also, South Korea exports and imports an average of 294 and 2,927 tons of oak mushroom every year, respectively. The import of the oak mushroom is dramatically increasing.

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Bioluminescent Mushroom

It is known that there are 68 species of bioluminescent fungi in the world (Desjardin et al., 2010; Desjardin et al., 2008). According to related articles, about 14 species of mushrooms in South Korea are bioluminescent, such as *Omphalotus japonicus, Armillariella mellea, Armillariella tabescens*, and *Panellus stypticus*. In fact, however, *Omphalotus japonicus* is the only bioluminescent fungus which was recorded in South Korea. The mycelium of bioluminescent *Armillariella mellea,* and *Armillariella tabescens* was observed only through a laboratory test. The other bioluminescent fungi are found in foreign article records. It is known that bioluminescent fungi mainly grow in subtropical areas. The Mycenaceae species accounts for 72 percent of the total bioluminescent fungi.

Distribution of *Omphalotus japonicus*

Omphalotus japonicus was first found in Gwangneung, Gyeonggi Province in 1940. This mushroom usually grows on dead *Carpinus laxiflora*, and rarely on dead *Quercus serrata* in September. It is known that this mushroom is distributed in Northeast Asian Countries, such as South Korea, Japan, and China. In Japan, this mushroom is classified into the vulnerable species, not the endangered species. In South Korea, this mushroom can be categorized into the vulnerable species because it is only found in Gwangneung, Gyeonggi Province. The shape of this mushroom looks similar to *Pleurotus ostreatus*, This is why people often mistake *Omphalotus japonicus* for *Pleurotus ostreatus*, and eat the poisonous mushroom. For this reason, North Korea calls *Omphalotus japonicus* "Poisonous oyster mushroom" (Yoon, 1978).

The reason why *Omphalotus japonicus* is bioluminescent is that it contains toxic substance, lampteroflavin. The structure of lampteroflavin was found in the early 1970s. Illudin S is another substance which makes mushrooms luminous and poisonous. It is recently reported that Illuding S is effective in suppressing the growth of cancer cells. Therefore, it may be possible to use Illudin S for treating cancer cells. Some say that mushrooms give out light to attract invertebrats which can help mushrooms to spread their spores. Others say that bioluminescent mushrooms are merely the result of biochemical response and have no ecological value (Weitz, 2004). No one can surely say which theory is right, but it is very interesting that fungi have the bioluminescent system.

A : *Omphalotus japonicus* on *Carpinus laxiflora*　　B : *Omphalotus japonicus* on *Carpinus laxiflora*

C : *Omphalotus japonicus* on oak log cultivation　　D : Bioluminescant on mushrooms

[Reference: Desjardin, D.E., B.A. Perry, D.J. Lodge, C.V. Stevani, E. Nagasawa. 2010. Luminescent *Mycena*: new and noteworthy species. Mycologia 102(2): 459-477.; Desjardin, D.E., A.G. Oliveira, C.V. Stevani. 2008. Fungi bioluminescence revisited. Photochemical & Photobiological Sciences 7: 170-182.; Weitz, H.J. 2004. Naturally bioluminescent fungi. Mycologist 18(1): 4-5.; Yoon, Y.B. 1978. Mushrooms of North Korea. Encyclopedia Publishing Company. 225p.]

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