THE SECOND REPORT ON THE STATE OF THE WORLD'S **FOREST GENETIC RESOURCES**

COUNTRY REPORT

REPUBLIC OF KOREA

Country Report on
Forest Genetic Resources
of Korea

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Part 1. The Contribution of Forest Genetic Resources to Sustainable Development

Chapter 1. Value and Importance of Forest Genetic Resources

1-1. Role of Forests in the National Economy

○ The Republic of Korea is a forest country where forests occupy 62.7% of its territory; it has established and implemented ten-year Basic Forest Plans since the 1^{st} Forest Rehabilitation Plan in 1973. The 1^{st} and 2^{nd} Ten-Year Forest Rehabilitation Plans (1973−1987) played an important role in completing land greening, being recognized as a successful global model. After the successful greening, in the 3^{rd} Basic Forest Plan (1988−1997), policies were promoted to create a foundation for generating forest resources; the 4^{th} Basic Forest Plan (1998−2007) aimed to realize the "Green Country" by establishing the foundation of sustainable forest management. In the 5^{th} Basic Forest Plan, a policy to establish a virtuous cycle of various forest benefits was promoted, along with the vision of a "Green Welfare State" where all people can feel happy in the forest. The 6^{th} Basic Forest Plan (2018−2037) became a 20-year plan aiming to promote policies centered on a circular economy of forest resources in order to utilize and conserve forests in terms of forest economy, welfare, and ecology. The growing stock per unit area of the forest of the Republic of Korea was 146 m^3/ha in 2015, exceeding the OECD average (131 m^3/ha); it was 161.4 m^3/ha in 2019, which was increased by approximately 16 times compared to that in 1960 (9.6 m^3/ha) (Statistical Yearbook of Forestry, 2020). Forests in the Republic of Korea create public value amounting to KRW 221 trillion per year (as of 2018), such as through the absorption and storage of greenhouse gases, water resource conservation, and air purification functions (National Institute of Forest Science, 2020). There is an increasing trend in the amount of the population that has benefited from forest welfare services (13.47 million people in 2012 to 17.98 million in 2016). The populations of mountain villages in the Republic of Korea are on the decline and aging, but it is expected that there will be a continuous increase in population inflow (58 thousand people in 2013, to 63 thousand in 2014, and to 69 thousand 2015). It is considered necessary to seek new development opportunities for mountain villages, based on the wide area and various resources of the forest in terms of balanced national land development (Korea Forest Service, 2018).

1-2. Economic, Environmental, Social, and Cultural Values of Forest Genetic Resources

○ Forests in the Republic of Korea, which occupy 62.7% of the country's land, are a treasure trove inhabited by 92% (about 20,000 species) of the total genetic resources. These biological resources have been evaluated as core materials in the bio-industry, which is attracting attention as a growth engine for the future food and health of mankind in the era of the 4^{th} industrial revolution. The diversity of genetic resources is expected to decrease worldwide due to global environmental changes, such as climate change and population growth. In accordance with the signatures of the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), the sovereignty over genetic resources has become increasingly competitive between countries. As the Republic of Korea has shown a high dependency on foreign genetic resources in the pharmaceutical, cosmetic, and food industries, it is estimated that the cost burden of the industries will reach KRW 140−250 billion per year due to the 2017 introduction of the Nagoya Protocol in Korea (Korea Institute of Intellectual Property, 2018). Therefore, it is necessary to strengthen national efforts for securing, preserving, and managing forest genetic resources.

○ The Korea Forest Service implements national policies and institutional support related to forest genetic resources through the establishment of basic and implementation plans and the preparation of sub-regulations in relation to “the Act on Preservation, Management, and Use of Genetic Resources of Agriculture” (Ministry of Agriculture, Food and Rural Affairs), “the Seed Industry Act” (Ministry of Agriculture, Food. and Rural Affairs), “the Framework Act on Intellectual Property” (Ministry of Science and ICT), “the Act on the Acquisition, Management, and Utilization of Bio-Resources for Research” (Ministry of Science and ICT), “the Act on Access to and Utilization of Genetic Resources and Benefit-Sharing” (Ministry of Environment), and “the Forest Protection Act” (Korea Forest Service). In addition, the Korea Forest Service has designated and operated the “National Authorities Responsible for Forest Genetic Resources” (e.g., the National Institute of Forest Science, the Korea National Arboretum, and the National Forest Seed and Variety Center) to professionally manage various issues related to security, safe conservation and management, and efficient utilization of forest genetic resources.

○ Through systematic collection and evaluation of forest genetic resources, the Korea Forest Service has secured and preserved 2.46 million genetic resources (as of 2020), such as plant seeds, clonal germplasm, forest mushrooms, and forest insects. Furthermore, it enacted “the Arboretum and Garden Construction and Promotion Act” to designate rare plants (571 species) and special plants (360 species) for special management. It also has conducted research on the development of techniques to evaluate genetic diversity, such as DNA markers. It has evaluated the nationwide genetic diversity of rare and useful tree species since 1972 to select and manage *in situ* conservation groups in forest genetic resource reserves. This information is included in the Forest Genetic Resources Database (DB) and is disclosed to the public on the website for the Bio Resource Information Service (BRIS) of the Ministry of Agriculture, Food, and Rural Affairs.

1-3. Contributions of Forest Genetic Resources Towards Relevant Sustainable Development Goals

- ○ The Korea Forest Service has promoted reinforced cooperation and connection between the United Nation's Sustainable Development Goals (SDGs) and national forest policies. It has made efforts to improve indicators to reinforce the linkage between the detailed targets of the SDG 15 “Protect and promote sustainable use of terrestrial ecosystems,” which is related to national forest policy, and on-site policies while establishing an international sharing system on SDG implementation cases. In particular, it has promoted plans to make the implementation performance in the Republic of Korea on the agenda at the 2021 World Forestry Congress.
- ○ In order to realize a virtuous cycle system of sustainable forest management (SFM), forest management has been promoted through the procedure of “Plan, Do, Check, and Act,” and the implementation of SFM has been supported by operating a market-based forest certification system. There is another support as well. In the case of certifications of building materials for green building and of products with environmental marks, the organization has encouraged the use of more domestic wood with forest certification. There is also support for obtaining certifications for health functional food, halal and kosher for clean forest products, and processed food from forests with forest certification.
- ○ In addition to the direct use of forest genetic resources, a Forest Happiness Index has been developed to comprehensively evaluate people-specific sentiment indicators, such as the forest’s public value via conservation of forest genetic resources and positive effects from forests (Korea Forest Service, 2018).

Part 2. State of Diversity in Forests and Woodlands

Chapter 2. State of Forests

- As of 2019, the forest area of the Republic of Korea was 6.229 million hectares, accounting for 62.7% of the total land area (10.04 million ha) (Korea Forest Service, 2020). The forest area in the 1960s was 6.701 million hectares, accounting for approximately 68% of the total land area. However, the area has decreased annually due to the increased demand for urban development in line with the increasing population; from 1986 to 1990, there was a net decrease in the area at an annual average of 11 thousand ha. From 1991 to 2010, the average annual reduction in the area was approximately 5,000 ha, which was lower than that of the previous period; however, the area had an annual average reduction of approximately 9,000 ha in the last four years (2016–2019) (see Figure 1 and 2). This can lead to a decline in the habitat of biological species in the forest.
- As of 2019, the total growing stock was 1.017 billion m^3 (161.4 m^3/ha), which was 16 times higher than that in the 1960s (64 million m^3 [9.6 m^3/ha]). The past desolate forest has been transformed into a dense forest that can become a habitat for diverse forest-dependent species with the possibility of producing wood (Korea Forest Service, 2020).
- The forests in the Republic of Korea are classified into four forest cover types: conifer forest, broadleaf forest, mixed forest, and bamboo grove/unstocked land. The classification is based on the dominant tree species constituting the stand that covers 75% or more of the canopy cover. The country regularly produces forest cover-type maps via aerial photograph interpretation and uses them as basic data for forest management. In 2015, the ratios of forest cover types were 36.9% conifer forests, 32.1% broadleaf forests, 26.9% mixed forests, and 4.1% bamboo grove/unstocked land. Such ratios indicate a gradual decreasing trend in conifer forests and an increasing trend in

broadleaf forests (Korea Forest Service, 2020).

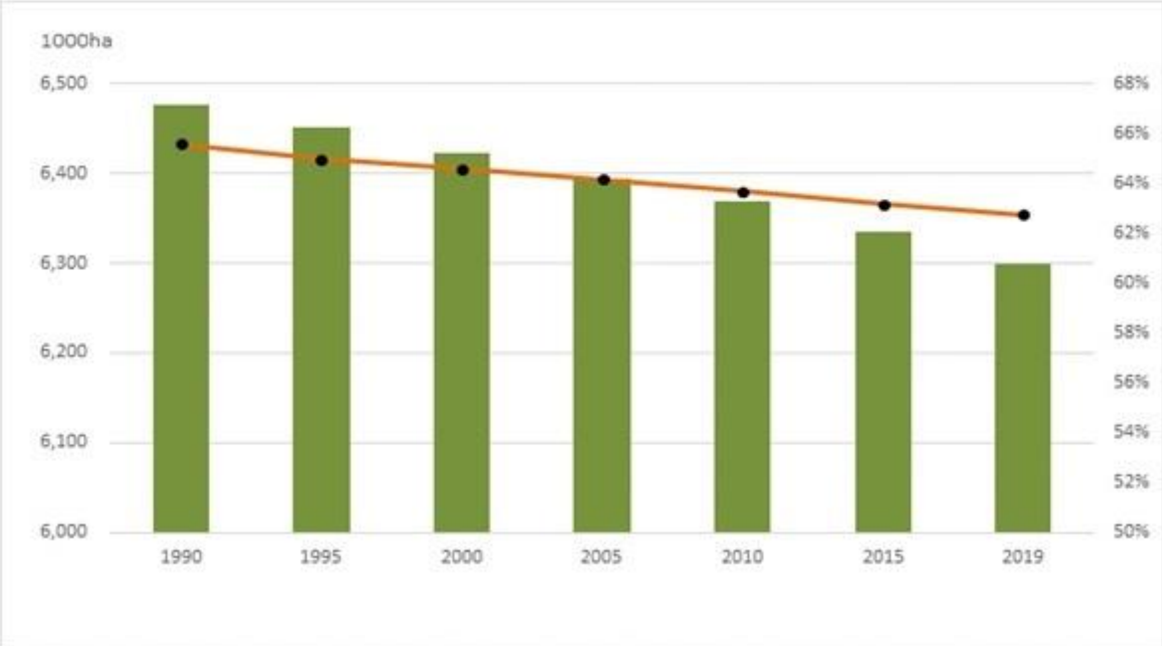
○ Forest age classes in the Republic of Korea are classified per ten years. As of 2015, the area of Age-Class I was 3.3%, while that of Age-Class IV occupied 46.6%. In other words, as most forests were created under Forest Rehabilitation Plans in the 1970s−1980s, most of them belong to Age-Class IV (see Figure 3) (Korea Forest Service, 2020). The composition of various stand structures is regarded as an important indicator of biodiversity. Since the Republic of Korea has relatively more areas with specific age-classes than other countries, the creation of a foundation for sustainable forest management is required to solve the age-class imbalance problem.

○ As for the area inhabited by the main tree species in 2015, the coniferous species such as red pine (*Pinus densiflora)* and black pine (*Pinus thunbergii)* were the most dominant, occupying approximately 26% (1.562 million ha) of the total forest area. There are other tree species for timber production, including Japanese larch (*Larix kaempferi*; 273,000 ha, 4.5%) and Pitch pine (*Pinus rigida*; 259,000 ha, 4.3%). Korean pine (*Pinus koraiensis)*, which can provide additional income through uses other than timber, accounted for 171,000 ha (2.8%). Hinoki cypress (*Chamaecyparis obtusa)*, which has a huge healing effect on forests, had been planted mainly in the southern region. As for broadleaf tree species, oak species (*Quercus* spp.) such as *Quercus mongolica* and *Quercus variabilis* Blume are widely distributed, occupying 975,000 ha (16.1%); chestnut (*Castanea*) trees (77,000 ha, 1.3%), which can potentially provide additional income, and black locust (*Robinia pseudoacacia*) (21,000 ha, 0.4%) are present; and birch (*Betula spp*.) (22,000 ha, 0.4%), which is popular in landscape planning, are planted mainly in the northern part of the Republic of Korea.

○ In the case of broadleaf tree species, there was a mixed distribution of diverse tree species rather than a stand dominated by one kind of tree species. Other broadleaf tree species, which were not classified as a specific tree species, occupied 933,000 ha

(15.4%). Given that, other broadleaf tree species occupied more areas than coniferous species (see Table 1).

