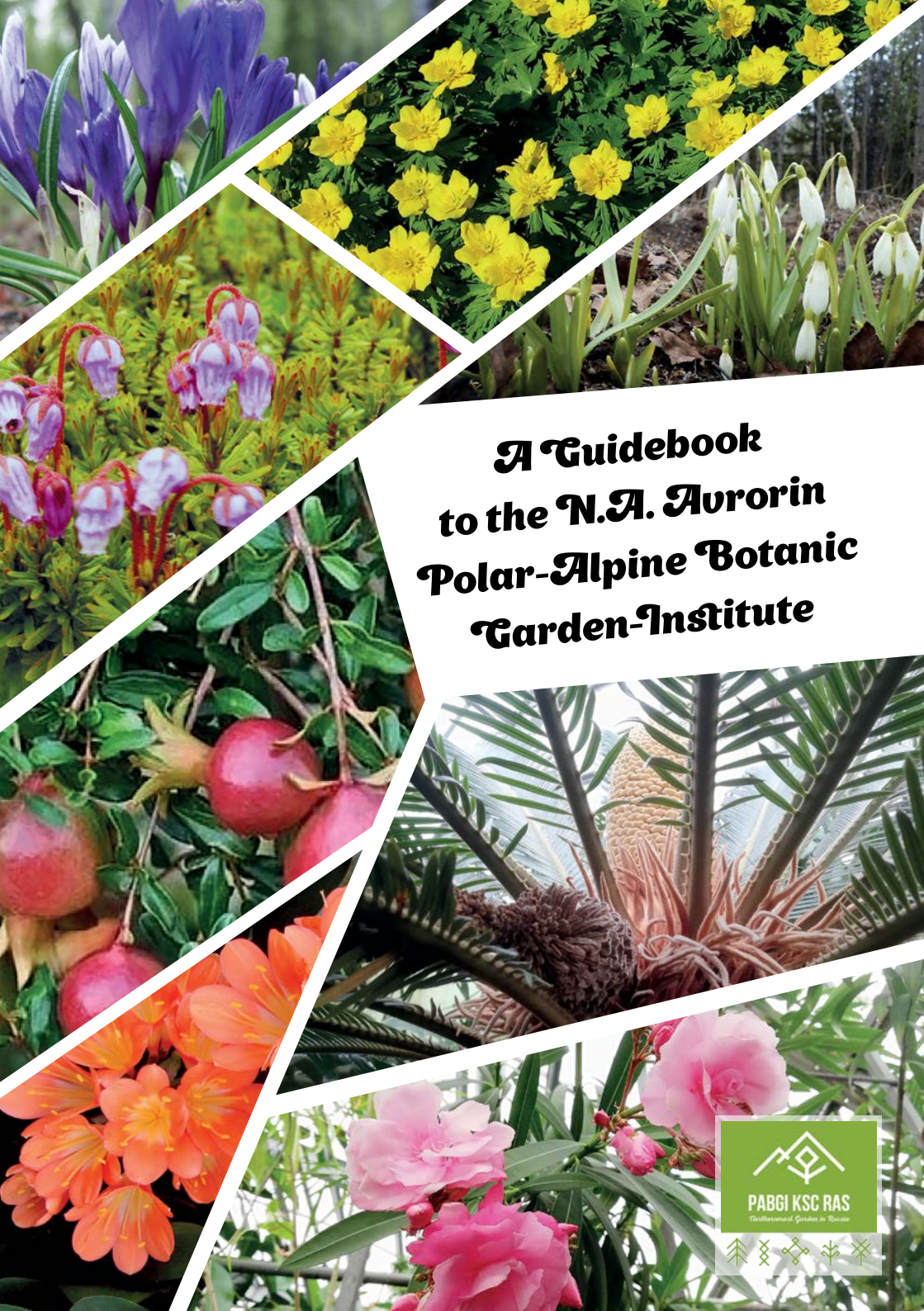

A Guidebook to the N.A. Avrorin Polar-Alpine Botanic Garden-Institute

PABGI KSC RAS

Russian Academy of Sciences
Kola Science Center
N. A. Avrorin Polar-Alpine Botanic Garden-Institute
Murmansk Branch of Russian Botanic Society

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A Guidebook to the N. A. Avrorin Polar-Alpine Botanic Garden-Institute

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The Botanic Garden in autumn
Photo by D.A. Davydov

Vudyavryok River
Photo by D.A. Davydov

Content

Downy birch (Betula pubescens) of the same age as the Botanic Garden on the central parkway
Photo by D. A. Davydov

Introduction

The Polar-Alpine Botanic Garden Institute (PABGI) is situated in the Khibiny Mountains, in the western part of the Kola Peninsula within the Arctic Circle. It was founded in 1931, so 2021 marks the 90th anniversary of its foundation. Over the years, the Botanic Garden has focused on multi-dimensional research and is well known both in Russia and abroad. PABGI is the northernmost botanic garden in Russia. It is now one of the most important tourist attractions in the Murmansk Oblast; tens of thousands of people visit every year.

The Botanic Garden is one of the oldest subdivisions of the Kola Science Center of the Russian Academy of Sciences. The main research areas are:

1. introduction and adaptation of plants to the Arctic environment;
2. study of the flora and vegetation of the Murmansk Oblast and other arctic and mountainous territories such as the Caucasus, Altai, Urals and Spitsbergen;
3. creation of the scientific basis for nature conservation;
4. choice of appropriate plants for indoor and urban planting and floriculture in the Arctic;
5. development of biological methods of pest control;

- study of photosynthesis, gas exchange and productivity of arctic plants and their communities;
- study of soils, soil formation processes and methods for increasing soil fertility;
- increasing scientific knowledge and providing environmental education.

As well as scientific and educational work, PABGI provides guided tours around the greenhouse, nurseries and Ecological Trail. Whilst climbing the slope of Mount Vudyavrchorr visitors can learn about diversity of plant communities found in the Murmansk Oblast.

The Botanic Garden occupies two sites: the main site in the Khibiny Mountains near the city of Kirovsk, and the Experimental Site near the city of Apatity.

The distance between the sites is only 30 km, but the average annual temperature in the Khibiny is 2-3 degrees lower than at the Experimental Site, and the snow cover melts 2-3 weeks later. The tree collection of the Experimental Site therefore has more favourable growing conditions and a significantly greater variety of species and cultivars.

This guidebook provides a brief description of excursion routes through the main collections and the conservation area. A visit to the Botanic Garden is of interest throughout the year, but it is best to visit during different seasons to see the early spring display of snowdrops; the vibrant colors of the short northern summer; the incredibly beautiful but very short autumn; and experience «tropical summer» in the greenhouse on a long polar night.

Crocus heuffelianus
Photo by N.E. Koroleva

History of the N.A. Avrorin Polar-Alpine Botanic Garden-Institute

The outstanding geobotanist Vladimir Sukachev was the first person to propose a permanent botanic station in the Khibiny Mountains, after an expedition in 1920. However, funding was not available at that time.

In 1930, on the initiative of the academician Alexander Fersman, the USSR Academy of Sciences founded the Khibiny Mountain Research Station «Tietta», from which the Kola Scientific Centre developed. In the same year, a botanical expedition from the Academy of Sciences lead by a well-known botanist, Sergey Ganeshin, worked in the Khibiny; the team of researchers included geobotanists A. Korchagin and M. Selyaninova-Korchagina, bryologist (specialist in mosses) O. Gaaze and lichenologist K. Rassadina.

Sergey Ganeshin was charged with organising the Polar-Alpine Botanic Garden and studying the non-native flora of this region. However, he tragically died on August 30th 1930, lost in the mountains in a snowstorm and suffering a sudden cardiac arrest.

In the summer of 1931, a young botanist, Nikolay Avrorin, was brought in. He had just graduated from the Department of Geography of the Leningrad University. On August 26th, his proposal to create the world's first botanic garden beyond the Arctic Circle was supported by the heads of research.

A month later, the Polar-Alpine Botanic Garden was founded by Decree of the Biological Group of the USSR Academy of Sciences as part of the Khibiny Mountain Research Station, and Nikolay Avrorin was appointed its first head. It is interesting that the the original aims remain the same 90 years later.

In the summer of 1932, Botanic Garden staff and members of the Kola Complex Expedition (N. Avrorin, L. Bobrova (Kachurina), M. Kachurin and A. Korovkin) carried out the first trial planting of plants obtained from the Botanical Institute of the USSR Academy of Sciences (Leningrad). In 1933, the first small greenhouse was built, in which work began on plant propagation for indoor planting in residential and public premises. During the first botanical expedition to the Altai in 1934, M. Kachurin collected and mailed about 5000 specimens of 160 plant species. In 1936, a second expedition took place – to the Eastern Sayan Mountains. Between June and October, A. Korovkin collected 7,200 specimens of 120 plant species. At the same time, the first nurseries were established for introduced herbaceous plants and trees and the Ecological Trail (the Geographers' Trail) was laid along the slope of Mount Vudyavrchorr.

In 1936 Avrorin was awarded the degree of Candidate of Biological Sciences for his studies on growing hundreds of plant species from different regions above the Arctic Circle. In 1953 he wrote his doctoral thesis based on this work "Resettlement of Plants to the Polar North. Ecological and Geographical Analysis", which remains important today.

First plantings in the Botanic Garden, 1932. N. Avrorin is in the centre.
Photo from the archive of the Kola Science Center

Park territory of the Botanic Garden, 1937
Photo from scientific archive of the Kola Science Center

Avrorin laid the scientific foundations for landscaping and municipal planting in the North and in polar cities.

Before the start of the Second World War, the Botanic Garden staff studied the biology of introduced plants in the Arctic, identified the most decorative and winter-hardy species, and carried out an inventory of the flora of the Murmansk Oblast. During these years, the park territory was significantly expanded.

In 1940, at the First All-Union Conference of Employees of Botanic Gardens, the Polar-Alpine Botanic Garden was recognised as one of the seven leading gardens of national importance. In 1941, Avrorin prepared the first practical guide to planting in urban areas in the North; since then plants grown in the Polar-Alpine Botanic Garden have been planted on the streets of the cities and towns of the Murmansk Oblast.

Planned work to further develop the Botanic Garden was halted by the beginning of the Second World War. Most of the Kola Base of the USSR Academy of Sciences was evacuated to the city of Syktyvkar; only a skeleton staff of 10 employees, headed by Avrorin, remained in the city of Kirovsk. Their activities were all aimed at the needs of the front. The staff grew plants for food and medicine in the nurseries; they also developed simple methods for processing local berries into juice, syrup and jam without adding sugar, but with the maximum preservation of vitamin C. Avrorin prepared the manuscript «Vitamins in the conditions of the Far North» which, along with the handbook on mushrooms by Boris Mishkin, was of great practical importance. Mishkin also developed simple methods for preparing concentrates from local plants high in vitamins.

Nikolay Avrorin (1906-1991)
Photo from PABGI archive

By August 1941, the collection of living plants numbered around 2,000; due to the efforts of the staff during the War years, the whole collection and herbarium plants were safeguarded.

In 1942, the head of the Enzymology Laboratory of the Institute of Biochemistry of the USSR Academy of Sciences A. Kursanov (future Full Member of the USSR Academy of Sciences) was sent to Kirovsk. Together with N. Dyachkov, they developed techniques for obtaining pure glucose from lichens, while engineers of the corporation "Apatit" developed a factory capable of processing 100 kg of dry lichens per day which operated from January to May 1944.

In 1942 vegetables were grown in the Garden for the wounded soldiers in an evacuation hospital.

Because of his outstanding contribution to the successful establishment of the Botanic Garden, Avrorin was awarded

House No. 8 in the Botanic Garden was built in 1939 and used as a residential building; now it is a laboratory building and a museum. Photo from scientific archive of the Kola Science Center

the Order of the Red Star in 1945.In the first year after the war the Botanic Garden had only 10 staff members, but in 1946 Nikolay Avrorin obtained the status of an independent scientific institution for the Garden within the Kola Base of the USSR Academy of Sciences and staff numbers increased to 30. During this time, the flora and biochemistry groups were restored. New members joined the collective – O. Kuzeneva, E. Chernov, R. Shlyakov, E. Shlyakova, T. Tamberg, V. Neofitova.

In 1951, the Kola Branch of the USSR Academy of Sciences was allocated a plot of land 3 km from the Apatity railway station for experimental botanic work. The «PABGI Experimental Site» is still on this site, at the entrance to the city of Apatity. This enabled comparative studies between the mountains at the main Botanic Garden in Kirovsk and the foothill plain, where the main collection of trees and shrubs is now located.

In 1960, Nikolay Avrorin moved to Leningrad, where he became the head of the Botanic Garden of the Botanical Institute of the USSR Academy of Sciences. Roman Shlyakov, an outstanding taxonomist and bryologist, was subsequently appointed director of PABGI. Two years later, he was replaced by Tatyana Kozupeeva, a specialist in indoor floriculture and greenhouse cultivation of tropical and subtropical plants in the Arctic. She ran the Garden for almost a quarter of a century, until 1986. In 1967 it was awarded the status of research institute and became the Polar-Alpine Botanic Garden-Institute (PABGI). At that time, it consisted of four research departments:

1. Flora and Plant Resources;
2. Introduction and Adaptation of Plants;
3. Plant Physiology;
4. Soil Science and Microbiology.

In 1976, on the initiative of Tatyana Kozupeeva, a Department of Decorative Floriculture and Landscape Design was organised.

In 1981, at the 50th anniversary of the

Tatyana Kozupeeva and Gennady Andreev, 1965
Photo from PABGI archive

Garden, PABGI was awarded the Order of the Badge of Honor for outstanding contributions to the development of botanical science and to the conservation and enhancement of plant resources of the Arctic.

