Botanical Gardens and Their Role in Plant Conservation

Asian Botanical Gardens, Volume 2

Edited by
T. Pullaiah and David A. Galbraith

CRC Press
Taylor & Francis Group

15 The Role of the Kuzbass Botanical Garden in Solving Environmental Problems and in Plant Conservation *in situ* and *ex situ*

Andrey Kupriyanov

CONTENTS

15.1 INTRODUCTION

The scientific concept of *introduction* has been used since the sixteenth century. It originated from the Latin word of the same form: *introduction*. Introduction is a purposeful human activity aimed at bringing plants (genera, species, subspecies, varieties, forms) under cultivation in a particular natural-historical area where they have not previously grown. Additionally, the term means bringing into cultivation plants from the indigenous flora. Introduction is part of the system of botanical sciences. Institutions dealing with this science are botanical gardens. Collections of living plants that are grown in open field conditions and in greenhouses and used for research and for arranging displays form the basis of botanical gardens. The fundamental nature of introduction lies in studying the adaptive processes that occur in plants at all levels of life systems, namely from biochemical processes to changes in growth and development rhythms. This process is referred to as plant acclimatization; it ensues in nature due to global climate changes or when plants spread to new territories. Acclimatization takes an extremely long time. In introduction experiments, botanists-introducers model this process, reducing to a great extent the natural timescale that spans geological periods. Studying the processes occurring in plants during their acclimatization is the fundamental aim of introduction. Practical implementation of introduction leads to the enrichment of mankind

DOI: 10.1201/9781003281252-15

with new useful plants. The global success of introduction provides an opportunity to overcome the world food crisis. The sharp increase in the productivity of agricultural crops that were bred by virtue of the mobilization of the world plant resources made it possible to accomplish the "Green Revolution" in the middle of the twentieth century and thus feed humanity. The success of introduction disproved the grim predictions of an inevitable food crisis made by Malthus. Hunger on Earth is a social, not a biological, phenomenon that is possible thanks to the progress of introduction. The inexhaustibility of introduction arises from the unlimited resources of intraspecific and form diversity of plants in wildlife. It only remains for humanity to exploit the natural potential of the plant world to prevent food and environmental crises and to provide the population with safe medicinal drugs. The innovativeness of introduction developments should be revealed in integration projects and consist in both bringing a new plant into cultivation and in unlocking its useful properties. In Siberia and Russia, with their extreme climatic features, the search for new cultivated plants for many sectors of the national economy is not over yet. In the twenty-first century, introduction is as innovative as physics and chemistry.

In 1989, Botanic Gardens Conservation International (BGCI) compiled a list of characteristic features distinguishing a botanical garden from other institutions. The list includes the presence of research collections; the registration of collections, which provides data about the natural habitat of species; labeling of plants; accessibility to visitors; and an opportunity to perform research on the plant collections. Thus, the basic object of activity in any botanical garden is collections; the main methods employed in its work are collecting and introducing new plants.

Botanical gardens have unique, unparalleled opportunities to unite the traditional taxonomy and the needs of agriculture, forestry, and medicine as well as the study and conservation of biological diversity.

Currently, there are more than 2,200 botanical gardens in 153 countries of the world. The number of collections in them vary from hundreds to dozens of thousands of taxa. It is known that there are more than 400 botanical gardens and dendrological parks (arboretums) in Europe, about 200 in the USA, 150 within the territory of the USSR, and 107 in modern Russia. (Kuzevanov, 2013). Siberia boasts eight large botanical gardens (Figure 15.1).

The Kuzbass Botanical Garden is one of the youngest academic botanical gardens in Russia. It was laid out on 28 December 1991 in the south of Western Siberia (Kemerovo) covering an area of 186.3 hectares.

15.2 THE LOCATION OF THE KUZBASS BOTANICAL GARDEN

The site of the Kuzbass Botanical Garden is on the eastern outskirts of Kemerovo; its area is 186.3 hectares. The territory of the garden is confined to the flood plain and the first terrace above the flood plain of the Tom. The absolute elevation of the river surface varies from 117 to 132 m above sea level. The soil cover is represented by meadow chernozem gley soils, meadow marsh soils, and drained podzolic soils.