Figure 1.Changes in forest area and rates



* forest area(green bar), forest rates(orange line)

Figure 2. The annual rate of forest area loss by year

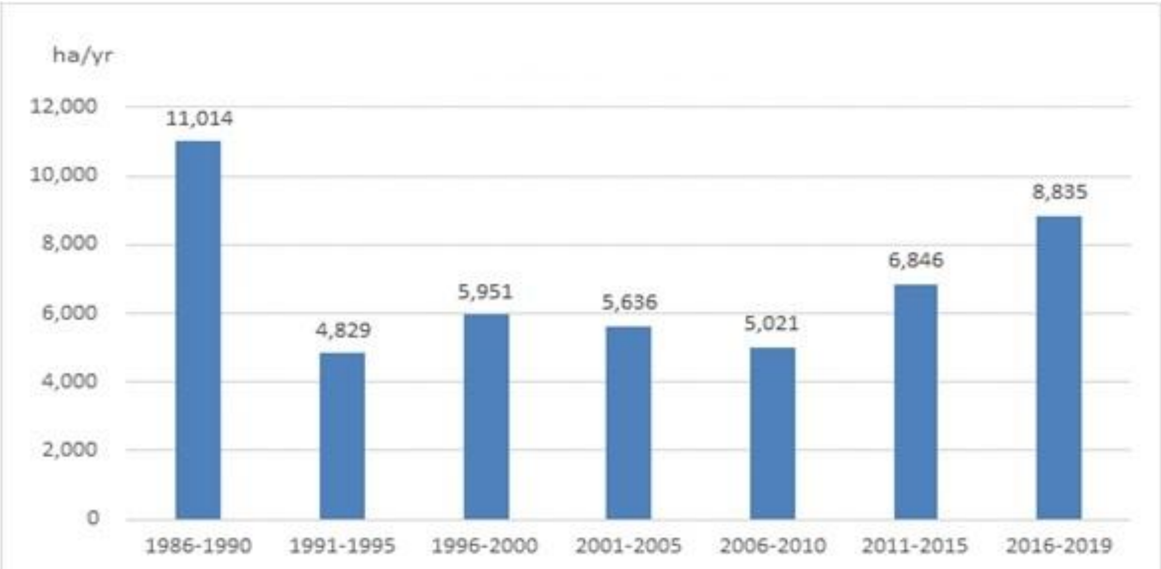


Figure 3. Forest area by forest cover type and age class (as of 2015)

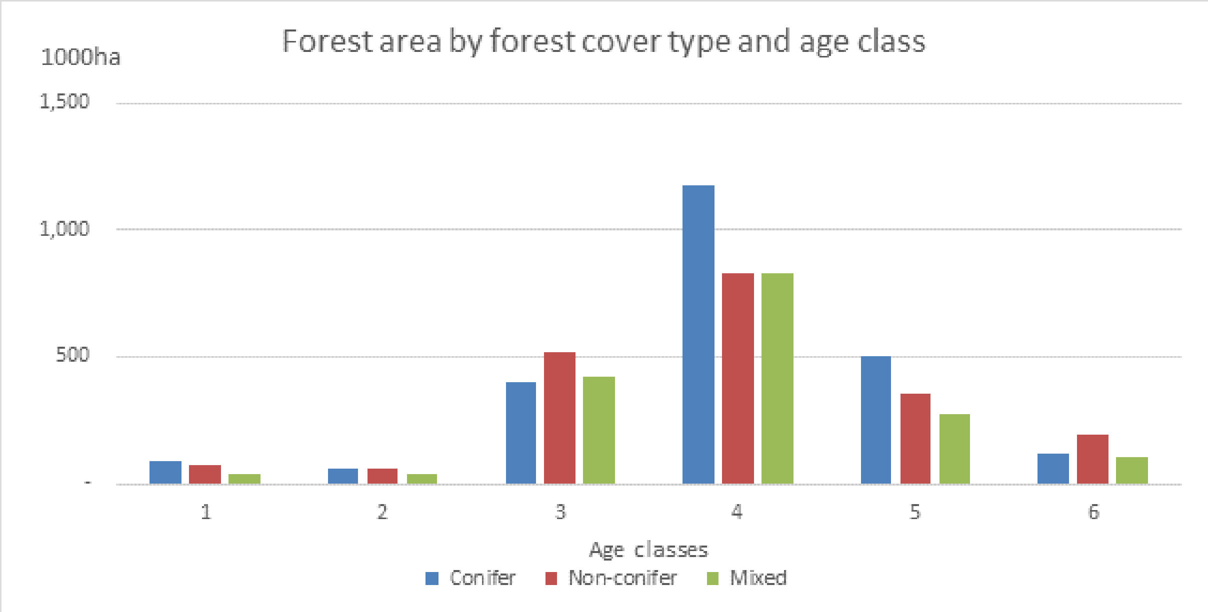


Table 1. Forest area by main tree species (as of 2015)

Category	Coniferous species					
	Red pine (*Pinus densiflora*), Black pine (*Pinus thunbergii*)	Korean pine (*Pinus koraiensis*)	Japanese larch (*Larix kaempferi*)	Pitch pine (*Pinus rigida*)	Hinoki cypress (*Chamaecyparis obtusa*)	Other conifers
Forest area (ha)	1,562,843	170,905	272,800	259,355	52,423	20,696

Category	Broadleaf species				
	Oak species (*Quercus spp.)*	Chestnut (Castanea)	Black locust (*Robinia pseudoacacia*)	Birch (*Betula spp*.)	Other broadleaf species
Forest area (ha)	975,181	77,440	21,289	22,442	932,503

Chapter 3. State of Other Wooded Land

3-1. Definition and Scope of Other Wooded Land

○ In the Food and Agriculture Organization (FAO) Global Forest Resources Assessment (FRA)-2020, some areas are classified as "other wooded land" and "other land with tree cover" (FAO, 2018). In the Republic of Korea, as there are no definitions or data on other types of wooded land, such as land with tree growth other than forests, this report attempts to present the production performance of trees in urban settings and non-timber forest products, which are managed by the Korea Forest Service.

3-2. Trees in Urban Settings

○ Regarding data on trees in urban settings in the Republic of Korea, this report targeted urban forests within living zones without forests that are included in the "National Urban Forest Statistics" published by the Korea Forest Service (Korea Forest Service, 2018). Urban forests within living zones encompass roadside greenery such as street trees, riverside greenery, school forests, and fence greenery; urban parks and green spaces include parks within living zones, theme parks, green areas, and amusement parks excluding urban natural parks and graveyards.

○ The urban forest area within living zones in the Republic of Korea increased from 36,000 ha (in 2011) to 47,000 ha (in 2017), showing an increasing trend of approximately 1,571 ha per year. However, information on the urban forest area by type within living zones is not available, and detailed information on planted tree species has not yet been collected. Considering that, basic data must be collected to determine the status of species (see Figure 4).

3-3. Current Status of Non-timber Forest Products

○ As for non-timber forest products in the Republic of Korea, the annual production of each item is aggregated according to the "Forest Products Production Survey." There have been supporting measures to develop and foster forest products as income sources by selecting items for support in order to increase the income of forestry workers. Non-timber forest products that occupied the largest production area in 2015 were as follows: shiitake (*Lentinula edodes*) (60,212 ha), chestnut (*Castanea*) (16,899 ha), astringent persimmon (11,601 ha), landscaping trees (9,670 ha), and bracken (*Pteridium aquilinum)* (3,280 ha). In 2019, the following had high production: landscaping trees (KRW 391.1 billion), five-flavor magnolia vine (*Schisandra chinensis*; KRW 241.2 billion), astringent persimmon (KRW 219.4 billion), deodeok (*Codonopsis gongshanica*; KRW 218.7 billion), and shiitake (*Lentinula edodes*; KRW 201.8 billion) (see Tables 2, 3, 4).

Figure 4. Changes in urban forest areas within living zones

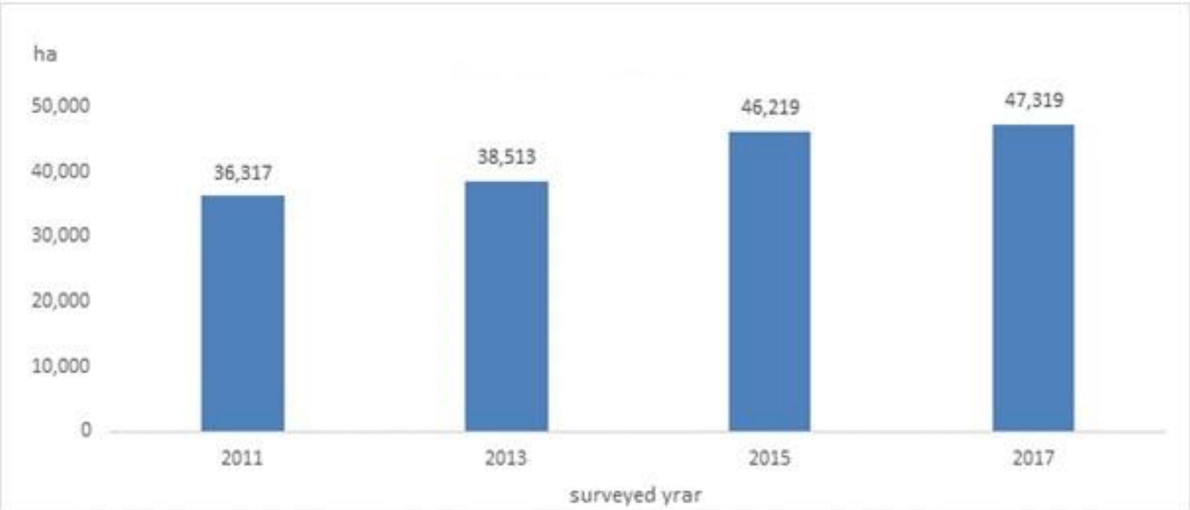


Table 2. The production scale of the main non-timber forest products

(Units: household, ha, and ton)

Items	Number of forest farm households	Production area	Amount of production
Astringent persimmon	26,288	11,601	184,381
Landscaping trees	9,070	9,670	60,964 (1000 trees)
Chestnut (*Castanea*)	8,733	16,899	46,358
Shiitake (L*entinula edodes*)	4,512	60,212	20,207
Bracken (*Pteridium aquilinum*)	8,057	3,280	11,651
Jujube (*Zizyphus jujuba*)	6,589	2,744	9,436
Five-flavor magnolia vine (Schisandra chinensis)	6,068	2,761	7,751
Deodeok (*Codonopsis gongshanica*)	3,545	3,086	13,255
Chuinamul (*Aster Scaber*)	2,898	715	6,395
Balloonflower (*Platycodon grandiflorus*)	5,147	1,819	5,795
Bokbunja (*Rubus coreanus* Miq.)	4,584	1,286	5,959
Wild-cultivated Ginseng (*Panax ginseng* C.A. Meyer)	804	2,179	144

* The 2015 Agriculture, Forestry, and Fisheries Survey (number of households and area), and the 2019 Production Survey of Forest Products

Table 3. The amount of production of the main non-timber forest products (Production Survey of Forest Products from 2017 to 2019)

(Unit: KRW 1 hundred million)

Items	2017	2018	2019
Landscaping trees	6,204	6,086	3,911
Five-flavor magnolia vine (*Schisandra chinensis*)	1,362	1,708	2,412
Astringent persimmon	2,194	2,128	2,194

Deodeok (*Codonopsis gongshanica*)	1,315	1,497	2,187
Shiitake (*Lentinula edodes*)	2,119	1,911	2,018
Bokbunja (*Rubus coreanus* Miq.)	1,721	1,281	1,407
Chestnut (*Castanea*)	1,050	1,145	1,059
Balloonflower (*Platycodon grandiflorus*)	1,148	1,206	983
Jujube (*Zizyphus jujuba*)	809	814	807
Bracken (*Pteridium aquilinum*)	682	836	658
Wild-cultivated Ginseng (*Panax ginseng* C.A. Meyer)	379	409	431
Korean lawn grass (*Zoysia japonica)*	581	622	407
Chuinamul (*Aster Scaber*)	362	381	235

Table 4. Items targeted for support among forest products as income sources

Category	Items
Forest fruits	Chestnut (*Castanea*), Persimmon (*Diospyros kaki*), Pine nut (*Pinus*), Walnut (*Juglans regia*), Jujube (*Zizyphus jujuba*), Ginkgo (*Ginkgo biloba*), Acorn (*Quercus aegilops*), Hazelnut (*Corylus*), Crimson glory vine (*Vitis coignetiae*), Tara vine (*Actinidia arguta*), Bokbunja (*Rubus coreanus* Miq.), Wild berry (Rubus crataegifolius), Pomegranate (*Punica granatum* L.), and Wild pear (*Pyrus pyrifolia*)
Mushrooms	Shiitake (*Lentinula edodes*), Pine mushroom (*Tricholoma matsutake*), Wood-ear mushroom (*Auricularia spp*.), Seogi mushroom (*Umbilicaria esculenta*), Neungee mushroom (*Sarcodon aspratus*), Red-tipped clavaria (*Ramaria botrytis* var. aurantiiramosa), Cauliflower mushroom (*Sparassis crispa*), and Poria cocos *(Wolfiporia extensa)*
Wild vegetables	Deodeok (*Codonopsis gongshanica*), Bracken (*Pteridium aquilinum*), Balloon flower (*Platycodon grandiflorus*), Chuinamul (*Aster Scaber*), Chamnamul (*Pimpinella brachycarpa*), Japanese Angelica (*Aralia elata* [Miq.] Seem), Orange daylily (*Hemerocallis fulva* var. fulva), Alpine broad-leaf allium (*Allium*

	microdictyon Prokh.), Gondre (*Cirsium setidens* [*Dunn*] *Nakai*), Asian royal fern (*Osmunda japonica* Thunb.), Cow parsnip (*Heracleum moellendorffii*), Goat's beard (*Aruncus dioicus*)
Medical herbs	Barrenwort (*Epimedium koreanum. Nakai*), Ovate-leaf atractylodes (Atractylodes ovata), Cham-ssuck (*Artemisia dubia* Wall.), Bupleurum (*Bupleurum falcatum* L.), Common Garden peony (*Paeonia lactiflora*), Gastrodia (*Gastrodia elata* Blume), Wild-cultivated Ginseng (*Panax ginseng* C.A. Meyer), Tora (*Cassia tora* L.), Manchurian chrysanthemum (*Chrysanthemum zawadskii* var. latilobum Kitamura), Heartleaf Houttuynia (*Houttuynia cordata* Thunb. f. polypetaloidea T.Yamaz.), Angelica (*Angelica gigas*), Cnidium (*Cnidium officinale Makino*), Tuber fleeceflower (*Fallopia multiflora* [Thunb.] Haraldson), Licorice (*Glycyrrhiza uralensis*), Manchurian angelica (*Aralia cordata* var. continentalis [Kitag.] Y.C.Chu), Ladybell (*Adenophora triphylla* var. japonica [Regel] H. Hara), Snake-tongue starviolet (*Hedyotis diffusa* Willd.), and Chinese yam (*Dioscorea batatas*)
Medicinal	Five-flavor magnolia vine (*Schisandra chinensis*), Stalkless-flower eleuthero (*Eleutherococcus sessiliflorus* [Rupr. & Maxim.] S.Y.Hu.), Asiatic dogwood (*Cornus officinalis*), Chinese boxthorn (*Lycium chinense*), Hardy rubber tree (*Eucommia ulmoides* Oliver.), Oriental raisin tree (*Hovenia dulcis* Thunb.), Castor aralia (*Kalopanax septemlobus*), Chinaberry tree (*Cedrela sinensis*), Mastic-leaf prickly ash (*Zanthoxylum schinifolium*), Korean Chopi (*Zanthoxylum piperitum*), Varnish Tree (*Rhus verniciflua* Stokes), Chinese pea tree (*Caragana sinica*), Manchurian striped maple (*Acer tegmentosum* Maxim.), Mountain hawthorn (*Crataegus pinnatifida*), Japanese Elm (*Ulmus davidiana* var. japonica), Korean dendropanax (*Dendropanax morbiferus*), Silkworm thorn (*Cudrania tricuspidata*), Silvery mountain ash (*Sorbus commixta* Hedl.), Burning bush spindletree (*Euonymus alatus* [Thunb.] Siebold), and Tree peony (*Paeonia suffruticosa*)
Tree by-products	All by-products from trees (including bamboo), such as sap, leaves, branches, bark, tree roots, and tree sprouts
Ornamental forest plants	Wildflowers, Native orchids, Landscaping trees, Bonsai, Grass, and Moss
Other forest products	In addition to the abovementioned items, items excluding wood (including wood products), soil, and stone, are considered as forest products defined in subparagraph 7 of Article 2 of the "Forest Resources Creation and Management Act"

Chapter 4. State of Diversity Between Trees and Other Woody Plant Species

4-1. Number of Tree Species and Other Woody Plant Species

○ As of 2020, according to the 「Checklist of Vascular Plants in Korea」, there are 4,357 species of plant resources including herbaceous plants (i.e., 3,738 native species and 619 alien species). Among them, 859 species of woody plants (i.e., 715 native species and 144 alien species) have been identified (Korea National Arboretum, 2020).

