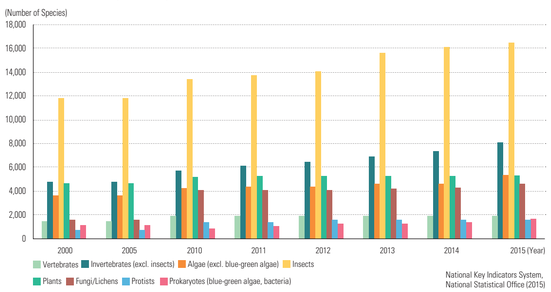
Plants

A total of 45,295 plant and animal species have been surveyed to wildly inhabit Korea. Among the native species, insects represent the largest proportion at 36.3% with 16,447 species, followed by invertebrates (8,167 species), birds (5,382 species), and plants (5,349 species). A survey conducted in 2000 recorded a total of 28,462 species, which increased to 29,916 in 2005 after a comprehensive survey and data compilation process. The number of recorded species has been increasing after the full-fledged biological survey. 33,253 species were recorded in 2008, 38,011 in 2011, 39,150 in 2012, and 45,295 in 2015. The number of native species to Korea is expected to increase as the survey continues.

Plant species of Korea, a temperate region, display vast species diversity and high endemism. 4,300 vascular plant species are known to exist in Korea, among which 280 are pteridophyta, 53 are gymnosperms, and 3,963 are angiosperms. Out of 3,963 angiosperms, 2,910 are dicotyledoneae and 1,053 are monocotyledoneae. Korean flora is characterized by rich diversity and a high ratio of endemic plants, including endemic vascular plant genera, such as *Pentactina*, *Echinosophora*, *Abeliophyllum*, *Hanabusaya*, *Mankyua*, and *Megaleranthis*.

The rich floristic diversity and high endemism of Korea may be due to several factors. First, the Peninsula, which extends southward from Northeast Asia to the Japanese Islands from 42˚ 2′ to 33˚ 4′ north in latitude, enables the accommodation of diverse plant and animal species. A major mountain range that runs from the north to the south connects to other mountain chains. Second, the mountains and hills, which occupy nearly 65 percent of Korea's territory and connect to each other, contribute to the diversity. The presence of about 4,000 islands provides a diverse geographical environment that accommodates diverse flora. Third, Korea has climatic variability (from a mean annual temperature of 16˚C in Jejudo of South Korea to 5˚C in the Gaemagowon (Gaema Highland) of North Korea along with a wide range of temperature variations, *i.e.*, a minimum winter temperature of -45˚C at Baekdusan, North Korea and a maximum summer temperature of 40˚C in Daegu, South Korea. Mean annual precipitation also varies greatly, from 1,700 mm in Jejudo and along the southern coastal region of South Korea to 950 mm in northern inland regions of North Korea. Distinct climatic zones from warm temperate to boreal also provide various conditions for diverse plants to grow. Fourth, there is relatively little volcanic and seismic activity, and no extensive glacial activity. These conditions, combined with other conditions, such as complex bedrock and soil systems, secured the survival of Tertiary flora. Finally, the Korean Peninsula, which has served as a migration route and refuge during both glacial and interglacial periods, has guaranteed the survival of both northern and southern floras.

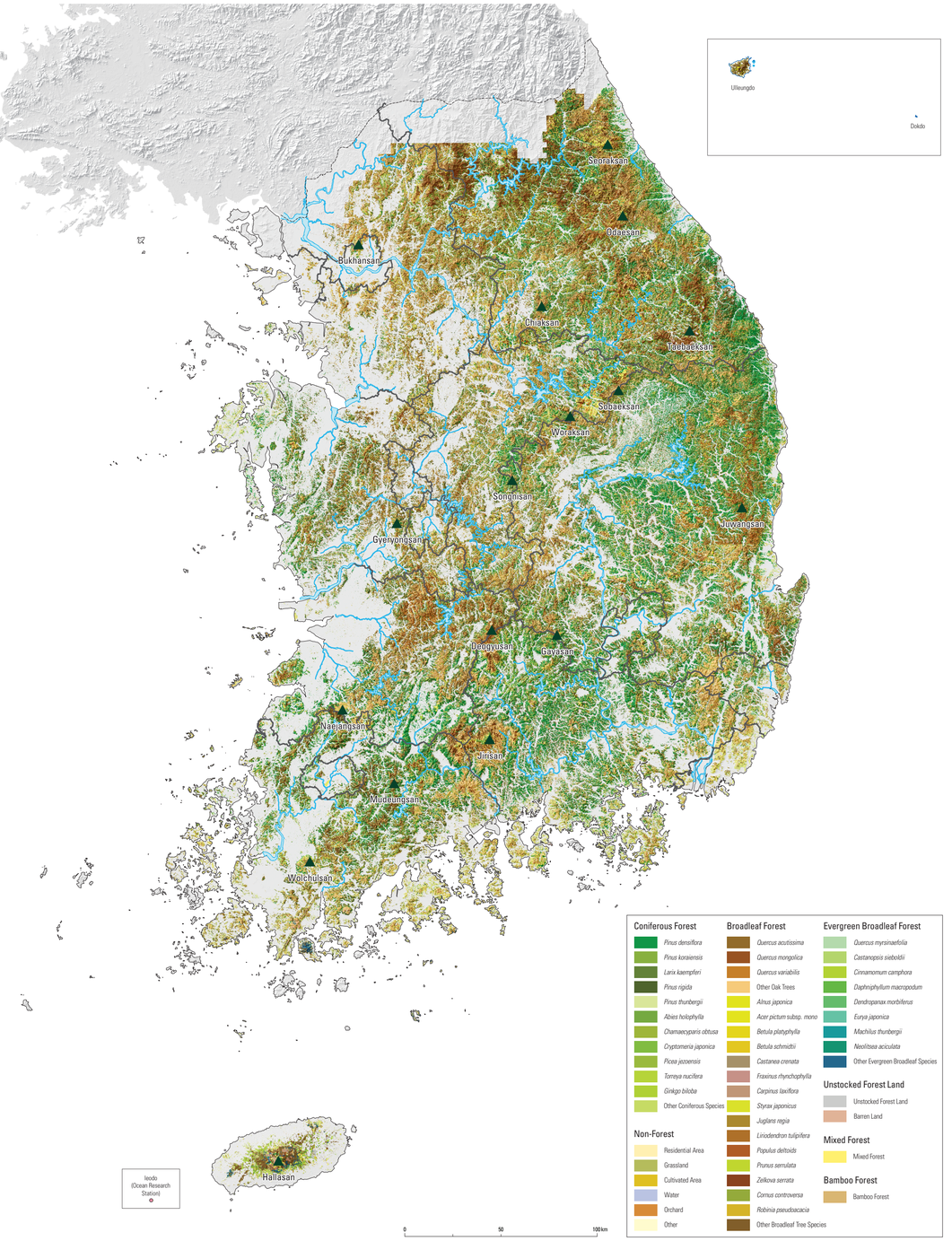
Number of Native Species by Year



National Key Indicators System, National Statistical Office (2015)

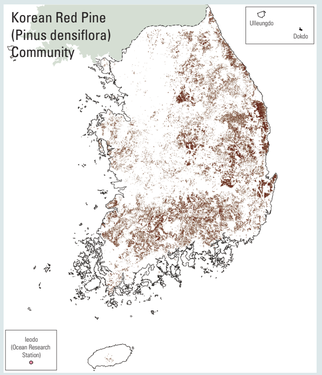
Status of Vegetation

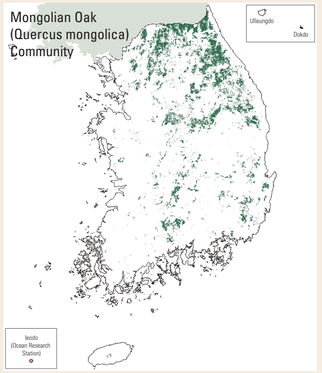
Major Plant Species

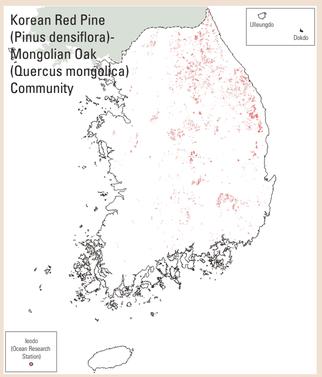


Korea Forest Service (2013)

Major Plant Communities

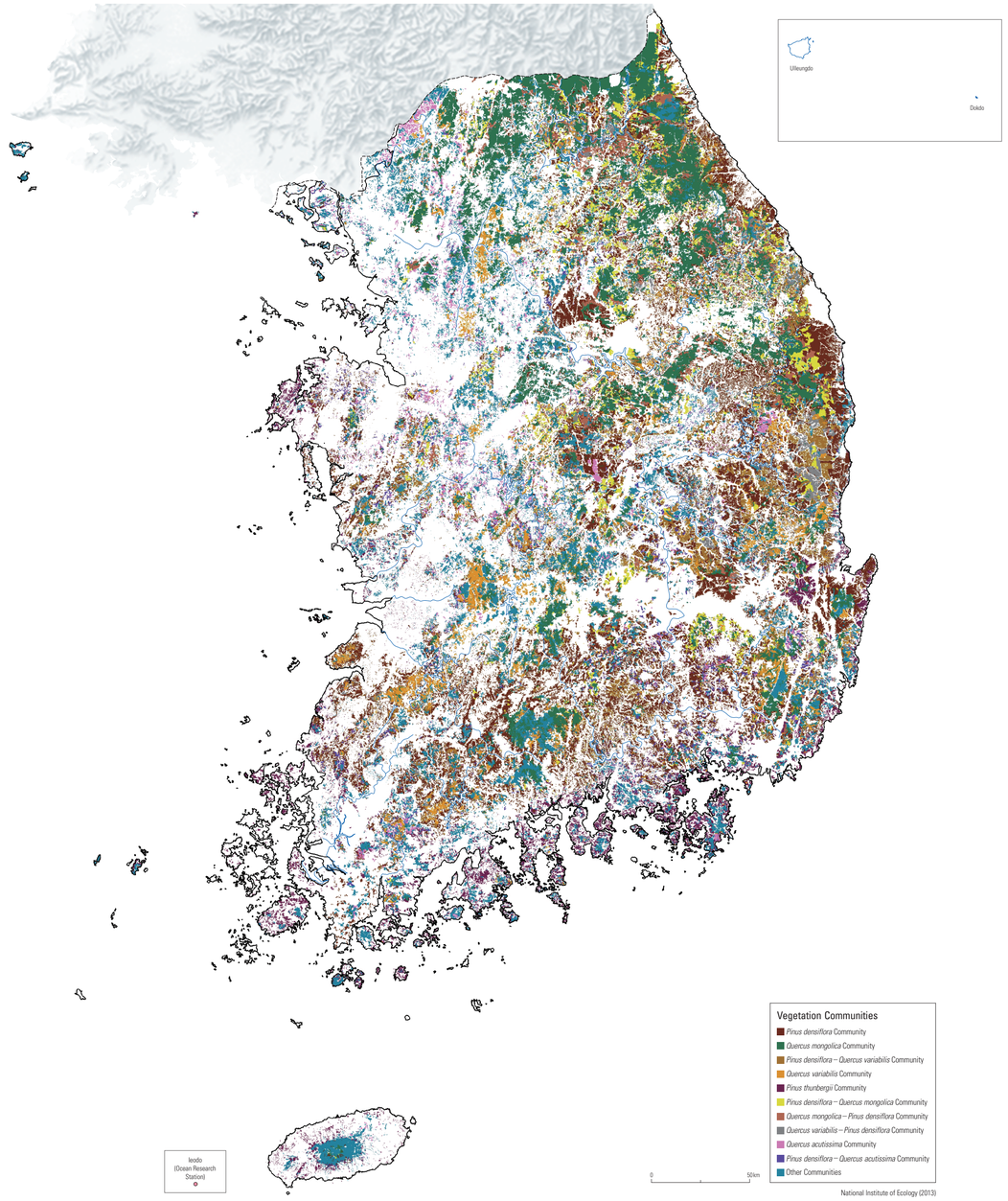




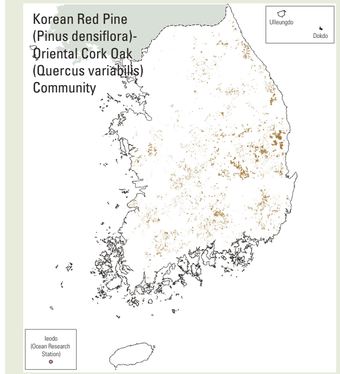


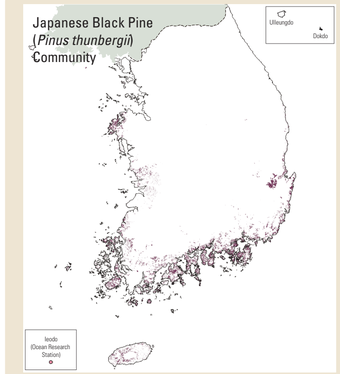
National Institute of Ecology (2013)

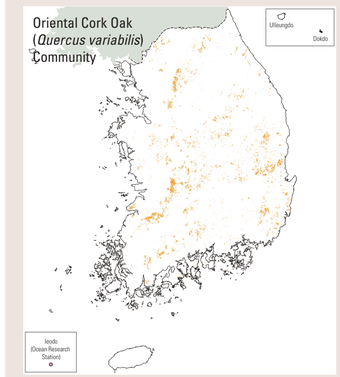
Actual Vegetation Map



National Institute of Ecology (2013)







National Institute of Ecology (2013)

The actual vegetation map illustrates the spatial distribution of vegetation and provides baseline data for better management and proper usage of the natural environment. The National Natural Environmental Survey analyzed the status of the vegetation distribution, including all natural and planted forests. The National Institute of Ecology produced the actual vegetation map based on recent satellite images from the second and third National Natural Environmental Survey and results of previous actual vegetation maps, forest type maps, and degree of ecological naturalness.