The climate is continental: winters are cold and protracted; summers are short and warm. The average annual air temperature is 0.9°C. The warmest month is July with an average temperature of +24.5°C. The coldest month is January with an average temperature of –24°C. The record cold maximum is –57°C. The first autumn ground frosts are observed from 26 August to 14 September; spring ground frosts are observed from 28 May to 11 June. The average frost-free period is 110 days. Autumn is short, with a rather warm September and cold October. By mid-October, cool temperatures above zero gradually change to cold temperatures below zero. November is fully included in the winter months with an average air temperature of –9.7°C. Such climatic conditions are a significant obstacle to the introduction of plants in the Kuzbass Botanical Garden.

FIGURE 15.1 The most significant botanical gardens in Siberia: (1) Tomsk (the Botanical Garden of Tomsk State University; (2) Novosibirsk (Central Siberian Botanical Garden of the Siberian Branch of the RAS); (3) Kemerovo (the Kuzbass Botanical Garden of the Federal Research Centre of Coal and Coal Chemistry of the Siberian Branch of the RAS); (4–5) Barnaul (the Botanical Garden of Altai State University; the Botanical Garden of the Institute of Horticulture of Siberia); (5) Irkutsk (the Botanical Garden of Irkutsk State University); Siberian Branch of the RAS); (7–8) Yakutsk (Botanical Garden of the North-Eastern Federal University; Yakutsk Botanical Garden of the Institute of Biological Problems of the Cryolithozone" SB RAS).

FIGURE 15.2 General view of the Kuzbass Botanical Garden.

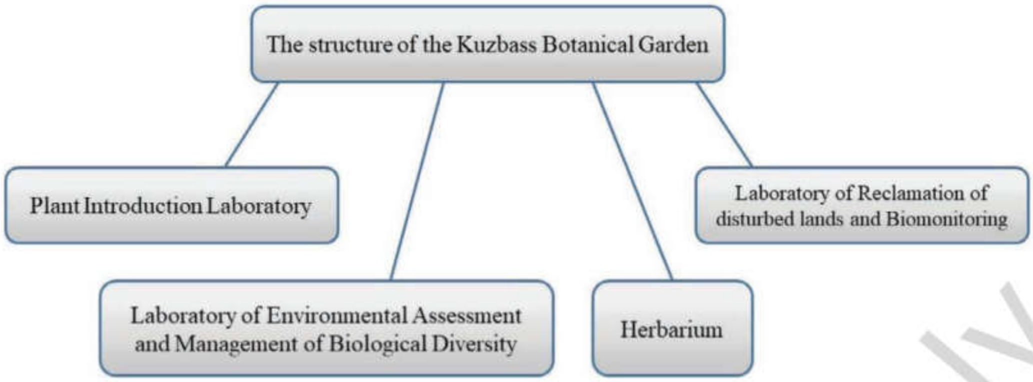

FIGURE 15.3 The structure of the Kuzbass Botanical Garden.

15.3 BOTANICAL RESEARCH

Botanical studies of the Kuzbass area have had a rich history since the eighteenth century; such outstanding Russian botanists as I. Gmelin (eighteenth century), P. N. Krylov and V. V. Reverdatto (nineteenth century), and N. N. Laszczynski and V. P. Sedelnikov (twentieth century) worked here. The materials of botanical expeditions are stored in the herbaria of Moscow (MW), Saint Petersburg (LE), Tomsk (TK), and Novosibirsk (NS).

Present-day research conducted by the botanical garden staff is aimed at studying the flora of southern Siberia, including Kemerovo Oblast and Kazakhstan. At present, floristic research is focused on a thorough study of the floristic composition of the specially protected natural areas (SPNA). A complete inventory of the flora of the Kemerovo Oblast was carried out.

The Kuzbass Botanical Garden has strong ties with Kazakhstan where joint research centered on the topic “A study of endemic plants of particular floristic regions of Kazakhstan and the creation of a database on the herbarium fund” has been repeatedly performed in liaison with the joint-stock company “IRPH ‘Phitochemistry’” (Director General, Academician of the National Academy of Sciences of the Republic of Kazakhstan S. M. Adekenov). Scientists of the Kuzbass Botanical Garden participated in the implementation of the research grant of the Ministry of Education and Science of the Republic of Kazakhstan for 2018–2020 (No. AP05132458, “Molecular genetic analysis of the gene pools of the rare plant species populations of Northern Kazakhstan”) as well as the grant of the Ministry of Education and Science of the Republic of Kazakhstan for 2018–2020 (state registration No. 0118RK00404; No. AP0513246, “Research and protection of ornamental and rare plants of the Syrdarya-Turkestan Natural Park”).