※ As 12 bamboo species in Korea are recognized as herbaceous plants in academia, they are not included in the number of woody species.

○ As a result of analyzing the collected data through the National Forest Resources Survey, the major dominant tree species were identified as *Pinus densiflora* Siebold & Zucc., *Pinus thunbergii* Parl., *Pinus koraiensis* Siebold & Zucc., *Larix kaempferi* (Lamb.) Carrière, and *Pinus rigida* Mill. for coniferous species, and *Quercus* spp., *Prunus* spp., *Castanea crenata* Siebold & Zucc., *Fraxinus rhynchophylla* Hance, and *Styrax japonicus* Siebold & Zucc. for broadleaf trees (see Table 5).

4-2. Number of Native and Introduced Species Managed or Utilized in Forestry Context

○ As of 2020, the number of native species of woody plants in the Republic of Korea was 715 (excluding 12 bamboo species), and 144 species were intentionally introduced and planted or naturalized from abroad (Korea National Arboretum, 2020). There are 85 main species used as seedlings for forestry projects, such as *Abies koreana* E.H.Wilson, *Pinus thunbergii* Parl., *Quercus variabilis* Blume, and *Quercus mongolica* Fisch. ex Ledeb.; and 31 introduced species, such as *Pinus strobus* L., *Prunus serotina* Ehrh., and *Amorpha fruticosa* L. (see Table 6). Some introduced species, such as *Robinia pseudoacacia* L., *Amorpha fruticosa* L., *Cedrela sinensis*

Juss., and *Styphnolobium japonicum* (L.) Schott, may grow naturally outside the management areas. Considering that, introduced species serve an important role in economic terms, but it is necessary to manage and utilize them systematically while considering the impact on ecosystems.

4-3. Drivers of Changes in Number of Species and Threats to Species

○ In the Republic of Korea, the conditions for maintaining biodiversity have been deteriorating due to continuous and exclusive use of forests and climate change, and there is the risk of disturbances to forest ecosystems due to the influx of unexpected and alien (or invasive) forest insect pests and diseases. Furthermore, the selection of specific species based on economic feasibility can increase the simplification of species and the risk of extinction (Korea Forest Service, 2017). As for these threats, the “OECD Environmental Outlook to 2050” predicted the biodiversity to decline by about 10% between 2010 and 2050 globally (Korea Forest Service, 2017).

○ In particular, according to the “Korean Peninsula Climate Change Forecast Report 2020” in relation to climate change, it is predicted that the annual average temperature change in the second half of the century (2081-2100), compared to the present (1995-2014), will be extreme under the SSP scenario in East Asia. In detail, the average annual temperature in East Asia is projected to rise by 2.7 to 7.3 ℃ in the latter half of the century compared to the present, depending on the level of greenhouse gas emissions. Furthermore, the increases in annual average temperatures for each region are expected to be higher in regions at higher latitudes and relatively lower in those at lower latitudes or areas adjacent to the ocean. This indicates a direct impact on the distribution of trees by altitude in forest regions in the future, crises in the survival of subalpine coniferous forests, and others.

○ Although the number of woody plant species in the Republic of Korea remains largely unchanged, some vulnerable species closer to extinction as well as newly introduced species are expected to affect the changes in species diversity in the future. Research that enables the long-term monitoring of changes and the response to macro-environmental changes is needed so as to identify such changes and make long-term predictions.

Table 5. Main tree species appearing in each region (Korea Forestry Promotion Institute, 2017)

Tree layer					Sub tree layer				
Taxa	RD	RF	RC	IV	Taxa	RD	RF	RC	IV
Pinus densiflora	25.9	10.3	35.2	23.8	*Pinus densiflora*	19.1	12.7	30.7	2.8
Quercus mongolica	16.4	7.7	14.2	12.8	*Quercus mongolica*	12.9	9.1	12.3	11.4
Quercus variabilis	9.1	6.7	9.3	8.4	*Quercus variabilis*	8.4	7.6	8.7	8.2
Quercus serrata	4.7	6.6	3.5	4.9	*Quercus serrata*	5.1	6.2	4.1	5.2
Pinus rigida	3.1	2.3	3.4	2.9	*Pinus thunbergii*	3.2	2.0	5.6	3.6
Castanea crenata	2.6	3.7	2.4	2.9	*Styrax japonicus*	4.4	2.8	1.2	2.8
Pinus thunbergii	2.9	1.5	3.6	2.7	*Castanea crenata*	2.1	3.6	1.9	2.5
Quercus acutissima	2.1	3.2	2.6	2.7	*Robinia pseudoacacia*	2.7	2.3	2.0	2.3
Larix kaempferi	2.0	1.6	3.7	2.4	*Pinus rigida*	1.8	2.1	2.8	2.2
Prunus serrulata var. *pubescens*	1.4	3.4	0.9	1.9	*Larix kaempferi*	1.7	1.3	3.7	2.2
Robinia pseudoacacia	2.2	1.9	1.5	1.8	*Quercus acutissima*	1.9	2.3	2.3	2.2
Pinus koraiensis	1.9	1.2	2.4	1.8	*Prunus serrulata* var. *pubescens*	1.8	2.8	1.7	2.1
Quercus aliena	1.5	2.7	1.1	1.8	*Acer pseudosieboldianum*	2.6	2.3	0.8	1.9

Fraxinus rhynchophylla	1.1	2.5	0.6	1.4	*Quercus aliena*	1.4	2.2	1.2	16
Styrax japonicus	1.6	1.8	0.4	1.3	*Fraxinus rhynchophylla*	1.4	2.4	1.0	1.6
Quercus dentata	0.9	2.1	0.7	1.2	*Pinus koraiensis*	1.6	1.2	2.0	1.6
Cornus controversa	0.7	1.7	1.1	1.2	*Styrax obassis*	2.1	2.0	0.5	1.5
Prunus leveilleana	0.8	1.9	0.5	1.1	*Platycarya strobilacea*	1.4	1.5	1.0	1.3
Platycarya strobilacea	1.1	1.5	0.7	1.1	*Prunus leveilleana*	1.4	1.9	0.5	1.2
Acer pseudosieboldianum	1.1	1.4	0.3	0.9	*Lindera erythrocarpa*	1.3	1.7	0.6	1.2
Acer pictum var. *mono*	0.6	1.5	0.6	0.9	*Quercus dentata*	1.0	1.5	0.5	1.0
Carpinus laxiflora	0.9	1.0	0.8	.9	*Juniperus rigida*	0.9	1.8	0.2	1.0
Ulmus davidiana var. *japonica*	0.6	1.5	0.3	0.8	*Morus australis*	.9	1.5	0.4	0.9
Betula schmidtii	0.6	1.1	0.7	0.8	*Cryptomeria japonica*	1.0	0.4	1.1	0.8
Morus australis	0.6	1.6	0.2	0.8	*Ulmus davidiana* var. *japonica*	0.8	1.3	0.4	0.8
Alnus incana subsp. *hirsuta*	0.6	1.4	0.3	0.8	*Acer pictum* var. *mono*	0.7	1.1	0.4	0.8
Styrax obassis	0.7	1.4	0.2	0.8	*Carpinus laxiflora*	0.8	0.7	0.8	0.8
Lindera erythrocarpa	0.7	1.2	0.3	0.7	*Celtis sinensis*	0.5	0.8	0.9	0.7
Juniperus rigida	0.5	1.3	0.1	0.7	*Tilia amurensis*	0.5	0.8	0.7	0.7
Tilia amurensis	0.5	0.9	0.6	0.7	*Alnus firma*	0.6	0.7	0.6	0.6

※RD : Relative Density, RF : Relative Frequency, RC : Relative Coverage, IV : Importance Value

Table 6. Main woody plants for forestry projects

Category	Main species for forestry projects (85 species)
Native Species	*Juglans mandshurica* Maxim., *Picea jezoensis* (Siebold & Zucc.) Carrière, *Quercus myrsinifolia* Blume, *Quercus aliena* Blume, *Betula costata* Trautv., *Acer pictum* var. *mono* (Maxim.) Maxim. ex Franch., *Pinus thunbergii* Parl., *Abies koreana* E.H.Wilson, *Quercus variabilis* Blume, *Ulmus laciniata* (Trautv.) Mayr, *Stewartia koreana* Nakai ex Rehder, *Cinnamomum camphora* (L.) J.Presl, *Ulmus davidiana var. japonica* (Rehder) Nakai, *Zelkova serrata* (Thunb.) Makino, *Maackia amurensis* Rupr., *Acer palmatum* Thunb., *Acer pseudosieboldianum* (Pax) Kom., *Aralia elata* (Miq.) Seem., *Fraxinus mandshurica* Rupr., *Styrax japonicus* Siebold & Zucc., *Sorbus commixta* Hedl., *Cornus walteri* Wangerin, *Alnus incana* subsp. *hirsuta* (Turcz. ex Spach) Á.Löve & D.Löve, *Fraxinus rhynchophylla* Hance, *Betula schmidtii* Regel, *Castanea crenata* Siebold & Zucc., *Acer triflorum* Kom., *Abies nephrolepis* (Trautv. ex Maxim.) Maxim., *Torreya nucifera* (L.) Siebold & Zucc., *Betula ermanii* Cham., *Cornus kousa* Burger ex Hance, *Prunus sargentii* Rehder, *Quercus acutissima* Carruth., *Pinus densiflora* Siebold & Zucc., *Populus koreana* × *Populus nigra* var. *italica*, *Tetradium daniellii* (Benn.) T.G.Hartley, *Quercus mongolica* Fisch. ex Ledeb., *Paulownia coreana* Uyeki, *Alnus japonica* (Thunb.) Steud., *Kalopanax septemlobus* (Thunb.) Koidz., *Chionanthus retusus* Lindl. & Paxton, *Betula pendula* Roth, *Pinus koraiensis* Siebold & Zucc., *Abies holophylla* Maxim., *Quercus serrata* Murray, *Taxus cuspidate* Siebold & Zucc., *Styrax obassis* Siebold & Zucc., *Cornus controversa* Hemsl., *Aesculus turbinata* Blume, *Tilia amurensis* Rupr., *Hovenia dulcis* Thunb., *Populus × tomentiglandulosa* T.B.Lee ex M.Kim, *Phellodendron amurense* Rupr., *Populus suaveolens* Fisch. ex Loudon, *Dendropanax trifidus* (Thunb.) Makino ex H.Hara, *Machilus thunbergii* Siebold & Zucc. ex Meisn.
Introduced Species	*Ailanthus altissima* (Mill.) Swingle, *Diospyros kaki* L.f., *Larix kaempferi* (Lamb.) Carrière, *Picea abies* (L.) H.Karst., *Eucommia ulmoides* Oliv., *Quercus rubra* L., *Pinus rigida* Mill., *Pinus rigitaeda* HYUN & Ahn, *Hibiscus syriacus* L., *Liriodendron tulipifera* L., *Firmiana simplex* (L.) W.Wight, *Alnus firma* Siebold & Zucc., *Cornus officinalis* Siebold & Zucc., *Prunus armeniaca* L., *Cryptomeria japonica* (Thunb. ex L.f.) D.Don, *Prunus serotina* Ehrh., *Pinus strobus* L., *Robinia pseudoacacia* L., *Populus nigra* L. × *Populus suaveolens* Fisch. ex Loudon, *Toxicodendron vernicifluum* (Stokes) F.A.Barkley, *Ginkgo biloba* L., *Populus × anadensis* Moench, *Amorpha fruticosa* L., *Cedrela sinensis* A.Juss., *Pinus taeda* L., *Chamaecyparis obtusa* (Siebold & Zucc.) Endl., *Juglans regia* L., *Chamaecyparis pisifera* (Siebold & Zucc.) Endl., *Styphnolobium japonicum* (L.) Schott

Chapter 5. State of Genetic Diversity within Forest Trees and Other Woody Plant Species

5-1. Genetic Diversity Assessment State of Forest Trees and Other Woody Plant Species

○ The National Institute of Forest Science has conducted studies to monitor and assess the genetic diversity of forest genetic resources since 1972 for the conservation and sustainable use of the resources. As of 2019, genetic diversity assessments have been conducted for 36 tree species and 480 populations (National Institute of Forest Science, 2019) (see Table 7).