After Tatyana Kozupeeva retired, the country went through a difficult period from 1986 to 1998, during which PABGI was headed by Gennady Andreev, a botanist and horticulturist who was taught by Avrorin. Despite enormous difficulties due to the severe economic crisis, Gennady Andreev managed to preserve the collections, basic structure and staff of the institute. In 1989, a new greenhouse complex was built, which made it possible to significantly increase the number and type of decorative plant species for use in the industrial and residential buildings in the cities of Murmansk Oblast. That same year, the Kuzomensky base was established on the White Sea coast to study the feasibility of phytomelioration

PABGI 50th anniversary memorial sign
Photo by O.A. Belkina

Botanic Garden in winter
Photo by B.B. Vakhmistrov

of disturbed lands (planting of trees or shrubs to provide shelter from the wind and to protect soil from erosion).

In 1998, after the death of G.N. Andreev, Vladimir Zhirov, Corresponding Member of the Russian Academy of Sciences and a specialist in the field of biochemistry of stress and adaptation of plants to extreme environmental conditions, became PABGI's director.

In 2002, on its 70th anniversary, PABGI was named after its founder and first director N.A. Avrorin.

In 2010, the reconstruction of the main greenhouse was carried out.

Today, the N.A. Avrorin Polar-Alpine Botanic Garden-Institute is a comprehensive research institution within the Ministry of Science and Higher Education of the Russian Federation.

Chamaedorea elegans in the greenhouse of the Botanic Garden
Photo by Anny Moore

Laboratory building against the backdrop of Mount Vudyavrchorr
Photo by E.I. Kopeina

Botanic Cirque of Mount Vudyavrchorr
Photo by E.A. Borovichev

Environmental conditions and layout of the garden

The Polar-Alpine Botanic Garden-Institute is located in the North-West of Russia in the central part of the Murmansk Oblast. The main area is located in the Khibiny Mountains and includes part of the shore of Lake Bolshoy Vudyavr, the banks of the Vudyavryok River, and the slopes of Mount Vudyavrchorr and Takhtarvumchorr.

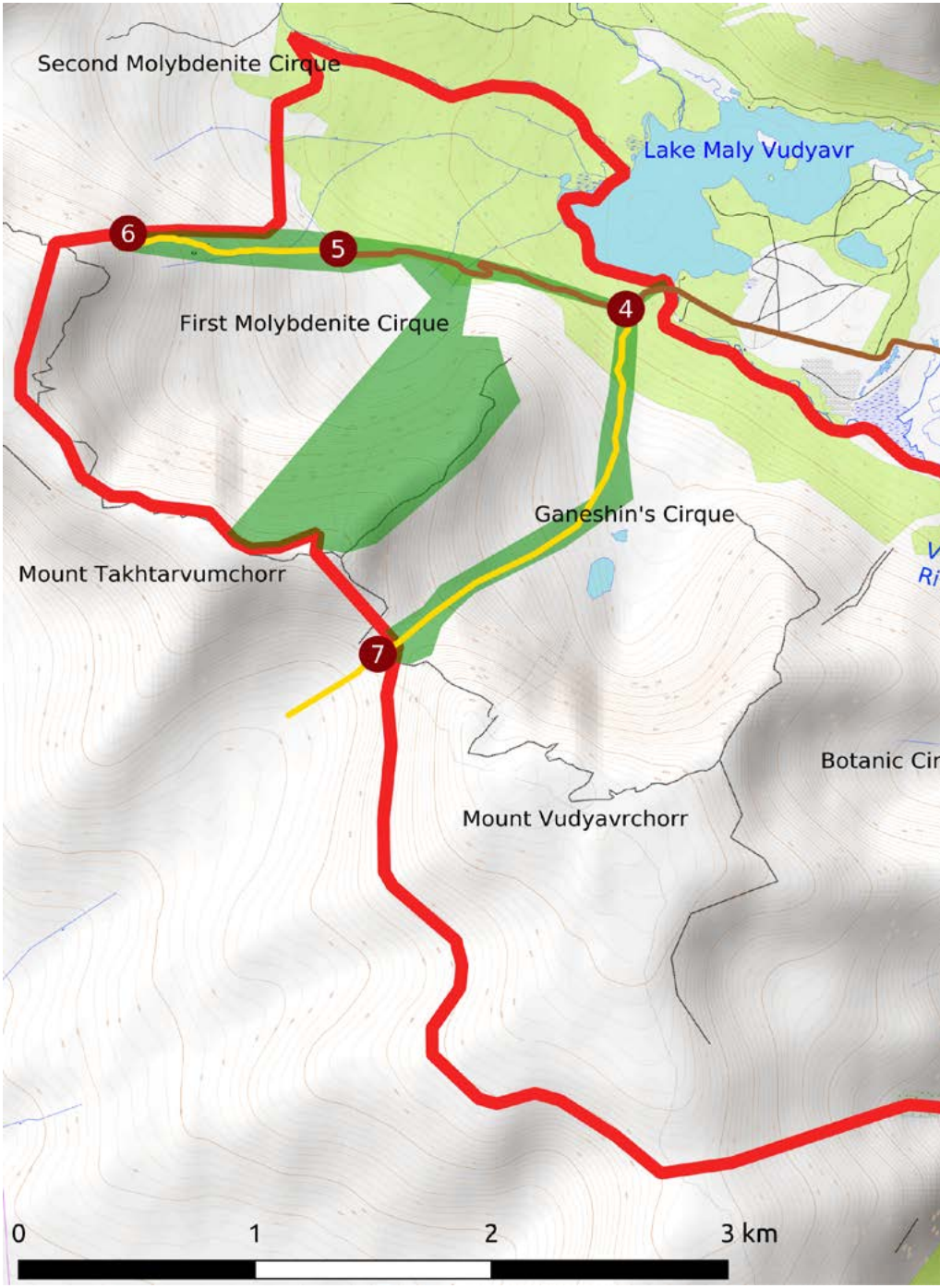
The Khibiny Massif is the mountain range at the centre of the Kola peninsula which extends from Northern Russia into the Barents and White Seas. They occupy a relatively small (1,327 km2) horseshoe shaped area topped by a high plateau and drained by a series of deep canyons. The mountains are not particularly high - most are between 1,000–1,200 m above sea level – but have steep slopes with glaciers, icefields and snowfields in places. The highest point of the Khibiny is Mount Yudychvumchorr (1,200.6 m above sea level). The highest point of Mount Vudyavrchorr on the PABGI land is 1,068 m above sea level.

Most of the geographical names in the Khibiny are of Saami origin. As a rule, the Saami first named a body of water or a valley, and only then a mountain or mountain range. The Saami toponyms are translated from the end. For instance, the name of Lake Vudyavr consists of two words, the last of which *yavr* denotes the category of the object – "lake", while *vud* means "hill". Thus, Vudyavr means "mountain lake". The nearby Mount Vudyavrchorr was named after its location by the lake; the root *chorr* describes the type of object – "mountain range with a flat peak". The river that connects Lake Maly Vudyavr with Bolshoy Vudyavr is called Vudyavryok, where *yok* is "river"; hence the translation is "river of a mountain lake".

The name of Mount Takhtarvumchorr is derived from the Takhtarvum valley, from *takhte* - "to want, to long for"; *arre* - "rest": "valley of longed-for rest".

The Khibiny is one of the world's largest alkaline massifs, formed some 380 million years ago, and is extremely rich in minerals due to soil removal during the last ice age. These are mainly apatite and nepheline ores (holocrystalline plutonic rocks that look a little like granite). The tops of the mountains are plateau-like; sharp mountain peaks are rare. The massif has experienced the impact of ice sheets; their traces are particularly evident. Part of the Botanic Garden territory is the Botanic Cirque, an amphitheatre-like valley created by glacial erosion. The Botanic Cirque is open on the downhill side while the cupped section is steep. The floor of the cirque is bowl-shaped because of the convergence zones of ice flows from different directions and the debris accompanying them.

Although the Botanic Garden is located above the Arctic Circle, the climate here is not as harsh as in the eastern regions of Russia at the same latitude. The average annual temperature is –0.5 °C, with average February temperatures –11.6 °C, and +12.5 °C in July. The main reason for the relative mildness of the climate is the proximity of the Barents Sea which is affected by the warm current of the Gulf Stream. Winter is long and snowy (persistent frosts last between 8-9 months), but relatively mild, often with strong winds.


Second Molybdenite Cirque
Lake Maly Vudyavr
6
5
4
First Molybdenite Cirque
Ganeshin's Cirque
Mount Takhtarvumchorr
7
Botanic Cir
Mount Vudyavrchorr
0
1
2
3 km

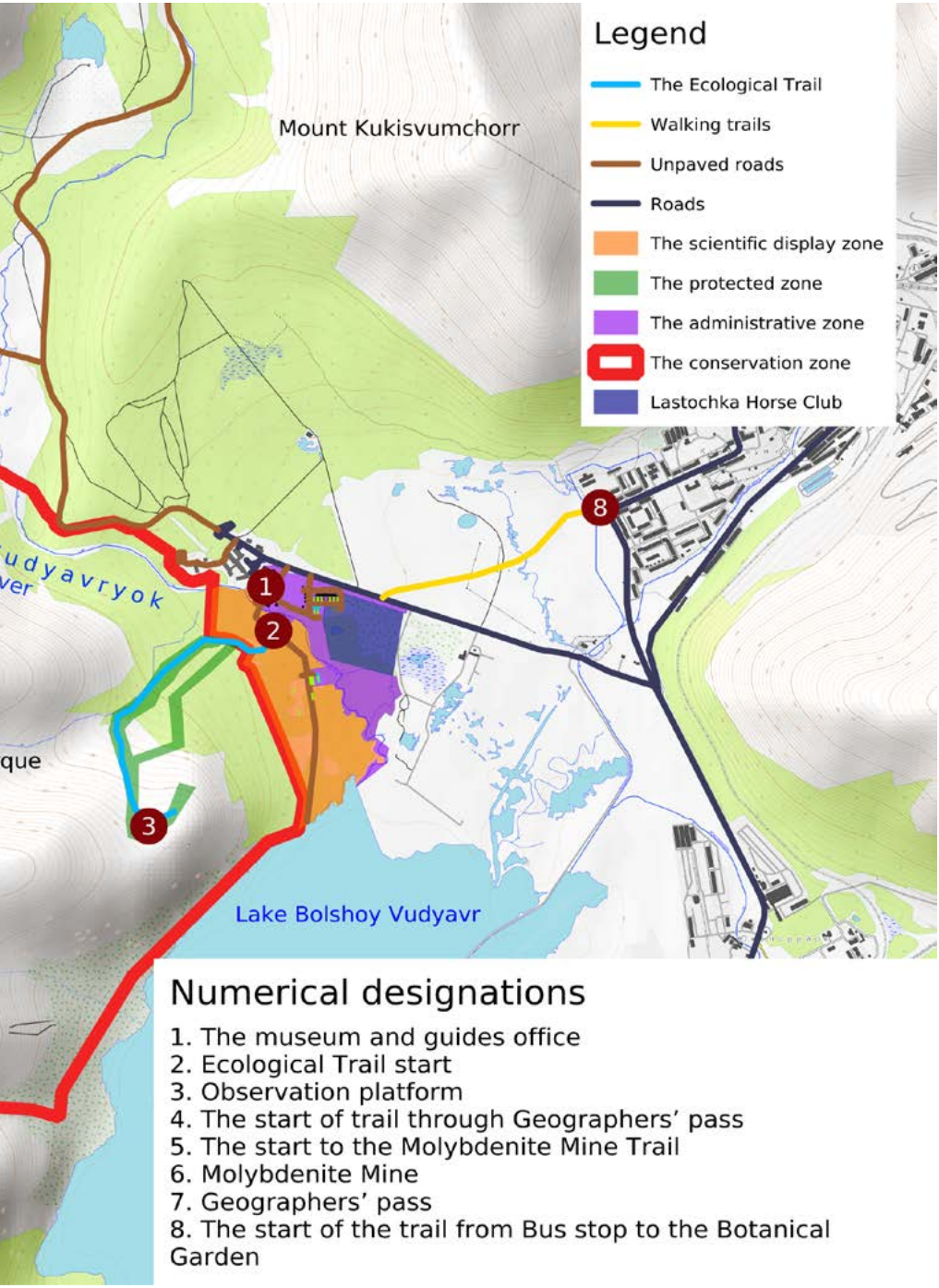
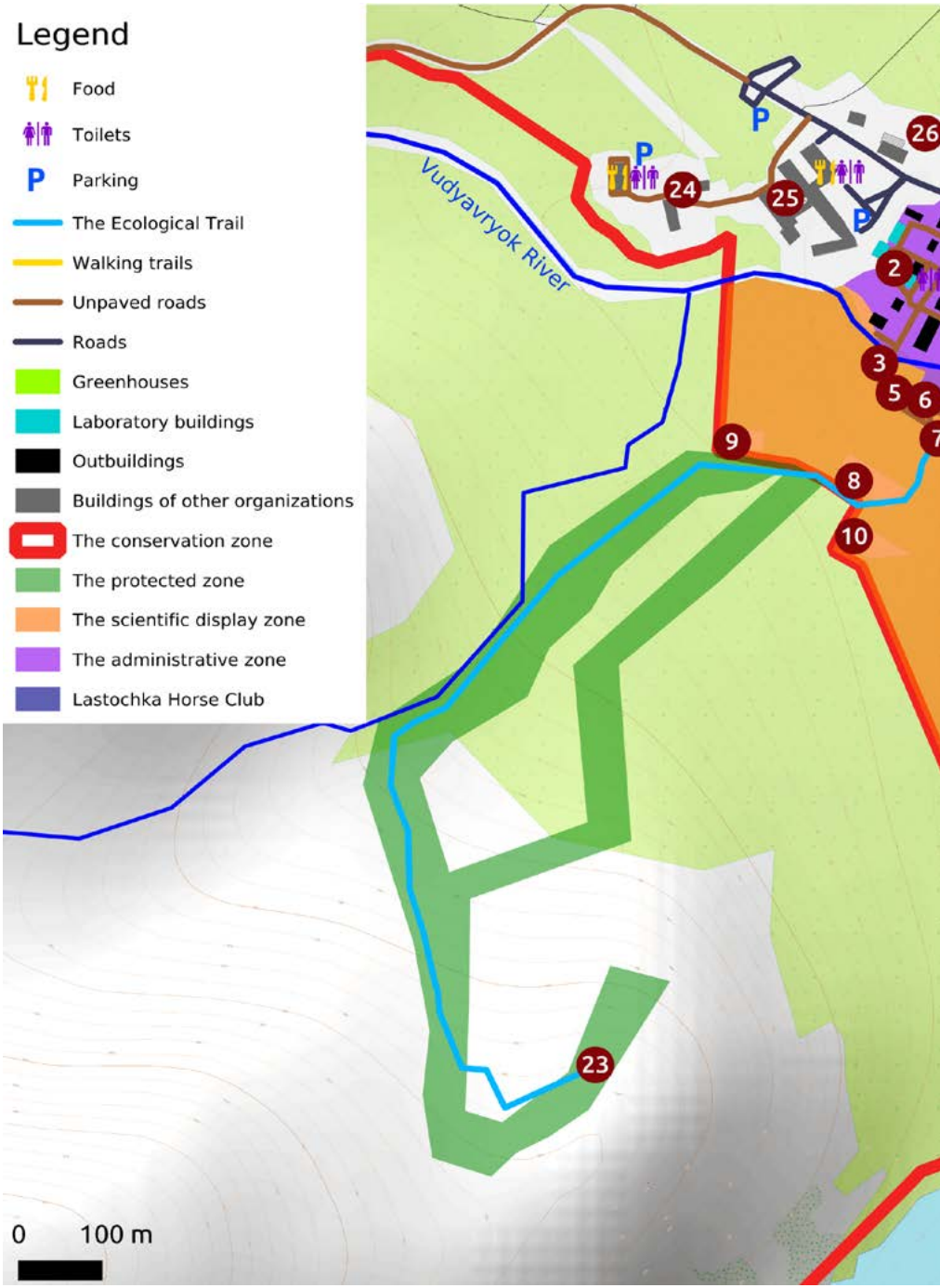