The Kuzbass Botanical Garden has organized 26 expeditions to Kazakhstan since 2006: 11 expeditions to the area of the Kazakh Uplands; 9 expeditions to the Syrdarya Karatau and the West Tian Shan; 3 to the East Kazakhstan region (Kazakhstan Altai, the Saur Mountains, and the Zaysan Basin); 3 to the North Kazakhstan region; 2 expeditions to the West Kazakhstan region; and 1 to the Dzungarian Alatau. I. A. Khrustalyova, O. A. Kupriyanov, T. O. Strelnikova, and Yu. A. Manakov took an active part in them.

15.4 HERBARIUM

The emergence of the Kuzbass Botanical Garden Herbarium is associated with the first collections assembled by T. Ye. Buko in the Kuznetsk Alatau in the 1990s, totaling 1,500 sheets.

At present, the Herbarium contains about 60,000 sheets. It consists of four sections: Kemerovo region, Kazakhstan and Central Asia, Siberia, and Bryophytes. The Herbarium was entered into the international database Index Herbariorum under the acronym KUZ.

The garden has collections of the genera *Stipa*, *Festuca*, and *Artemisia*. Some of the materials were deposited for storage by Siberian and Kazakh scientists: A. L. Ebel, Yu.A. Kotukhov, N. N. Lashchinsky, V. P. Amelchenko, O. M. Maslova, D. V. Zolotov, and others.

The section "Kemerovo region" contains 19,654 herbarium sheets of vascular plants that belong to 1,584 species, 548 genera, and 123 families. Almost all staff members of the botanical garden became the main collectors: S. A. Sheremetova, T. Ye. Buko (about 7,000 herbarium sheets), A. N. Kupriyanov (more than 4,000 sheets), A. L. Ebel, Yu. A. Manakov (more than 2,000 sheets), Ye. A. Kuzmina, T. O. Strelnikova (about 1,500 sheets), L. A. Gorshkova, I. A. Khrustalyova, G. I. Yakovleva, O.A. Kupriyanov (about 1,000 sheets), Yu. V. Morsakova, D. V. Chusovlyanov (about 500 sheets), V.N. Bersenyova, O. V. Barysheva, S. A. Skoblikov (more than 300 sheets), N.V. Demidenko, R. T. Sheremetov, D. A. Sidorov (more than 200 sheets), and others.

The section "Kazakhstan and Central Asia" (KAZ) of the Herbarium contains more than 20,000 sheets of inserted herbarium that are included in the main collection fund. Most herbarium collections were carried out from 1996 to 2019. At present, there are herbarium materials from nine areas: Akmola Region (Akmolinskaya Oblast), Almaty Region (Almatinskaya Oblast), Aktobe Region (Aktyubinskaya Oblast), East Kazakhstan Region (Vostochno-Kazakhstanskaya Oblast), Jambyl Region, Karaganda Region, Kostanay Region, Pavlodar Region, and Turkistan Region. The herbarium collection of Kazakh species was most intensively enlarged from 2010 to 2019.

The section "Siberia" of the Herbarium has about 20,000 sheets and covers the areas of the south of Western and Eastern Siberia, Khakassia, and Tyva.

The section "Bryophytes" of the Herbarium was put together in 2005 by A.Ye. Nozhinkov, PhD (Biol.). The collection of bryophytes comprises 1,760 specimens of mosses and liverworts represented by 157 genera and 345 species that were collected on the territory of Siberia and Kazakhstan (Sheremetova et al., 2021a).