In 2012, 42% of the total land area of South Korea was covered by forests, with 37% consisting of broadleaf forest, 33% of coniferous forest, and 29% of mixed forest. Analysis of the vegetation distribution data of the National Natural Environmental Survey (2012) indicates that the Korean red pine (*Pinus densiflora*) community covers the largest area (26.6%) followed by the Mongolian oak (*Quercus mongolica*) community (18.9%), Korean red pine (*Pinus densiflora*)-Oriental cork oak (*Quercus variabilis*) community (6.3%), Oriental cork oak (*Quercus variabilis*) community (5.7%), black pine (*Pinus thunbergii*) community (5.4%), and Korean red pine (*Pinus densiflora*)-Mongolian oak (*Quercus mongolica*) community (5.2%).

The Korean red pine community is the most common and representative forest type that can be found from Jejudo to Hamgyeongbuk-do. Traditionally Korean red pine forests have been protected and managed. Thus, they are broadly distributed throughout the whole country. However, the forests were severely damaged due to resin and wood collection during the Japanese colonial period. After 1970, pine forests had to be cut because of the rampant spread of pine leaf gall midge or *Thecodiplosis japonensis* and natural succession of broadleaf trees such as Mongolian oak (*Quercus mongolica*), which made Korean red pine (*Pinus densiflora*) dominant areas even smaller.

Mongolian oak (*Quercus mongolica*), which belongs to the family Fagaceae, is a deciduous broadleaf tree growing at high altitude. It is distributed in the middle and southern parts of the country. South Korean forests are typically characterized by Mongolian oak (*Quercus mongolica*) communities. The species even covers 33.5% of the Baekdudaegan area. Mongolian oak (*Quercus mongolica*) is also a characteristic species of the boreal and temperate broadleaf forests of central Korea. It is known to have covered the southern lowlands 17,000 – 15,000 years ago, the central area (including the highlands) 10,000 – 4,500 years ago, and almost the entire country (excluding the Gaemagowon and Baekdusan) for the past 4,500 years.

Forest Type Map

The forest type map shows the distribution of different types of forests and is a valuable source of information that can be used to analyze the changes in Korean forests over the last 50 years.

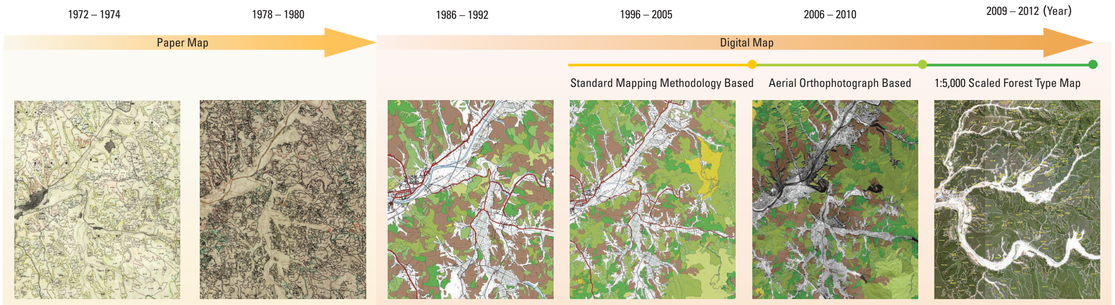
Forest type maps show the classification of forests into coniferous forest, broadleaf forest, and mixed forest, according to the species composition of the forest. Bamboo forests are classified into natural forests.

The forest type maps have been produced at a scale of 1:25,000 with the National Forest Inventory five times since 1972. Maps started to be digitized from the third edition of the forest type map (1986 – 1992), and the production system was standardized from the fourth digital forest type map (1996 – 2005). More detailed 1:5,000 scale forest type maps had been produced since 2009 in connection with the National Spatial Data System project. In 2012, 16,270 sheets of forest type maps of the whole territory were completed.

Comparing the present forest distribution to that represented in the fourth forest type map (1996 – 2005) reveals that the proportion of coniferous forest decreased from 42.18% to 37.8%, that of broadleaf forest (excluding evergreen broadleaf forest) increased from 25.2% to 46.9%, and that of mixed forest decreased from 29.5% to 11.6%.

The increased proportion of the broadleaf forest area can be explained by the increased resolution of the 1:5,000 scale map, which allowed improved differentiation between broadleaf forest and mixed forest from the previous map, and by the decline of coniferous forests due to climate change.

Changes in Forest Type Map



The 1st Forest Type Map

Following the 1st National Forest Inventory (1972 – 1974), 783 sheets of forest type map at a scale of 1:25,000 were created for the first time. No contour lines were used, only the boundaries of different forests were displayed. The 1st National Forest Inventory differentiated tree communities into the following three types: coniferous, broadleaf, and mixed forest.

The 2nd Forest Type Map

In accordance with the 2nd National Forest Resource Inventory (1978 – 1980), 752 sheets of forest type map at a scale of 1:25,000 were created. As with the 1st Forest Type Map, plant communities were categorized into three major groups: coniferous, broadleaf, and mixed forest.

The 3rd Forest Type Map

Based on the 3rd National Forest Resource Inventory (1986 – 1992), 742 sheets of forest type map at a scale of 1:25,000 were created. A digitizing project commenced for the first time and 751 digitized maps were also created. With the 3rd Forest Type Map, forest classification detailed major species, such as *Pinus densiflora*, afforested *Pinus densiflora, Pinus koraiensis, Larix kaempferi, Pinus rigida,* oak trees, *Populus nigra,* afforested oak trees, *Castanea crenata,* and afforested coniferous trees.

The 4th Forest Type Map

In consonance with the 4th National Forest Inventory (1996 – 2005), 750 paper forest type maps at a scale of 1:25,000 were created and digitized using the standard digital mapping method and system for forest type map. Standard mapping system for digital forest map (1:25,000) organized the mapping processes and quality control processes to minimize errors.

The 5th Forest Type Map

Since 2006, all forest type maps have been created using only the standard digital mapping method. Forest aerial photo DB was built with digital orthophotographs, and GIS based aerial photo interpretation system and image loaded field survey system were also developed as foundations for creating the digital forest type maps.

Forest Type Map at a Scale of 1:5,000

Since 2009, a 5-year plan for creating a forest type map at a large scale (1:5,000) has been in operation. There are 16,270 maps covering the entire national forests that deliver detailed and accurate information on the national forest inventories.

National Institute of Forest Science (2013)

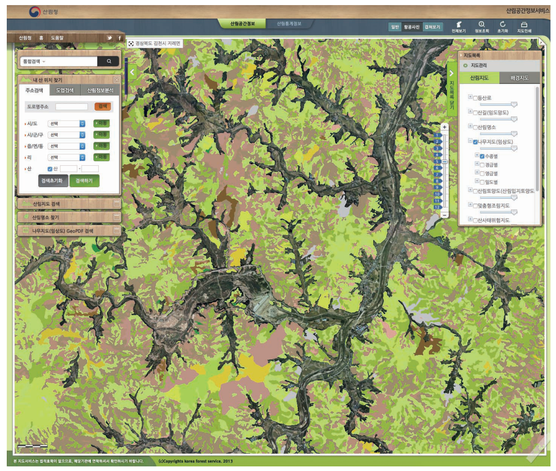
Mapping Processes

Basic Data Collection	◦ Digital aerial photo, 1:25,000 scaled forest type map, National Forest Management Plan, afforested location map and statistics, and so forth.
Forest Type Interpretation and Zoning	◦ Attributes of forest type map: based on the species composition and proportion of crown at canopy - Land Use: classification of forest and non-forest - Forest*: stocked land and unstocked forest land - Forest Origin: planted forest and natural forest - Forest Type: coniferous forest, broadleaf forest, and mixed forest - Tree Species: all existing species for planted forests and major species for natural forests - Age Class: absolute age class by afforestation year for planted forests and average age class of major canopy species for natural forests - DBH Class: average DBH for planted forests and average DBH of major species for natural forests - Crown Closure: canopy closure ratio of major canopy species ◦ Minimum Mapping Area: 0.1 ha for planted forests and 0.5 ha for natural forests
Forest Type and Sample Plot Inventory	◦ Forest Type Inventory: correction based on field survey ◦ Sample Plot Inventory: circular sampling with a radius of 11.28 m at the center of forest type map sheet
Zoning by Forest Type and Editing	◦ Correction of attributes and delineation of forest type over against field surveys
Producing the Forest Type Map	◦ Editing for structure through edge matching between map sheets ◦ Printing and inspection

* Definition of forest: minimum area of a forest is 0.1 ha and minimum width is 20 m.
Forests include unstocked forests or barren lands within the forest land

National Institute of Forest Science (2013)

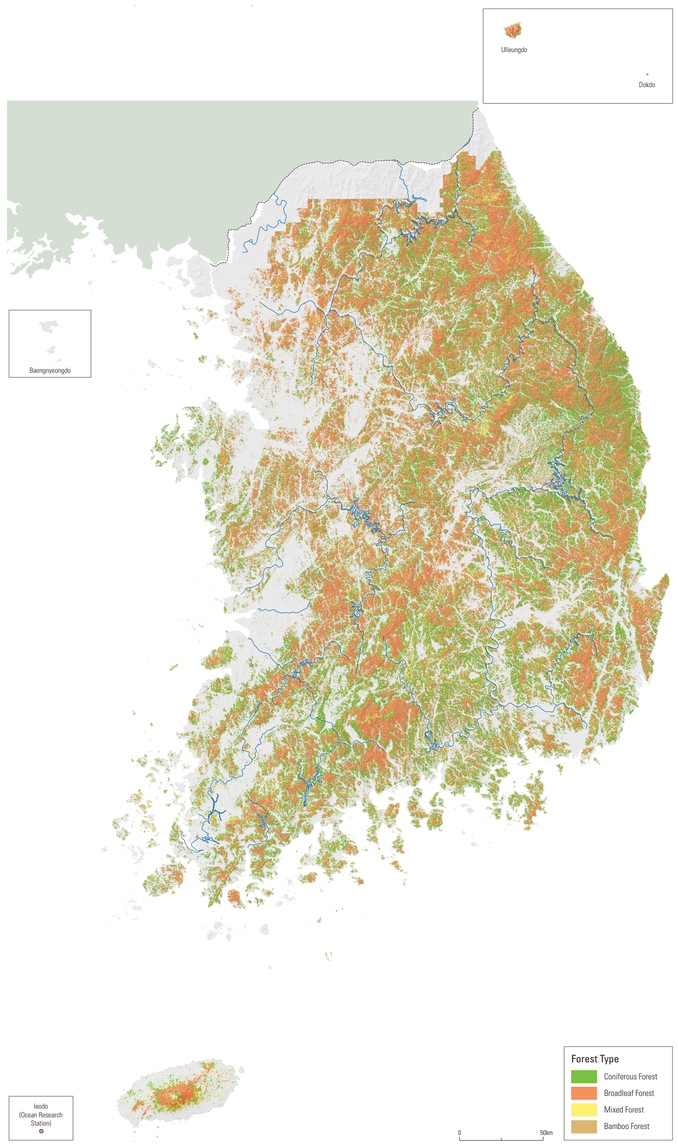
Forest Spatial Information Service



National Institute of Forest Science (2013)

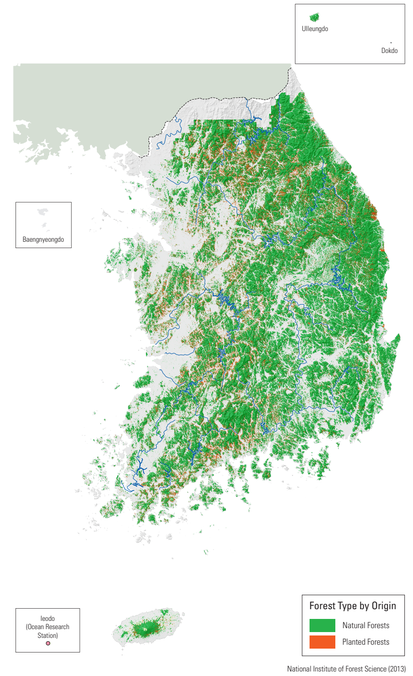
Digital forest type map is a representative forest thematic map that displays the distributions of various forest types. It is an important thematic map that is compiled on a national scale in addition to topographic map, soil map, geological map, and so forth. Compared to paper-printed forest type map in the past, a digital forest type map is outstanding in data management and utilization, allowing fast and accurate data search and effective support for various planning and decision making processes.