Fig. 1. Locations of the main routes within PABGI


Legend
Food
Toilets
Parking
The Ecological Trail
Walking trails
Unpaved roads
Roads
Greenhouses
Laboratory buildings
Outbuildings
Buildings of other organizations
The conservation zone
The protected zone
The scientific display zone
The administrative zone
Lastochka Horse Club
Vudyavryok River
P
P
P
24
25
26
2
3
5
6
7
8
9
10
23
0
100 m

Numerical designations

1. Entrance
2. Museum and guides office
3. Garden's 50th anniversary memorial sign
4. Insectarium
5. Alpine garden
6. Historical building of the main laboratory complex
7. - Ecological Trail start
8. Main nursery for introduced herbaceous plants
9. Nursery for plants of the Murmansk Oblast
10. Subsidiary nursery
11. Seed nursery for herbaceous perennials and Snowdrop garden
12. Greenhouse complex
13-15. Subsidiary nurseries
16. Alpine rock garden
17. Display of medicinal plants
18. Ecological nursery of plants of the Murmansk Oblast
19. Nursery for rare and useful plants of the Murmansk Oblast
20. "Siberia" plot
21. Conifers display area
22. Main collection of woody introduced plants
23. Observation platform
24. Snow Village
25. Tirvas Hotel & Spa
26. Tirvas cross skiing area
27. Lastochka Horse Club
28. Chapel

Fig. 2. Layout of PABGI

View of the spur of Mount Vudyavrchorr, the "baby mammoth"
Photo by N.E. Koroleva

Pass of Geographers, First and Second Molybdenite amphitheatre? of Mount Takhtarvumchorr
Photo by D. A. Davydov

CLIMATE

A characteristic feature of the weather in the Murmansk Oblast is its extreme variability. Sunshine can be followed by snow, even in summer, sleet, strong wind and fog. Frequent incursions of warm air masses from the Atlantic lead to rapid thaws, while cold Arctic air can bring a sharp and prolonged temperature drop during any season.

The Khibiny Mountains experience a high level of precipitation reaching up to 900 mm per year, half of this in the form of snow in winter. Due to humid air rising on the windward slopes, the annual amount of precipitation in the mountains is more than twice that in the foothills.

Summers are short, cool and humid, the growing season (when the average daily air temperature is above +5 °C) is just 95–120 days.

One of the most important factors for growing plants is the timing and level of daylight. In summer, there is first 47 days of midnight sun, when the sun remains visible at midnight, then midnight twilight, when reading is possible without artificial light on a clear night. In winter, the pitch-black polar night lasts for 14 days.

The Khibiny Mountains are within the northern taiga subzone. The vegetation is characterised by a clearly pronounced zonation: from the mountain-forest belt up to 450m, to the krummholz birch forest belt, with the mountain-tundra belt above. Open arctic mountain desert occupies the plateau above 800 m.

You can get to the Botanic Garden by taking bus No. 128 from Apatity (takes about 30-40 min) or bus No. 1 from Kirovsk (takes about 15-20 min), to bus stop "Magazin Luch". You then walk about a mile along the Umetsky field. While you walk to the entrance, see if you can spot within the landform a "baby mammoth" drinking from the lake. In rainy and foggy weather it hides, wrapped in soft clouds.

LAYOUT OF THE GARDEN

The Polar-Alpine Botanic Garden-Institute is both a research institution and a specially protected natural area, important for its rare plants and plant communities. The Garden is divided into four zones, shown in Figure 1.

The administrative zone is located on the left bank of the Vudyavryok River and includes laboratory buildings, the greenhouse complex, outbuildings, and a museum (Fig. 2: 2). The museum gives you an insight into the rich history of the Garden, the main areas of research and an understanding of how much thought and effort was invested by many generations of employees to create this unique collection.

On the right bank of the river in its lower reaches is a scientific display zone which includes open field nurseries.

Most of the site is a conservation area which covers the northern, northeastern and part of the southern and southeastern slopes of Mount Vudyavrchorr, as well as Ganeshin's cirque and the First and Second Molybdenite Cirques of Mount Takhtarvumchorr (Fig. 1).

Alpine garden. Photo by E.A. Borovichev

Historical building of the main laboratory complex Photo by O.A. Belkina

The walkway begins at the Garden's 50th anniversary **memorial sign** (Fig. 2: 3) and curves around one of the oldest display areas, the **Alpine garden** (Fig. 2: 5). Work on its creation began in the first years of the Botanic Garden.

To the left of the path is the **historical building of the main laboratory complex**, an object of significant cultural heritage value (Fig. 2: 6) which has a memorial plaque dedicated to the academic A.E. Fersman who took an active part in the creation of the garden.

On the right side of the path is a recreation area, from which the **Ecological Trail** begins (Fig. 2: 7) and leads up to the **main nursery for introduced herbaceous plants** (Fig. 2: 8).

After passing through the nursery and a short walk through picturesque forest, you reach the **nursery for plants of the Murmansk Oblast** (Fig. 2: 9). Following the Ecological Trail, you gradually climb up the slope of Mount Vudyavrchorr to the **observation deck** (Fig. 1: 3; Fig. 2: 23).

Returning to the recreation area, you can continue your walk along the central path. On the left hand side you will see a **seed nursery for herbaceous perennials** (Fig. 2: 11). The path then leads to the greenhouse complex which houses a collection of tropical and subtropical plants (Fig. 2: 12).

Encountering plants from the tropics and subtropics gives a most striking impression, especially in winter when the contrast between the snow-covered taiga forest and the hot humid kingdom of palms and bananas is so vivid.

Behind the greenhouse, on the left of the path, lies the **Alpine rock garden** (Fig. 2: 16) and a **display of medicinal plants** (Fig. 2: 17).

Not far away, on the right hand side of the path, is a **display area with rare and useful plants of the Murmansk Oblast** (Fig. 2: 19).

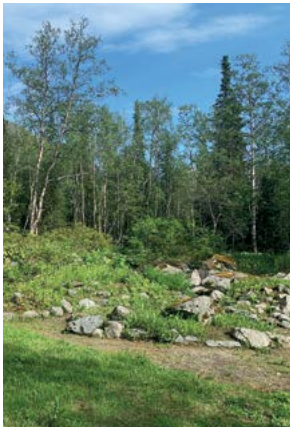
Recreation area. Photo by D.A. Davydov

If you continue your journey along the path, you can visit the tree and shrub nurseries. On the right hand side are **conifers** (Fig. 2: 21) and the **"Siberia" plot** (Fig. 2: 20), with the **main collection of woody introduced plants** on the left (Fig. 2: 22).

The path ends on the shore of Lake Bolshoy Vudyavr, where you can enjoy a picturesque view of the surrounding mountains and Kirovsk.

Greenhouse complex
Photo by L.A. Ivanova

Tropical plants in greenhouse
Photo by D.A. Davydov



Alpine rock garden
Photo by D.A. Davydov

Gentiana septemfida
Photo by N.E. Koroleva

The herbaceous plant nurseries

Experimental perennial herbaceous plant nurseries are located on lake terraces in the park area of the Botanic Garden (Fig. 2).

The access road (Fig. 2: 8) begins immediately behind the historical building of the main laboratory complex, to the right of the main path. The nursery is on the third lake terrace (340 m above sea level) among the spruce and birch forest. Here, and in auxiliary nurseries, 1,145 species of perennial herbaceous plants are grown. An overview of the species is given in a guidebook on the Polar-Alpine Botanic Garden (1974).

Some species are represented by several specimens from different regions or from their seed progeny. Plants of all continents except Antarctica are cultivated in PABGI, mainly from the mountains of Eurasia and North America (the Alps, Carpathians, Rhodopes, Caucasus, Pamir, Tien Shan, Himalayas, Rocky and Atlas Mountains). The nursery collection increases every year with the addition of new species, many of which were introduced into culture for the first time. All plants in the nursery survive the winter without shelter; caring for them consists of annual weeding and watering in the driest months, as well as fertilising once every 3-5 years.

The outer border (a rectangular flower bed in the form of a narrow strip) of the nursery is planted with *Bergenia crassifolia*. In spring, the fleshy leaves emerge green from under the snow, so *Bergenia* is useful

The main nursery of herbaceous introduced plants. In the foreground is a border bed of Bergenia crassifolia. Photo by N.N. Trostenyuk

Trollius ranunculinus
Photo by N.N. Trostenyuk

Trollius asiaticus
Photo by N.E. Koroleva

in border plantings. The pink flowers of summer are followed by last year's leaves turning purple in autumn. In Siberia the dry leaves of *Bergenia* are brewed like tea.

From the spring snow melt until the new snow fall in autumn, plants flower sequentially in the Botanic Garden. First to bloom are the bulbous and tuberous ephemeroids. In late May or early June, right after the snow melts, you can see the blue stars of *Scilla rosenii*, the violet-pink flowers with a white center of *Erythronium sibiricum* and yellow inflorescences of *Corydalis bracteata*.

The earliest *Aquilegia* to bloom is *Aquilegia glandulosa* which is so well acclimatised that it self-seeds abundantly, sometimes completely filling neighboring plots and escaping into the forest beyond the nurseries. *Aquilegia sibirica* is similar, but somewhat smaller in size. Blooming later are *Aquilegia pyrenaica* and *A. amurensis* and many others. Most *Aquilegia* flowers have spurs that collect dew and raindrops, thus one of the Russian names is "vodosbor" ("water collector").

Highly decorative and easy to cultivate in Arctic conditions are the bright orange and yellow globeflowers (*Trollius asiaticus*, and the smaller, later blooming *T. chinensis* and *T. ranunculinus*.

The collection of bellflowers is notable for its variety. It contains small Caucasian species – *Campanula tridentata* and *C. collina*. The Transcaucasian endemic *C. autraniana* and large *C. latifolia*, *Codonopsis clematiaea*, an inhabitant of the mountains of Central Asia, and *C. ussuriensis* from the Far East, also look like bellflowers. The inside of their bluish corolla appears to be painted with purple and orange circles.

The decorative *Paeonia anomala* tolerates winter well in the botanic garden and forms beautiful clumps with large red flowers. The species is rarely found in the south of the region and is included in the Red Data Book of the Murmansk Oblast.

Perennial primroses are indispensable for low border and group plantings. The

Paeonia anomala
Photo by N.E. Koroleva

Candle larkspur (Delphinium elatum)
Photo by N.E. Koroleva

most stable is *Primula elatior* var. *tatrica*. Also interesting are *P. minima*, *P. clusiana* and glaucous primroses, as well as *P. sikkimensis* and *P. alpicola*.

The assortment of decorative plants suitable for cultivation in the Murmansk Oblast region also includes *Geum coccineum* and white-flowered anemones – *Anemone crinita* and *A. fasciculata*.

From the middle of summer, the blue inflorescences of various species of Delphiniums, or larkspurs, rise up like candles. They tolerate shade well and can be used to decorate the edges of parks and groups of trees and shrubs.