A typical herbarium contains 64 taxa: Asteraceae: *Artemisia* (8), *Galatella* (1), *Hieracium* (1), *Pilosella* (1), *Achillea* (2), *Rhaponticoides* (1), and *Cousinia* (1); Boraginaceae: *Myosotis* (1); Caryophyllaceae: *Gypsophila* (1); Euphorbiaceae: *Euphorbia* (1); Poaceae: *Agrostis* (1), *Agrotrigia* (2), *Elymotrigia* (7), *Elymus* (5), and *Stipa* (19); Ranunculaceae: *Pulsatilla* (1), *Ranunculus* (3), and *Thalictrum* (2); and Rosaceae: *Potentilla* (1).

The Herbarium created the integrated information system titled the Kuzbass Digital Herbarium, which made it possible to acquire the most in-depth scientific information about the regional flora diversity and conduct its documentation in digital form in accordance with the standards of global information databases. The research permitted the generalization of all available data; the collections provided insight into the actual diversity of the flora of Kemerovo Oblast. The state of the collections in the Kuzbass municipalities was determined, and those areas where additional research was necessary (blind spots) were identified. The data obtained from the texts of original labels and the geographical coordinates of the areas where the plants were collected (reflected electronically on maps) will allow researchers to compile complete lists related to individual districts of Kemerovo Oblast automatically.

15.5 RESULTS OF BOTANICAL RESEARCH

In the twenty-first century, botanical research performed by KuzBG staff members is progressing to fundamentally new perspectives of understanding and generalizing previously obtained and accumulated materials. The number of publications devoted to the issues of studying the Kemerovo Oblast vegetation cover has significantly increased. The number of herbarium collections from different Kuzbass districts has increased dramatically since the beginning of the twenty-first century thanks to the expeditionary research pursued by KuzBG staff during the expeditions organized in collaboration with scientists from the Central Siberian Botanical Garden of the Siberian Branch of the Russian Academy of Sciences and Tomsk State University (A. L. Ebel, N. N. Lashchinsky, V. A. Cheryomyshkina, O. Yu. Pisarenko, N.V. Makunina, N. V. Shchegoleva, A. A. Zverev, A. V. Klimov,

G. I. Yakovleva, and others). In the last 20 years, evidence of more than 150 new species not found in Kuzbass earlier has been provided, and data about new locations of rare plants have been obtained. Additionally, the specific features of rare species populations have been studied; the bibliography of research papers on flora and vegetation has increased by more than 350 publications (Sheremetova et al., 2021b).

The *Black Data Book of Siberian Flora* (2016) was published on the basis of joint botanical research performed in collaboration with other Siberian botanists. This monograph provides the first consolidated data on invasive plants in the territory of Siberia. It includes 58 higher vascular plants, which are adventive for the local flora and pose an economic and environmental threat. The morphological description provided for each plant is supplemented with the history of the species naturalization in Siberia. In addition, a distribution map with the assessment of its aggressiveness is created. Data on the biology and ecology of such plants are supplied. The monograph explores the consequences of their introduction and possible practical applications. The data obtained for Siberia for the first time make it possible to understand the consequences of human economic activity as well as the distribution, abundance, and number of invasive species, their reproduction, and the rate of distribution. The book proposes recommendations for curbing the spread of these plants and outlines preventative measures that can be adopted to combat invasive species.

The monograph *The River Tom Basin (Floristic and Physiographic Specific Features)* (2020) by S. A. Sheremetova and R. T. Sheremetov is the most significant floristic generalization of numerous botanical studies performed in the territory of Kemerovo Oblast. The book presents the results of 15 years of floristic research. The primary purpose of the monograph was to assess and compare the current state and trends in the development of the flora of the River Tom basin based on the basin approach. The authors substantiate the use and appropriateness of the basin approach for comparative floristic research.

The results of botanical research in the territory of Kazakhstan are presented in numerous publications and monographic reviews: *A guide to plants of Karkaraly National Park* (Kupriyanov et al., 2008); *A guide to vascular plants of Bayanaul National Park* (Kupriyanov et al., 2013); *The flora of Burabay National Park* (Sultangazina et al., 2014); *The floristic diversity of Boralday* (Kupriyanov et al., 2017a); *Pyrogenous successions in the pine forests of the Kokshetau Uplands after fires* (Sultangazina et al., 2017); *The flora of the Big Ulutau* (Kupriyanov et al, 2017b); *A compendium of the flora of the Kazakh Uplands* (Kupriyanov, 2020); and “Rare plant species of Northern Kazakhstan” (Sultangazina et al., 2020). Herbarium collections served as the basis for the description of new species from the territory of Kazakhstan: *Achillea* × *kasakhstanica* Kupr. et Alibekov, *A. kamelinii* Kupr., *A. tianschanica* Kupr. et Kulemin, *Artemisia saurense* Kupr. *Rhaponticoides zaissanica* Kupr., A.L. Ebel et Khrustaleva, *Cousinia* × *pavlovii* Kupr., Lashchinskiy et A.L. Ebel.