Major Forest Types



National Institute of Forest Science (2013)

Natural Forests and Planted Forests



National Institute of Forest Science (2013)

Forest Extent and Growing Stock

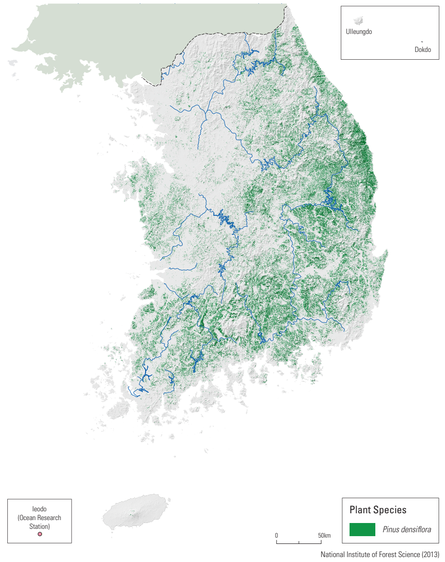
Korea Forest Service (2015)

Coniferous forests are widely distributed in Gyeongsangbuk-do and broadleaf forests are mostly in Gangwon-do. Especially in Gangwon-do, broadleaf forests make up 54.9% of the total forest area. This figure shows an increase in the area of coniferous forest compared to the data (32.4%) from the basic forest statistics in 1995. Andong-si in Gyeongsangbuk-do has the largest area of coniferous forest, while Inje-gun of Gangwon-do has the largest area of broadleaf forest.

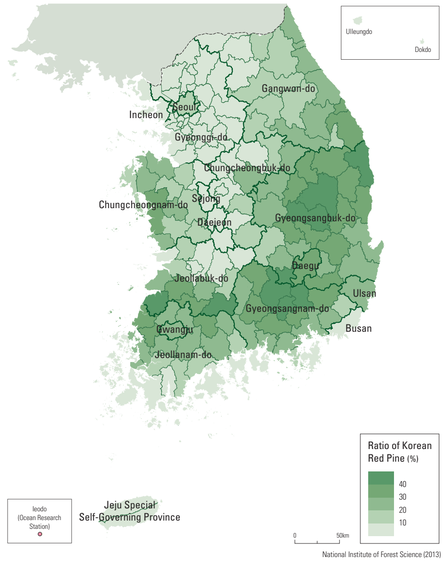
Forests are divided into planted forest and natural forest based on their origin. Most of the planted forests in the central region of South Korea are dominated by species such as Korean pine (*Pinus koraiensis*), Japanese larch (*Larix leptolepis*), and pitch pine (*Pinus rigida*). In the southern part of the country, Japanese cedar (*Cryptomeria japonica*) and Hinoki cypress (*Chamaecyparis obtusa*) imported from Japan, are partially planted. Planted forests comprise around 15.5% of the total forest area. Natural forests are formed by natural seedling or sprouting. Except for Korean red pine (*Pinus densiflora*), most natural forest areas regenerate naturally by sprouting. Tree species in the natural broadleaf forests are almost mutually exclusive. Generally, species richness per unit area of broadleaf forest is low, but pure stands are rarely formed. In most natural broadleaf forests, the high forest canopy is occupied by oak species, such as Mongolian oak (*Quercus mongolica*), sawtooth oak (*Quercus acutissima*), and other types of trees such as loose-flower hornbeam (*Carpinus laxiflora*), Sargent's cherry (*Prunus sargentii*), East Asian ash (*Fraxinus rhynchophylla*), maple trees, palmate maple, East Asian white birch, birch trees, Amur Linden (*Tilia amurensis*), Japanese elm (*Ulmus davidiana*), wedding cake tree (*Cornus controversa*), and Manchurian walnut (*Juglans mandshurica*). The sub-tree layer is formed with younger trees of species such as heartleaf hornbeam (*Carpinus cordata*), Korean maple (*Acer pseudosieboldianum*), and fragrant snowbell (*Styrax obassia*). Over half of Korea's natural forests are covered by broadleaf trees while over 80% of planted forests are comprised of coniferous trees.

Major Tree Species

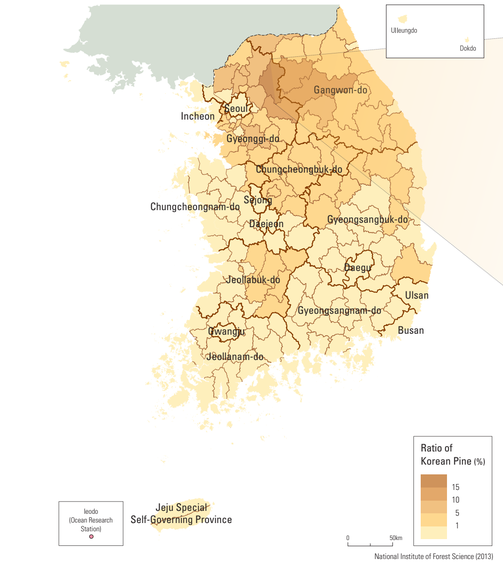
Distribution of Korean Red Pine (*Pinus densiflora*)



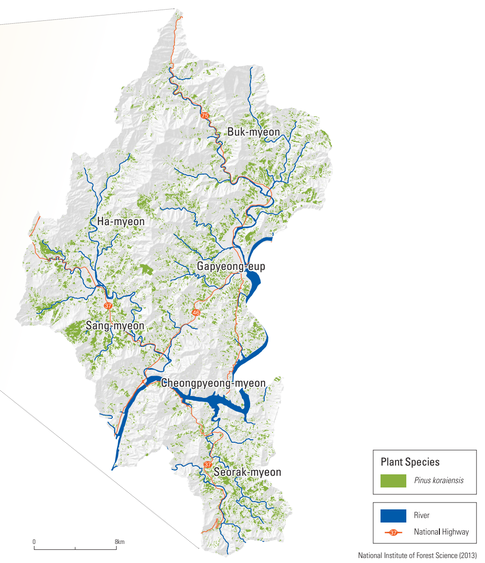
Ratio of Korean Red Pine (*Pinus densiflora*) by Province



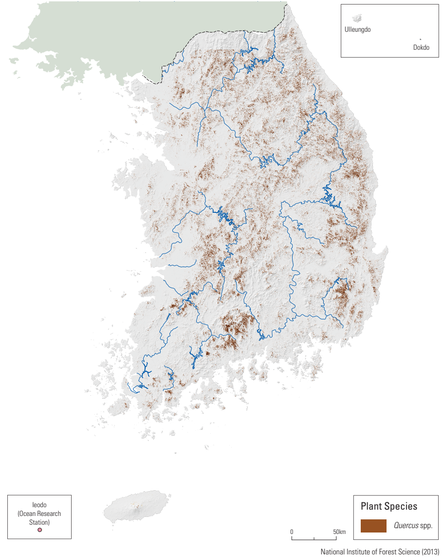
Ratio of Korean Pine (*Pinus koraiensis*) by Province



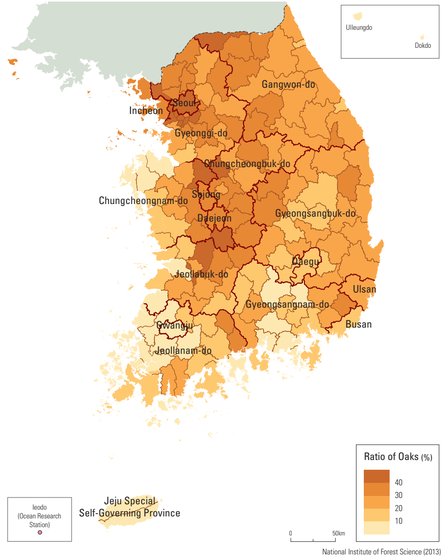
Distribution of Korean Pine (*Pinus koraiensis*) of Gapyeong-gun, Gyeonggi-do



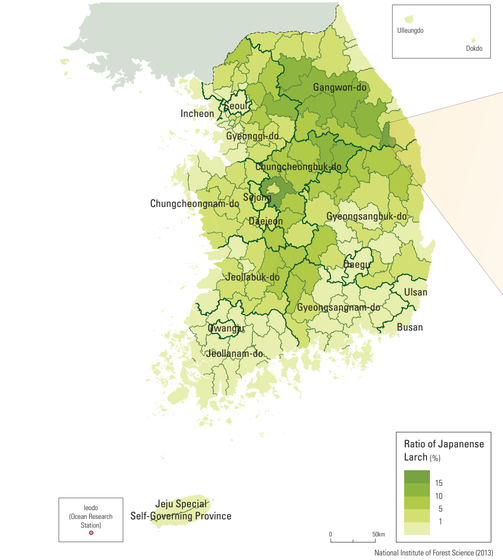
Distribution of Oak Species (*Quercus* spp.)



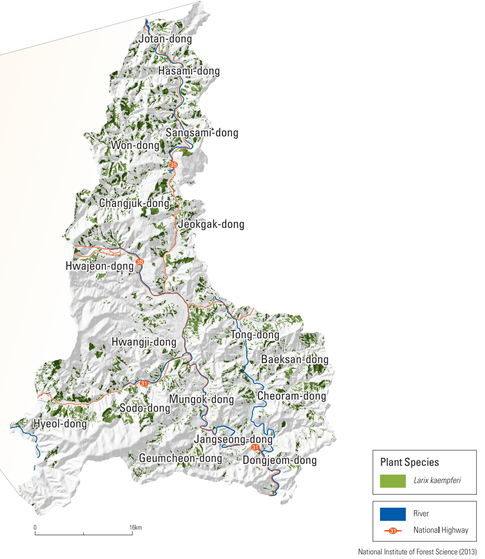
Ratio of Oaks (*Quercus* spp.) by Province



Ratio of Japanese Larch (*Larix kaempferi*) by Province



Distribution of Japanese Larch (*Larix kaempferi*) of Taebaek-si, Gangwon-do



Forests cover 63.2% of the South Korean territory. Loose-flower hornbeam (*Carpinus laxiflora*) forests are native to Korean forests but today, much of the native forest has been destroyed and replaced by oak species such as Mongolian oak (*Quercus mongolica*), sawtooth oak (*Quercus acutissima*), Oriental cork oak (*Quercus variabilis*), and Jolcham oak (*Quercus serrata*). Other species, including black locust (*Robinia pseudoacacia*), East Asian alder (*Alnus japonica*), Sargent's cherry (*Prunus sargentii*), and snowbell tree (*Styrax japonicus*) can be easily found in Korean forests. The largest forest consisting of one dominant species is of a representative coniferous tree, the Korean red pine (*Pinus densiflora*). Known as the most favorite tree of Korea, the Korean red pine has been protected under governmental policy and lumbering has been prohibited.

The Korean red pine (*Pinus densiflora*) accounts for 21.9% of the total forests in South Korea. Although evenly distributed across the nation, they are mostly dominant in Gangwon-do and the eastern coasts of Gyeongsangbuk-do. In Andong-si and Uljin-gun of Gyeongsangbuk-do, the proportion of Korean pine dominance is 49.9%. Changnyeong-gun of Gyeongsangnam-do shows the highest distribution rate of Korean red pine trees at 52.9% among all cities.

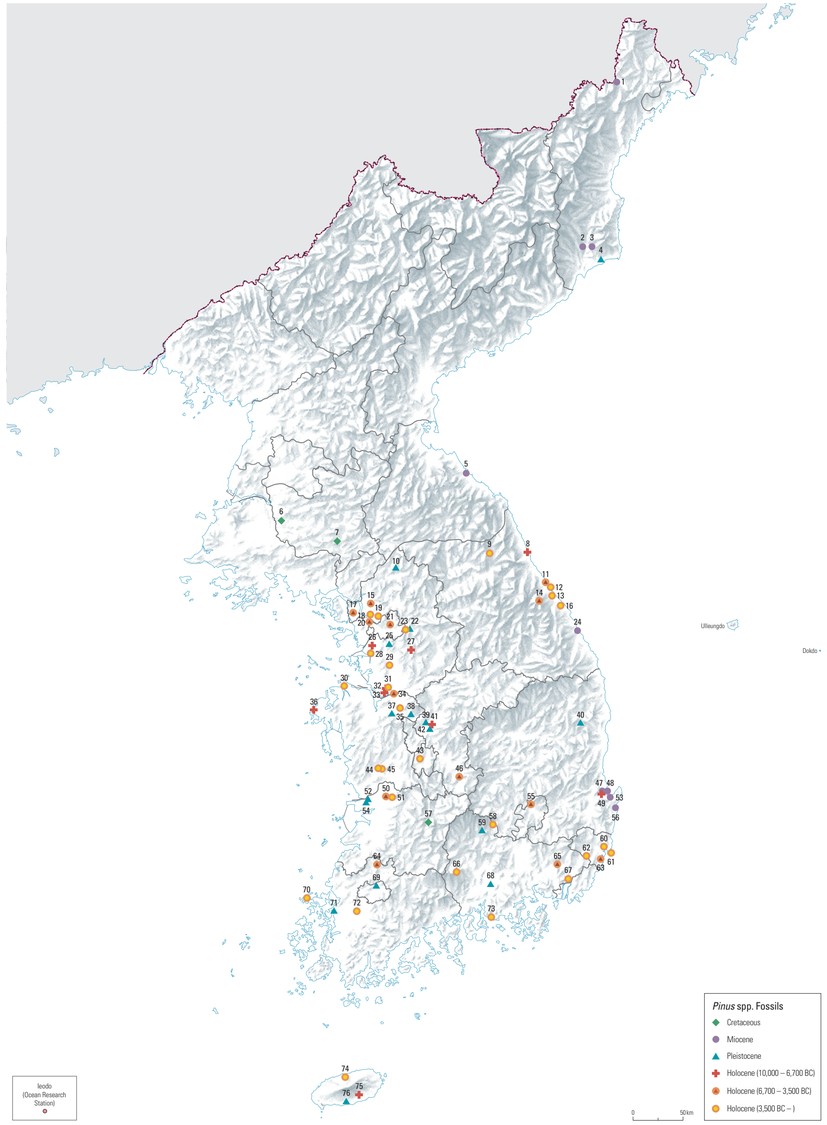
Oak species are the major broadleaf tree species in South Korea, including Jolcham oak (*Quercus serrata*), Galcham oak (*Quercus aliena*), Oriental cork oak (*Quercus variabilis*), Mongolian oak (*Quercus mongolica*), and Japanese emperor oak (*Quercus dentata*). Oak covers 24.2% of the total forest area, higher than that of pines. Oak distribution is the greatest in Hongcheon-gun of Gangwon-do, followed by Inje-gun and Chuncheon-si. In Gimpo-si of Gyeonggi-do, 52.9% of forests are composed of oak species, which is the highest distribution rate among all cities of South Korea.