Numerous decorative species of lilies are cultivated in the Botanic Garden, among them: the European lilies *Lílium bulbíferum* and *L. davidii*; the Far Eastern lilies – *L. debile* and *L. cernuum*; the Caucasian lilies – *L. kesselringianum*, *L. monadelphum*, *L. szovitsianum*, and *L. martagon*. The fleshy starchy bulbs of *L. martagon* are edible raw, boiled and baked.

In the middle of summer, groups of tall flowering plants are especially prominent. Along the path and at the entrance to the nursery grows *Aruncus dioicus*, a large herbaceous plant with yellow-white inflorescences. For single plantings, rhubarb is quite suitable, with large wavy leaves and tall panicles of white and pink flowers. The nutritional qualities of rhubarb are widely known: leaf petioles are used to make jams, jelly and compotes.

Among the food plants in the nursery are numerous species of onions. The leaves of *Allium altaicum* and *A. victorialis* provide a lot of vitamin-containing green mass, from which you can prepare delicious spring salads. *A. atrosanguineum*, with its beautifully colored inflorescences, and *A. ursinum* with white flowers are very decorative.

Among the fodder plants are large hogweed and *Persicaria (Polygonum)* which have spread widely by self-seeding throughout the nursery and in its surroundings. In hot weather, the leaves

Aruncus dioicus. Photo by N.N. Trostenyuk

of some species of hogweed produce oils that can burn the skin when touched. *Polygonum weyrichii* is found in the wild on the Kuril Islands, Sakhalin and in Northern Japan, reaching a height of 2-2.5 m. Some species of legumes can be used as fodder plants such as *Lupinaster pentaphyllus*. Its leaves are similar to those of lupine, but the inflorescences (white-pink or purple umbrella-shaped heads) are similar to clovers. *Hedysarum alpinum* is a promising forage, decorative and medicinal plant, with beautiful crimson-red inflorescences and bead-shaped flat beans. It is found in the east of the Murmansk Oblast and is included in the regional Red Data Book.

The seed nursery for herbaceous perennials is located to the left of the main path (Fig. 2: 11). Founded in the early 1970s, it is used for increasing stock production, and seed exchange with other botanic gardens. Its mainstay is plants that are included in the selection for landscape planting in the cities of Murmansk Oblast. Currently, it includes 154 species represented by 25-80 specimens of each.

Seed nursery for herbaceous perennials. Photo by N.N. Trostenyuk

Primula amoena
Photo by N.E. Koroleva

Allium victorialis
Photo by N.E. Koroleva

Scilla rosenii and Corydalis bracteata. Photo by N.E. Koroleva

Scilla rosenii
Photo by E.I. Kopeina

Siberian fawn lily (Erythronium sibiricum)
Photo by E.I. Kopeina

As soon as the snow melts, you can see species from the first introductory expeditions flowering: *Scilla rosenii*, *Corydalis bracteata*, *Erythronium sibiricum*.

In June, primroses begin to flower in the seed nursery. The first to appear are the golden yellow flowers of *Primula elatior* var. tatrica. A little later, Caucasian species include *Primula amoena* with bright violet-blue flowers and *P. juliae* with its star-shaped, crimson-pink flowers.

The flowering of *Ranunculus crenatus* adds to the decorative effect of the nursery during this period.

All summer long, one can enjoy the the various coloured flowers of the Iceland poppy (*Papaver nudicaule*).

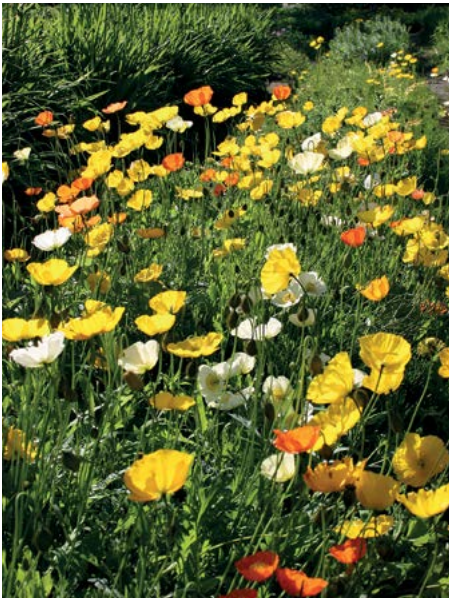
In the middle of summer, *P. orientale*, *Betonica macrantha*, *Erigeron multiradiatum* and *E. aurantiacus, Hemerocallis dumortieri*, and *Primula alpicola* come into bloom.

In autumn blossoming aconites, queen of the Alps (*Eryngium alpinum*), fleabane (*Erigeron sp.*) and *Anaphalis margaritacea* decorate the nursery.

In 1986, a display «Garden of Snowdrops» was established next to the seed nursery; its main components are geophytes from the Carpathians: *Narcissus angustifolius*, spring snowflake (*Leucojum vernum*), *Galanthus* and alpine squill (*Scilla bifolia*).

To the left of the path, behind the greenhouse of tropical and subtropical plants, is an Alpine rock garden founded for the 1975 Botanical Congress (Fig. 2: 16).

The original rock garden was created in 1975 and reconstructed in 1987. It is about 100 m^2 in area and consists of 12 display areas showing different geographical zones with characteristic plants selected for each. There are currently 125 plant species from 80 genera and 36 families; with 107 species of herbaceous perennials,



Papaver nudicaule
Photo by N.N. Trostenyuk

Primula alpicola
Photo by N.N. Trostenyuk

Ranunculus crenatus
Photo by E.I. Kopeina

Spring snowflake (Leucojum vernum)
Photo by E.I. Kopeina

Aconitum lycoctonum
Photo by N.E. Koroleva

16 species of shrubs and 2 tree species. The rock garden is scenic from early spring to late autumn.

At the display sites «Africa» and «Australia», you can see the daisies (*Bellis* spp.) and *Acaena magellanica*. Most of the plants in the "America" display blossom in July, among them *Dodecatheon*, *Penstemon*, *Primula parryi*, *Claytonia* and *Arnica*. In August, it is the turn of *Hymenoxys hoopesii* to bloom.

The relatively small "Caucasus" site contains 22 species of perennials. It is most decorative in spring and early summer as the green leaves of species of *Primula saguramica*, *Sedum spurium* and *Veronica gentianoides* emerge from under the snow to flower in June. The first plant to bloom in the rock garden is *Scilla rosenii*.

The "Carpathians" area is decorative throughout the entire growing season due to the flowering of such species as *Galanthus*, *Geum montanum*, *Veronica urticifolia*, *Aconitum moldavicum*, and sweet cicely (*Myrrhis odorata*). The "Central Europe" display is distinguished by tall plants such as *Aconitum lamarckii*, the great yellow gentian (*Gentiana lutea*), and queen of the Alps (*Eryngium alpinum*). *Homogyne alpina* and *Podophyllum hexandrum* are used here as ground cover.

The rock garden contains plants from Central Asia such as *Podophyllum hexandrum*, *Clementsia semenovii*, *Saussurea lappa*, and species from the Urals – the Ural primrose (*Primula uralensis*), *Lagotis uralensis* and *Trollius apertus*. Of Far Eastern origin are *Allium ochotense*, *Lilium distichum*, *Acomastylis rossii*. The largest display area «South Siberia» houses chives (*Allium schoenoprasum*), badan (*Bergenia crassifolia*) and *Stemmacantha carthamoides*.

Throughout the rock garden there are shrubs and trees such as *Mahonia*

Galanthus
Photo by N.E. Koroleva

Great yellow gentian (Gentiana lutea)
Photo by N.N. Trostenyuk

aquifolium, *Pinus mugo*, Hungarian lilac (*Syringa josikaea*), *Rhododendron ferrugineum*, *Lonicera alpigena* (Europe), *L. hispida* (Asia), *L. chrysantha* (Far East), *Sorbus sambucifolia* and *Ribes triste* from Kamchatka, and the false spirea (*Sorbaria sorbifolia*) from Siberia.

Near the Alpine rock garden is the nursery for medicinal plants used in traditional and folk medicine, created in 1987. Previously, plants with medicinal properties were tested and kept in almost all other existing nurseries in the Botanic Garden. One of the most notable plants is *Valeriana officinalis*. The oil obtained from its roots is a main constituent of valerian drops, a sedative for nervous excitement and insomnia. In the nursery, you can see other species of valerian: *V. montana*, *V. alliariifolia*, *V. kassarica* and *V. tripteris* – all are used in folk medicine.

The great yellow gentian (*Gentiana lutea*), a tall, dark green plant with yellow inflorescences found in the mountains of Europe and Asia Minor, provides the bitter substances which improve the functioning of the digestive system. The crested gentian (*G. septemfida*) is also used in folk medicine.

Some species of foxgloves (for example, *Digitalis ciliata*) help regulate the activity of the cardiovascular system. The same effect is produced by glycosides contained in the leaves and shoots of *Adonis vernalis*; it blooms in the nursery with bright yellow flowers in June. The purple hellebore (*Helleborus purpurascens*) blooms in early summer. Its roots are used in official medicine for the production of cardiac glycosides. Preparations of a well-known medicinal plant, lily of the valley (*Convallaria majalis*), are used in official medicine for diseases of the cardiovascular system. It blooms in the nursery in the middle of summer, much later than in Central Russia.

Scopolia carniolica was introduced to PABGI and many other botanic gardens; its rhizomes are used for the preparation of the drug «Scopolamine» which has antispasmodic properties

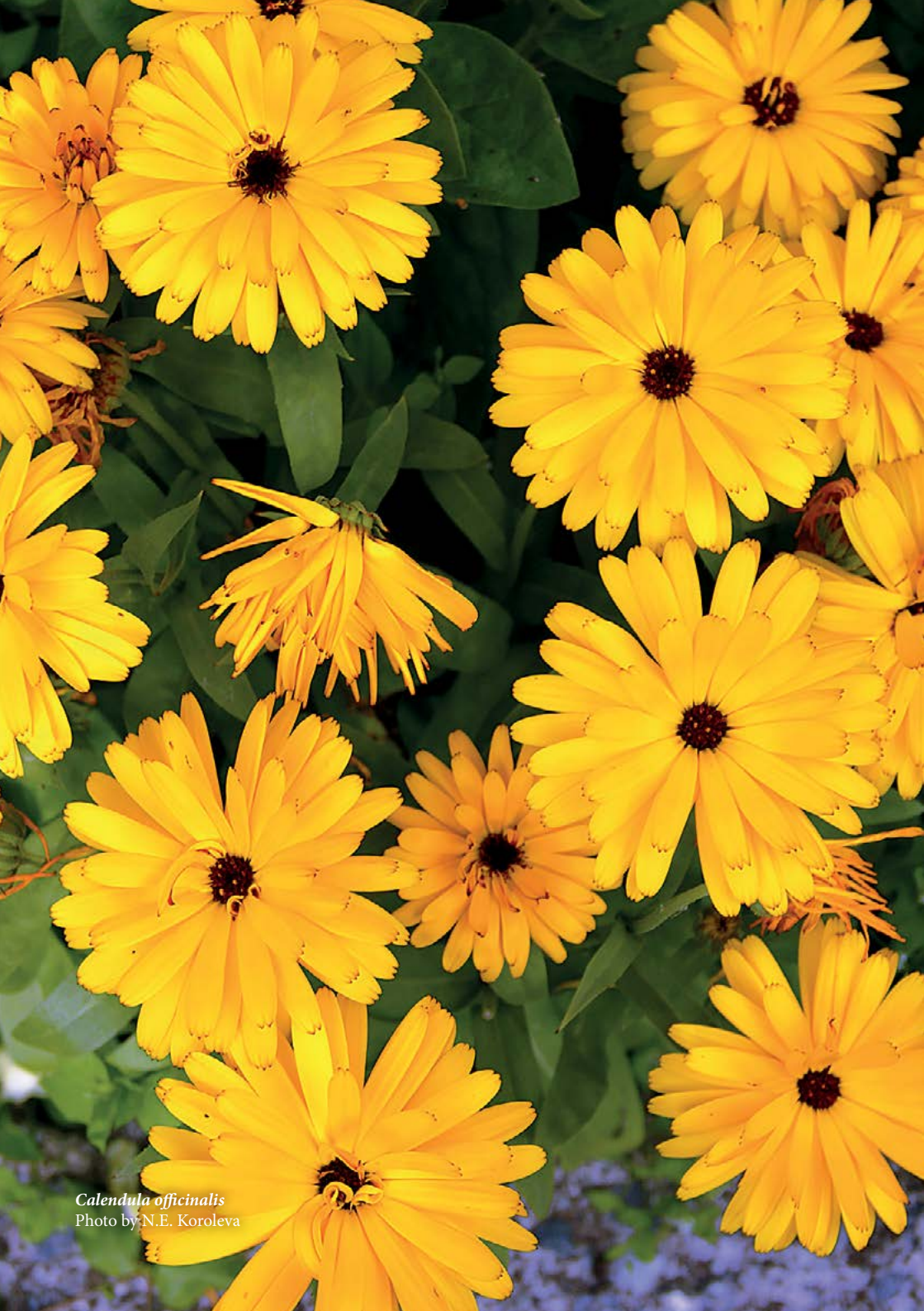
The medicinal plant nursery also houses a number of species of wolf's bane (aconites). The rhizomes of *Aconitum soongaricum* and *A. septentrionale* are used for the preparation of the components of some analgesic and anti-inflammatory drugs.

Rhaponticum carthamoides is a large, decorative medicinal plant, the roots of which contain tonic substances. They are used in conventional medicine and are included in the recipe for the dessert drink "Sayany". This comes from the highlands of Southern Siberia and Mongolia, where it is known to the locals as «Maral root».