5-2. Prioritization of Tree Species for Genetic Diversity Assessment

○ For the systematic conservation and sustainable use of forest genetic resources, the National Institute of Forest Science prioritize the tree species through consultation with experts in each field related to forest genetic resources. Genetic diversity is mainly evaluated on the prioritized tree species; the species are selected based on such criteria as economic feasibility (e.g., current and potential value as a resource), ecological value, risk of threats/extinction, propagation potential, research accumulation, and evaluation by experts (National Institute of Forest Science, 2019). Since 2006, the "Medium-term Plan of Conservation Priorities for Forest Genetic Resources" has been established. Tree species of conservation priority are determined every decade, and the second plan (2016-2025) is currently being implemented. This plan focuses on tree species that are vulnerable to climate change and that can move northward in order to respond to the new climate system; tree species used for timber, special use, and landscaping to achieve future utilization; and rare and endemic species in response to the risk of extinction. It encompasses 50 tree species, including *Abies koreana, Abies holophylla, Betula costata,* and *Stewartia koreana*. The list of tree species with conservation priorities is reviewed through meetings among experts every year in consideration of the demand for scientific and social research during implementation of the 10-year medium-term plan.

5-3. Status of Current and Emerging Technologies used for Assessing and Monitoring Genetic Diversity

○ Genetic diversity can be assessed by measuring molecular-level variations, such as in proteins and DNA, which generally correspond to molecular markers. The National Institute of Forest Science has employed various applicable molecular marker analysis methods in line with the development of molecular biological analysis technologies to evaluate genetic diversity (National Institute of Forest Science, 2019). In early research periods (from the 1970s to the 1990s), the isozyme technique, which can explore genetic mutations at the protein level, was mainly utilized. As the polymerase chain reaction (PCR) became common in the early 2000s, the DNA marker technique using DNA and PCR became widespread. In the early stages of genetic diversity research using DNA markers, the inter-simple sequence repeat (ISSR) method was in wide use, which is based on primers consisting of arbitrary sequences that can be utilized even without prior sequence information for analysis targets. Since the 2010s, simple sequence repeat (SSR) or microsatellite methods using sequence-based specific primers for the analyzed species have been commonly used. The single nucleotide polymorphism (SNP) method using next-generation sequencing (NGS), which enables the analysis of a large amount of sequence information in a short time, is utilized more recently.

5-4. Trends in Changes in Genetic Diversity

○ It is expected that the decline in habitats due to climate change has impacted forest biodiversity globally. *Pinus densiflora* is the tree species with the widest distribution area in the Republic of Korea. As it has high environmental adaptability and grows well in lowlands and coasts as well as in mountainous areas, it is distributed throughout the country. The National Institute of Forest Science conducted a comparative analysis between the genetic diversity of 52 populations of *Pinus densiflora* and predicted changes in the distribution area of *Pinus densiflora* in forests based on the climate change scenario RCP 8.5. It is predicted that the distribution area of *Pinus densiflora* will decrease starting from the West-South region; by 2090, 74.1% of the current distribution area will disappear, after which the forests of this species will be found only in Gangwon and Gyeongbuk areas. Such a decrease in the *Pinus densiflora* distribution is predicted to cause losses of unique genes in groups of *Pinus densiflora*, increase inbreeding, and result in lower genetic diversity of *Pinus densiflora* in the long term. Meanwhile, as the rate of decrease in the distribution and genetic diversity of *Pinus densiflora* is predicted to increase due to disease and insect damage, such as pine wilt disease, appropriate measures are needed to conserve this species (National Institute of Forest Science, 2019).

5-5. Policy on Conservation of Genetic Diversity

○ The Republic of Korea joined the Convention on Biological Diversity (CBD) as the 154th signatory in 1994. The Korea Forest Service established the "6th Basic Forest Plan (2018～2037)," a legal plan based on the "Forestry Basic Law" to "protect and promote sustainable use of terrestrial ecosystems" in relation to UN SDG 15. It has prepared strategies for maintaining and promoting the health of the forest ecosystem and has promoted detailed plans, such as the establishment of a sustainable management foundation for forest biodiversity, including the genetic diversity of forest genetic resources, the enhancement of the value of forest ecosystem services, the reinforcement of forest protected area management, and the restoration of genetic diversity of forest genetic resources (Korea Forest Service, 2018). Furthermore, as the basic plan for the forest sector related to the national biodiversity strategy, the 3rd Forest Biodiversity Master Plan (2018~2022) based on the "Forest Resources Creation and Management Act" was established on a five-year basis. The conservation and management of forest genetic resources are being promoted through scientific evaluations, such as genetic diversity assessment, to promote strategies for *in*- and *ex-situ* conservation of forest trees and other woody plant species (Korea Forest Service, 2018).

5-6. Considerations for Utilizing Information on Genetic Diversity and Developing Research Capacity

○ Research on forest genetic resources in the Republic of Korea is conducted mainly by the National Institute of Forest Science at the national level; the research chiefly focuses on forest trees and other woody plant species that are the representative component of forests. The genetic diversity of forest genetic resources is studied as a means for providing the most basic indicators for *in*- and *ex-situ* conservation. The resulting data are utilized as recommended scientific data to establish conservation strategies for forest genetic resources, such as selecting populations to be conserved when designating protected areas of forest genetic resources for *in situ* conservation, setting standards for securing seeds for *ex situ* conservation, and selecting genetically appropriate individuals to restore genetic diversity in areas of damaged forest genetic resources. As climate crises such as climate warming are predicted to intensify in the future, genetic studies on environmental adaptability need to be expanded along with genetic diversity research. To this end, it is necessary to expand the number of researchers and educational personnel in related fields and to build their capacities.

Table 7. Status of genetic diversity assessment of forest genetic resources

Tree Species	Number of Populations	Assessment Tool	Year
Pinus densiflora	25	Isozyme	1972-1986
	1	Isozyme	2003
	2	Isozyme	2009
	1	ISSR	2010
	60	SSR (Microsatellite)	2013
Pinus koraiensis	6	Isozyme	1972-1986
Abies holophylla	6	ISSR	2010
	1	Isozyme	2007
Pinus thunbergii	12	Isozyme	1986
	4	ISSR	2011
Abies koreana	9	Isozyme	1984
	3	ISSR	2006
Pinus pumila	1	Isozyme	1987
Taxus cuspidata	12	Isozyme	1996-1999
Abies nephrolepis	5	Isozyme	1999
	8	ISSR	2006
Picea jezoensis	3	Isozyme	1984
	4	ISSR	2007
Populus maximowiczii	1	Isozyme	1999
Cornus controversa	5	Isozyme	1990-1993
	9	Isozyme	2002
Quercus mongolica	18	Isozyme	1987-1992
	15	Isozyme	2000
	1	ISSR	2012
Quercus variabilis	4	Isozyme	1992
	10	Isozyme	2000
	1	ISSR	2012
	20	SSR (Microsatellite)	2016
Stewartia koreana	6	ISSR	2003

Camellia sinensis	38	ISSR	2009
Vaccinium uliginosum	2	ISSR	2003
Juniperus chinensis var. *sargentii*	2	Isozyme	2004
Thuja koraiensis	3	Isozyme	2005
Machilus thunbergii	10	Isozyme	2005
Berchemia berchemiaefolia	5	ISSR	2006
Acer pictum subsp. *mono*	11	ISSR	2008
Acer tegmentosum	8	ISSR	2009
Acer tegmentosum	9	SSR (Microsatellite)	2019
Ulmus davidiana var. *japonica*	8	ISSR	2010
Exochorda serratifolia	9	ISSR	2011
Phellodendron amurense	6	ISSR	2011
Tilia amurensis	13	AFLP	2012
	11	SSR (Microsatellite)	2017
Tilia mandshurica	8	SSR (Microsatellite)	2017
Fraxinus chiisanensis	7	SSR (Microsatellite)	2018
Fraxinus rhynchophylla	11	SSR (Microsatellite)	2018
Cephalotaxus koreana	16	AFLP	2013
Prunus padus	10	AFLP	2014
Acer pseudosieboldianum	14	AFLP	2015
Carpinus laxiflora	10	AFLP	2015
Betula costata	10	SSR (Microsatellite)	2019
Koelreuteria paniculata	6	SSR (Microsatellite)	2016
Total	36 Tree Species and 480 Populations		

Part 3. State of Forest Genetic Resource Conservation

Chapter 6. *In situ* Conservation of Forest Genetic Resources

6-1. Current Status of *In situ* Conservation

- The Republic of Korea has designated protected areas with diverse purposes and implemented *in situ* conservation at a national level. The protected areas can be classified into protected areas of the natural environment managed by the Ministry of Environment in accordance with relevant laws such as the "Natural Park Act," and protected forest areas managed by the Korea Forest Service in accordance with the "Forest Protection Act." As of the end of 2019, the protected natural environment areas with forest resources were as follows: 257 protected areas in specific islands (1,379.3 ha), 33 ecological and landscape conservation areas (28,579.4 ha), 79 natural parks (811,200 ha), and 392 wildlife protected areas (92,998.9 ha) (National Institute of Biological Resources, 2019). The protected forest areas totaled 447,634 ha: protected landscape areas (16,162 ha), protected living environments (13 ha), protected disaster prevention areas (4,276 ha), water resource conservation areas (255,134 ha), and 413 protected areas of forest genetic resources (172,049 ha). Under the "Baekdudaegan Protection Act," among protected forest areas, the 275,465 ha included in Baekdudaegan, which is the main mountain range in the Republic of Korea, has been designated as the Baekdudaegan protected area to carry out active conservation activities (Korea Forest Service, 2020).
- The Korea Forest Service has expanded the designation of *in situ* conservation forest based on genetic diversity assessment since 1972. Under the 2010 reorganization of the "Forest Protection Act," *in situ* conservation forest were renamed to protected areas of forest genetic resources. Overall, 8,337.6 ha in 75 areas of 21 species were

evaluated for genetic diversity, which corresponds to 4.8% of the total protected areas of forest genetic resources (see Table 8).

6-2. Methods for *In situ* Conservation

○ *In situ* conservation may not achieve its objectives if it is conducted without clear conservation objectives, target species, and systematic conservation strategies. *In situ* conservation has three objectives: conservation of ecosystems (communities), conservation of species, and conservation of genetic diversity (National Institute of Forest Science, 2013). Ecosystem (community) conservation takes into account the interaction between environmental factors and species to conserve the natural habitats of ecosystems and species. For species conservation, a conservation list including endangered species and rare endemic species is prepared at the national level, and *in situ* conservation is carried out based on threat assessment studies by collecting data on natural habitat distribution and monitoring populations. However, even if *in situ* conservation is conducted to conserve ecosystems and species, it does not guarantee the genetic diversity of species. This is because the population and number of species are limited depending on the size of the selected protected area; thus, genetic diversity of species cannot be sufficiently conserved. Hence, it is necessary to evaluate genetic diversity in the population of target species and determine the area for *in situ* conservation.

6-3. Activities for *In situ* Conservation at the National (Regional) Level, including Corporations and Stakeholders

○ The protected areas, including forests registered in the World Database on Protected Areas (WDPA), account for 16.74% (16,692 km^2) of the land area (WDPA, 2020). The Republic of Korea has promoted *in situ* conservation activities by expanding protected areas led by national organizations. In order to implement CBD Aichi Target 11, “at least 17% of the land is recommended to be expanded to protected areas.” The Cultural Heritage Administration has designated 11 forest areas with historical and cultural conservation value as natural protected areas under the “Cultural Heritage Protection Act,” while designating and conserving 264 old-growth and giant trees and plant communities as a natural monument (Cultural Heritage Administration, 2020). In addition to natural monuments, 13,900 old-growth and giant trees have been designated and managed by the Korea Forest Service as national protected trees (Korea Forest Service, 2020). In 2016, the Korea Forest Service designated seven coniferous species (*Abies koreana*, *Abies nephrolepis*, *Picea jezoensis*, *Taxus cuspidata*, *Thuja koraiensis*, *Juniperus chinensis* var. sargentii, and *Pinus pumila*) that declining individuals in natural habitats. It established ″Measures for the Conservation and Restoration of Coniferous Species in Endangered Alpine Areas,” and investigated the nationwide distribution of these seven coniferous species and their declines in natural habitats. Furthermore, it created technical support teams composed of experts in genetics, physiology, and ecology to carry out *in situ* restoration activities.

6-4. Demand, Challenges, and Opportunities to Enhance *In situ* Conservation of Forest Genetic Resources

○ *In situ* conservation is advantageous for conserving various forest genetic resources on a large scale. However, the decrease in forest area due to continuous conversion of forest land use and climate change have led to the large-scale withering of *Abies koreana*, an endemic and rare species in the Republic of Korea, as well as reduced seed production capacity and less naturally regenerated seedlings. Along with the increased frequency of natural disasters (e.g., typhoons, forest fires, etc.), the above are obstacles to the conservation of forest genetic resources. For the future conservation of forest genetic resources in their native habitats in a changing environment, such as due to climate change, it is necessary to conserve and manage them based on evaluations of genetic diversity in conservation target species, environmental factors such as climate data for conservation target areas, and scientific data such as the investigation of ecological functions.

- ○ In CBD, genetic diversity is evaluated as essential for the maintenance of an appropriate population level and recovery in response to climate change. Regarding genetic diversity research for the sustainable conservation of forest genetic resources, genetic analysis techniques such as next-generation sequencing (NGS) have been developed and commercialized, enabling easier access to the genetic information of species. It has consequentially enabled the study of adaptation of genetic diversity as well as neutral genetic variations in the population. Furthermore, genetic monitoring has been continuously performed for protected areas selected for *in situ* conservation. These research data are reflected in national policies, or they are considered while developing conservation strategies for forest genetic resources.
- ○ The goal of the next CBD, "Post-2020 Global Biodiversity Framework," emphasizes the importance of the role of *in situ* conservation in response to the crisis of biodiversity loss. It recommends expanding *in situ* conservation areas from 17% to 30% by 2030 through Other Effective Area-based Conservation Measures (OECM) as well as through further designation of protected areas. Although the protected areas designated by the State law play effective roles in *in situ* conservation, it is difficult to continuously expand them due to restrictions on economic activities in local communities. Therefore, rather than expanding protected areas, *in situ* conservation activities through OECM, which enables relaxed regulations and consultation with

local communities, are required. The Republic of Korea is also planning to actively carry out *in situ* conservation activities by discovering potential OECM areas through consultations between relevant ministries. In addition, the systematic management base will be expanded through qualitative evaluation based on scientific evidence as well as quantitative expansion.