Korean pine (*Pinus koraiensis*) is an evergreen coniferous tree species and one of the oldest trees associated with Korean history, along with the Korean red pine (*Pinus densiflora*). It is widely distributed in the Korea Peninsula, Japan, China, and Siberia. Preferring a cold climate, it can be easily found in higher elevations. Its major habitats in Korea include Gapyeong-gun and Yangju-si of Gyeonggi-do, and Hongcheon-gun of Gangwon-do. Korean pine covers 2.4% of the total national forest area. With 20.0% of the total forests composed of this species, Gapyeong-gun of Gyeonggi-do has the highest distribution of Korean pine among all regions.

Japanese larch (*Larix kaempferi*) is a deciduous conifer. It is called deciduous pine because it belongs to Pinaceae, but it sheds its leaves annually. The species comprises 4.5% of the entire national forest. Hongcheon-gun, Pyeongchang-gun, and Jeongseon-gun have the highest Japanese larch population. With 19.1% of the forest possessed by this species, Taebaek-si of Gangwon-do displays the highest distribution rate of Japanese larch.

Natural History of Pine Tree (*Pinus* spp.)

Pine Tree (*Pinus* spp.) Fossils in Geological Time



No.	Location	Geological Time
1	Hoeryeong	Miocene
2	Gilju, Myeongcheon	Miocene
3	Gilju, Myeongcheon	Miocene
4	Hwadae	Pleistocene
5	Tongcheon	Miocene
6	Sariwon	Cretaceous
7	Pyeongyang	Cretaceous
8	Sokcho-si, Yeongrangho	Holocene (10,000 – 6,700 BC)
9	Daeamsan	Holocene (3,500 BC –)
10	Yeoncheon-gun	Pleistocene
11	Sokcho-si, Hyangho	Holocene (6,700 – 3,500 BC)
12	Jumunjin	Holocene (3,500 BC –)
13	Gangneung-si	Holocene (3,500 BC –)
14	Donghae-si	Holocene (6,700 – 3,500 BC)
15	Paju-si	Holocene (6,700 – 3,500 BC)
16	Gangneung-si	Holocene (3,500 BC –)
17	Gimpo-si	Holocene (6,700 – 3,500 BC)
18	Ilsan	Holocene (3,500 BC –)
19	Goyang-si	Holocene (3,500 BC –)
20	Gimpo-si	Holocene (6,700 – 3,500 BC)
21	Seoul	Holocene (6,700 – 3,500 BC)
22	Hanam-si	Pleistocene
23	Hanam-si	Holocene (3,500 BC –)
24	Donghae-si	Miocene
25	Uiwang-si	Pleistocene
26	Siheung-si	Holocene (10,000 – 6,700 BC)
27	Goyang-si	Holocene (10,000 – 6,700 BC)
28	Siheung-si	Holocene (3,500 BC –)
29	Gunja	Holocene (3,500 BC –)
30	Dangjin-si	Holocene (3,500 BC –)
31	Pyeongtaek-si	Holocene (3,500 BC –)
32	Pyeongtaek-si	Holocene (10,000 – 6,700 BC)
33	Pyeongtaek-si	Holocene (10,000 – 6,700 BC)
34	Pyeongtaek-si	Holocene (6,700 – 3,500 BC)
35	Cheonan-si	Holocene (3,500 BC –)
36	Taean-gun	Holocene (10,000 – 6,700 BC)
37	Asan-si	Pleistocene
38	Cheonan-si	Pleistocene
39	Cheongwon-gun	Pleistocene
40	Yeongyang-gun	Pleistocene
41	Cheongju-si	Holocene (10,000 – 6,700 BC)
42	Cheongju-si	Pleistocene
43	Daejeon	Holocene (3,500 BC –)
44	Buyeo-gun	Holocene (3,500 BC –)
45	Buyeo-gun	Holocene (3,500 BC –)
46	Gimje-si	Holocene (6,700 – 3,500 BC)
47	Pohang-si	Miocene
48	Pohang-si	Miocene
49	Pohang-si	Holocene (10,000 – 6,700 BC)
50	Iksan-si	Holocene (6,700 – 3,500 BC)
51	Iksan-si	Holocene (3,500 BC –)
52	Gunsan-si	Pleistocene
53	Pohang-si	Miocene
54	Gunsan-si	Pleistocene
55	Daegu	Holocene (6,700 – 3,500 BC)
56	Pohang-si	Miocene
57	Jinan-gun	Cretaceous
58	Haman-gun	Holocene (3,500 BC –)
59	Geochang-gun	Pleistocene
60	Ulsan	Holocene (3,500 BC –)
61	Ulsan	Holocene (3,500 BC –)
62	Moojechineup	Holocene (3,500 BC –)
63	Ulsan	Holocene (6,700 – 3,500 BC)
64	Gochang-gun	Holocene (6,700 – 3,500 BC)
65	Miryang-si	Holocene (6,700 – 3,500 BC)
66	Jirisan	Holocene (3,500 BC –)
67	Gimhae-si	Holocene (3,500 BC –)
68	Jinju-si	Pleistocene
69	Gwangju	Pleistocene
70	Sinan-gun	Holocene (3,500 BC –)
71	Muan-gun	Pleistocene
72	Muan-gun	Holocene (3,500 BC –)
73	Sacheon-si	Holocene (3,500 BC –)
74	Jeju-si	Holocene (3,500 BC –)
75	Seogwipo-si	Holocene (10,000 – 6,700 BC)
76	Seogwipo-si	Pleistocene

* Relatively fewer fossils have been excavated in the northern part of the Korean Peninsula due to insufficient research.

International Union for Quaternary Research (2015)

The earliest occurrence of the genus of pine tree or *Pinus* on the Korean Peninsula dates to the Cretaceous; the presence of *Pinus* spp. on the Peninsula continued throughout the Miocene, Pleistocene, and Holocene to the present day. During the Quaternary, *Pinus* spp. had a wide distribution and maintained dominance over the Korean Peninsula. *Pinus* spp. later diversified into cold-tolerant and warm-tolerant species. Cold-tolerant *Pinus* spp. (*haploxylon*) with 5 needles occupied the northern and high mountains, but *Pinus* spp. (*diploxylon*) with 2 needles was common in lowlands and coastal regions.

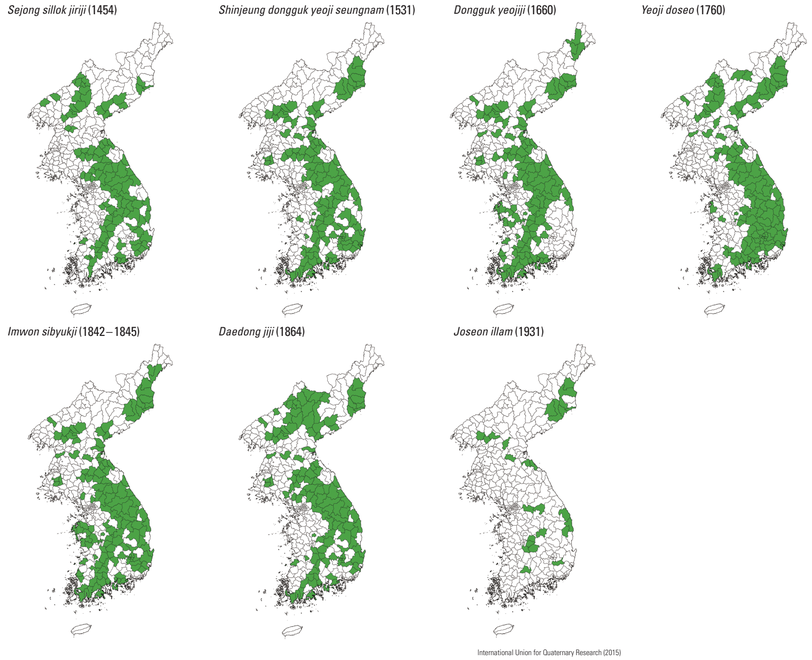
Since the Holocene, *Pinus* species exhibiting niche characteristics have been occupying different habitats and locations, becoming a dominant component of the vegetation. Dominance of *Pinus* spp. may be partially due to anthropogenic disturbances, such as agriculture, fire, and land-use patterns at lowland sites. Boreal *Pinus* species including dwarf stone pine (*Pinus pumila*), Korean pine (*Pinus koraiensis*), Chinese hard pine (*Pinus tabulaeformis*) migrated into the Korean Peninsula during the Pleistocene glacial epochs, away from the harsh environment of the northeast Asia. Their distribution is currently confined to the alpine and subalpine belts of the Korean Peninsula.

Black pine (*Pinus thunbergii*) is found mainly in the southern and central-southern coastal areas of Korea. Ulleungdo white pine (*Pinus parviflora*) occurs in isolation in Ulleungdo and some Japanese islands. Species like black pine (*Pinus thunbergii*) with larger, winged seeds and often dispersed by wind have wider distributional ranges than species without winged seeds, such as dwarf stone pine (*Pinus pumila*) and Korean pine (*Pinus koraiensis*) that are dispersed by birds and rodents. These species have narrow distribution ranges around the montane and high mountain areas. Species with disjunctive distributions, such as dwarf stone pine (*Pinus pumila*) in the alpine and subalpine belts of northern and central Korea, Korean pine (*Pinus koraiensis*) in mountainous areas, and Ulleungdo white pine (*Pinus parviflora*) in Ulleungdo are more vulnerable to climate change such as global warming than other *Pinus* spp..

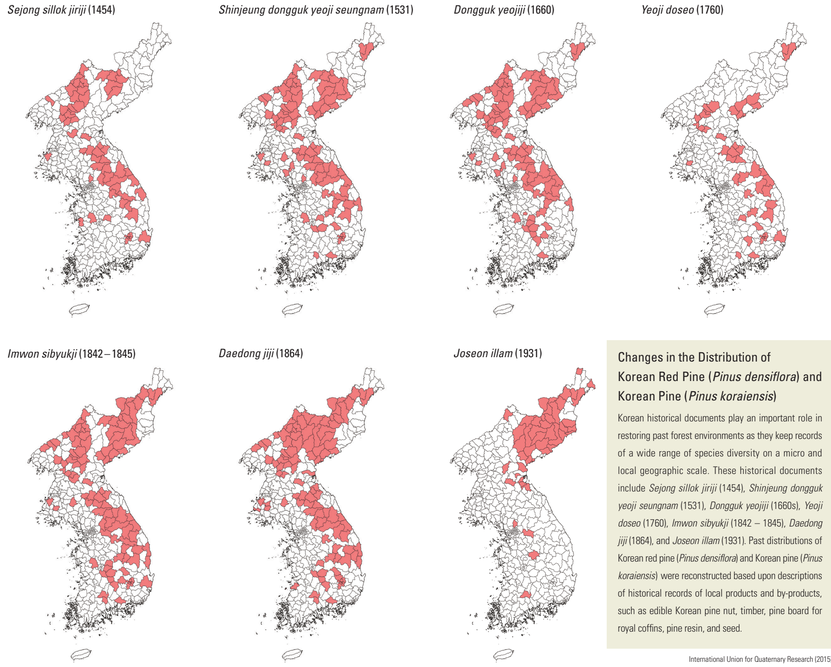
Korean red pine (*Pinus densiflora*) and black pine (*Pinus thunberigii*) in lowland and coastal areas are under the influence of deforestation, over development, and insect outbreak.