Rhodiola rosea, popularly known as «golden root», is very easy to cultivate. Its natural habitat is on the Arctic coasts of Europe and Asia, as well as in the highlands. Preparations from the golden root that possess tonic, adaptogenic (in herbal medicine a natural substance considered to help the body adapt to stress) and stimulating properties are used in conventional and folk medicine.

The well-known food and vitamin plants lovage (*Levisticum officinale*), *Allium victorialis* and wild garlic (*A. ursinum*) are also grown here.

Medicinal plants well known in folk medicine that are grown in the nursery include the badan (*Bergenia crassifolia*) (haemostatic action), the burnets – *Sanguisorba officinalis* and *S. tenuifolia* (astringent and bactericidal action), pyrethrums - *Pyrethrum macrophyllum*, *P. coccineum*, etc. (insecticidal preparations), *Veronica spicata* and *V. sibirica* (mucilage, soothing and expectorant substances).



Calendula officinalis
Photo by N.E. Koroleva

False spirea (Sorbaria sorbifolia) in the collection of woody plants of the Botanic Garden
Photo by N.A. Konstantinova

Tree and shrub Nurseries

Collections of trees and shrubs were established on the main site in Kirovsk at the founding of the Botanic Garden. Some are now 70-80 years old. Later on, nurseries of woody plants were also established at the Experimental site near the town of Apatity.

The total area of of introduced woody plants at the Botanic Garden is 1.15 ha.

To the right of the central path, there is a botanical-geographical area known as «Siberia» (Fig. 2: 20) with the display of conifers (Fig. 2: 21) on the left – the main collection of woody plants (Fig. 2: 22).

The decorative woody plant display was designed as a natural landscape in the 1990s. It consists of the most viable specimens of decorative species from the tree nursery. Among them are many species of *Spiraea* (*S. media*, *S. chamaedryfolia*, *S. nipponica*, *S. latifolia*), *Sorbus* (*S. sambucifolia*, *S. intermedia*), the false spiraea (*Sorbaria sorbifolia*), *Duschekia fruticosa* and *Lonicera involucrata*.

There is a decorative form of the Siberian spruce (*Picea obovata*) with narrow hanging branches which was transplanted from the forest-park zone, and the Manchurian cherry (*Prunus maackii*) with a characteristic dark amber trunk and loose inflorescences of white flowers. The black berries of the Manchurian cherry are eaten by bears, so the inhabitants of Siberia and the Far East call this plant «bear berries».

Mahonia aquifolium from the barberry (*Berberidaceae*) family is a dwarf evergreen shrub with shiny leathery leaves, bright

Display of decorative woody plants
Photo by I.M. Shcherbakova

Twinberry honeysuckle (Lonicera involucrata)
Photo by I.M. Shcherbakova

yellow inflorescences and dark blue berries. Mahonia is native to the west of North America from British Columbia to California. It cannot grow in the nursery above the level of snow cover.

Species of Scotch (or Wych) elm (*Ulmus glabra*), American ash (*Fraxinus americana*), Manchurian ash (*F. mandschurica*), and English oak (*Quercus robur*) do not grow above 1 metre high as without protection of the snow cover their branches freeze-out in winter

The decorative plant display includes plants of various species and cultivars obtained in an exchange from Finland, when the staff of the dendrology group headed by Leryi Kazakov worked closely with their Finnish colleagues and took part in joint expeditions.

The most interesting specimens on this plot are plants of one of the most spectacular forms of the bird cherry (*Prunus padus*) - colorata. Its bark and shoots are purple or dark purple, the leaves are bright purple when emerging and in summer they turn dark green with purple veins. The buds are red, the blossoming flowers are pink, the autumn leaf colour is pink-red and the fruits are dark red. This cultivar flowers in late June and early July. Note also the rose hip cultivar 'Tornedal' which was cultivated in the Tornionjoki valley in northern Finland for over 300 years: it is distinguished by soft pink double flowers in late June-July. The attractive Birchleaf Spirea (*Spiraea betulifolia*) 'Tor' is a compact shrub with small white corymbose inflorescences 5-6 cm in diameter in the second half of July.

The main collection nursery for woody plants is on the left side of the main path (Fig. 2: 22) and includes both species and cultivars of trees and shrubs.

One of the oldest plantings in the Botanic Garden is a collection of currants including 11 cultivars and 6 species. The first samples were planted here in the late 1930s and 1940s. The green-fruited form of blackcurrant has been in continuous cultivation since 1939; the black currant var. «Krasnoyarskaya» since 1941. Several varieties, forms and cultivars of blackcurrant were obtained from our own seeds or from cuttings in the 1950s. Among them, the 'Aconitifolia' form has deeply dissected leaves; the Siberian variety, which differs from the European one in a lower height of about 1.5 m (rarely up to 1.7 m) and larger berries 10-15 mm in diameter; and cultivars 'Marmita', 'Neapolitanskaya', 'Pechorskaya'.

The collection of honeysuckles consists of 10 species, 3 forms, 1 variety, 1 subspecies and 1 hybrid. The introduced honeysuckle plants are distinguished by high winter hardiness. In favourable years they bloom profusely and bear fruit. Honeysuckle blooming can be observed from mid-June to late July; note that the flowers are of different colors.

Lonícera chamissoi
Photo by N.A. Konstantinova

In mid-late June, the blue honeysuckle (*Lonicera caerulea*), *L. edulis* and *L. stenantha* bloom with creamy yellow flowers, while *L. hispida* has inconspicuous greenish-yellow flowers. The flowers of the twinberry honeysuckle (*L. involucrata*) are yellow with dark reddish bracts; the Alpine honeysuckle (*L. alpigena*) is yellow with a reddish-brown coating on the outside; *L. nigra* is dull pink; and *L. chamissoi* - dark violet or dark purple.

In mid-late July, it is time for *L. chrysantha*, *L. xylosteum* and *L. vesicaria* to bloom; the colors of their flowers range from greenish-white to yellowish-white. The flowers of the Tatarian honeysuckle (*L. tatarica*) are of various colors, from white to dark pink, while those of *L. maximowiczii* are violet-red.

In early to mid-August, honeysuckle fruits begin to ripen. They are varied in color and shape: dark blue oblong in the blue honeysuckle (*L. caerulea*) and *L. stenantha*; round red in *L. chrysantha* and *L. xylosteum*; round black in *L. nigra*. Of interest are the fruits of *L. chamissoi* - a red, elliptical or almost spherical berry from two completely fused ovaries.

The collection of lilacs consists of 8 species, 2 subspecies and 3 hybrids. Their blooming begins in the second half of July, when the air is scented with a delicate light aroma. Despite their considerable age (more than 50-60 years), most of the bushes on display bloom profusely every year. Plants of many species (*Syringa josikaea*, *S. villosa*, *S. sweginzowii* and *S. oblata*) successfully withstand low winter temperatures with little to no damage. However, one-year-old shoots of the Himalayan lilac (*S. emodi*), *S. komarowii*, *S. meyeri*, the Japanese tree lilac (*S. reticulata*), *S. henryi* and *S. prestoniae* may be damaged by cold winter temperatures.

The collection of rose hips has been cultivated since the mid-1930s and consists of 8 species, 1 form, 2 cultivars and 2 hybrids. Flowering begins in mid-July. The most resistant to local climatic conditions are the beach rose (*Rosa rugosa*), *R. amblyotis* and the prickly rose (*R. acicularis*).

The redleaf rose (*R. glauca*) has bright leaves and stipules; in early spring they become red-purple, with a beetroot tint. Young shoots with thin thorns are of the same color. During summer, the leaves gradually acquire a gray-green color with a bluish tint, hence its name in Russian is "gray rose".

Shaped and varietal rose hips are highly decorative. The burnet rose (*R. spinosissima*) form 'Plena' has white double flowers with a yellow center. Its origin is unknown, double forms have probably appeared in different places and at different times. The white double form is known as 'Burnet Double White' in England and Norway, 'Totenviksrose' in

Sweden, 'Plena' in Denmark and Poland, and 'Juhannusruus' in Finland. It was first supplied to the Botanic Garden as live plants in 1951 from St. Petersburg; the present sample in the collection was grown from cuttings obtained in 1952. The beach rose (*Rosa rugosa*) 'Fru Dagmar Hastrup' is a short, compact cultivar discovered in Denmark in 1914, with simple dark pink flowers that lighten over time.

The collection includes two evergreen species of rhododendron: the Caucasian rhododendron (*Rhododendron caucasicum*) and *R. myrtifolium*, which bloom profusely in favourable years from the second half of June to mid-July, and bear fruit.

The collection of rowan trees is diverse. In addition to trees with the usual complex pinnate leaves (*Sorbus aucuparia* and *S. americana*), there are rowan trees with simple leaves – the Mougeot's whitebeam (*S. mougeotii*) and *S. buschiana* – on display. The Koehne mountain ash (*S. multijuga*) that is found in mixed forests of western and central China bears large white fruits with a diameter of 0.6-0.8 cm.

The small shrub *Dasiphora friederichsenii* has white flowers, in contrast to *D. fruticosa* with yellow flowers; its blossoming lasts for about 13-15 days. *Sorbaria* is a shrub with paniculate inflorescences and leaves that look like rowan leaves. Several species of *Spiraea* (*S. media*, *S. chamaedryfolia*, *S. nipponica* and *S. betulifolia* with white, yellowish-white and light pink flowers) begin to bloom in the second half of June. In July, *S. densiflora* and *S. menziesii* have pink flowers. August is the time for buds of the late-flowering species to open – *S. latifolia* (flowers from white to pink), *S. corymbosa* (yellowish-white) and *S. lasiocarpa* (white).

The collection contains several species of barberries: the common barberry (*Berberis vulgaris*), *B. thunbergii*, *B. integerrima* and the Amur barberry (*B. amurensis*). Almost all of them bloom and bear fruit with varying degrees of abundance and regularity.

***Beach rose (Rosa rugosa)* 'Fru Dagmar Hastrup'**
Photo by D.A. Davydov

The collection also contains trees: small-leaved lime *Tília cordata*, the Norway maple (*Acer platanoides*), the bird cherry (*Prunus padus*), and *Populus tristis*.

Work on the creation of the botanic-geographic area «Siberia» began in the mid-30s and has continued through recent decades.

Siberian fir *Abies sibirica* and Siberian larch (*Larix sibirica*) were supplied to the Garden as live plants in 1936-37 from St. Petersburg. Fir is easily distinguishable from spruce by its flat needles with a rounded tip. The fir cones point vertically upward - after maturation, the seed scales break off, leaving the axis behind. However, in the Khibiny, fir trees only produce seeds

Siberian fir (Abies sibirica)
Photo by I.M. Shcherbakova

in good years. Siberian larch grows rather rapidly in the Botanic Garden, producing cones almost every year.

Thanks to the self-seeding of mature trees, a natural replenishment of the site with new plants occurs. Nature alone is insufficient to create the Altai forests in the Khibiny, so we use planting stock grown from seeds and vegetatively propagated plants from the Experimental Site, as well as seeds collected in natural conditions in Southern Siberia. Planting stock of Siberian origin from other botanic gardens was also used.

In addition to fir and larch, the site contains the main landscape-forming species of Southern Siberia: Siberian pine (*Pinus sibirica*), Siberian spruce (*Picea obovata*), Scots pine (*Pinus sylvestris*), Siberian linden (*Tilia sibirica*), and common aspen (*Populus tremula*).

In the understorey (shrub layer) widespread tree and shrub species grow: *Sorbus sibirica*, *Spiraea media* and the elm-leaved spirea (*S. chamaedryfolia*), bird cherry, *Lonicera altaica* and *L. tatarica*, false spirea, *Cornus alba*, *Crataegus sanguinea*, *Sibiraea laevigata*.

In order to create the impression of mountainous terrain on the site and reflect the natural environment of the highland forests of the Altai in the plantings of Siberian pine (*Pinus sibirica*), two Alpine rock gardens containing badan (*Bergenia crassifolia*) were created. Under the canopy of the forest, the following herbaceous plants were planted: *Actaea rubra*, buttercup anemone (*Anemonoides ranunculoides*) and *Paeonia anomala*. A small area is set aside for an introduction nursery, where dozens of species of herbaceous plants of the Altai Mountains are tested under conditions of primary culture. The specific features of their growth and development are studied and experiments carried out to identify the rate of seed germination and optimize the seed and vegetative reproduction of introduced species, as well as how best to cultivate them in the Arctic

Siberian larch (Larix sibirica)
Photo by I.M. Shcherbakova

Badan (Bergenia crassifolia)
Photo by N.E. Koroleva

Nurseries for plants of Murmansk Oblast

The Polar-Alpine Botanic Garden is engaged in the cultivation of species represented in the flora of the Murmansk Oblast. They are grown in three nurseries - the main collection, the ecological nursery and the nursery for rare and useful plants.

The main collection nursery for plants of the Murmansk Oblast (Fig. 2: 9), often referred to as «living herbarium» in the literature, is located above the other nurseries at an altitude of 345 m above sea level. Here the snow melts much later (in mid-June) and in summer the plants suffer from drought more than in other areas, so specimens of many species do not root well and die quickly. In recent years, the care of this nursery has been carried out irregularly, and now a significant part requires reconstruction.

Clearing the forest area for the «living herbarium» began as early as 1938–1939, but work was suspended during the Second World War. The nursery has existed in its present form since 1963. It was formed in association with Lydia Nikolaevna Filippova who was then the head of the laboratory of flora and plant resources. The plants were brought to the nursery in soil, already mature, from various parts of the Murmansk Oblast: the lower reaches of the Ponoy River, the Lovozero Mountains, the Tersky coast, the islands of the Kandalaksha Gulf, the coast of the Lumbovsky Gulf of the White Sea, the Rybachy and Sredny peninsulas.