15.6 CREATION OF COLLECTIONS AND DISPLAYS

At present, scientific collections and displays comprising 1,630 species are assembled in the 40-hectare area of the botanical garden. The species include medicinal plants – 157 species. Collections of the genera *Lilium* L. – 190 species and varieties; *Hemerocallis* L. – 80 species and varieties; *Hosta* Tatt – 65 species and varieties; *Allium* L. – 66 species, *Bergenia* Moench – 37 taxa; *Astilbe* Hamilt. – 21 species and varieties; *Paeonia* L. – 50 species and varieties; *Iris* L. – 40 species and varieties; *Phlox* – 40 species and varieties; *Salix* L. – 122 species, hybrids, and varieties; *Syringa* L. – 33 species and varieties. A collection of the natural flora of – 504 species, rare and endangered plants – 75 species, the arboretum – 150 species.

The first display, “Systematikum,” was created in 2005. It aims to demonstrate natural flora plants, mainly from the south of Siberia, and to assess the primary introduction of wild plants in cultivation. Plants are arranged in a systematic order in accordance with A. Takhtajan’s system. In total, more than 450 species of the natural flora of the south of Western Siberia were planted in the display. The Kuzbass Botanical Garden creates such conditions for plants that are as close as possible to their natural habitats. The collection of natural flora plants delights visitors and staff with continuous flowering throughout the growing season. *Erythronium sibiricum* (Fisch. et Mey.) Kryl., *Tulipa patens* C. Agardh ex Schult. & Schult. f., *Adonis vernalis* L., *Brunnera sibirica* Steven, and others start blooming in mid-April. *Allium microdictyon* Prokh., *Bupleurum longifolium* ssp. *aureum* (Fisch. ex Hoffm.) Soó), *Linum perenne* L., and others bloom in June and July. *Sanguisorba officinalis* L., *Eryngium planum* L., and others bloom in August.

The apothecary garden of the Kuzbass Botanical Garden was laid out in 2006 and covers an area of 0.9 hectares. Its purpose is to reflect the diversity of wild-growing and cultivated official medicinal plants in Kemerovo Oblast as fully as possible and to apply the grown material in the educational process at schools and universities as well as in research. At present, the collection of medicinal plants comprises more than 150 species (curated by I. N. Yegorova). Plants in the display are arranged in groups depending on the content of biologically active substances, including plants containing vitamins, terpenoids, bitterness, polysaccharides, saponins and phytoecdysones, cardiac glycosides, simple phenols and phenol glycosides, phenylpropanoids and lignans, anthracene derivatives, tannins, flavonoids, coumarins and chromones, alkaloids, and biologically active substances of various groups. The apothecary garden has become a platform for educational and outreach activities as vocational and university students have their internships here.

The garden of topiary forms was created in 2007 and covers an area of 1 hectare. It aims to demonstrate the potential of clipping woody plants and plant plasticity under systematic clipping conditions (curated by O. O. Vronskaya). This part of the botanical garden always attracts and surprises visitors with its variety of options for shaping Siberian plants.

O. O. Vronskaya created a collection of lilies and day lilies in 2008. It comprises 190 species and varieties of lilies (*Lilium* L.) and 80 species and varieties of day lilies (*Hemerocallis* L.). The phenological spectra and the flowering time of species and varieties of the genus *Lilium*, the biomorphological parameters of vegetative organs (shoot height, number of flowers in an inflorescence, diameter of flowers), the flowering duration of one flower, and inflorescence were studied. An assessment of both the decorative indicators of species and varieties as well as the prospects of the introduction of some varieties was undertaken. The indicator role of the basic pigments of the photosynthetic apparatus (chlorophyll a and b, carotenoids) in the leaves of lily species and varieties in different vegetation phases was revealed to determine their resistance.