Geographical Distribution of Pine Tree (*Pinus* spp.) in Joseon Dynasty

Korean Red Pine (*Pinus densiflora*)



Korean Pine (*Pinus koraiensis*)



Descriptions of local products and tributes from historical documents of Korea were successfully used to reconstruct spatial and temporal changes in species for the vegetation history during historic times.

Korean red pine (*Pinus densiflora*) is mainly distributed in the eastern regions like Gyeongsang-do and Gangwon-do. This could be explained by a distinct topographic condition of Korea due to the north-south running Taebaeksan-maek (Taebaek Mountain Range), conditions with rocky land and high altitude, relatively moderate temperatures and low humidity, and by the natural environment and artificial conditions. A mild climate also explains the abundance of Korean red pine in Jeollanam-do, Jeollabuk-do, Chungcheongnam-do, and Chungcheongbuk-do.

Areas of the temporal distribution of the Korean red pine (*Pinus densiflora*) based on historical literature are 107 sites in year 1454, 133 in 1531, 139 in 1660, 148 in 1760, 162 in 1842 – 1845, 125 in 1864, and 27 in 1931. Korean red pine has been widely distributed across the nation from 1531 to 1864, however, a decrease in population is observed around the Gyeonggi-do region in 1760 and 1864, compared to 1660 and 1842 – 1845. The species has been observed at 841 sites from 1454 to 1931, 107 sites from 1454, which increased to 162 sites from 1842 to 1845. The area of Korean red pine forests had decreased around 1931 due to excess forest use and forest lumbering under Japanese occupation. The extensive afforestation policies that started in 1970s has led to artificial planting of the species.

Past distributions of Korean pine (*Pinus koraiensis*) were reconstructed based upon descriptions of historical records of local products and by-products. The extensive distribution of Korean pine during the 19th century and from 1530 to 1660 in high montane areas of eastern and northern Korea may indicate a relatively cooler climate. Counties with Korean pine were few in 1454 and 1760 as well as in 1931, which may imply a milder climate at those times.

Korean pine (*Pinus koraiensis*) was frequently present in northern, central and eastern regions Pyeongannam-do and Pyeonganbuk-do (84 counties), and Hamgyeongnam-do and Hamgyeongbuk-do (69 counties) of North Korea, and Gangwon-do (94 counties), Gyeongsangnam-do and Gyeongsangbuk-do (83 counties), and Chungcheongnam-do and Chungcheongbuk-do (46 counties) of South Korea. On the other hand, the species are rare in the lowlands mostly located on the western portion of the Korean Peninsula where the climate is relatively mild and wet, *i.e.*, Jeollanam-do and Jeollabuk-do (18 counties) and Gyeonggi-do (13 counties) of South Korea, and Hwanghaenam-do and Hwanghaebuk-do (23 counties) of North Korea.

Changes in the Distribution of Korean Red Pine (*Pinus densiflora*) and Korean Pine (*Pinus koraiensis*)

Korean historical documents play an important role in restoring past forest environments as they keep records of a wide range of species diversity on a micro and local geographic scale. These historical documents include *Sejong sillok jiriji* (1454), *Shinjeung dongguk yeoji seungnam* (1531), *Dongguk yeojiji* (1660s), *Yeoji doseo* (1760), *Imwon sibyukji* (1842 – 1845), *Daedong jiji* (1864), and *Joseon illam* (1931). Past distributions of Korean red pine (*Pinus densiflora*) and Korean pine (*Pinus koraiensis*) were reconstructed based upon descriptions of historical records of local products and by-products, such as edible Korean pine nut, timber, pine board for royal coffins, pine resin, and seed.

International Union for Quaternary Research (2015)

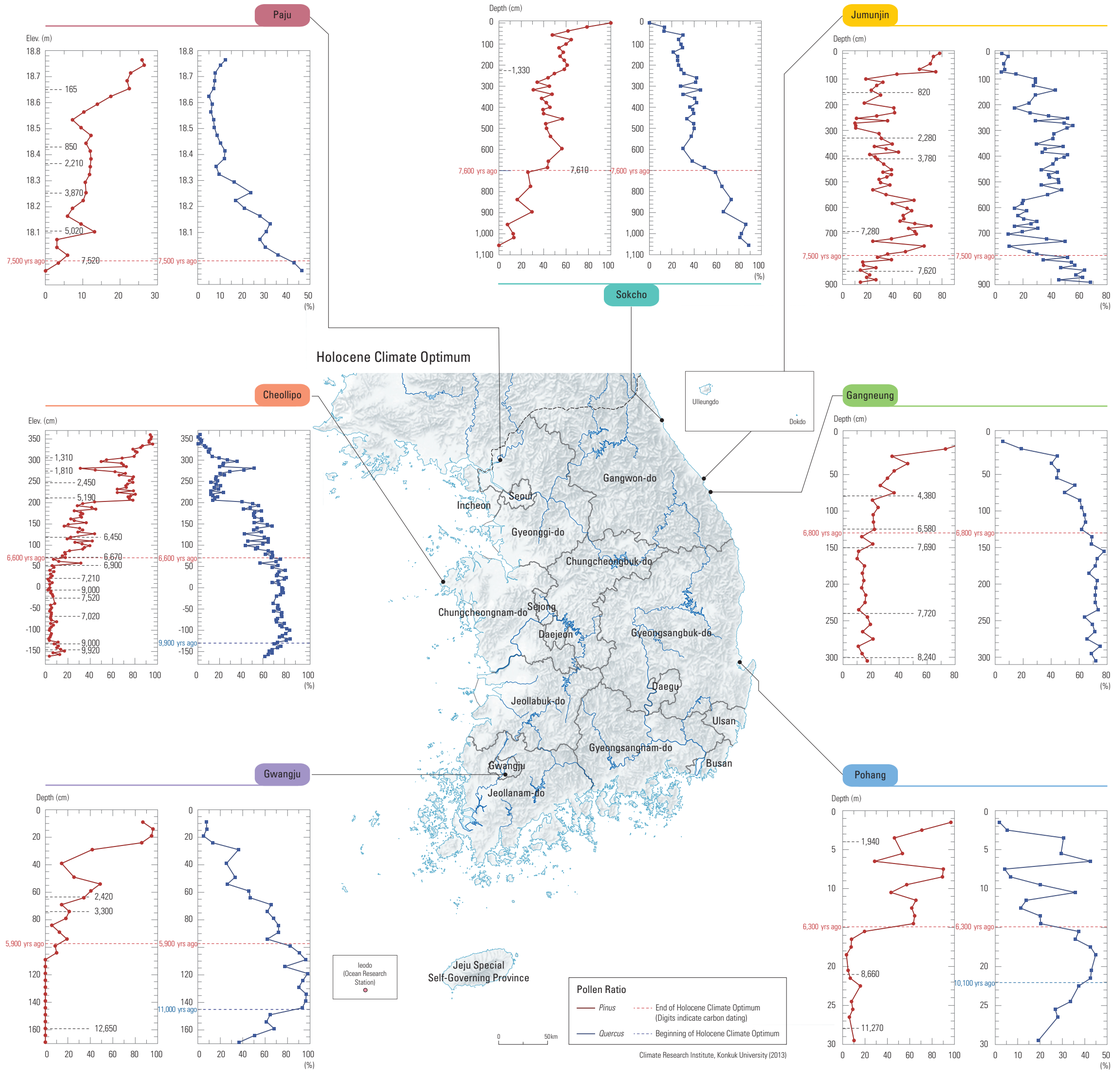
Vegetation and Climate of the Holocene

Pine trees (*Pinus* spp.) and Oak trees (*Quercus* spp.) are the most commonly found trees in the Korean peninsula. The decline of the population of these species are closely related to climate change. Representative deciduous broadleaf tree of Korea, *Quercus* spp. prefers warm and humid climate. Moreover, the species displays endurability in sunlight deficient environment, slow growth, and good adaptation under stable climate without disturbances. Therefore, under warm and stable climate environment, relative ratio and population of *Quercus* spp. among total plant species are expected to increase. On the contrary, dry and unstable climate conditions become favorable for *Pinus* spp..

Recently, *Pinus* pollen has been increasing while that of *Quercus* spp. has been decreasing, which signifies climate cooling. In addition, the period of a decrease in the ratio of *Quercus* spp. and an increase in that of *Pinus* spp. is considered as the end of Holocene Climate Optimum (the mildest climate in the past 10,000 years). Such periods of changes in vegetation fall under from the past 7,500 to 5,900 years, showing spatial variation. In both east and west coast, the end of optimal climate of the Holocene period appears in later years from high latitudes to low latitudes.

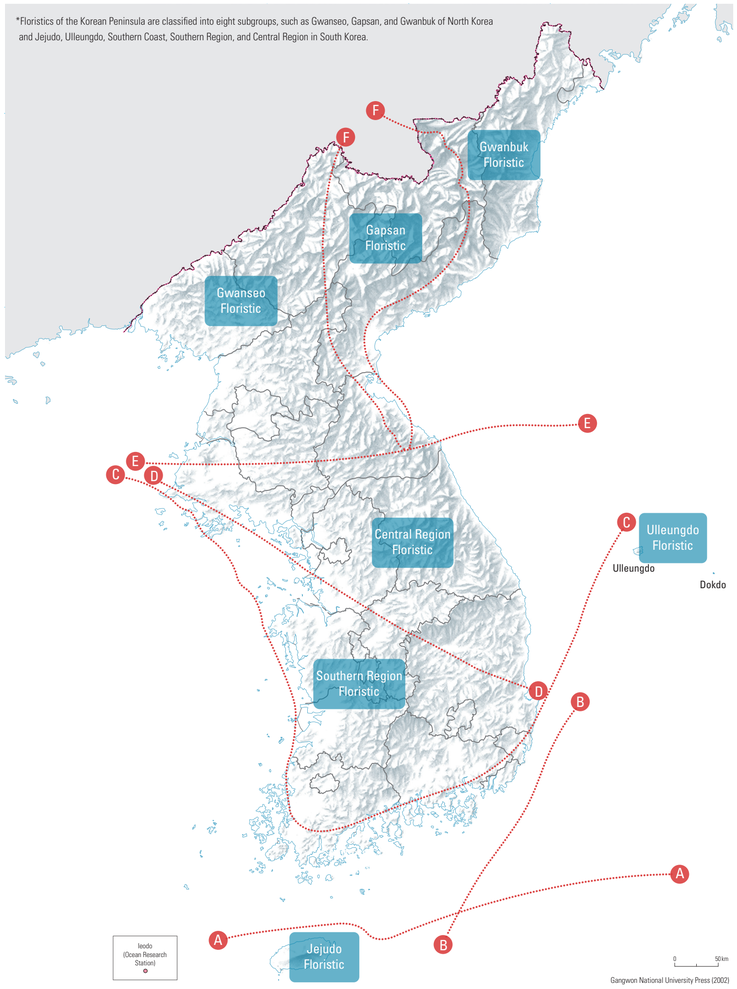
Pollen Data Showing the Holocene Climate Optimum in South Korea

Research Area			Latitude	Longitude	Holocene Climate Optimum	
					Beginning	End
East Coast Area	E1	Yeongrangho, Sokcho-si	38° 35' 03" N	128° 35' 03" E	?	about 7,600 years ago
	E2	Hyangho, Jumunjin-si	37° 54' 28" N	128° 45' 03" E	?	about 7,500 years ago
	E3	Sunpogaeho, Gangneung-si	37° 49' 10" N	128° 53' 16" E	?	about 6,800 years ago
	E4	Pohang-si	36° 00' 25" N	129° 22' 31" E	about 10,100 years ago	about 6,300 years ago
West Coast Area	W1	Unjeong, Paju-si	37° 42' N	126° 44' 00" E	?	about 7,500 years ago
	W2	Hwaseong-si	37° 09' 12" N	126° 46' 00" E	?	about 7,400 years ago
	W3	Cheollipo, Taean-gun	36° 47' 57" N	126° 09' 04" E	about 9,900 years ago	about 6,600 years ago
	W4	Gwangju-si	35° 12' 36" N	126° 52' 10" E	about 11,000 years ago	about 5,900 years ago
	W5	Gwangju-si	35° 07' 24" N	126° 44' 38" E	?	about 5,900 years ago



Floristics and Plant Communities

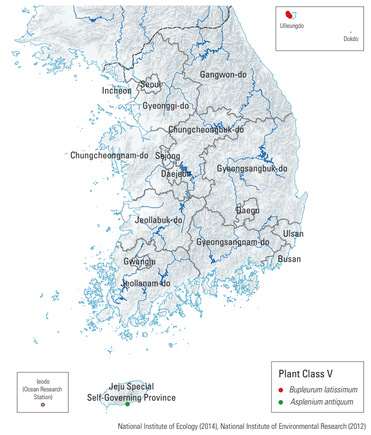
Floristics in the Korean Peninsula



Plant distribution is determined by numerous environmental factors such as topography and climate, and the dispersal ability of each plant species. By regions, phytogeographical categories are decided upon plant's original characteristics. Such regions of plant distribution are called floristics. Floristics of the Korean Peninsula are classified into eight subgroups. The eight subgroups include Gwanseo, Gapsan and Gwanbuk in North Korea and Jejudo, Ulleungdo, southern coast, southern region, and central region in South Korea.