Due to the rockiness of the site, soil was brought in and spread on all nursery beds. The size of each bed is 1x1 m, they

Northern hollyfern (Polystichum lonchitis)
Photo by N.E. Koroleva

are raised about 15-20 cm. There are 10 rows with 49 beds in each. The species are arranged in a systematic order (based on the Adolf Engler system which was in use at that time), starting with horsetails, clubmosses, ferns and finishing with asters (*Asteraceae*).

The nursery is a visual aid where in one place you can see plants of various zones and habitats of the region - forest, tundra, rocks, etc. as well as representatives of most plant families of the Murmansk Oblast. The main purpose is to display species of native flora and gain information on the seasonal development of plants.

The rare species listed in the regional Red Data Book are an important component – Lapland poppy (*Papaver lapponicum*), *Helianthemum arcticum*, *Micranthes hieraciifolia*, *Paeonia anomala* and *Rhodiola rosea*. At the entrance to the nursery, attention is immediately

Matteuccia struthiopteris
Photo by N.E. Koroleva

Rhodiola rosea
Photo by D.A. Davydov

drawn to two Red Data Book ferns – the northern hollyfern (*Polystichum lonchitis*) wintering with green frond leaves, and the parsley fern (*Cryptogramma crispa*) with openwork leaves.

In 1967-1970 the ecological nursery for local flora was established in the park at an altitude of 320 m above sea level. Compared to the collection nursery, it has more favourable conditions for the development of plants: it is warmer, has better light, richer soils and a more stable hydrological regime.

The species of plants growing in this nursery are less diverse, but each species is represented by a large number of specimens of different age. This site serves as a source to replenish the main collection and for scientific research. Many plants that do not produce seeds in the collection nursery successfully bear fruit here.

The nursery for rare and useful plants of the Murmansk Oblast was founded in 1995 (Fig. 2: 19). It is located at right angles to the main path, on the opposite side of the nursery for medicinal plants, below the ecological nursery, and is easily accessible for tourists.

The 260 m^2 display includes 54 species, 11 of which are included in the list of endangered species of the International Union for Conservation of Nature (IUCN).

The most decorative examples of the local flora are planted here - *Helianthemum arcticum*, *Tanacetum bipinnatum*, *Erigeron borealis*, *Paeonia anomala*, *Rhodiola rosea*, the glacial buttercup (*Ranunculus glacialis*), the snow buttercup (*R. nivalis*) and *Matteuccia struthiopteris*.

Glacier buttercup (Ranunculus glacialis)
Photo by D.A. Davydov

Eucharis grandiflora in the greenhouse of the Botanic Garden.
Photo by D.A. Davydov

Collection of greenhouse plants

The collection of tropical and subtropical plants (Fig. 2: 12) is located in two sections of the greenhouse complex: tropical-subtropical (area 555 m^2) and succulent (150 m^2).

Greenhouse management began in PABGI in 1933, when the first greenhouse was built. It was a small, semi-basement block greenhouse, in which mainly planting stock for open and protected ground was grown. Over the past 90 years the greenhouse facilities underwent several renovations. In 1935-1936, a specialised greenhouse with a larger area and volume was constructed for demonstration purposes. In the 1970s, the greenhouse complex consisted of seven specialised greenhouses. Its last modernisation and retrofitting carried out in 2009-2012 turned it into a modern greenhouse complex adapted for growing a large number of tropical and subtropical plants. Currently, the collection greenhouses are equipped with specialised equipment for plant cultivation under Arctic conditions. The use of a supplementary illumination system for plants is necessary, to increase the duration of daylight hours. This makes it possible for plants to go through all stages of the life cycle and for most to bloom and bear fruit even during the period of the polar night.

The seeds for the collection were ordered according to 'delectuses' (catalogues with information about seeds) published by Russian and foreign botanic institutions. Live plants in the form of cuttings, seedlings and adult specimens came from the collections of various botanic gardens, arboretums, flower companies and numerous amateur gardeners in the Murmansk Oblast.

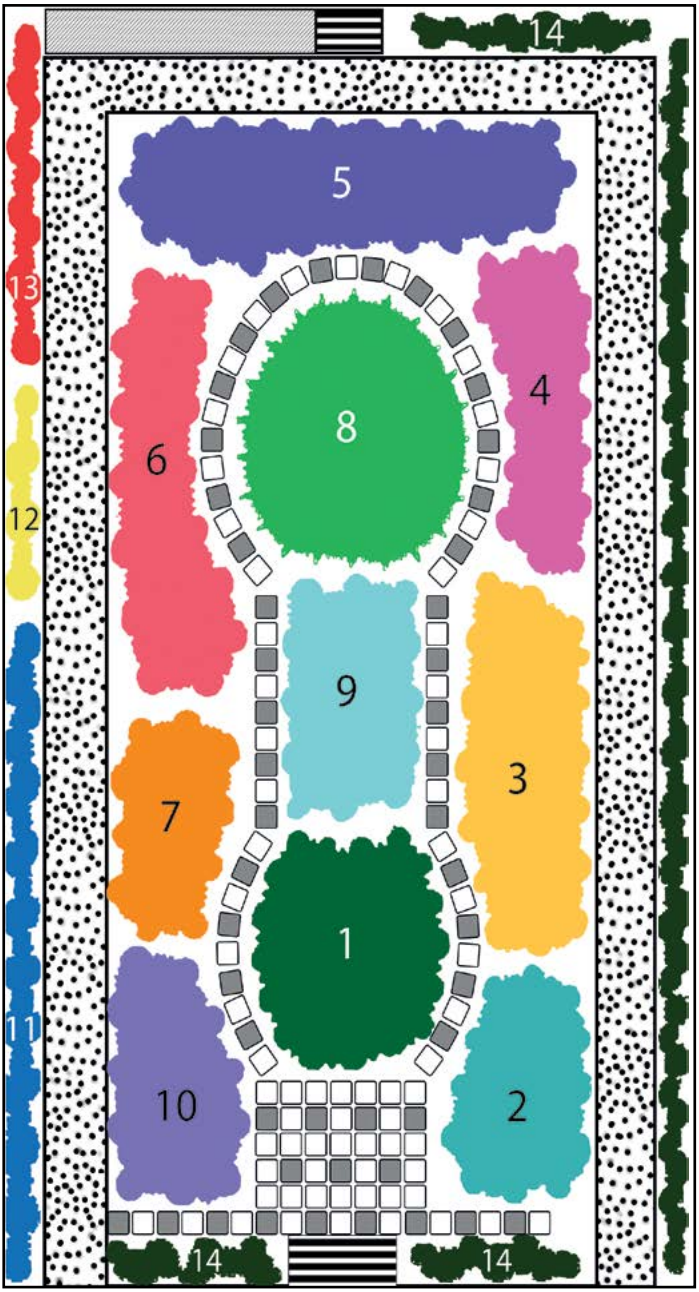
At present, the collection contains 788 specimens that belong to 616 species, 302 genera, 113 families. Among them are endemics of specific tropical and subtropical regions, rare plants from around the world both edible, medicinal and decorative, with other useful and interesting species of biological, geographical and economic value, and representatives of various morphological and ecological groups of plants. Collection plants are divided into three groups: **drought-resistant plants of deserts and semi-deserts, plants of humid tropics and plants of the subtropics.**

Some of the plants are presented in the greenhouse as botanic and geographical displays or taxonomic groups (ferns, conifers, palms). Other plants that do not reach large sizes are grouped by families and shown in pot culture on racks.

Immediately at the entrance to the greenhouse, there is a display **of succulents**. It comprises almost a third of the species collected over the 90-year history of PABGI. Succulents are real extremists: they have to go without water for a long time, the scorching sun shines on them during the day and at night they resist the cold. In their natural habitats the differences between day and night temperatures at the soil surface can vary by as much as 45 °C.

During a long evolution they have developed adaptations for life in extreme conditions, which created the unusual external appearance and internal structure of these plants. Their metabolic processes

Layout of plant groups in the display of the tropical-subtropical department



1 – succulents

2 – African plants

3 – plants of the subtropics of Southeast Asia

4 – Mediterranean plants

5 – a collection of fruit plants

6 – plants from Australia and New Zealand

7 – American plants

8 – conifers

9 – arec palms

10 – ferns

11 – tropical plants from the Begoniaceae family

12 – representatives of the family Piperaceae and Bromeliad family

13 – representatives of the families Commelinaceae and Geraniaceae

14 – representatives of the families Araceae and Marantaceae, ornamental plants, recommended for landscaping interiors and winter gardens

Potted plants of different taxonomic groups
Photo by L.A. Ivanova

Display of succulent plants
Photo by L.A. Ivanova

are slowed down and as a result they grow slowly. In the vast majority of succulents the stems, leaves and underground organs are full of sap and contain a reserve of water. Their leaves have a small number of stomata and a thick cuticle (wax-like layer on the surface) covered with a firm waxy coating to conserve moisture.

Desert cacti are the most numerous among the succulents in the collection. These plants are strikingly dissimilar, but they have some common properties. All of them, with the exception of *Pereskia* do not have leaves, the photosynthetic function is performed by fleshy green stems.

Among the cacti, you can find both giants and dwarfs of every possible shape– columnar (*Cereus*), flat (prickly pear – *Opuntia*), leafy (*Zygocactus*), spherical (*Echinocactus* and *Mammillaria*), as well as curling, climbing or with creeping lianas.

Not all cacti live in deserts. Forest or epiphytic cacti (*Heliocereus*, *Zigocactus*, *Rhipsalis*, *Rhipsalidopsis*, *Epiphyllum*) grow in tropical forests on tree trunks with orchids and representatives of the *Bromeliad* family. So it is not surprising that forest cacti differ in shape and requirements from their thorny desert relatives – they have long, leafy hanging down stems.

Because of their external appearance, both desert and forest cacti are often grown as decorative foliate and beautifully blossoming indoor ampelous (plants with climbing, drooping or creeping stems) or groundcover plants or as container plants. Many hybrid forms and cultivars (cultivated varieties) have been introduced.

Each year (usually in autumn), visitors to the greenhouse are amazed by the blossoming cacti from South American deserts – *Cereus repandus* or «wax candle», *Selenicereus grandiflorus*, the hedgehog

Brasiliopuntia brasiliensis
Photo by D.A. Davydov

cactus (*Echinopsis*), *Rebutia*, and the chin cactus (*Gymnocalycium*).

Some inhabitants of deserts and semi-deserts are used in their homeland for economic purposes – as raw materials for the production of medications (aloe, *Sedum spectabile*), dyes and building materials (*Cereus*, prickly pears). Some succulents are valuable food plants and are widely cultivated in Israel, Mexico, Thailand, Indonesia, China and many other countries around the world.

Among succulent plants, agaves are notable – the largest perennial evergreen succulents from the *Agavoideae* subfamily. In the deserts of Mexico, there are 136 species of *Agave*. They bloom only once in a lifetime and then die, leaving behind numerous suckers. In their homeland, agave provides valuable food, fiber and medicine: sisal, drinks, molasses and sugar are prepared from its leaves and juice. And one kind, the blue agave (*Agave*

Large-flowered cactus (Selenicereus grandifloras)
Photo by L.A. Ivanova

Cereus repandus
Photo by L.A. Ivanova

Echinopsis eyriesii
Photo by L.A. Ivanova

Rebutia cajasensis
Photo by L.A. Ivanova

Gymnocalycium mihanovichii
Photo by L.A. Ivanova

Agave univittata
Photo by N.E. Koroleva

tequilana), is used to make the world-famous alcoholic drink tequila.

In the deserts and semi-deserts of Africa there are no cacti and agaves, though there are many species of succulent such as spurge (*Euphorbia*), aloe, pigmyweeds (*Crassula*), *Stapelia* and *Haworthia*. All have fleshy leaves often collected in rosettes and covered with a wax coating; many have bright beautiful inflorescences.

There are many other species that have adapted to arid growing conditions in a different way. For example, there are plant species that grow and bloom only during the rainy season, entering a long dormant state in the hot season, during which they survive only due to nutrients stored in the bulbs.

They include *Amaryllis, Crinum*, and *Hippeastrum* – beautifully flowering bulbous species from the *Amaryllidaceae* family.

Other representatives of the same family such as *Clivia*, *Eucharis* and *Agapanthus* native to the east coast of Africa, where there is no severe drought, retain their leaves all year round. Instead of a bulb, they have short rhizomes with thick, fleshy roots that provide the plants with stored moisture.

Similar to typical desert plants of the

Candelabra aloe (Aloe arborescens)
Photo by L.A. Ivanova

Hippeastrum hybridum
Photo by L.A. Ivanova

Crinum macranthemum
Photo by L.A. Ivanova

subtropics adapted to drought conditions are representatives of the *Asparagaceae* family – *Asparagus* and *Ruscus*.

The leaves of asparagus are reduced, the shoots changed into platyclades (twigs), and the shoots of *Ruscus* have become flat leaf-like leathery stems (phylloclades) that turn their edges towards the sun, significantly reducing water loss through evapo-tranpsiration.

The main areas of the display greenhouse contain **plants of tropical rainforests.** In such forests, there is high air humidity and a large amount of precipitation that is more or less evenly distributed throughout the year.

A typical representative of the African tropics is the familiar indoor fig tree (*Ficus*). Scientists have indentified up to 600 species of fig trees. In the collection they are represented by 14 species, two of which grow in tropical Africa: the Cape fig (*Ficus capensis*) and the fiddle-leaf fig (*F. lyrata*) - beautiful evergreen trees with a dense crown and shiny leaves, inhabitants of the upper layer of tropical forests.