6-5. Priorities for Capacity Building and Research in the Field of *In situ* Conservation

○ To achieve effective *in situ* conservation in the Republic of Korea, the central government agencies, such as the Korea Forest Service, the Ministry of Environment, and the Cultural Heritage Administration, as well as local governments manage forest genetic resources. Furthermore, each organization has established its own research institutes and conducted various research projects related to *in situ* conservation, such as surveying species distribution, evaluating genetic diversity, and ecological monitoring as national R&D projects. The National Institute of Forest Science and Korea National Arboretum are affiliated organizations of the Korea Forest Service that conduct *in situ* conservation research; the National Institute of Biological Resources and the National Institute of Ecology are affiliated organizations of the Ministry of Environment. The National Institute of Cultural Heritage is affiliated with the Cultural Heritage Administration. Cooperation among national research institutes has been established to effect *in situ* conservation. Development of cooperation based on networks with domestic as well as foreign universities and institutions has also been conducted. Researcher training is also in progress.

Table 8. Current status of *in situ* conservation forest (protected areas of forest genetic resources) that have been assessed for genetic diversity

Species	Number of stands conserved	Area (ha)
Pinus densiflora	28	7,023.1
Pinus koraiensis	2	33
Abies holophylla	2	137
Pinus thunbergii	1	14
Abies koreana	2	32
Pinus pumila	1	2
Picea abies	3	9
Taxus cuspidata	4	110
Abies nephrolepis	3	228
Populus Maximowiczii	1	5
Cornus controversa	2	16
Quercus mongolica	9	354
Quercus variabilis	5	107
Stewartia koreana	2	4
Picea jezoensis	1	62
Camellia sinensis	4	9.3
Exochorda serratifolia	1	8.4
Prunus padus	1	30.9
Cephalotaxus koreana	1	72.1
Fraxinus chiisanensis	1	70.3
Betula costata	1	10.5
21	75	8,337.6

Chapter 7. *Ex situ* Conservation of Forest Genetic Resources

7-1. *Ex situ* Conservation of Forest Genetic Resources

○ Diverse threats, such as losses or degradation of habitats due to human activities, invasion of invasive species, over-exploitation of plant resources, pests, diseases, and climate change, have been gradually increasing, and there are clear limits to the *in situ* conservation of forest genetic resources. Therefore, *ex situ* conservation has been emphasized as a crucial conservation method in order to stably conserve and sustainably use plant resources within such a changing environment. *Ex situ* conservation is a concept encompassing from the level of simple conservation of resources, such as conservation of seeds, pollen, and tissue through cryopreservation or seed banks, to the level of sustaining resource survivability through the development of tissue culture or propagation cultivation methods (Mounder et al., 2004).

○ Specialized facilities are essential for *ex situ* conservation of forest genetic resources. *In*- and *ex- situ* conservation has been conducted at various levels in facilities such as seed banks, gene banks, collection gardens, clone banks, and in vitro cultures.

7-2 Current Status of *Ex situ* Conservation

○ *In*- and *ex- situ* conservation of forest genetic resources has been mainly carried out by the Korea National Arboretum (see Table 9), which performs various research projects for the stable conservation of species and operates *ex situ* conservation facilities, such as a collection garden, seed bank, and propagation center. As of 2020, the seed bank of the Arboretum has 2,474 species of Korean native plants, which accounts for 66.2% of all Korean native plants, as well as 715 species of woody plants. The Seed Vault of the Baekdudaegan National Arboretum (i.e., the

Baekdudaegan Global Seed Vault) has 92,681 domestic and foreign wild plant species as of 2020. For *ex situ* conservation of national rare and endangered forest genetic resources, ten national and public arboretums created a network to continuously search and collect rare plant resources (e.g., seeds and living collection).

○ *Ex situ* conservation of forest genetic resources based on genetic diversity has been mainly led by the National Institute of Forest Science (see Table 10). The Institute collects the seeds, living samples, and DNA of woody plants, medicinal plants, and plants on islands such as Jeju Island, based on genetic diversity among the three factors constituting the forest ecosystem, that is, genetic diversity, species diversity, and ecosystem diversity. It also carries out tasks for stable and efficient conservation, such as assessments of genetic diversity, development of seed storage and regeneration technologies, evaluation of seed characteristics, creation of *ex situ* conservation centers, and duplicate conservation. Research projects are conducted, such as evaluation of genetic diversity of natural habitats, establishment of seed and clonal germplasm (germplasm and vegetative genetic resources) collection strategies, evaluation of basic characteristics for seed storage facilities, viability testing for long-stored seeds, long-term storage conditions of recalcitrant seeds, and development of regeneration technology to improve germination rates. In particular, as a seed management agency for the conservation and restoration of seven endangered alpine conifers, the institute conducts trait evaluation and conservation of seeds of alpine conifers such as *Abies koreana*, *Abies nephrolepis*, and *Picea jezoensis*, which are annually collected. Since 1999, seeds have been stored, and 1,827 species and 36,374 samples have been separately managed by group and family. Saplings have been cultivated for tree species requiring field collection, and *ex situ* conservation banks have been created and managed for each group and family (19 tree species and 10.1 ha). The institute also has conducted *ex situ* conservation through such methods as conservation of pollen, DNA, and seeds; cultivation of successor trees; and creation of conservation banks for important plant resources, such as natural monuments and protected trees, depending on risks of loss of genetic resources.

- *Ex situ* conservation for commercially and economically promising tree species is mainly led by the National Forest Seed and Variety Center (see Table 11). This center concentrates on resource collection and *ex situ* conservation for the industrialization of forest genetic resources and operates *ex situ* conservation facilities such as a gene bank, clone bank, and seed orchard. In particular, for breeding and implementing strategies for the production and supply of genetically improved forest reproductive material, a clone bank that conserves clones of plus trees selected in natural forest for collecting superior phenotypes has been established for the *ex situ* conservation of actual or potential forest genetic resources (see Table 12). Forest genetic resources, which are collected and preserved for trait improvement, such as through the development of forest tree varieties, require intensive management of their origin. A system has been established, and resources are managed in order to control the individual history and growth information of resources in clone banks by combining genetic information of resources with electronic drawings created by the geographic information system. As of 2019, a clone bank of 79.44 ha was created including 21 species (an area of 65.42 ha with 11 coniferous trees, and an area of 14.02 ha with 10 broadleaf trees). In the clone bank, 5,153 clones are distributed in six areas for duplicate conservation.

7-3 Demand, Challenges, and Opportunities to Enhance *Ex situ* Conservation of Forest Genetic Resources

- The Global Strategy for Plant Conservation (GSPC) 2020 of the CBD emphasizes *ex situ* conservation as a means for effective conservation of plant diversity. It presents specific goals for the *ex situ* conservation of 75% of threatened species. Currently, basic *ex situ* conservation of forest genetic resources is being performed in the Republic of Korea in various facilities, such as arboretums, botanical gardens, seed banks, clone banks, DNA banks, and *ex situ* conservation banks. However, as mentioned above, *ex situ* conservation requires approaches at various levels. In particular, for rare and endangered plants and promising tree species with high utility, the conservation of species and genetic diversity should be considered; thus, continuous improvement of research capacities is required to sustainably improve the viability of *ex situ* conservation resources through the development of regeneration, propagation, and cultivation methods.

○ Arboretums and botanical gardens play a core role in the *ex situ* conservation of plant diversity, including forest genetic resources. It is reported that arboretums and botanical gardens worldwide preserve more than 30% of the global plant species diversity, especially the *ex situ* conservation of more than 41% of endangered species (Mounce et al., 2018). In the Republic of Korea, various arboretums and botanical gardens are operated by the state and private sectors; as of 2020, 90 arboretums and botanical gardens are registered with the Korea Forest Service (Statistical Yearbook of Forestry, 2020). Although direct and indirect conservation activities for plant resources are being carried out in various arboretums and botanical gardens of various entities, systematic *ex situ* conservation of national forest genetic resources is mainly operated by the national arboretum. The Korea Forest Service is promoting the creation of a national arboretum to establish a foundation for the stable conservation and sustainable use of forest biological resources at the national level. While considering the climate and vegetation zones in the Republic of Korea, projects to create national arboretums in each region are in progress; national arboretums are currently being completed and operated in three regions. In particular, in the

Baekdudaegan National Arboretum, established in 2015, the Seed Vault, the world's first permanent storage facility for wild plant seeds, was established for the stable *ex situ* conservation of forest genetic resources at national and local levels while protecting them against various threats, including natural disasters such as climate change.

○ Due to the reduction in habitat areas and genetic diversity triggered by urbanization, withering of alpine conifers, decreased seed production triggered by climate change, and higher frequencies of natural disasters such as typhoons and wildfires, there have been difficulties with *in situ* conservation and collection of quality resources. Considering that, there has been ongoing development of a seed yield prediction model for the sustainable collection and use of forest genetic resources, such as seeds and clonal germplasm (germplasm and vegetative genetic resources), and of real-time technology for monitoring seed yield in connection with IT technology. In addition to the collection of new resources and identification of seed vitality through quality evaluation of long-stored seeds, there has been ongoing development of a non-destructive technique to identify seeds that enables an extended use period of seeds; furthermore, there is an attempt to improve resource utilization efficiency through the development of dormant seed regeneration technology. In addition to developing technology for collecting seeds in natural habitats and improving utilization rates of pre-stored seeds, there have been attempts to build *ex situ* conservation banks in each area after preparing strategies for their creation. As for the tree species required to create the banks, plants of seedling propagation by population and family, and of clonal germplasm (germplasm and vegetative genetic resources) propagation have been targeted based on genetic diversity evaluated in natural habitats. As duplicate conservation has been implemented by utilizing the Seed Vault facility, in which seeds are permanently stored, forest biological resources (e.g., woody seeds) are stably conserved based on genetic diversity. Meanwhile, it is essential to establish an integrated database system that utilizes seed collection research data to estimate the impact of environmental changes on forest ecosystems, such as climate change, as well as resource information, such as resource trait evaluation data and late growth-related data.

Table 9. *Ex situ* conservation status of forest genetic resources of the Korea National Arboretum

	No. of accessions					
	Seed	Clonal Germplasm	Microorganism	DNA	Extract	Specimen
Conserved species	3,858	8,219	-	-	-	18,759
Number of conserved units	11,924	776,278	-	-	-	1,164,892

Source: Korea National Arboretum (as of Dec. 31st, 2020)

Table 10. *Ex situ* conservation status of forest genetic resources of the National Institute of Forest Science

	No. of accessions					
	Seed	Clonal Germplasm	Microorganism	DNA	Extract	Specimen
Conserved species	1,827	132	557	101	131	2,919
Number of conserved units	36,374	20,464	5,119	26,731	26,731	30,463

Source: National Institute of Forest Science (as of Dec. 31st, 2020)

Table 11. *Ex situ* conservation status of forest genetic resources of the National Forest Seed and Variety Center

	No. of accessions					
	Seed	Clonal Germplasm	Microorganism	DNA	Leaf tissue	Specimen
Conserved species	173	29	-	82	52	85
Number of conserved units	5,771	58,003	-	132,448	109,520	4,667

Source: The National Forest Seed and Variety Center (as of Dec. 31st, 2020)

Table 12. Current status of forest tree species in a clone bank

Species (Taxa)	Area (ha)
Pinus densiflora Siebold & Zucc.	19.57
Pinus thunbergii Parl.	5.50
Pinus rigida Mill.	2.86
Pinus *rigida* × P. *taeda*	4.43
Pinus *taeda* L.	0.32
Pinus koraiensis Siebold & Zucc.	18.93
Larix kaempferi (Lamb.) Carrière	6.71
Cryptomeria japonica (Thunb. ex L.f.) D.Don	2.30
Chamaecyparis obtusa (Siebold & Zucc.) Endl.	2.52
Abies holophylla Maxim.	1.43

Abies koreana E.H.Wilson	0.85
Quercus acutissima Carruth.	4.71
Quercus variabilis Blume	1.14
Quercus serrata Murray	2.80
Quercus mongolica Fisch. ex Ledeb.	1.67
Fraxinus rhynchophylla Hance	1.13
Fraxinus mandshurica Rupr.	0.70
Alnus japonica (Thunb.) Steud.	0.06
Alnus incana subsp. *hirsuta* (Turcz. ex Spach) Á .Löve & D.Löve	0.15
Zelkova serrata (Thunb.) Makino	1.11
Juglans mandshurica Maxim.	0.55
Total	79.44

Source: The National Forest Seed and Variety Center (as of Dec. 31st, 2020)

Part 4. State of Use, Development, and Management of Forest Genetic Resources

Chapter 8. State of Use of Forest Genetic Resources

8-1. State of Use of Forest Genetic Resources

○ The use of forest genetic resources can be mainly divided into forest management, forest industry, and forest education and research. As for forest reproductive material used for forest management, the used tree species and the amount of supply are determined by the forest management plans stipulated in the "Creation and Management of Forest Resources Act." There are guidelines (i.e., implementation guidance for seeds and seedling projects) on production, storage, inspection, certification, and supply of seeds and seedlings. In the last five years (2015-2019), 95.9% of produced seeds were provided from seed sources, and the remaining 4.1% were produced in good breed stands. Seeds were produced from the following sources: 70.1% in seed harvest stands, 23.7% in seed orchards, and 2.1% in seed harvest forests. For the last five years (2015-2019), forest reproductive materials were planted throughout 23,454 ha of forests with an annual average supply of 51 million plants. Furthermore, 44.4 thousand micro-propagated plantlets of *Larix kaempferi* were obtained through vegetative propagation in four years from 2016 (2016–2019) and were planted in 20.3 ha of forests (Korea Forest Service, 2020).