The Korean Peninsula is inhabited by 4,338 taxa of plant species. Five South Korean floristic regions contain about 3,300 naturally growing taxa. About one thousand taxa, including East Asian edelweiss (*Leontopodium japonicum*), Manchurian poplar (*Populus maximowiczii*), big-bract thorowax (*Bupleurum euphorbioides*), and Siberian lily (*Lilium dauricum*), are estimated to inhabit the central region; 1,300 taxa, including Korean stewartia (*Stewartia pseudocamellia*), Korean winter hazel (*Corylopsis coreana*), and Korean forest poppy (*Coreanomecon hylomeconoides*), inhabit the southern region; 2,000 taxa, including camphor (*Cinnamomum camphora*), wild dampalsu (*Elaeocarpus sylvestris* var. *ellipticus*), waxberry (*Myrica rubra*), and other southern plant species, inhabit the Jejudo region; and 700 taxa, including pointed-petal trillium (*Trillium tschonoskii*), false lily of the valley (*Maianthemum dilatatum*), and giant knotweed (*Fallopia sachalinensis*), inhabit Ulleungdo. Also, around 3,000 taxa, including dark-bark spruce (*Picea jezoensis*), Korean viburnum (*Viburnum koreanum*), Korean twisted-stalk (*Streptopus koreanus*), and alpine clubmoss (*Lycopodium alpinum*), are found in Gwanbuk, Gapsan, and Gwanseo of North Korea.

Plant Class V



Plant communities are classified into 5 different classes, which allows an objective and qualitative approach in assessing environmental impacts on plant species and prioritization of species conservation in the decision-making process. Class V is a taxonomic group that is distributed in extremely limited areas, discontinuously, or in isolated places. Class V consists of 256 taxa, including *Sibbaldia procumbens, Diapensia lapponica, Cymbidium kanran, Saururus chinensis, Quercus gilva, Asplenium antiquum, Ceratopteris thalictroides, Brasenia schreberi, Ranunculus kazusensis, Sophora koreensis, Lycoris chinensis, Cotoneaster wilsonii, Bupleurum latissimum, Eriophorum gracile, Scleria mutoensis, Tephroseris phaeantha, Crinum asiaticum,* and *Anaphalis sinica.*

Class IV is a taxonomic group that is only distributed in one floristic region including Ulleungdo. Class IV consists of 384 taxa, including *Waldsteinia ternate, Anemone reflexa, Hanabusaya asiatica, Rodgersia podophylla, Eleutherococcus gracilistylus, Neocheiropteris ensata, Spiraea chartacea, Coreanomecon hylomeconoides, Corydalis alata, Thalictrum petaloideum, Boehmeria hirtella, Elatostema umbrellata, Ulmus macrocarpa, Chenopodium aristatum,* and *Drosera rotundifolia.*

Class III is distributed in two floristic regions. It consists of 316 taxa, including *Tipularia japonica, Iris ensata, Trillium camschatcense, Maianthemum bifolium, Monochoria korsakowii, Polypogon monspeliensis, Carex phacota, Symplocarpus renifolius, Sanguisorba hakusanensis, Farfugium japonicum, Viburnum odoratissimum, Lonicera subhispida, Campanula glomerata, Thymus quinquecostatus,* and *Abies koreana.*

Class II exists in all regions on highlands of over 1,000 m and is generally distributed around the Baekdudaegan. It consists of 135 taxa, including *Huperzia miyoshiana, Equisetum hyemale, Caltha palustris, Distylium racemosum, Cirsium setidens, Paeonia japonica, Primula jesoana, Aruncus dioicus, Euphorbia esula, Phellodendron amurense, Brachybotrys paridiformis, Cymopterus melanotilingia, Carex okamotoi,* and *Gymnadenia conopsea.*

Class I is distributed in three different regions. It consists of 167 taxa, including *Pteris multifida, Dryopteris crassirhizoma, Aristolochia contorta, Aconitum jaluense, Hylomecon vernalis, Hemiptelea davidii, Nanocnide japonica, Quercus acuta, Tetragonia tetragonoides, Sisymbrium luteum* and others.

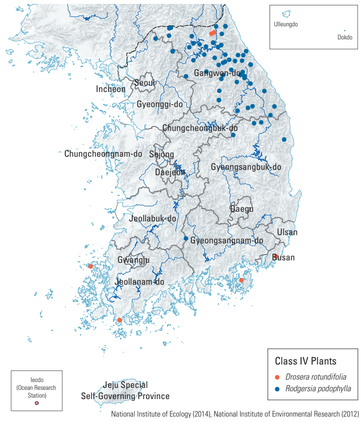
Ulleungdo Hare's Ear (*Bupleurum latissimum*)

Living in the coastline forests and valleys of Ulleungdo, it is classified as endangered wildlife class V. It is a perennial herbaceous plant with a straight stem and grows up to 60 – 100 cm height. It is a compound umbel, with yellow flowers that bloom between May and June. Its schizocarp is oval with a flat backside.

Bird's Nest Fern (*Asplenium antiquum*)

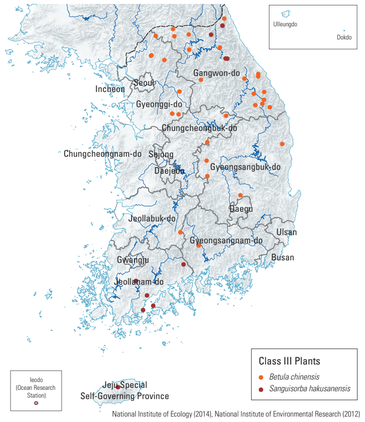
Classified as endangered wildlife class V, *A. antiguum* is a perennial evergreen species. It is an epiphyte living on trees or rocks. Samdo in Jejudo is acknowledged as the plant's northern limit line. The species has been protected as Natural Monument Number 18 since December, 1962.

Distribution of Class IV Plants



National Institute of Ecology (2014), National Institute of Environmental Research (2012)

Class III Plants



National Institute of Ecology (2014), National Institute of Environmental Research (2012)

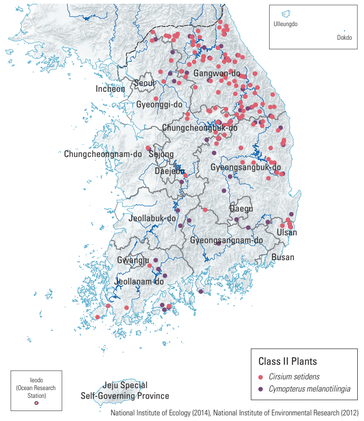
Round-Leaved Sundew (*Drosera rotundifolia*)
A representative native carnivorous plant species, *D. rotundifolia* can often be found in acidic wetland soil except in Jejudo. It is also distributed on bumpy small locations to maintain depth (2 – 5 cm) of water during times of drought. It is a perennial herb, with white flowers blooming on racemose inflorescence in July. Carnivorous leaves catch insects and help supply the plant with key nutrients.

Rodger's Bronzeleaf (*Rodgersia podophylla*)
R. podophylla is a perennial herb living in shade and can be found in the high mountain lands of Gyeonggi-do, Gyeongsangbuk-do, and north to Gangwon-do. It grows up to 1 m height, and blooms with light yellow flowers on panicles between May and July.

Dwarf Small-Leaf Birch (*Betula chinensis*)
B. chinensis is a deciduous woody plant species that is distributed north to Jirisan. It usually grows on the rocky terrains of high mountain peaks and can be found on cliffs. Its flowers bloom between April and early June, and it bears fruit in August and September.

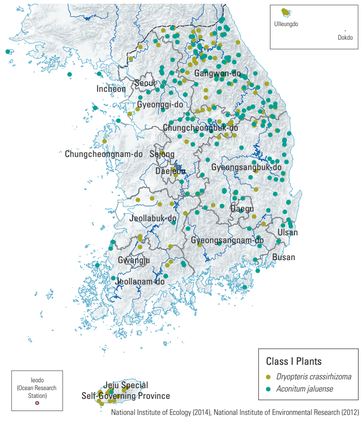
Korean Mountain Burnet (*Sanguisorba hakusanensis*)
S. hakusanensis is a perennial herb distributed on high mountain ridges north of Jirisan, such as Jeollabuk-do, Gyeongsangbuk-do, Chungcheongbuk-do, and Gangwon-do. Its flowers bloom on cylinder-shaped spikes between August and September.

Class II Plants



National Institute of Ecology (2014), National Institute of Environmental Research (2012)

Class I Plants



National Institute of Ecology (2014), National Institute of Environmental Research (2012)

Korean Thistle (*Cirsium setidens*)
C. setidens is a perennial herb that can be easily found anywhere near forests or mountain valleys except in Jejudo and Ulleungdo. Commonly known as *Gondre* or Korean thistle, it flowers from July to October.

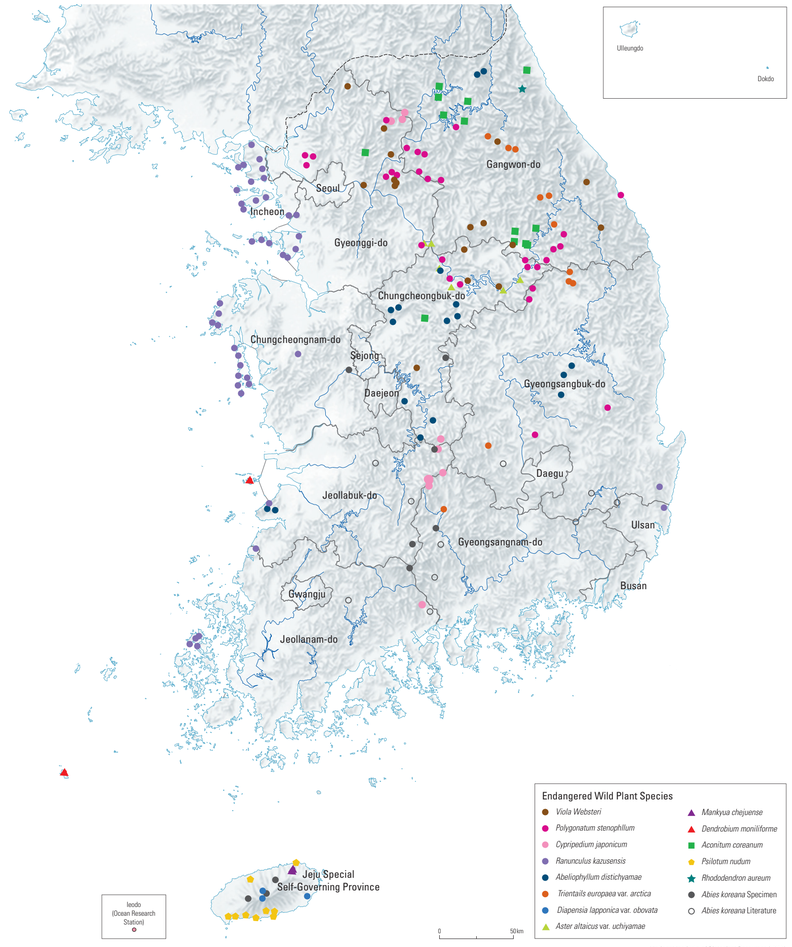
Big Spring Parsley (*Cymopterus melanotilingia)*
C. melanotilingia is distributed across the entire territory of South Korea, and is a perennial herb found in grassy hills, woodlands, and mountain forests. Its stem grows up to 30 – 100 cm and reddish purple flowers bloom between August and October.

Monkshood (*Aconitum jaluense*)
A. jaluense is a perennial herb that grows in forest shade and can be easily found anywhere in South Korea. It grows well in the rich soil of deciduous broadleaf forests at an altitude of 400 m or higher. Purple flowers bloom on racemose inflorescence during August and October.

Wood Fern (*Dryopteris crassirhizoma*)
D. crassirhizoma is distributed across the entire country and grows in deep shade in forests, valleys, and slopes. It is a summer-green perennial that grows well in wet and organic rich environment.

Endangered Wild Plant Species

Distribution of Endangered Plants



National Institute of Biological Resources (2015)

Protection of biological species includes recovering the ecosystem equilibrium, and provides an abundant and diverse benefits to humans. Around 13 million species are estimated to inhabit the earth, with 70 species becoming extinct every day. Also, 25% of all species are predicted to disappear by 2050. The current extinction rate is reported to be 1,000 times faster than the natural extinction rate.

An estimated total of 100,000 biological species inhabits South Korea, including 45,292 species, of which are 5,349 plant species. According to the criteria of the IUCN Red List, 4,058 species have been designated as the Korean Red List.

The IUCN Red List of Threatened Species

The International Union for the Conservation of Nature (IUCN) has been collecting and managing data on the conservation status of plant and animal species since 1963. Species are classified into nine groups (Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, Conservation Dependent, Least Concern, Data Deficient, Not Evaluated), which are assessed by criteria such as population, geographic distribution, risk of extinction, and so forth.

Korean Lady's Slipper (*Cypripedium japonicum*) (Class I)
A small population of *Cypripedium japonicum* remains in the regions of Gyeonggi-do, Gangwon-do, Jeollanam-do, Jeollabuk-do, and Chungcheongbuk-do. Affected by illegal collection and characterized by a low seed setting rate, the species displays high fluctuation in population numbers.