In addition, the display includes *F. auriculata* and *F. binnendijkii* which looks similar to some narrow-leaved willows, as well as the spectacular

Natal lily (Clivia miniata)
Photo by L.A. Ivanova

Fruiting of Ficus auriculata
Photo by L.A. Ivanova

Clivia nobilis
Photo by N.E. Koroleva

Benjamin fig (*F. benjamina*) and the rubber fig (*F. elastica*) that used to be of great industrial importance as a natural source of rubber. Widely used in indoor floriculture are the climbing fig (*F. pumila*) and *F. sagittata*, a very decorative shrub species with lodging or climbing stems.

A valuable commercial plant grows nearby, *Coffea arabica*, which blooms and bears fruit.

One of the largest and oldest specimens on display is the date palm (*Phoenix dactylifera*), widespread in the tropics of Africa and the oldest cultivated plant in history. The date palm is dioecious, i.e. male and female flowers are formed on different trees. The male date palm blooms in the PABGI greenhouse regularly and profusely.

Evergreen woody plants, *Dracaena deremensis* and the striped dracaena (*D. fragrans*) are also indigenous inhabitants of Africa, resembling palm trees in appearance and growing up to six metres tall in nature. They are often used as decorative plants in homes and offices.

At the very beginning of the display there are large plants with upright ten-metre shoots and giant white inflorescences. This is *Strelitzia nicolai* named after one of the Russian grand princes.

Better known is its South African relative – *Strelitzia reginae* which is known throughout the world for its exotic beauty. Due to the similarity of the inflorescences with the crowned crane, these two species are also known as «bird of paradise».

The tropics of Southeast Asia are distinguished by a great richness of species including useful plants cultivated both in their homeland, and on many other continents.

The display also contains hibiscuses from the *Malvaceae* family; their

Fruiting of coffee tree (Coffea arabica) in the PABGI greenhouse. Photo by D.A. Davydov

inflorescences are called the «flower of love». These vibrant, luxurious plants symbolise the tranquility and beauty of the south-eastern tropics. Many hibiscus species have long been bred in gardens and greenhouses as decorative plants for the grace of their flowers. Among the most popular in the world for cultivation is a tropical species, the China rose (*Hibiscus rosa-sinensis*). In temperate latitudes, more cold-resistant species are popular – *H. syriacus* and the swamp rose mallow (*H. moscheutos*).

Among representatives of the extensive *Zingiberaceae* family (which has more than 1,000 species) grown in the PABGI greenhouse are perennial herbaceous plants with thick rhizomes – the true cardamom (*Elettaria cardamomum*), the orange gingerlily (*Hedychium coccineum*) and the Kahili ginger (*H. gardnerianum*). In their natural habitats in the forests of the eastern coast of India, they form continuous thickets in dense shade, in glades, along the banks of rivers and streams and on marshy and periodically flooded lowlands. True cardamom is cultivated in Indochina and Central America as a spice plant.

The real gem of the collection is

Date palm (Phoenix dactylifera) Photo by D.A. Davydov

the dragon tree (*Dracaena draco*), an evergreen slow-growing plant that got its name from the resinous red sap. It has an outward resemblance to an inverted umbrella with a green cap of foliage and a massive trunk reaching 20 m in height. The natural habitat of the dragon tree includes the islands of Macaronesia and North Africa, where it grows on open rocky, sometimes steep, slopes among coastal cliffs.

The chestnut vine (*Tetrastigma voinierianum*), named for its close relationship with grapes, is an evergreen ligneous liana. This beautiful,

Inflorescences of Strelitzia nicolai
Photo by L.A. Ivanova

Inflorescences of Strelitzia reginae
Photo by L.A. Ivanova

unpretentious plant has hefty stems and large palmate compound leaves. *Tetrastigma* can grow very quickly, so it is widely used in office buildings with high ceilings; domestic, industrial or educational institutions; and winter gardens.

The PABGI collection contains the avocado (*Persea americana*), a fast-growing tree reaching a height of 18 m. This is a representative of the rich tropical rainforests of South America and is cultivated in many tropical and subtropical regions.

Every year in the greenhouse, the guava (*Psidium guajava*, a species of the *Myrtaceae* family) blooms profusely and bears fruit. It is an important tropical agricultural plant known for its delicious juicy fruits. Its homeland is South and Central America, but it is widely cultivated in the subtropical regions of Asia, Africa, South and North America.

A striking representative of the tropical rainforests of South America is the pitanga (*Eugenia uniflora*) or Suriname cherry endemic to Brazil. It is now naturalised and grown in Central America and Southeast Asia. The species is used for decorative purposes and for producing fruits that are both eaten fresh and processed.

In the tropical forests of South America, epiphytic orchids with inflorescences which sometimes have a strong pleasant aroma are widespread. The PABGI collection contains several representatives of the *Orchidaceae* family, species of the genera *Paphiopedilum*, *Phalaenopsis* and *Dendrobium*.

Representatives of the extensive family of *Piperaceae*, the peperomias, are displayed separately; they are represented by 13 species (*Peperomia rubella*, *P. incana*, *P. glabella*, *P. involucrata* and *P. obtusifolia*). Their natural range is in the tropical forests of Asia and America where they grow under the canopy of trees and on fallen trunks of trees and shrubs.

To the left of the entrance is a collection of tropical ferns. Among them are the maidenhair fern (*Adiantum*) with creeping branching rhizomes; the ribbon fern (*Pteris cretica*) with a rhizome covered with brown films; an epiphytic fern (*Dennstaedtia cicutaria*); the golden polypody (*Phlebodium aureum*); swordferns (*Nephrolepis*) and spleenworts (*Asplenium*) which are popular in home gardening.

Under the tree canopy you can see plants of tropical swamps – the umbrella palm (*Cyperus alternifolius*) in the *Cyperaceae* family originally from Madagascar, and the paper reed (*Cyperus papyrus*) from the banks of the Nile from which paper was made in ancient times (papyrus).

Notice the large leaves of *Alocasia odora* with inflorescences resembling Calla. These large plants up to two or more meters in height form dense thickets in the marshy areas of Southeast Asia.

Among other widespread plants of tropical swamps is the inchplant (*Tradescantia zebrina*), the shoots of which spread across the surface of the soil and easily take root. Its close relative, *Tradescantia spathacea*, originally from Mexico, is notable for its exotic inflorescence called «Moses-in-the-cradle».

Tropical plants from the *Begoniaceae* family are of great interest to visitors. Their variety can amaze anybody, even a fairly experienced florist.

Out of 28 taxa in the collection, the most numerous are decorative foliate species: the painted-leaf begonia (*Begonia rex*), *B. masoniana*, *B. cleopatra*, *B. heracleifolia*, *B. convolvulacea* and *B. incana*.

In nature, these plants live beneath the forest canopy in the shade; their inflorescences are small and unexciting. Beautifully flowering begonia cultivars with bright, simple and double inflorescences of various colors are mainly the result of selection by plant breeders.

Next to the begonias you can see representatives of the *Araceae* family – beautifully flowering and decorative leafy anthuriums (*Anthurium*), dumb canes (*Dieffenbachia*), and peace lilies (*Spathiphyllum*).

The large-leaved Swiss cheese plant (*Monstera deliciosa*) also belongs to the *Araceae* family; its dense thickets

Alocasia odora
Photo by N.E. Koroleva

Inflorescence of Alocasia odora
Photo by N.E. Koroleva

The color palette of leaves of painted-leaf begonia (Begonia rex)
Photo by L.A. Ivanova

Inflorescence of Tradescantia spathacea – "Moses-in-the-cradle". Photo by L.A. Ivanova

Begonia tuberhybrida pendula
Photo by N.E. Koroleva

Fruits and leaves of the Swiss cheese plant (Monstera deliciosa)
Photo by N.E. Koroleva

greet the visitors at the greenhouse entrance. *Monstera* comes from the tropical rainforests of Central America, is easily cultivated and commonly used for planting in residential and industrial buildings.

Plants of the *Gesneriaceae* family – *Sinningia*, African violets (*Saintpaulia*), Achimenes and the Cape primrose (*Streptocarpus*) – present the most interest for indoor floriculture. All of them are decorative because of their pubescent leaves of different hue and large vivid inflorescences.

The homeland of *Sinningia* and *Achimenes* is Latin America; *Saintpaulia* comes from the tropical highlands of East Africa.

A separate grouping in the PABGI collection comprises representatives of the flora of Australia and New Zealand, one of the most ancient land areas on our planet with a fantastic assortment of bizarre and beautiful plants.

More than half of the flora of these countries is endemic, i.e. species not found in natural conditions elsewhere. In New Zealand about 60% of the plants are endemic, 75% of Australian plants.

Hakea auriculata is a West Australian subtropical shrub from the *Proteaceae* family; it is found in open wastelands, on granite hillsides and limestone rocks. The seeds of these plants open only when exposed to high temperatures which is an adaptation to the seasonal fires that are common in Australia.

Another striking representative of the

Painter's-palette (Anthurium andraeanum)
Photo by L.A. Ivanova

Blooming of African violets (Saintpaulia)
Photo by D.A. Davydov

Australian flora is *Brachychiton discolor* from the *Sterculiaceae* family, a large tree growing in subtropical and tropical Australia and New Guinea.

One more species of Australia and Oceania is the Australian pine tree (*Casuarina equisetifolia*) which has been part of the PABGI collection since 1967. This plant has no leaves and photosynthesis is carried out by green twigs resembling equisetum, hence its scientific name.

Screwpines (plants of the genus *Pandanus*) have narrow arched leaves and aerial stilt roots; they grow in their natural environment to a rather impressive size. Owing to such roots, they have adapted to life under conditions of strong winds in the tropics of the Eastern Hemisphere and on Madagascar. The natives call screwpines «wandering trees».

Next to Casuarina and *Pandanus* is a representative of the *Myrtaceae* family – the crimson bottlebrush (*Melaleuca citrina*) an evergreen shrub from Southeastern Australia where it grows in humid subtropical forests on sandy soils. Its shoots are ribbed and silkily pubescent. The flowers are in a cylindrical inflorescence with bright red stamens for which the crimson bottlebrush is called in Russian by a second name "krasivotychinochnik", or «beautiful stamens».

In the PABGI collection there is an endemic New Zealand species – the New Zealand cabbage tree (*Cordyline australis*) which was introduced into cultivation more than 160 years ago. There is also *C. terminalis*, a decorative plant that has many cultivars and garden forms with various leaf colors. Under natural conditions it is found in woodlands and shrublands of Australia.

Another Australian plant that attracts attention is a very hardy and unpretentious evergreen herbaceous liana with a flexible and elastic stem and antennae – the kangaroo vine (*Cissus antarctica*) from the *Vitaceae* family. This decorative plant is widely used for indoor planting in kindergartens, hospitals and offices.

Recently our collection has been increased with the addition of the black poui (*Jacaranda mimosifolia*), a subtropical species from the *Bignoniaceae* family, originally from the dry tropical and subtropical foliate forests of South America. Thanks to its extraordinary

beauty it long ago won the hearts of plant lovers and was taken to all continents (except Antarctica) and successfully adapted to suitable climatic conditions.

Representatives of the subtropics in the collection are extremely diverse. The fig tree (*Ficus carica*) is one of our largest specimens. This is the most famous and very ancient species of the genus Ficus, a valuable fruit plant that has been widely cultivated from ancient times to the present. The fig tree comes from ancient Mesopotamia, grows in the subtropics of Central Asia and Asia Minor, in the Carpathians, Crimea, on open rocky slopes mainly on limestones and up to an altitude of 1,000-1,500 m above sea level.

In the PABGI greenhouse, you can see the garden dwarf form of the pomegranate (*Punica granatum*), a representative of the *Lythraceae* family. Pomegranate culture is widespread around the globe whereas wild trees are found in the subtropical forests of Southern Europe and Western Asia (as far as the Himalayas), reaching 2,000 m above sea level on the mountain slopes.

The display contains a large representative of one of the most ancient genera of vascular plants – *Cycas revoluta*, originally from subtropical Japan and China.

This evergreen tree-like gymnosperm plant can live for over a hundred years. Based on its appearance it can be called a stem succulent due to the fact that a reserve of water is stored in the hefty trunk and used during periods of drought; the trunk also stores a large amount of starch.

Cycas revoluta grows very slowly and you should not be surprised if only one leaf appears during the season; this is normal for the plant. In our greenhouse, more than 30 leaves appear on the trunk every year.

Cycas revoluta is considered a most attractive house plant due to its decorative leaves; it is widely used for indoor

Inflorescence of Crimson bottlebrush (Melaleuca citrina). Photo by L.A. Ivanova

Striped dracaena (Dracaena fragrans) Photo by N.E. Koroleva

Pomegranate (Punica granatum) cv. nana Photo by L.A. Ivanova

Male strobilus on Cycas revoluta Photo by N.E. Koroleva

Blooming of Camellia sasanqua cv. 'alba' in the PABGI greenhouse. Photo by L.A. Ivanova

Blooming of Japanese camellia (Camellia japonica). **Photo** by N.E. Koroleva

planting, and grows well in rooms and winter gardens.

Some of the most beautiful flowering plants in the collection are the Japanese camellia (*Camellia japonica* and *C. sasanqua*). These are evergreen trees, growing up to 15 m in height in natural conditions. *Camellia* has a beautiful flower, delicate and refined, exalted by prose writers and poets of various countries. It is originally from the humid subtropical forests of Japan, the southern part of the Korean Peninsula, and the island of Taiwan. The flower has no scent, but in perfumery a certain set of floral notes is called «camellia».