A collection of willows (*Salix* L.). was put together in 2010 (curated by O. O. Vronskaya, PhD, Biol.). The role of willows in soft landscaping and planting greenery in Siberian cities and towns is significantly belittled. The Kuzbass Botanical Garden holds a unique collection totaling about 120 forms, varieties, and species of the genus *Salix* L.

Alliums grow on almost all continents. The genus is characterized by an amazing variation in the flower shapes, colors, and sizes. Flowers are arranged in globular, cone-shaped, umbellate, and panicle inflorescences. They differ in flowering time and duration and are low-maintenance plants. Thus, alliums are an attractive option for novice gardeners. Nevertheless, this species is not in demand with flower growers and landscapers. The allium collection (curated by A. Ye. Nozhinkov) comprises 56 species. The collection aims to demonstrate the variety of *Allium* species and forms as well as their uses in landscape design. The collection includes species with high decorative qualities: *Allium caeruleum* Pall., *Allium schoenoprasum* L., *Allium sphaerocephalon* L., *Allium cristophii* Trautv., and others.

The collection of the *Paeonia* L. varieties and species dates back to 2008 and 45 varieties resistant to Siberian weather conditions. The planting material was provided by the Altai Botanical Garden. In subsequent years, it was enriched with the varieties brought from the Research Institute of Horticulture of Siberia named after M. A. Lisavenko (Barnaul) and amateur flower growers' private collections.

The KuzBG collection of the genus *Paeonia* L. currently holds 45 varieties that vary in the flower structure and shape. Japanese peonies have very unusual flowers. They can open quite easily and

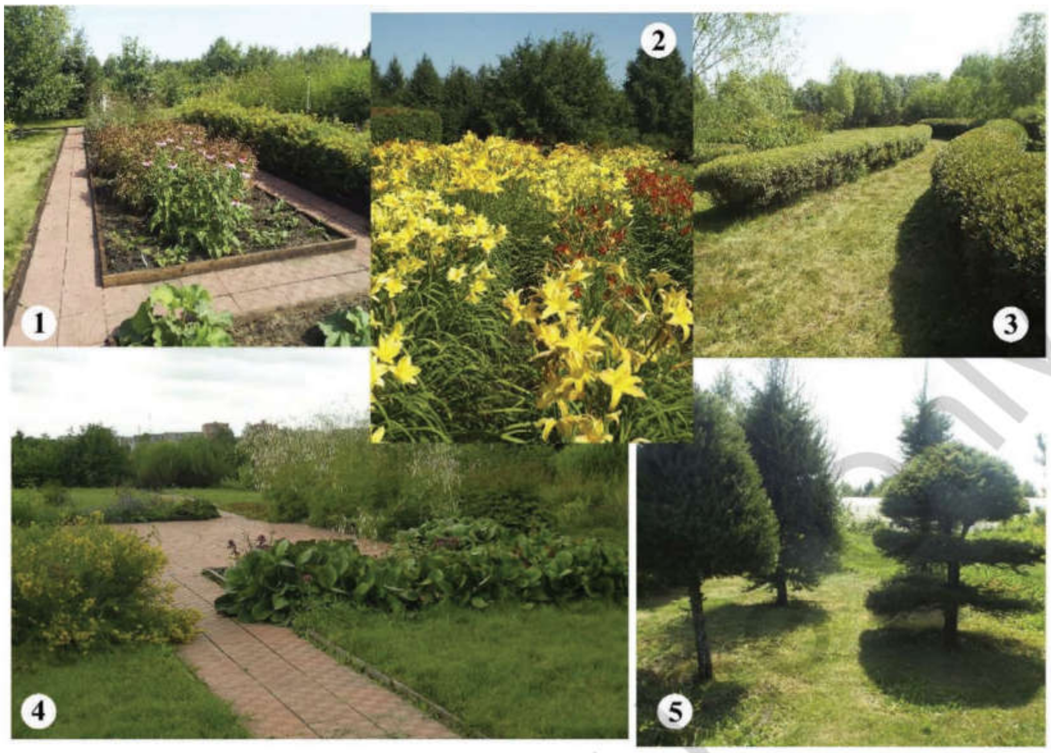

FIGURE 15.4 Expositions and collections of the botanical garden: (1) exposition of medicinal plants; (2) collection of *Lilium* L. species; (3) exposition of the *Salix* L. species; (4) sistematicum; (5) exposition of topiary forms.

quickly. Additionally, most beautiful flower arrangements can be made with them. Japanese peonies are highly frost resistant in the conditions of the south of Siberia.