Pincushion Plant (*Diapensia lapponica* var. *obvata*) (Class I)
Diapensia lapponica var. *obovata* is the world's smallest shrub and is also known to have survived the glacial era. In Korea, a small population remains only at the summit of Hallasan, which is the southern limit for this species. Often this shrub is incidentally swept away by wind and landslides.

Yellow-Flowered Rosebay (*Rhododendron aureum*) (Class II)
A small population of *Rhododendron aureum* is found at the Seoraksan summit. Endangered and vulnerable to climate change, it is a northern plant commonly distributed at elevations between 1,800 and 2,400 m on Baekdusan.

Danyang Aster (*Aster altaicus*) (Class II)
Endemic to South Korea, *Aster altaicus* grows naturally on fields of pebble and sand alongside Hangang from Yeoju-si of Gyeonggi-do to Cheongju-si of Chungcheongbuk-do. Its population fluctuates depending on a variety of factors, including habitat loss caused by stream flooding.

Northern Water Hemlock (*Cicuta virosa)* (Class II)
A northern aquatic plant, *Cicuta virosa* grows naturally in limited areas of Gangwon-do and Jeollabuk-do. It grows in communities in mountainous wetlands or old reservoirs, thus it has experienced a decrease in population due to wetland development and ecological succession.

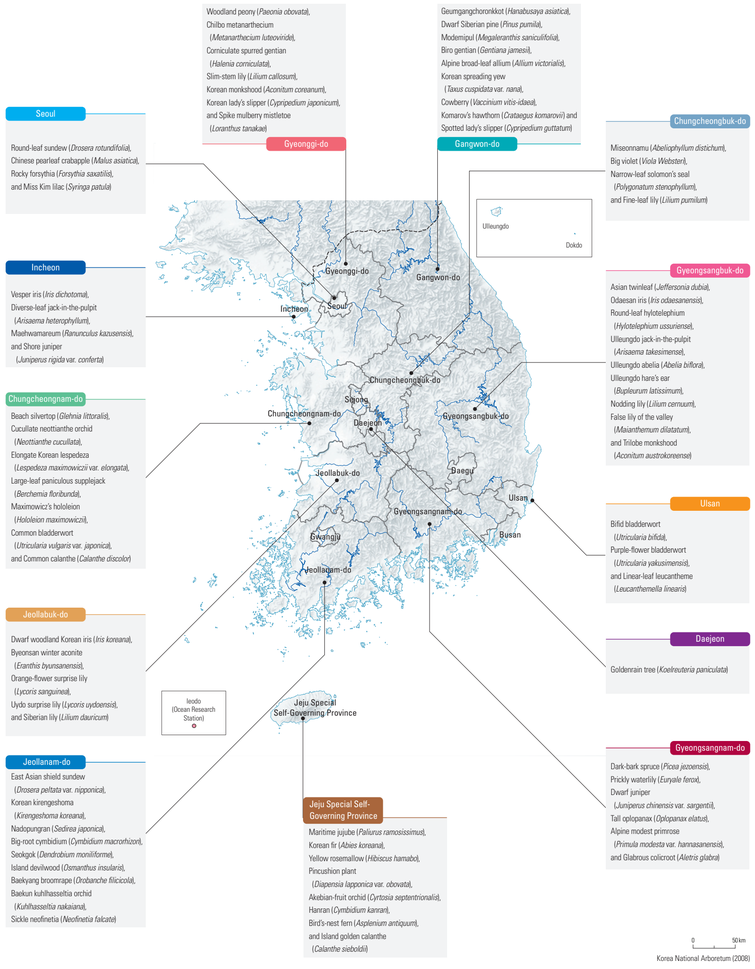
Mankyua (*Mankyua chejuense*) (Class II)
Endemic to South Korea, *Mankyua chejuense* grows naturally in Gotjawal of Jejudo. It preserves the morphology of the primitive bracken fern family. It has experienced a decrease in population due to large-scale developmental projects and illegal collection.

The Ministry of Environment designated 92 Specific Wild Animal and Plant Species for the first time in 1989. Currently, 246 species are under protection and management. Among these species, plants account for 77 species: 9 species of class I and 68 species of class II.

The Korean Peninsula is located between 42° N and 33° N and connected to the continent of Eurasia. It is a peninsular state, easily affected by continental and oceanic climates. The peninsula is long from north to south and thus shows distinct seasonal changes with numerous mountainous regions showing diverse flora. Distinct climatic and geographic characteristics allow the coexistence of southern and northern plants throughout the whole country. Among Korea's endangered plant species, 24 species are northern plants and 30 are southern plants. The distribution range and the distributional limit of these plants are expected to change under climate change scenarios. Particularly, the population of northern plant species and their distribution range are decreasing. Currently, 15 of 436 endemic species are designated as endangered wild plant species. Also, as orchid species are severely declining due to illegal collection, 19 orchid species are under legal protection to eradicate illegal collection.

Rare Plant Species

Distribution of Rare Plant Species



Korea National Arboretum (2008)

Many wildlife species are endangered by habitat change caused by climate change and global warming. The IUCN warns that around 30% of global plant resources in the 21st century will face the crisis of extinction.

Along with the global effort to conserve rare plant species, scholars in South Korea are collecting basic data and conducting research projects on native flora. First, 571 rare species were selected based on an endangered plant assessment standard and category proposed by the IUCN in 2008. Selected rare plant species have been catalogued by their grade and used as basic data for conservation.

Rare plant species in South Korea are classified into four classes: 4 species of Extinction in the Wild, 144 species of Critically Endangered, 122 species of Endangered, and 199 species of Vulnerable. Also, there are 70 species in the category of Least Concerned and 112 species in the category of Data Deficient. Taxonomically, there are 53 pteridophytes, 7 gymnosperms, 242 dicotyledons, and 87 monocotyledons of angiospermae.

The Korean National Arboretum and associated institutions are putting effort into conserving biodiversity by conducting local conservation, propagating rapidly decreasing endangered plant species, and recovering natural habitats.

Number of Korean Rare Plant Species by Conservation Grade

Classification	Pteridophyta	Gymnosperm	Dicotyledon	Monocotyledon	Total
EW (Extinction in the Wild)	2	-	1	1	4
CR (Critically Endangered)	20	2	80	42	144
EN (Endangered)	15	1	82	24	122
VU (Vulnerable)	16	4	79	20	119
Total	53	7	242	87	389
Other	LC (Least Concerned) 70, DD (Data Deficient) 112				

Korea National Arboretum (2008)

Endemic plants are native plants that grow in limited places. The population of an endemic species generally decreases or is maintained as a small group because an endemic species is either a remnant species that was once widely distributed but became confined to small areas due to environmental factors, or a new species created by regional speciation. Of 4,171 native plant species based on 2015 Korean Plant Names Index, 328 are endemic species, accounting for 7.8% of the total native plant species.

Among Korean endemic plant species, there are 6 species that show distinctive taxonomic and morphological differences compared to other plant species. Those are Miseonnamu (*Abeliophyllum distichum*) found in Jincheon of Chungcheongbuk-do, Korean necklace pod (*Echinosophora koreensis*) found in Bukcheong of Hamgyeongbuk-do, Geumgangchorongkkot (*Hanabusaya asiatica*) and Korean pentactina (*Pentactina rupicola*) found in Geumgangsan, Modemipul (*Megaleranthis saniculifolia*) found in Jirisan, and Jejugosarisam (*Mankyua chejuense*) found in Jejudo. They hold a high plant resource value because each plant species is the only species of its genus.

Modemipul (*Megaleranthis saniculifolia*)

Geumgangchoronkkot (*Hanabusaya asiatica*)

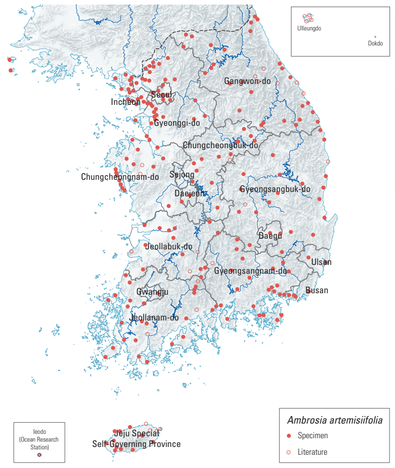
Miseonnamu (*Abeliophyllum distichum*)

Korean Necklace Pod (*Echinosophra koreensis*)

Naturalized Plants of Korea

Distribution of Major Naturalized Plants

Annual Ragweed (*Ambrosia artemisiifolia*)

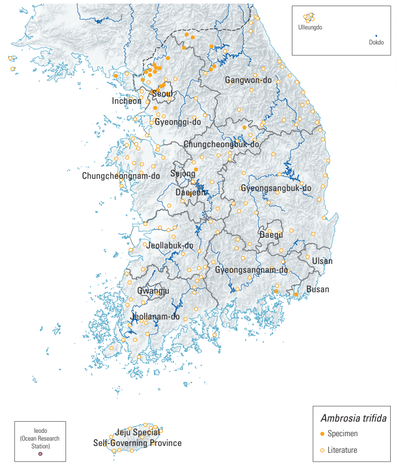


Korea National Arboretum (2015)

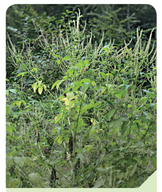
Annual Ragweed (*Ambrosia artemisiifolia*)

Ambrosia artemisiifolia is an annual herbaceous plant that belongs to Asteraceae. It has abundant branches and the whole plant is covered by short thorny trichomes. It reaches a height of 1 – 2 m, and its leaves grow to 3 – 11 cm. Bud-shaped flowers bloom at the end of the stems and branches between August and September in a bud shape.

Giant Ragweed (*Ambrosia trifida*)



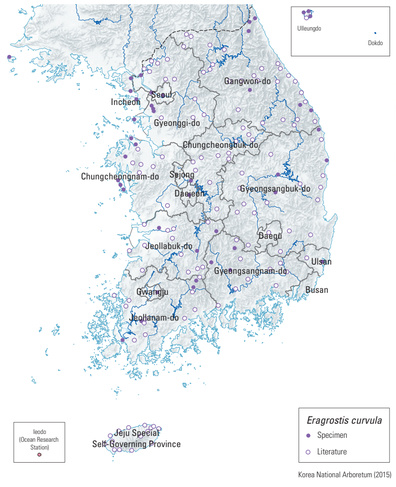
Korea National Arboretum (2015)



Giant Ragweed (*Ambrosia trifida*)

Ambrosia trifida grows up to 3 m and can be differentiated from *Ambrosia artemisiifolia*, showing more densely growing trichomes. Leaves are split into three or five leaflets and have sawtooth edges. White trichomes are growing on leaf stalks.

Weeping Lovegrass (*Eragrostis curvula*)

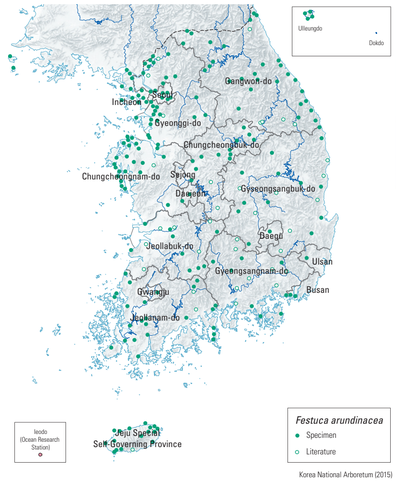


Korea National Arboretum (2015)

Weeping Lovegrass (*Eragrostis curvula*)

Eragrostis curvula is a species of Poaceae that is perennial, reaching a height of 60 – 120 cm. Leaves are 2.0 – 2.5 mm wide, and are considered narrow compared to the leaves of its close relative, *Eragrostis ciliannensis*, which has leaves that are 2 – 6 mm wide. The stem consists of 5 – 6 nodes, and its basal sheaths are hairy. Long white hairs grow from the junction of flower nibs.

Tall Fescue (*Festuca arundinacea*)



Korea National Arboretum (2015)

Tall Fescue (*Festuca arundinacea*)

Festuca arundinacea is a perennial Poaceae species that grows up to 15 – 50 cm. It has long narrow leaves of 10 – 20 cm long and 1.0 – 2.5 mm wide. The leaves are doubled up and ligules are visually indistinct. Flowers blooming between May and September are either red or light green. One or two branches grow from each node.

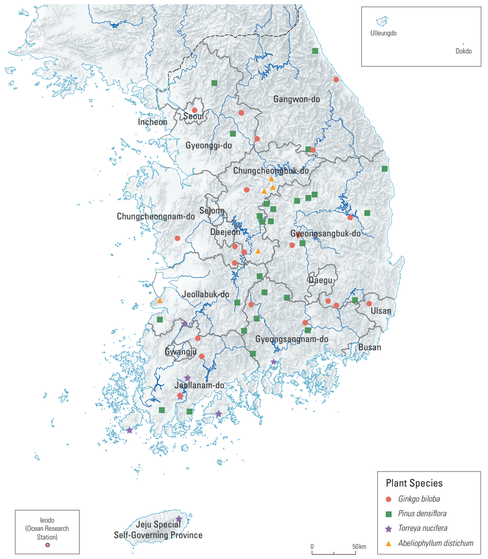
Naturalized plants are species that have been introduced from outside of the country by anthropogenic or natural factors, and have successfully adapted to the natural ecosystem. Due to recent rapid industrial development, international migration and trade have become active, followed by an increase in the number and distribution areas of naturalized plants. 321 naturalized plants had been recorded by 2010. Many of the naturalized plants have originated from Europe and America. Taxonomically, Asteraceae are the most abundant, followed by Poaceae, Brassicaceae, and Fabaceae. Most are annual rather than perennial, and herbaceous rather than woody. As woody plants have a longer life cycle and slower growth speed, they are less adaptive to new environments and are distributed around a limited range.