Part of the display represents the genus *Citrus*. Many gardeners at least once in their lives have tried to grow a full-fledged fruiting lemon plant (or another representative of the genus) from a seed. In our collection you can see the fruiting lemon cultivar 'Pavlovsky' created more than 120 years ago in the city Pavlovo-na-Oke, as well as the cultivar 'Ponderosa' distinguished by very large fruits weighing up to 600 g after fragrant creamy white flowers.

The scientific name of the genus comes from the Latin *citrus* – "lemon tree". The genus contains more than 30 species, many of which are natural hybrids and are quite popular among enthusiasts of indoor floriculture. Lemon is an evergreen tree originally from Southeast Asia, but is now cultivated in all subtropical regions of the world. In Russia lemon trees grow in open ground only on the Black Sea coast.

Beneath the canopy of tall trees you can find the paperplant (*Fatsia japonica* or *Aralia japonica*) and *Schefflera*. These are spectacular short evergreen plants with a strong stem, representatives of the Araliaceae family. They are native to China and Japan, where they grow mainly on the coast.

Inflorescences of heavenly bamboo (Nandina domestica). Photo by L.A. Ivanova

Another evergreen plant with an open crown that comes from these eastern countries is the heavenly bamboo (*Nandina domestica*) which is rightfully included in the list of elite indoor plants. Even in a greenhouse the color of its leaves changes depending on the season: in summer they are pure green, by autumn they acquire a red-green hue, in spring they turn brown and by the next summer their green color returns. The small white-pink flowers are collected in large racemose, lilac-like inflorescences. Therefore, it is also called «home lilac» in Russian.

Every year from March to October, you can see short container plants with large (up to 20 cm in diameter) beautiful spherical inflorescences of small four-petal flowers of the same size, mostly blue

Schefflera octophylla
Photo by N.E. Koroleva

Fruiting of lemon (Citrus limon) in the PABGI greenhouse. Photo by N.E. Koroleva

Nerium oleander
Photo by N.E. Koroleva

and white. This is the French hydrangea (*Hydrangea macrophylla*). Introduced from the subtropics of Japan, hydrangea was quickly introduced to European territory where it is often grown as a decorative plant in gardens and parks and as a pot plant indoors.

Though inconspicuous, one of the most remarkable plants on display is the bay laurel (*Laurus nobilis*) of the *Lauraceae*, an evergreen tree with a dense pyramidal crown or a tall shrub. The forests of laurel and other sclerophyllous tree species still conserved in protected areas in Southern Europe and on the Canary Islands are relics of the almost extinct Tertiary Mediterranean flora.

Another equally well-known representative of the Earth's subtropical regions is the oleander (*Nerium oleander*). The plant has beautiful pink flowers but its sap is poisonous.

The strawberry tree, a member of the heather family with red-brown trunks and branches, is another representative of the ancient forests of the eastern Mediterranean and the Caucasus.

It is very decorative at its flowering period with clusters of white, creamy or pale pink lantern shaped flowers; the fruits outwardly resemble strawberries hence its name. A characteristic feature is the annual shedding of the bark exposing the young, pistachio-colored trunk.

Next to the strawberry tree is the carob tree (*Ceratonia siliqua*) a plant of the *Fabaceae* family. It has long been cultivated in the Mediterranean. Its fruits, bent into the shape of a horn, contain juicy sweet pulp and hard flat brown seeds which are surprisingly similar to each other and regardless of the size of the tree have the same weight – 0.189 g. Due to this consistency they were used as a measure of weight in ancient times in the East. The term «carat» comes from the Latin name for the carob tree – *Ceratonia*.

The pride of the collection is the Norfolk Island Pine (*Araucaria heterophylla*), an evergreen coniferous tree endemic to Norfolk Island which is located in the Pacific Ocean not far from Australia.

The Norfolk Island Pine is a symbol of the island, its image appears on the flag. Branches of the tree grow horizontally in whorls at right angles to the trunk, forming a beautiful pyramidal crown. The plant is easy to cultivate and suitable for long-term in indoor cultivation.

Blooming of the strawberry tree (Arbutus unedo) in the PABGI greenhouse. Photo by L.A. Ivanova

A branch of Araucaria heterophylla Photo by L.A. Ivanova

The sugi (*Cryptomeria japonica*) is a tall large-stemmed coniferous plant which is endemic to Japan and China. In its natural range it grows in the mountains at an altitude of 1,100 to 2,500 m above sea level where it forms pure stands. Its needles are bluish-green, rigid, subulate and curved. This species has long been cultivated as a decorative tree.

Also in the collection of conifers is the Mediterranean cypress (*Cupressus sempervirens*), a variety of evergreen tree with a narrow pyramidal crown which is distinguished by its rapid growth and forms cones in the greenhouse.

The Lawson cypress (*Chamaecyparis lawsoniana*) is one of the long-cultivated North American plants of the genus Ephedra; in Europe there are several hundred of its cultivars differing in the shape of the crown and the color of the scaly leaves. Its natural range is the western coast of the United States between southwestern Oregon and northwestern California.

The display contains an amazing relict evergreen coniferous plant the English yew (*Taxus baccata*) whose ancestors grew at the time of the dinosaurs. This plant is incredibly long-lived; the oldest in Britain is thought to be between 2000-3000 years old. This plant is also unique because, unlike other conifers with dry cones, it forms so-called 'arils'. It looks like a berry but is in fact a fleshy growth that surrounds the conifer seed and is attractive to birds. The seed, which is poisonous, is dispersed in the droppings of the birds. . Its range includes the Crimea, the Caucasus, the Balkans, North Africa and Asia Minor. In the subtropics of Central and Southern Europe, this tree can grow up to 27 m.

In total more than 2000 samples of plants of tropical and subtropical flora were studied at PABGI over a 90-year period. As a result, the staff selected a number of potted and cutting plants and developed science-based technologies for their cultivation in the Arctic. They also developed recommendations for the use of plants within landscaping schemes that flower and are adapted to extreme conditions. The experience gained in growing tropical and subtropical plants in the PABGI collections enabled the development and implementation of many indoor planting projects in residential, public and industrial premises in the Murmansk Oblast and the creation of winter gardens and so- called "zones of psychological relief."

Cycas revoluta in the greenhouse of the Botanic Garden
Photo by Anny Moore

Walking the Ecological Trail

Vertical zonality is the most striking feature of the vegetation of the protected area of PABGI and the Khibiny and other mountains in the Murmansk Oblast. Zonation is where belts of different vegetation types - coniferous (northern taiga) forests, krummholz birch forests, mountain tundra and mountain deserts – succede each other as you gain elevation. The alternation of vegetation types in the mountains to some extent reflects the latitudinal zonality on the Kola Peninsula. The boundaries are not sharp but fuzzy and graded, for example fragments of krummholz birch forests may be found in favourable areas within the mountain-tundra belt, whereas groupings of tundra species – in suitable conditions (for example on talus deposits) may occur in the mountain-forest belt. On the south-facing slopes the upper boundaries of the belts are higher than on the north-facing slopes. In addition to these clear vegetation zones there are communities that do not strictly obey the vertical distribution but are confined to specific substrates or moisture conditions. For example, plant communities growing on talus deposits and rocks, meadows and swamps.

The main groups of plant communities of the PABGI protected area are:

1) coniferous (spruce) forests with a large component of birch,
2) swamp forests,
3) krummholz birch forests,
4) mountain tundra communities,
5) mountain deserts,
6) meadows,
7) stony places, talus deposits, rocks,
8) anthropogenic.

You can experience the changes in the vegetation of the protected area by taking a walk along the Ecological Trail. This was set out in the Botanic Cirque of Mount

Spruce-birch forest along the banks of the Vudyavryok River. Photo by N.E. Koroleva

Thicket of invasive white hellebore (Veratrum lobelianum) under the canopy of spruce-birch forests. Photo by N.E. Koroleva

Northern oak fern (Gymnocarpium dryopteris) in a spruce-birch forest. Photo by N.E. Koroleva

Vudyavrchorr practically from the very foundation of PABGI to improve the visitor experience. Several trails were created, of which now only fragments remain.

For a long time a trail led to the observation deck «Krugozor» (which means "Outlook") with rest areas equipped with benches set alongside. However, it gradually fell into disuse and became overgrown with birch undergrowth. Since the 2000s the Ecological Trail (length 4.5 km) along the right side of the Botanic Cirque has been used. With an ascent from 320 to 570 m above sea level, the trail passes through all vegetation zones with the exception of mountain deserts.

The route begins 320 m above sea level in the belt of spruce-birch and birch-spruce forests which are widespread on the lower of the slopes of Mounts Vudyavrchorr and Takhtarvumchorr, along the valley of the Vudyavryok River and the shores of Lakes Bolshoy Vudyavr and Maly Vudyavr. Most common in the protected area are spruce forests with a large component of birch and with groundcover of green mosses, dwarf shrubs and herbs. The forest is sparse, with Siberian spruce (*Picea obovata*) and downy birch (*Betula pubescens*) predominant as well as *Sorbus gorodkovii*, aspen (*Populus tremula*), grey alder (*Alnus incana*) and willow trees. The upper border of the spruce forest is at an altitude of 400 m above sea level.

At the first stop (beginning of trail) you can see fragments of riverine and sedges-sphagnum bogs with common cottongrass (*Eriophorum angustifolium*), and swamp-meadow forbs.

On the mountain slopes, in the spruce forests, you can see species that are adapted to life under the forest canopy, the so-called species of the "spruce series". Among them are bilberry (*Vaccinium myrtillus*) round-leaved wintergreen (*Pyrola rotundifolia*) and *Trientalis europaea*. In these forests a thick lichen and moss cover has developed. The most common species are Schreber's big red stem moss (*Pleurozium schreberi*) and *Hylocomium proliferum* (this stop is called «Spruce forest with herbs and dwarf shrubs»).

Krummholz birch forest
Photo by N.E. Koroleva

Lichen tundra
Photo by N.E. Koroleva

The krummholz birch forests belt of downy birch (*Betula pubescens*) replaces spruce-birch forests at altitudes 400 (450) m above sea level. The downy birch is very variable – it can be a multi-stem tree (with several trunks starting from one point), a tree bent at the base or a crooked tree; such variety is associated with the impact of snow. In addition to birch, the tree layer usually has mountain ash, tree-like willows (*Salix caprea* and *S. borealis*) and aspen. Fragments of mountain-tundra and rocky vegetation are found here on talus deposits and on the stony banks of streams: they include the Red Data Book species Lapland poppy (*Papaver lapponicum*), *Dryas octopetala* and tundra lichens (this stop is called «Krummholz birch forest, stream»).

The transition to mountain tundra at an altitude of 450 to 500 m above sea level is not sharp; in recent decades the upper border of krummholz birch forests has risen and birch undergrowth in the mountain tundra was sprawling.

In the tundra belt plants exist in harsh and contrasting ecological conditions that are mainly determined by the redistribution of the snow cover by the wind. The dwarf shrub tundra is dominated by species that are also common in forest belts – crowberry (*Empetrum hermaphroditum*), bog bilberry (*Vaccinium uliginosum*), dwarf birch (*Betula nana*), lingonberry (*Vaccinium vitis-idaea*) and lichens (*Cladonia stellaris*, *C. arbuscula*, *C. stygia*, etc.). In snowless conditions lichen carpets predominate while dwarf shrubs often have the form of a dense pillow, as in the pincushion plant (*Diapensia lapponica*), or pressed against the substrate, as in Alpine bearberry (*Arctous alpina*), *Loiseleuria procumbens* and *Dryas octopetala* (stop called «Dwarf shrub tundra»).

In the hollows, mountain-tundra grass meadows of wavy hair-grass (*Deschampsia flexuosa*) are widespread; their reddish

BView of the Botanic Garden from the observation platform
Photo by N.E. Koroleva

Dryas octopetala
Photo by N.E. Koroleva

Net-leaved willow (Salix reticulata) in rocky habitats. Photo by N.E. Koroleva

Blue heath (Phyllodoce caeruleas) found in the belt of krummholz birch forests and in mountain tundra
Photo by N.E. Koroleva

Epilithic lichens in the mountain tundra
Photo by N.E. Koroleva

colour is clearly visible from afar. Near the snowfields there are globeflowers (*Trollius europaeus*), *Saussurea alpina*, hornworts (*Anthoxanthum alpinum*), as well as dwarf shrubs (*Salix polaris*, *Cassiope hypnoides*), lichens and mosses (stop called «Nival saddle»).

On rocky ledges multi-species cushion communities are formed and if groundwater seeps out in rocky cracks – "hanging" mountain-tundra bogs with various shrub-grass and moss covers.

Here grow dwarf shrubs net-leaved willow (*Salix reticulata*) and polar willow (*S. polaris*), moss campion (*Silene acaulis*), grasses, *Bartsia alpina*, *Trollius europaeus* and moisture-loving bryophytes (stop called «Rocky wall»).

In the upper sub-belt of mountain tundra which has even more severe conditions the vegetation cover is not closed and is similar in species composition to **stony mountain deserts**.

Multi-species cushion communities of lichens are widespread here, consisting of *Alectoria ochroleuca* and *Flavocetraria nivalis*, plus bryophytes, mainly *Racomitrium lanuginosum* and a limited number of dwarf shrubs and herbaceous perennials (*Arctous alpina*, bog bilberry, crowberry, purple saxifrage *Saxifraga oppositifolia*). Moss-lichen cushions alternate with a cover of epilithic lichens, such as the map lichen (*Rhizocarpon geographicum*), and species of the genus *Stereocaulon*, *Umbilicaria* (stop called «Observation platform»).

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