The phlox collection was restored in 2016 on the initiative of T. A. Sukovatitsina. The pride of the collection is the old varieties created at the beginning of the twentieth century: Europe (1910), Viking (1914), Schneepyramide (1918), and many others. The variety Europe belongs to the widespread Continental Series created by Pfitzer. It is resistant to diseases and pests. The variety is decorative – no wonder it has been in demand for 100 years.

Moss gardens are elite displays in botanical gardens. The moss garden of the Saihō-ji Temple, which was laid out by the famous Japanese gardener Musō Soseki in the middle of the fourteenth century, is the gold standard of sophistication and elegance. The KuzBG Moss Garden was laid out in 2015 (curated by Dr. A. Ye. Nozhinkov).

15.7 BIODIVERSITY CONSERVATION

Biodiversity conservation is the foundation for humanity's habitat. All mankind strives for sustainable development, but it cannot be supported without preserving the entire complex of floral diversity as it plays the role of a buffer in the noosphere–biosphere interaction. One of the main tasks the Kuzbass Botanical Garden faces is biodiversity conservation (Global Strategy for Plant Conservation, 2011–2020; Strategy and Action Plan, 2014).

15.7.1 *Ex situ* Conservation of Plants

The Convention on Biological Diversity (1992) identifies two main ways to conserve the elements of biodiversity. *Ex situ* management means off-site conservation of plants, that is, outside their natural habitats. Article 8 of the Convention states that when a significant adverse impact on biological diversity is established, government agencies shall regulate and control the relevant processes and categories of activities. The role of botanical gardens in *ex situ* management becomes strategic as it is only possible to save populations of rare and endangered plants, study their biology, and ensure the preservation of populations in such gardens.

When designing a new coal deposit, it is mandatory to perform a pre-design study of the territories to identify rare and endangered species. In case such plants are discovered, the Kuzbass Botanical Garden commits to preserving the reserve part of the populations in the Garden territory (Kupriyanov et al., 2017c). This methodology was reflected in Strategies for biodiversity conservation in policies and in programs for the development of the energy sector in Russia and also in the United Nations Development Programmes (Kupriyanov et al., 2017c). At present, the following populations of rare and endangered plants of southern Siberia are conserved in the botanical garden: *Adonis villosa* Ledeb., *Allium vodopjanovae* Friesen, *Astragalus follicularis* Pall., *Epipactis helleborine* (L.) Grantz, *Erythronium sibiricum* (Fisch. et C.A. Mey.) Kryl., *Gypsophila patrinii* Ser., *Linum perenne* L., *Stipa pennata* L., *Thymus marschallianus* Willd., and *Ziziphora clinopodioides* Lam. (Klimova et al., 2021).

15.7.2 *In situ* Conservation of Plants

The modern theory of biodiversity conservation is based on the ecoregional approach. A concerted effort of a great number of specialists united by the World Wide Fund for Nature resulted in identifying 200 ecoregions with high biological diversity. They are key to global biodiversity conservation. This program was called Global-200. The Kuzbass Botanical Garden took an active part in the implementation of the WWF project "Ensuring long-term biodiversity conservation in the Altai-Sayan ecoregion." A.N. Kupriyanov was the scientific editor of the monographs *A System of Specially Protected Areas in the Altai-Sayan Ecoregion* (Kemerovo, 2001) and *Biological Biodiversity of the Altai-Sayan Ecoregion* (Kemerovo, 2003).