In general, naturalized plants have a short vegetative growth period and long reproductive growth period to adapt to various environments, generating and scattering many seeds. Moreover, naturalized plants are mostly heliophytes, growing well under direct sunlight in urban areas, roadsides, riverbanks, barren land, agricultural land, and forest roads. Some naturalized plants such as buffalo-weed (*Ambrosia trifida*), redflower ragleaf (*Crassocephalum crepidioides*), and white snakeroot (*Ageratina altissima*) are sciophytes, growing well in shaded forests.

As naturalized plants inhabit the habitats of Korean native plants, native plants can become exposed to extinction from the decrease of habitats and unavailability to reproduce by being fertilized with other similar plants. Infertile individuals or crossbreeds may be produced, harming the genetic resource of native plants. Moreover, naturalized plants cause harm to people and livestock, growing as weeds on agricultural lands and reducing crop yields. Continuous observation and monitoring upon introduction is required for a systematic management of naturalized plants. In South Korea, surveys of introduced species and their distribution by their introduction routes have been conducted, in addition to the construction of a basic database through invasive species assessment for the management of naturalized plants.

Natural Monuments

Distribution of Representative Natural Monument Plant Species



Cultural Heritage Administration (2015)

Plant Vulnerable to Climate Change: Distribution of Dwarf Siberian Pine (*Pinus pumila*)

Dwarf Siberian Pine by Elevation

Korean National Geographic Society (2000)

Natural monuments bear high academic and aesthetic values. Thus, legal protection and conservation have been adapted. Natural monuments include animals and their habitats, plants and their natural colony areas, minerals, caves, other natural and inorganic substances. There are 209 plant natural monuments, including 142 old trees, 17 rare plant species, 27 natural growing sites, and 33 forest and vegetation areas. State-designated plant natural monuments include endemic plant species, plant species growing in special environmental conditions such as dry land, wetlands, rivers, waterfalls, and hot springs. The list of state-designated plant natural monuments also includes plant species at their geographical distributional limit, famous trees, old trees, communities of evergreen broadleaf vegetation, specific plant communities, plant species at the distributional limit of their range, abnormally-shaped trees, holy trees at sanctuaries and village shrines, forests for fish shelter, primeval or virgin forests, alpine plants, and artificially planted historic woodlands. State-designated plant natural monuments are mostly *Ginkgo biloba, Pinus densiflora,* and *Juniperus chinensis. Torreya nucifera, Thuja orientalis, Wisteria floribunda, Camellia japonica, Chionanthus retusus, Prunus pendula, Poncirus trifoliata, Salix chaenomeloides, Cymbidium kanran, Berchemia berchemiifolia, Gleditsia japonica, Machilus thunbergii, Celtis sinensis, Castanea crenata, Quercus variabilis, Zelkova serrata, Picrasma quassioides, Lagerstroemia indica, Actinidia arguta,* and *Buxus koreana* are also natural monuments. Among the old trees, most of the designated natural monuments are *Pinus densiflora, Ginkgo biloba, Juniperus chinensis*. Old trees, communities, and the northern range limit of the southern evergreen conifer, *Torreya nucifera*, and the natural habitats of the endemic species, *Abeliophyllum distichum* are also state-designated natural monuments of Korea.

Representatve Plant Natural Monuments

Lacebark Pine (*Pinus bungeana*) of Jae-dong, Seoul (Large Old Tree)
Natural Monument No.8

Smoothlip Cymbidium (*Cymbidium kanran*) of Jejudo (Rare Plant)
Natural Monument No.191

Population of Spreading Yew Trees (*Taxus cuspidata*) in Sobaeksan (Natural Habitat)
Natural Monument No.244

Evergreen Forest on Judo, Wando-gun, Jeollanam-do (Forest Site)
Natural Monument No.28

Dwarf Siberian Pine (*Pinus pumila*) (Seoraksan, Inje-gun, Gangwon-do)

Dwarf Siberian pine (*Pinus pumila*) is a creeping evergreen coniferous sub-tree that inhabits the eastern part of the Russian Far East, Okhotsk coast, the arctic coast of eastern Siberia, Sakhalin, Kurile, Kamchatka of Russia, near Baikal Lake, northern Mongolia, northeastern China, Hokkaido and Honshu of Japan, North Korea, and South Korea. Its distribution extends from 35˚ 20′ N to 70˚ 31′ N, and from 105˚ E to 190˚ E, and the altitudinal range of the species within this broad region varies from sea level up to 3,200 m above sea level in some parts of northeastern Russia. The species inhabits regions near the coast of Sakhalin, up to elevations of 600 – 800 m above sea level at Okhotsk, Magadan, to 1,400 m at Verkhoyansk of Russia, and mainly at 2,300 – 2,700 m in Japan.

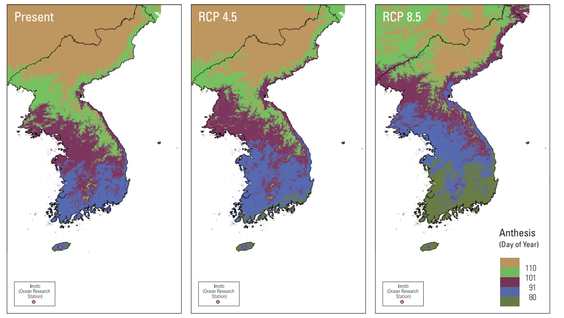
On the Korean Peninsula, dwarf Siberian pine grows from 42˚ N to 38˚ N on 17 mountains, including Kwanmobong, Bukpotaesan, Nampotaesan, Mantapsan, Hyangnobong, Buksubaeksan, Bujeongowon, Maengbusan, Sasusan, Bohyeonsan, Myohyangsan, Biraesan, Sungjeoksan, Nangnimsan, Haramsan, Geumgangsan, and Seoraksan, mainly with a lower limit elevation of 1,485 m above sea level and an upper limit elevation of 1,791 m above sea level.

From the end of the Tertiary period, and possibly earlier, dwarf Siberian pine was evolved as understory vegetation of highland coniferous forests in the temperate zone of East Asia, and occupied an intermediate position between taiga and mountain tundra assemblages during the Last Glacial Maximum. The extensive and continuous range of the species during the Pleistocene period was later divided into many fragmented ranges during the most recent climatic amelioration. The disjunctive distribution of dwarf Siberian pine on the Korean Peninsula suggests a continuous distribution of the species at high altitudes in this area in the past, probably before the hypsi-thermal or climatic optimum, when climate was 8 – 9˚C colder than today. Since dwarf Siberian pine adapts well under cold temperature, the rise in summer temperature due to global warming may cause the summit of Seoraksan, the southernmost distributional limit, to be no longer a habitat for the species.

Plant Phenology by Climate Change

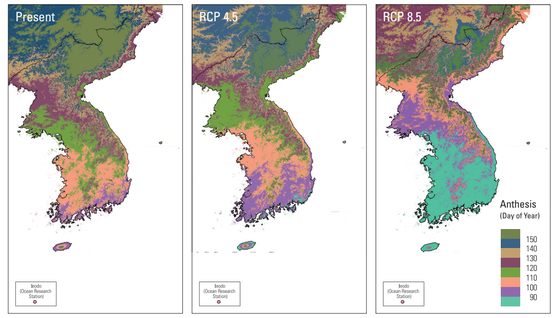
Prediction of Leaf-Out Dates under Future Climate Scenarios

Korean Goldenbell Tree (*Forsythia koreana*)



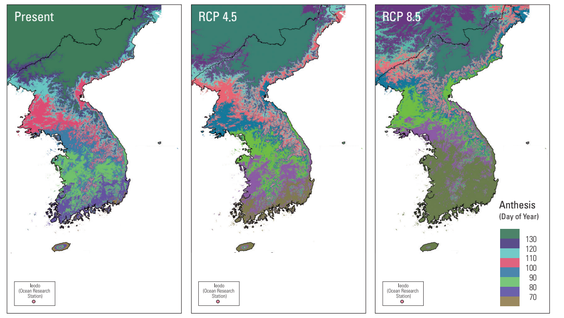
Korean National Arboretum (2012)

Korean Fir (*Abies koreana*)



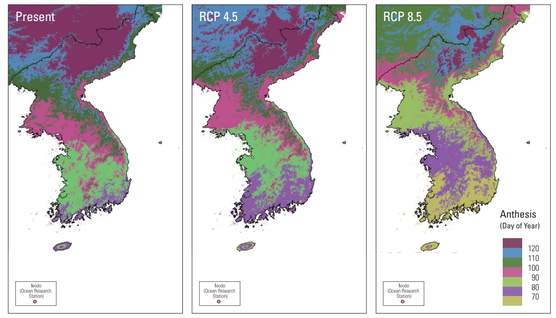
Korean National Arboretum (2012)

Spike Rosebay (*Rhododendron micranthum*)



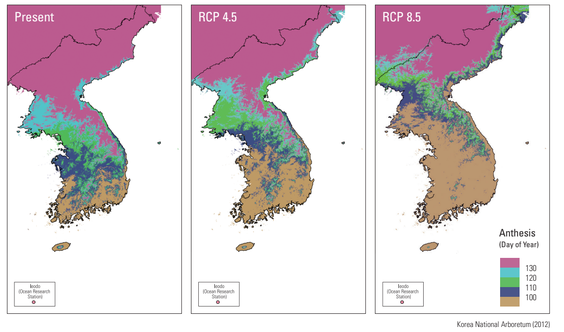
Korean National Arboretum (2012)

Rigid-Branch Yew (*Taxus cuspidata*)



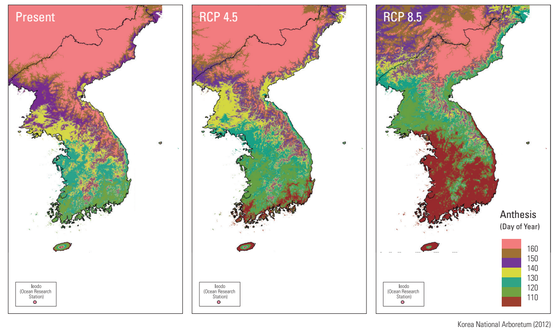
Korean National Arboretum (2012)

Needle Fir (*Abies holophylla*)



Korean National Arboretum (2012)

Korean Mountain Magnolia (*Magnolia sieboldii*)



Korean National Arboretum (2012)

As the temperature increases, the vegetation zone of the Northern Hemisphere is moving from the south to the north and from lowlands to highlands. An increase by 1˚C is expected to cause a migration of plants of middle latitude by 150 km to north and 150 m higher in altitude, causing difficulties for most plant species to keep up with the speed of climate change. Thus, the chance of extinction or shrinkage of habitat for plants increases. Detection of changes are possible by observing the microclimate, seasonal variations, and physiological changes of plants' blooming and bearing fruit through long-term monitoring.

Since 2009, the Korea National Arboretum has been carrying forward an adaptation plan for forest plant species that are susceptible to climate change. The plan, which builds regional microclimate change data, designates 100 climate change vulnerable species and monitors them after classifying them into either northern or southern species. Plant species will physiologically be influenced by climate change. Habitat change and distribution area change are predicted as consequences of interspecific competition. Thus, new endangered plant species are likely to appear because of global warming.

In the case of seasonal variation of plant phenology, the winter bud burst season and leaf unfolding season of rigid-branch yew (*Taxus cuspidata*) and Korean fir (*Abies koreana*) are expected to start earlier. Highland plants inhabiting the summits of Hallasan, Jirisan, and Seoraksan such as Korean fir (*Abies koreana*), dark-bark spruce (*Picea jezoensis*), Korean crowberry (*Empetrum nigrum*), rigid-branch yew (*Taxus cuspidata*), Khingan fir (*Abies nephrolepis*), Korean arbor-vitae (*Thuja koraiensis*) are expected to decrease in population. Conservation of northern plants living in isolated environments such as alpine, sub-alpine, islands, and wind holes is becoming an important issue.

Representative Concentration Pathways (RCP)

RCP are series of climate change scenarios that are used to determine greenhouse gas reduction policies per socio–economic settings. Four trajectories are presented upon calculations of different levels of carbon dioxide concentration. RCP 2.6 (420 ppm of CO_2) projects that Earth will be able to recover from the negative consequences of human activity by itself, but it is not seen as a feasible plan. RCP 4.5 (540 ppm of CO_2) suggests that greenhouse gas reduction policies will be carried out considerably, while RCP 6.0 (670 ppm of CO_2) projects they will be carried out to some degree. RCP 8.5 (940 ppm of CO_2) predicts that greenhouse gases will continue to be emitted at the current rate without any reductions.