○ For the collection, conservation, and use of forest genetic resources, a master plan is established every five years under the "Act on Preservation, Management, and Use of Agro-Fishery Bio-resources," and the implementation plan is updated annually. The 3rd Master Plan for Preservation, Management and Use of Agricultural Bio-resources (2019-2023) has been established and is being implemented. From August 2008, when the law came into effect, it became compulsory to comply with procedures for transboundary movement and domestic use of forest genetic resources. The collected and conserved forest genetic resources are distributed to applicants who need them for testing and research, and are used as materials for industrial or basic research, such as breeding and pharmaceuticals. The procedure and approval conditions for distribution of forest genetic resources are stipulated in the relevant laws; as of 2019, the total number of distributed forest genetic resources reached 460 thousand units (Korea Forest Service, 2019).

○ The Republic of Korea joined the International Union for the Protection of New Varieties of Plants (UPOV) as the 50th signatory in 2002 and has implemented a system for new plant variety protection with the establishment of the National Forest Seed and Variety Center (NFSV) since 2008. Newly developed varieties are examined for novelty and denomination and tested for examination of distinctness, uniformity, and stability (DUS); when it shall be deemed for those, the right to protection is granted, which is stipulated in the "Act on the Protection of New Varieties of Plants." Testing for examination of DUS is implemented according to the investigation criteria and methods for each characteristic defined in the Test Guideline (TG) by species. As of 2019, TGs for 282 forest species have been enacted, and 65 species and 208 varieties have been granted as new varieties. The granted varieties are classified as follows: 47 varieties of wildflowers (22.6%), 46 forest fruit trees (22.1%), 31 special-purpose trees (14.9%), 25 ornamental trees (12.0%), 2 timber trees (1.0%), and 57 other varieties (27.4%) (National Forest Seed and Variety Center, 2019).

○ The Republic of Korea has established a national strategy to achieve the UN's SDGs and implement sustainable forest management (SFM); forest genetic resources are produced and used in accordance with related legislations, implementation plans, and guidelines. Policies for the use of forest genetic resources aim to avoid damage to forest ecosystems and secure diversity in purpose and method of use.

8-2. Production, Demand, and Certification of Forest Reproductive Material

- Seed sources for the supply of forest reproductive material include seed orchards, seed harvest forests, and seed harvest stands, which produce seeds necessary for creating forest resources. Among the forest seeds produced in the last five years (2015-2019), approximately 23.7% of seeds were produced in seed orchards. Among seeds produced from seed sources, the seeds from seed orchard are preferentially supplied as forest reproductive materials. The seed orchards consist of 746.5 ha with 16 types of conifers, and 178.8 ha with 45 types of non-coniferous, totaling seven areas comprising 925.3 ha with 61 types. The seed orchards by species are as follows: *Larix kaempferi* seed orchard, 306.2 ha (33.1%); *Pinus densiflor*a, 146.1 ha (15.8%); *Pinus koraiensis*, 95 ha (10.3%); and *Chamaecyparis obtusa*, 85.8 ha (9.3%). When it is difficult to procure the required seeds from a seed orchard, seed harvest forests and seed harvest stands are designated and used as seed sources. In seed harvest forests, appropriate management removes individuals with poor traits, which allows genetically improved seeds to be produced in these forests. However, as seed harvest stands temporarily collect seeds to compensate for insufficient seed production in seed orchards, the abovementioned management method is not applied. As of 2019, seed harvest forests comprising 215.8 ha with 37 species, and seed harvest stands comprising 1,065.2 ha with 56 species were designated (see Table 13). A good breed stand that is not designated as a seed source is temporarily used for collecting seeds to respond to changes in social conditions or demands for special purposes.
- The seed production from seed sources varies annually due to changes in seed production conditions, such as seed yields impacted by variations in climatic conditions, and differences in harvest intensity in line with seed storage and afforestation demand. However, over the past five years (2015-2019), 36 tons of seeds on average were produced annually. As of 2019, the amount of seed production by

seed source was as follows: 10 tons from seed orchards, 1 ton from seed harvest forests, 19 tons from seed harvest stands, and 2 tons from good breed stands; the seed orchards accounted for 31% of the total seed production. Most forest reproductive materials required for national afforestation projects are supplied from seed sources, and the cumulative national afforestation project performance over the past five years (2015-2019) was 255 million plants (117,272 ha) (see Tables 14, 15, and 16).

○ The Republic of Korea has prepared and implemented a certification system related to forest management and the production and distribution of forest products, in order to promote sustainable forest management and expand the use of forest products and their processed goods. Regarding seeds and seedlings used by the state and local governments for afforestation, the species, production areas, production periods, and quality inspection results must be certified, which is stipulated in the "Creation and Management of Forest Resources Act." In addition, through the "Implementation Guidelines for Seed and Seedling Project", guidelines for procedures and implementation entities, such as details of seed production areas, quality inspection and certification of seeds and seedlings, and quality labeling, have been prepared and institutionalized.

8-3. Needs, Challenges, and Opportunities to Use Forest Genetic Resources

○ To implement the Paris Agreement adopted in 2015, the Republic of Korea added its response and adaptation strategies to climate change to the 6th Basic Forest Plan. As Net-Zero approaches were recommended at the 2018 IPCC General Assembly, the role of forests as a carbon sink has been emphasized. In accordance with national forest policy strategies, the expansion of national forests for creating more carbon sinks, changes in rotation periods, and increase in afforestation of tree species with excellent carbon sequestration capacity and environmental adaptability have been set as goals of national forest policies. As changes in species and increases in their supply are expected in response to changes in policy demand, policies to continuously expand seed orchard areas have been pursued to stably produce and supply genetically high-quality seeds.

○ Along with natural disasters, more forests have been recently damaged by human interventions such as various development projects. At a global level, as forest restoration has become a goal in international conferences such as the Convention on Biological Diversity (CBD) and the United Nations Framework Convention on Climate Change (UNFCCC), the demand for restoring damaged forests has been increasing. The Republic of Korea has shifted its forest restoration policy from erosion control and restoration projects for preventing disasters in damaged areas to projects for maintaining and improving the health of forest ecosystems before forests are damaged. The Korea Forest Service has promoted “the Restoration of Forest Ecology” project since 2006; it restored 546 ha of core areas by 2019, such as damaged forests in the Baekdudaegan region, abandoned military facilities, and the demilitarized zone (DMZ) (see Table 17). In order to prepare the legal basis for forest restoration projects, some amendments to the “Creation and Management of Forest Resources Act.” were released (Jan. 8th, 2019). The act includes project procedures and details, such as the definition of “forest restoration” and the establishment of a master plan for forest restoration. It is expected that there will be more systematic management and use of forest genetic resources, such as the utilization of native plants, as national policy for restoration of forest ecosystems is strengthened to restore their functions in the future (Korea Forest Service, 2020).

○ The Republic of Korea promotes welfare service policies based on biological, environmental, and cultural conditions of forest genetic resources. The provision of various environmental elements of forests as recreational opportunities has contributed to creating leisure environments for the people and improving public awareness of forest genetic resources. The Republic of Korea enacted the “Forest Welfare Promotion Act” in 2015, promoting a policy to create national leisure environments using forest genetic resources. As of the end of 2019, 29 healing forests and one national center for forest therapy were operating forest healing programs, with an additional center under development (see Table 18). As for visitors and programs in national healing centers, 83,000 people annually visit healing forests and use 5,322 programs in 2019 alone. As the demand for forests as a space for healing and recreation increases, the utilization of forest genetic resources is expected to increase. (Korea Forest Service, 2020).

○ Along with industrialization and urbanization, approximately 92% of the Korean population dwells in urban areas, and their quality of life has continued to deteriorate due to air pollution, including the recent increase in fine dust, and the urban heat island phenomenon. The need and demand for urban forests have been increasing, as they are known as a space for fine dust reduction, climate control function, and relaxation. As a result of the constant creation of urban forests, as of 2020, the urban forest area per capita within living zones reached 10.07 m^2, exceeding the World Health Organization recommendation standard of 9 m^2. However, they are still insufficient in metropolitan areas with a higher population density, such as Seoul, the Gyeonggi region, and Incheon. The Korea Forest Service established the “Plan to Build Green Infrastructure for Fine Dust Reduction and Quality City” in 2018 and created 5,151 ha of urban forests by 2019 (Korea Forest Service, 2020). In 2020, the “Act on the Creation and Management of Urban Forests” was enacted to lay the foundation for a systematic policy to expand green spaces within living zones.

○ Plants, insects, and microorganisms, which account for approximately 92% (around 20,000 species) of all biological species in the Republic of Korea, inhabit forests.

Although such genetic resources in forestry have been evaluated as core materials of the bio-industry, such as in medicines, cosmetics, and functional foods, there has been a high dependence on overseas forest genetic resources due to insufficient material development and supply bases for biomaterials. In this sense, policies for the industrialization of forest genetic resources are being promoted through R&D for biomaterials and the establishment of a platform to supply materials.

Table 13. Current status of seed source creation

Category	**Area**	**Species**	
Seed orchard	925.3 ha	61 Species	*Juglans mandshurica, Eleutherococcus senticosus, Quercus gilva, Betula costata, Acer pictum, Abies koreana, Quercus variabilis, Larix kaempferi, Cinnamomum camphora, Ulmus davidiana, Zelkova serrata, Picea abies, Fraxinus mandshurica, Quercus rubra, Qcer rubrum, Pinus rigida, Pinus rigisa× teada, Sorbus commixta, Ilex rotunda, Melia azedarach, Fraxinus rhynchophylla, Betula schmidtii, Liriodendron tulipifera, Prunus serrulata, Abies nephrolepis, Quercus acuta, Torreya nucifera, Cornus kousa, Cryptomeria japonica, Quercus acutissima, Pinus densiflora, Carpinus turczaninovii, Pinus strobus, Quercus mongolica, Prunus serotina, Alnus japonica, Toxicodendron vernicifluum, Ginkgo biloba, Kalopanax septemlobus, Idesia polycarpa, Chionanthus retusus, Betula pendula, Pinus koraiensis, Abies holophylla, Quercus serrata, Quercus glauca, Quercus salicina, Cornus controversa, Quercus palustris, Betula platyphylla, Chamaecyparis obtusa, Tilia amurensis, Hovenia dulcis, Phellodendron amurense, Chamaecyparis pisifera, Dendropanax trifidus, Machilus thunbergii, Schisandra repanda, Juglans nigra, Vaccinium oldhamii, Pinus thunbergii*

Seed harvest forest	215.8 ha	37 Species	*Juglans mandshurica, Betula costata, Acer pictum, Larix kaempferi, Sorbus commixta, Fraxinus rhynchophylla, Betula schmidtii, Liriodendron tulipifera, Quercus acutissima, Pinus densiflora, Kalopanax septemlobus, Betula pendula, Abies holophylla, Cornus controversa, Hovenia dulcis, Quercus aliena, Catalpa ovata, Ulmus davidiana, Zelkova serrata, Maackia amurensis, Picea abies, Eucommia ulmoides, Fraxinus mandshurica, Styrax japonicus, Quercus dentata, Betula davurica, Alnus incana, Acer triflorum, Prunus sargentii, Carpinus laxiflora, Quercus mongolica, Robinia pseudoacacia, Taxus cuspidata, Pterocarya stenoptera, Styrax obassis, Tilia amurensis, Phellodendron amurense*
Seed harvest stand	1,065.2 ha	56 Species	*Betula costata, Acer pictum, Quercus variabilis, Larix kaempferi, Cinnamomum camphora, Ulmus davidiana, Sorbus commixta, Fraxinus rhynchophylla, Liriodendron tulipifera, Torreya nucifera, Cornus kousa, Cryptomeria japonica, Quercus acutissima, Pinus densiflora, Pinus strobus, Alnus japonica, Betula pendula, Quercus salicina, Tilia amurensis, Zelkova serrata, Picea abies, Fraxinus mandshurica, Alnus incana, Prunus sargentii, Quercus mongolica, Castanopsis sieboldii, Fagus multinervis, Stewartia koreana, Quercus palustris, Camellia japonica, Aralia elata, Cornus officinalis, Zanthoxylum schinifolium, Pinus parviflora, Tsga sieboldti, Robinia pseudoacacia, Toxicodendron vernicifluum, Acer pictum, Kalopanax septemlobus, Larix gmelinii, Pinus koraiensis, Abies holophylla, Quercus serrata, Quercus glauca, Quercus salicina, Zanthoxylum piperitum, Cornus controversa, Chamaecyparis obtusa, Pinus thunbergii, Hovenia dulcis, Chamaecyparis pisifera, Machilus thunbergii, Phellodendron amurense, Dendropanax trifidus, Maackia amurensis, Prunus serotina*

Table 14. Current status of seed production from seed sources in the last five years

(Unit: kg)

	Seed orchard	Seed harvest forest	Seed harvest stand	Good breed stand	Total
2015	5,573	352	26,471	666	33,062
2016	1,737	201	31,262	529	33,729
2017	13,854	1,082	25,150	1,228	41,314
2018	11,842	973	26,158	2,709	41,682
2019	10,448	1,258	19,383	2,454	33,543

Table 15. Current status of seed production by tree species in 2019

Stand	Tree Species	Area (ha)	Amount of production (kg)
Seed orchard	*Larix kaempferi*	306	2
	Pinus densiflora	146	293
	Pinus koraiensis	95	8,352
	Chamaecyparis obtusa	86	335
	Others	273	1,272
Seed harvest forest	*Quercus acutissima*	25	1,000
	Others	119	258
Seed harvest stand	*Quercus acutissima*	102	11,885
	Liriodendron tulipifera	36	4,132
	Quercus variabilis	99	200
	Acer pictum	9	135
	Others	757	3,031

Table 16. Afforestation performance by ownership

	National forest		Non-national forest		Total	
	Area (ha)	Number of Plants (1000 plants)	Area (ha)	Number of Plants (1000 plants)	Area (ha)	Number of Plants (1000 plants)
2015	3,919	10,072	19,259	40,656	23,178	50,728
2016	4,112	10,893	19,805	41,161	23,917	52,054
2017	3,993	10,598	19,681	41,440	23,674	52,038
2018	4,045	10,126	19,044	40,573	23,089	50,699
2019	4,153	10,455	19,261	39,641	23,414	50,096

Table 17. Current promotion status of forest ecological restoration

(Unit: ha)

Total		**Restoration performance by year**										
		Total	**~ 2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Total		545.9	84.3	40.6	79.0	67.5	46.7	51.4	48.3	54.5	46.2	27.4
Core Areas	Total	343.3	71.4	33.5	42.7	50.2	35.4	35.5	28.4	17.0	20.2	8.9
	DMZ	250.7	41.0	22.5	27.0	46.4	26.4	24.8	23.4	12.0	18.2	8.9
	Baekdudaegan	92.6	30.4	11.0	15.7	3.8	9.0	10.7	5.0	5.0	2.0	-
Other Areas		202.6	12.9	7.1	36.3	17.3	11.3	15.9	19.9	37.5	26.0	18.5

Table 18. Current operation (creation) status of healing forests

(Unit: Number of forests)

Classification	2013	2014	2015	2016	2017	2018	2019
National	3(3)	3(3)	3(7)	4(6)	5(5)	10(-)	10(1)
Public	-(18)	-(23)	2(24)	6(25)	10(26)	16(24)	18(27)
Private	-(-)	-(-)	-(-)	1(-)	1(-)	1(2)	1(2)
Total	3(21)	3(26)	5(31)	11(31)	16(31)	27(26)	29(30)

Chapter 9. State of Genetic Improvement and Breeding Program for Forest Genetic Resources

9-1. Methods for Tree Improvement and Breeding

- ○ The traditional selective breeding and the accelerated breeding method using molecular biological techniques are utilized simultaneously in the tree improvement program of the Republic of Korea.
- ○ The tree improvement program of the major coniferous timber species of genus *Pinus* has been proceeded for approximately 60 years and is currently heading for the third-generation. Selective breeding for broadleaf tree species has been launched in recent years in response to the increasing demand for the species in the plantation and timber industry as the socio-environmental changes. Genomic selection for the accelerated breeding of the forest tree is applied to *Pinus densiflora*, one of the representative tree species in the Republic of Korea. The research project has encompassed other tree species to expand the use of genomic selection.

9-2. Priority of Uses and Traits in Tree Improvement and Breeding

- ○ The objective of the tree improvement program is the enhancement of timber production by increasing volume growth of forest trees. It is required to collect the phenotypic data by individual trees on the target traits, for instance height, diameter, or stem straightness. Those quantitative traits are still the principal targets in the tree improvement program in the Republic of Korea as the recent development of the wood processing technology is relatively reducing the requirement to improve the wood quality. The tree improvement research for disease resistance is conducted as well, for instance the project to enhance the resistance of pine species to pine wilt disease.

9-3. Composition of Tree Improvement and Breeding Program

○ The tree improvement in the Republic of Korea is conducted in the typical framework of the tree improvement programs. The recurrent projects are performed on the selection of plus trees, the progeny trials, and the establishment of the breeding population and the seed orchard. The progeny trials for developing the third-generation is in progress for the main coniferous tree species, such as *Pinus densiflora, Pinus koraiensis*, and *Pinus thunbergii*. The progeny trial of the first-generation has been initiated of late in the broadleaf species of which the tree improvement program constituted later than that of the coniferous species.

○ The tree improvement program reflects the socio-economic demands while conducting research on the different breeding stages considering the characteristics of each species. The species receiving latest attention become the additional target of the tree improvement in response to climate change and increasing demand for the high value timber. The plus tree selection followed by the readjustment of criteria for selecting the superior trees is being implemented in cherry trees and evergreen oaks in practice.

9-4. Status of Current and Emerging technologies Used for Tree Improvement and Breeding

○ The tree improvement program based on selective breeding began in earnest in 1968 via the "Project on the establishment of seed orchards by plus trees selection" after the foundation of the Institute of Forest Genetics in 1956. The plus trees were selected in 1959 and the progeny trials have been implemented for *Pinus densiflora, Pinus thunbergii, Pinus koraiensis*, and *Abies holophylla* since 1963. The genetic testing with full-sib progenies by artificial crossing has been conducted since 1977. The selection criteria established along with the tree improvement plan were applied until 1971. The application of the criteria resulted in the selection of only 370 plus trees during this period, 34 trees in annual average despite the intensive commitment of manpower and resources. The selection intensity was lightened to expand the breeding population and its genetic variation in 1972. It has led to the selection of 1,547 plus trees by 1986 with an annual average of 103 trees. A total of 2,828 plus trees, 1,625 conifer and 1,203 broadleaf species, have been designated as the plus trees at present with the majority of them being selected by 1987 in the coniferous species of *Pinus densiflora, Pinus thunbergii, Pinus koraiensis*, and *Larix kaempferi* (see Table 19). The clone banks of the plus trees were established with 5,095 trees of 21 species in 79.94 ha for the conservation and utilization of the breeding materials.

○ Progeny trials are conducted to enhance the genetic gain by fostering the advanced generation through the selection of individuals or families in the breeding population. The progeny trials of major coniferous species were established in 70 sites ranging 42.23 ha by 2014 after the development of the first trial with half-sib progeny in 1975. The growth characteristics have been evaluated for each family and combination through the regular surveys and analyses on the growth performance (see Table 20). A progeny trial has been recently arranged on *Quercus* spp. which is the one of the representative broadleaf species in the Republic of Korea. Seeds are being collected by family to continuously lay the foundation of the genetic testing for the other species from which plus trees were selected as well.

○ The accelerated breeding method is also applied to shorten the time required for tree improvement utilizing the advanced molecular biological technology. Genomic research, such as genomic selection or genome-wide association studies, are conducted in addition to the traditional tree improvement program. The advanced genetic analyses are actively conducted in the research projects on the natural population which are the potential materials of breeding. The current research topics of the tree biotechnology include the somatic embryogenesis and the gene editing using the genetic scissors. The mass propagation using the tissue-culture are utilized to support the production of seedlings of *Larix kaempferi*, which has the irregular seed production. The cumulative 44,000 tissue-cultured trees of the species have been planted by 2019 (see Table 21).

9-5. Demand, Challenges, and Opportunities for Tree Improvement and Breeding

○ The forest area accounts for the large portion (62.7%) of the national territory of the Republic of Korea. The various climatic zones from cold to subtropical are appeared due to the diverse topography. The demand for the improvement of the broadleaf tree species is increasing according to the environmental changes, which, in turn, increases the predicted expansion of the distributional range of the species. The tree improvement program of the evergreen oaks, the species in the warm temperate zone, has been commenced recently. The efforts to develop the tree improvement program of the broadleaf species are promoted as the program corresponds to the forest policy enhancing the economic value of the forests as well.

○ The latest integrated scientific technologies, including the information and communication technology and biotechnology, are applied in the tree improvement program and the management of the experimental forests. The field survey using the terrestrial LiDAR is performed to acquire the phenotype data of individual trees in the experimental forest. The application of the technology ameliorates the precision of the data and the efficiency of the tree improvement.

○ The research of accelerated breeding supports the tree improvement program utilizing the genomic tools and big data analyses.

9-6. Priority for Capacity Building and Research in the Tree Improvement and Breeding Field

○ The courses related to the tree improvement are provided in the undergraduate and graduate program in the universities. The students majoring the forestry are educated in the subjects of forest science, forest genetics, tree breeding, and quantitative genetics. There are programs for master and doctoral researchers and industry-academia courses operated by the National Institute of Forest Science. It aims to promote the continuous development of the forest science, including the tree improvement *per se* and researcher's capabilities in the field. Tree improvement research in Korea mainly focuses on the enhancement of genetic gain of the major timber species, the development of accelerated breeding technology and the establishment of the basis of improvement responding to the future demand.

9-7. Composition and Subjects of Tree Improvement and Breeding Program

○ The tree improvement research in the Republic of Korea is primarily executed by the National Institute of Forest Science. The research involves selecting the breeding materials for the tree improvement program, preparing the developed foundation for utilization. It aims to support the policy responding the changes in social demand for plantation and wood utilization. The National Forest Seed and Variety Center has been in charge of the management of seed orchards, seeds and seedlings since 2008. The establishment of the seed orchards and the management of the forest reproductive materials are accomplished by the center.

Table 19. Number of plus trees by tree species

Tree Species	Number of Plus Trees
Total	**2,828**
Subtotal (Conifer tree species)	**1,625**
Pinus densiflora	425
Pinus koraiensis	300
Pinus thunbergii	151

Pinus rigitaeda	150
Larix kaempferi	145
Chamaecyparis obtusa	114
Abies holophylla	100
Cryptomeria japonica	93
Pinus rigida	87
Pinus taeda	13
Larix gmelinii var. olgensis	4
Chamaecyparis pisifera	43
Subtotal (Broadleaf tree species)	**1,203**
Quercus acutissima	207
Quercus variabilis Blume	110
Quercus serrata Murray	110
Quercus mongolica	110
Fraxinus mandshurica Rupr.	104
Juglans mandshurica Maxim.	102
Zelkova serrata	102
Fraxinus rhynchophylla	100
Betula schmidtii Regel	50
Betula platyphylla	61
Betula costata Trautv.	48
Alnus sibirica	25
Tilia mandshurica	25
Tilia amurensis	18
Populus davidiana Dode	10
Alnus japonica	9
Carpinus laxiflora	6
Populus maximowiczii	4
Populus koreana Rehder	2

Table 20. Current status of progeny test forests of main coniferous species

Tree Species	**Classification**	**Number**	**Area (ha)**
Pinus thunbergii	Artificial cross	9	3.09
	Open-pollinated progeny	2	1.48
Pinus densiflora	Artificial cross	14	4.97
	Open-pollinated progeny	17	13.58
Pinus koraiensis	Artificial cross	2	0.59
	Open-pollinated progeny	26	18.52

Table 21. Current status of production and plantation of tissue-cultured plants of *Larix kaempferi*

Year	Number of produced trees (1000 trees)	Plantation area (ha)	Number of planted trees (1000 trees)
2016	26.90		
2017	21.00	11	18.90
2018	61.22	4	12.50
2019	19.48	6	13.00
Total	128.60	21	44.40

Chapter 10. Management of Forest Genetic Resources

10-1. Management of Forest Genetic Resources in Natural and Planted Forests, and Other Wooded Land

○ The Korea Forest Service enacted and implemented the "Sustainable Forest Resources Management Guidance" in 2004 to preserve and manage forests so that various functions can be optimally performed while maintaining the ecological and environmental integrity of the forest. Under this guidance, system maintenance, such as administrative procedures, is the core requirement for the conservation of forest biodiversity; the maintenance and promotion of forest productivity, health, and vitality; the conservation and maintenance of soil and water resources within forests; an increased contribution of forests to the global carbon cycle; the increased socioeconomic benefits of forests; and sustainable forest management. In addition, in terms of functions, all forests in the Republic of Korea are classified as timber production forests, water resource conservation forests, disaster prevention forests, natural environment conservation forests, recreation forests, and living environment conservation forests. After classification, management goals are set according to function to enable the optimal performance of various functions of forests, and the forest resources are managed so that various economic, social, and environmental functions can be harmoniously achieved.

10-2. Effects of Changes in the Forest Sector Regarding Forest Genetic Resources and Management

○ In the Paris Agreement in 2015 and the UN Intergovernmental Panel on Climate Change in 2018, achieving carbon neutrality (Net-Zero) by 2050 was recommended. The Korean government also decided to actively respond to climate change, along with the international community, by declaring carbon neutrality by 2050, providing institutional strategies such as the "Framework Act on Low Carbon, Green Growth" and "Act on the Management and Improvement of Carbon Sink," and strengthening the role of forests as carbon sinks.

○ The value of forest genetic resources has been re-evaluated, as interest in health and the environment has increased due to increased national income levels, improved quality of life, and the recent COVID-19 pandemic. In response to such social changes, the Korea Forest Service established a K-Forest promotion plan as a Korean-style forest new deal strategy in 2020. After introducing the information and communication technology of the 4^{th} industrial revolution, which has been accelerating throughout the sector, the organization is promoting policies to manage sustainable forest genetic resources in the climate crisis era.

10-3. Demand, Challenges, and Opportunities to Enhance Management of Forest Genetic Resources

○ In accordance with the Carbon Neutrality Declaration (2020) of the Korean government, there has been a growing demand for strengthening the role of forests as a key carbon sink. Forests in the Republic of Korea were intensively created in the 1970s and 1980s to overcome the decline in carbon absorption. The Korea Forest Service established the "2050 Carbon Neutral Promotion Strategy in the Forest Sector" to promote a management strategy that can enhance the ecological and economic value of forest genetic resources in a balanced manner. This strategy encompasses an increased carbon absorption capacity of forests, expansion of new forest carbon sinks, revitalization of wood and forest biomass use, conservation and restoration of forest carbon sinks, and reinforcement of related infrastructure.

○ The need for tree improvement has been further emphasized to promote economic forests (e.g., timber production forests) for increasing their economic feasibility and to expand new forest carbon sinks, and the demand for the supply and use of improved seeds has been increasing. Plantation utilizing genetically-improved seeds and seedlings, as products of the tree improvement program, enables the enhancement of economic feasibility and of carbon absorption. To increase the production and distribution of the improved seeds, the “promotion plan for creating and managing seed orchards” is established every five years, expanding the area of seed orchards every year. Through the renewal of seed orchards due to aging, the creation of advanced-generation seed orchards, and environmental improvement projects of seed harvest forests, the foundation to increase production of improved seeds has been continuously expanded.

10-4. Priority for Building Capacities and Research in the Field of Forest Genetic Resource Management

- ○ The Forest Training Institute, an institution specializing in forest training, nurtures professional talents in forestry and job competencies by operating various training courses to manage forest genetic resources, such as courses in forest resource creation, forest management, and seedling production management, as well as a specialized course for forest restoration.
- ○ In accordance with the “Forest Resources Creation and Management Act,” the “Basic Plan for Forest Science Technology” for the improved creation, cultivation, use, and function for public benefit and the “Mid-to-Long-term Technology Development Plan of the National Institute of Forest Science” to support the Basic Plan have been established and implemented. Specific research fields include the conservation and restoration of forest ecosystems, extended functions of forest-based public welfare, scientific management of forest disasters and pests, responses to a new climate

system, reinforcement of international forest cooperation, industrialization of forest biological resources, and promotion of timber use via optimal processing techniques. In consideration of the paradigm change in forest genetic resource management, the demand for establishing a virtuous cycle of forest genetic resources encompassing the previous focus of the creation and nurturing of forest resources for timber production and use has been recently reflected to expand research fields to create a virtuous cycle system for forest resources and activate forest management.

10-5. Genetic Considerations in Forest Management Process

○ The Republic of Korea has established and implemented measures to minimize damage to protected species and their natural habitats during forest projects to conserve and promote biodiversity. The currently growing trees in the forest that function to preserve ecological, cultural, historical, and academic values are selected as native tree species during reforestation projects. Young trees or seeds naturally grown or found in the same area are produced as seedlings and reforested, and light thinning is executed every five years or more for forest care to avoid sudden changes in the forest structure and improve stability. In addition, the forest edge (a distance of approximately 30 m from the boundary point between forests and non-forest areas, toward the forests) enhances the species and visual diversity of the ecosystem by growing various tree species and promoting their genesis; furthermore, there are ongoing projects to conserve and improve habitat environments in habitat areas for living organisms that need to be preserved.

10-6. Status of Current and Emerging technologies Used for Management of Forest Genetic Resources

○ There are various ongoing detailed studies related to improved seeds and seedlings, such as research on the arrangement and design of seed orchards to enhance the genetic gain, research on asexual propagation technology by developing somatic embryogenesis for the supply and active use of improved materials.

○ Other research is in progress: the creation of multi-layered mixed forests that provide a pleasant environment by reducing air pollutants such as fine dust that flows into living zones, an environmentally friendly tree trimming method to exert the functions of species diversity, ecological and landscaping maintenance, disaster prevention, the utilization of high value-added broadleaf forests, and the management of technologies by type.

Part 5. State of Capacities and Polices

Chapter 11. Institutional Framework for Conservation, Use, and Development of Forest Genetic Resources

11-1. National Coordination Mechanisms and Other Institutions Dealing with Forest Genetic Resources

○ The national basic plan for the conservation, use, and development of forest genetic resources in the Republic of Korea is the “Basic Plan for Preservation, Management and Use of Genetic Resources of Agriculture” in accordance with “the Act on Preservation, Management and Use of Genetic Resources of Agriculture.” The basic plan is established every five years, and related projects and R&D are annually promoted in line with detailed implementation plans. The main contents of the basic plan include the following details: 1) collection, trait evaluation, and registration of genetic resources; 2) efficient conservation and management of genetic resources; 3) promotion of use, such as distribution of genetic resources; 4) increase in diversity of genetic resources; and 5) establishment of genetic resource data. The Korea Forest Service has operated such systems as national authorities that manage and are responsible for forest biological resources to professionally implement this basic plan. As of 2020, three “National Authorities Responsible for Forest Genetic Resources” (i.e., the National Institute of Forest Science, Korea National Arboretum, and the National Forest Seed and Variety Center), and 44 “National Authorities Managing Forest Genetic Resources” (e.g., Baekdudaegan National Arboretum and Local Forest Environment Research Institute) have been designated to promote forest genetic resource-related policies.

11-2. State of Research and Development on Forest Genetic Resources

○ The Korea Forest Service aims to turn a crisis into an opportunity by strengthening its competencies in response to the post-COVID-19 era and by reflecting new R&D projects in line with the new forest policy direction. The organization has been participating in the following projects: “The Complete Collection Project of Native Plant Resources in the Korean Peninsula” to secure trait and genomic data of materials derived from living organisms; the “Multi-ministerial National Biological Research Resources Advancement Project,” which is a project to build and promote infrastructure for national biological research resources (e.g., materials and data) to facilitate bioresearch and industrial innovation; and the new project of “Digital Breeding-Based Seed Industry Innovation and R&D” to create an industrial innovation ecosystem and strengthen global competitiveness by supporting the development of core seed industry technologies using digital breeding technologies. It is also planning a new R&D project for innovative growth of a new industry utilizing forest biological resources that will aid in the future bio-economy. Furthermore, it is promoting projects focusing on application and development research through diversification of planning for convergence with other fields of technologies.

11-3. State of Education and Training Related to Forest Genetic Resources

○ Education and training on research, collection, conservation, trait evaluation, and use of forest genetic resources are conducted by the “National Authorities Responsible for Forest Genetic Resources,” such as the National Institute of Forest Science, the Korea National Arboretum, the National Forest Seed and Variety Center, and the Forest Training Institute, a professional forest education institution.

○ The National Institute of Forest Science and the Korea National Arboretum, the national research institutes of the Korea Forest Service, hire internship researchers and postdoctoral fellows from Korea and other countries to develop research technologies and provide them with education and training through research and development projects. Those projects encompass research and collection of forest genetic resources, evaluation of genetic diversity and breeding traits, variety development, propagation, and conservation. In addition, they publish manuals and promotional brochures on the results of R&D and distribute them to forest and biological resources-related workers, universities, and civilians. They also make efforts to disseminate information on research technologies by holding annual international and national symposiums. In particular, the Korea National Arboretum, which operates an exhibition arboretum, provides educational programs on research, collection, preservation, and restoration of forest genetic resources to public and private arboretums, universities, and private civic groups and societies. It also established the “National Bio-species Information System” to provide the public with information and education through the internet. The National Forest Seed and Variety Center joins diverse training/educational courses provided by the Forest Training Institute, so as to provide public officers from the Korea Forest Service and local governments and the general public with educational content encompassing the cultivation and protection of new forest plant species, national management of forest seeds, and seed production and distribution.

Chapter 12. International and Regional Cooperation for Forest Genetic Resources

12-1. International and Regional Cooperation and Projects on Forest Genetic Resources

○ The Republic of Korea has actively participated in the Convention on Biological Diversity (CBD) to contribute to the greening of global forests and response to climate change.

○ This country has shown international cooperation for forest genetic resources by signing the following international agreements: the United Nations Convention to Combat Desertification (UNCCD), the United Nations Framework Convention on Climate Change (UNFCCC), and the Convention of International Trade in Endangered Species (CITES) in wild flora and fauna. To solve global forest issues and conservation of forests, it has cooperated with the following organizations: the Food and Agriculture Organization (FAO) Committee on Forestry (COFO), the International Tropical Timber Organization (ITTO), the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA), the International Union for the Protection of New Varieties of Plants (UPOV), the Tropical Agricultural Research and Higher Education Center (Centro Agronómico Tropical de Investigación y Enseñanza; CATIE), the Central African Forest Initiative (CAFI), the Center for International Forestry Research (CIFOR), and the International Union of Forest Research Organizations (IUFRO) (Korea Forest Service, 2019, 2020).

○ As for regional cooperation for forest genetic resources, the country has joined the Asian Forest Cooperation Organization (AFoCO), the Asia-Pacific Forest Genetic Resources Program (APFORGEN), and the Asia-Pacific Association of Forest Research Institutions (APAFRI) (Korea Forest Service, 2019, 2020).

12-2. Benefits and Consequences of International and Regional Cooperation on Forest Genetic Resources

○ To raise awareness about the importance of forest genetic resources through international cooperation, and to strengthen efforts to conserve these resources, the Republic of Korea has made continuous efforts to increase forest biodiversity and protected areas within the country by conscientiously implementing CBD GSPC and meeting the Aichi Biodiversity Targets. As a result of conservation efforts on forest genetic resources, the country has achieved the following: designation of additional protected areas for forest genetic resources of 19,613 ha in the last five years from 2015, and forest ecosystem restoration of 227.8 ha of forest areas (Korea Forest Service, 2020).

○ At the 12th Meeting of the Conference of the Parties to the Convention on Biological Diversity that was held in Pyeongchang, the Republic of Korea in 2014, the "Forest Ecosystem Restoration Initiative (FERI)" proposed by the country was adopted to support the restoration of forest ecosystems in developing countries. Afterward, at the 14th Meeting of the Conference of the Parties to the Convention on Biological Diversity held in Egypt in 2018, the Sharm El-Sheikh Declaration was announced to implement investments in biodiversity mainstreaming in all fields encompassing legislation, policy, development, finance, and planning. FERI, a cooperative project between the Korea Forest Service and CBD, was explicitly declared as a representative initiative for science and technology cooperation.

○ As part of UNFCCC and UNCCD, after the Mongolian Greenbelt Forestation Project (1st stage: KRW 13.8 billion for a decade from 2007 to 2016), Urban Forest Creation (2nd stage: KRW 10 billion for five years from 2017 to 2021), and afforestation project of 4.8 million trees in the Kubuqi Desert in Inner Mongolia, China from 2007 to 2018, local technical guidance on post-management methods have been provided.

As a project to prevent desertification and increase the income of local residents in the Khuroson District of Tajikistan, approximately KRW 2 billion from 2019 to 2021 was provided to support the creation of a nursery and pilot forest of Saxaul (*Haloxylon ammodendron*), and to create and operate a pilot forest of *Pistacia vera* and a breeding center (Korea Forest Service, 2019, 2020).

- ○ AFoCO was established to strengthen cooperation among Asian countries in the forest sector in response to international issues, such as forest damage from climate change, and forest restoration; 13 countries (the Republic of Korea, Vietnam, Timor-Leste, Bhutan, Myanmar, Cambodia, Brunei, Philippines, Laos, Thailand, Indonesia, Kazakhstan, and Mongolia) and two observers (Singapore and Malaysia) are participating in the organization. The Action Plan for continuous maintenance and use of forest ecosystems and biodiversity was established after AFoCO international workshops, a general meeting (in Seoul and Gyeongju, April 2019), high-profile meetings, and the 3rd regular general meeting (in Seoul, October 2019). Along with IUFRO, through joint projects with APAFRI, the organization aims to strengthen research in the Asia-Pacific region while supporting academic events for building the capacities of member countries and technologies to generate forest tree breeding population for restoring deforested areas (Korea Forest Service, 2019, 2020).
- ○ The East Asia Biodiversity Conservation Network (EABCN) was established by multilateral memorandums of understanding signed by five countries (i.e., China, Japan, Russia, Mongolia, and the Republic of Korea) and six organizations at the 2014 CBD COP12 Side-event, in order to conserve biodiversity in East Asia regions and to implement the GSPC 2020 goals. The Central Asia Biodiversity Conservation Network was established to strengthen taxonomic research capabilities and secure genetic resources; a green road project involving four main Central Asian countries is in progress to provide basic data for research on the differentiation of native and

allied species linking the Korean peninsula and Central Asia.

- ○ The Republic of Korea is currently cooperating with 33 countries on the reduction of emissions from deforestation and forest degradation (REDD+), desertification prevention, biodiversity research, sustainable forest management, forest restoration, manpower training, forest conservation, and forest ecosystem services (Korea Forest Service, 2020).

12-3. Demand, Challenges, and Opportunities to Strengthen International and Regional Cooperation on Forest Genetic Resources

- ○ International cooperation for forests will be strengthened to achieve sustainable development goals by promoting afforestation projects to prevent desertification. International organizations and UNCCD parties are participating by activating research and networks to prevent desertification and by expanding multilateral forest cooperation, cooperation with tropical rainforest regions and Central African countries (e.g., ITTO and CAFI), and the scale of official development assistance (ODA) (Korea Forest Service, 2018, 2020).
- ○ There is a goal to create an international organization that reflects the common interests of Asian countries by expanding the target countries of AFoCO in Asia. In addition to the strengthened cooperation with other organizations and registration of the UN Observer Organizations, the Republic of Korea will make efforts to develop and expand new REDD+ projects, activate ODA projects to share forest carbon-related technologies, and successfully hold the 15th World Forestry Congress, in order to strengthen cooperation on climate change in response to the new climate regime (Korea Forest Service, 2018, 2020).

Part 6. Challenges and Opportunities

Chapter 13. Recommended Actions for the Future

13-1. Establishment of Information System and Long-Term Monitoring of Forest Genetic Resources

- ○ Scientific methods to evaluate the genetic diversity of forest genetic resources have been continuously developed along with the development of molecular biology technology. In particular, due to the development of next-generation sequencing, computer processing capacity, and bioinformatics, the availability of genetic data of forest genetic resources has been expanded. Considering that, research and advanced technology are required to construct an information system on forest genetic resource by utilizing diverse technologies.
- ○ As the climate crisis, such as climate warming, is expected to continue in the future, the importance of conservation and sustainable use of forest genetic resources as a carbon sink is predicted to continue to increase. In this sense, it is essential to establish preemptive strategies for the conservation of forest genetic resources, considering future climate changes, local environmental adaptability and succession stages of forest. To this end, based on the appropriate use of advanced technologies, it is essential to conduct research and set policies to evaluate genetic diversity, investigate genetic characteristics, conduct genetic monitoring for mid-to-long term, and restore the genetic diversity of forest genetic resources at the national level.

13-2. International Cooperation for Conservation, Sustainable Use and Development of Forest Genetic Resources

- ○ As part of the implementation of "the Global Plan of Action for the Conservation, Sustainable Use, and Development of Forest Genetic Resources," and as a member state of the Asia Pacific Forest Genetic Resources Programme, the Republic of Korea has cooperated in international activities. Furthermore, the National Institute of Forest Science signed a memorandum of understanding with the National University of Mongolia that promotes international joint research to preserve the genetic diversity of Saxaul (*Haloxylon ammodendron*), an important tree species for preventing desertification in Mongolia. Since forest genetic resources are distributed in a wide range across several countries, it is necessary to further strengthen international cooperation through information sharing, technological cooperation, and joint research among neighboring countries for effective conservation and sustainable use of forest genetic resources.

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