The necessity to identify the most important botanical sites in Europe (key botanical territories) was proclaimed at the first conference of the public European organization *Planta Europa* (France) in 1995 (Anderson, 2003). The only project to identify key botanical territories in Russia was conducted in Kemerovo Oblast. This process was accelerated significantly after *Plantlife International* became involved in the work. This wild plant conservation charity financed expeditionary research in 2007–2008 within the framework of the project "A Strategy for the Conservation of Plants in the Altai-Sayan Ecoregion." Twenty-one key botanical territories (KBT) that are of paramount importance for plant conservation in Kuzbass were identified in Kemerovo Oblast. The KBT locations, the main types of habitats, unique plant species, and vegetation types requiring conservation and monitoring were specified in accordance with the criteria complying with the Global Strategy for Plant Conservation (Buko et al., 2009).

The botanical garden has proposed and created seven regional zakazniks (nature reserves) in Kemerovo Oblast since 2012 (the Archekassky Ridge, the Bachatsky Hills, Karakansky, the Kokuiskoye Swamp, Relict, the Luchshevo Uvaly, Thaidon) and two botanical nature monuments (Artyshta and the Kostenkovsky Rocks). A list of prospective natural areas was prepared at the suggestion of the Kuzbass Botanical Garden at the beginning of 2019. The list included 16 sites for creating specially protected natural areas (SPNA). The inclusion of new areas in the regional SPNA system will increase the area by 165,000 hectares, thus making the proportion of protected areas equal to 15%.

15.7.3 Red Data Books

The Russian Red Data Book (2008) is a list of rare and endangered organisms. This annotated list of species and subspecies indicates their current and past distributions, number and reasons for

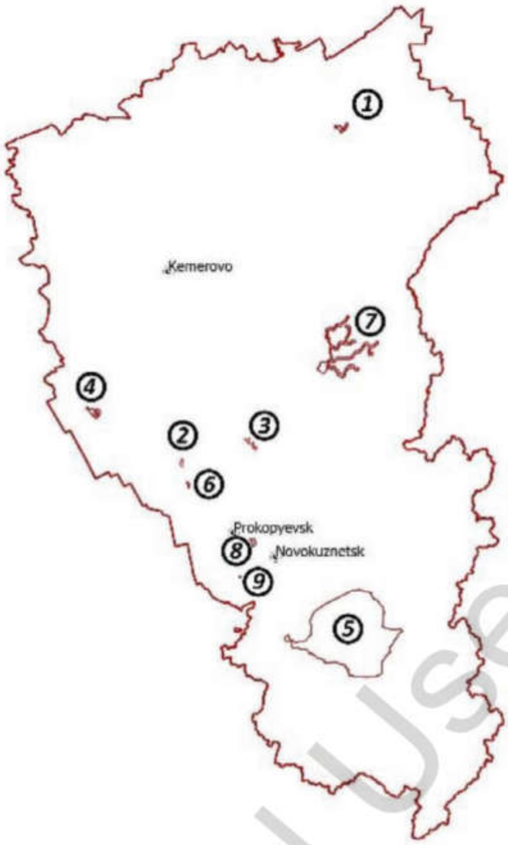

FIGURE 15.5 Nature reserves: (1) Archekassky Ridge; (2) Bachatsky Hills; (3) Karakansky; (4) Kokuiskoye Swamp; (5) Relict; (6) Luchshevo Uvaly; (7) Thaidon. Botanical nature monuments: (8) Artyshta; (9) Kostenkovsky Rocks.

its reduction, reproduction features, the measures already taken, and the measures necessary to conserve the species. The book advances the thesis that it is a document containing a data set concerning the protected flora and fauna and identifies measures to conserve them. Russian legislation makes provisions for publishing national and regional Red Data Books.

The Red Book of the Kemerovo Region – Kuzbass. (2021) is an integral part of the regional component of environmental education and upbringing. It is essential to enhance the population's local history knowledge and to shape public opinion concerning the necessity to conserve floral diversity, especially the rarest and most vulnerable plants living in the area. In this case, the Red Data Book is considered a source of local history information that public education specialists lack. Botanical research performed by the botanical garden staff in many ways contributes to the formation of a list of the species to be conserved. A.N. Kupriyanov is the executive editor of the second (2012) and third (2021) editions of the Kuzbass Red Data Book.

It is difficult to overestimate the importance of the Red Books. Since the plants included in them have state and regional protection, mining companies are obliged to carry out their activities taking into account the conservation of these species and their places of growth. Red Books are the most important factor in environmental education and education of the population and help to organize plant protection in certain areas. The presence of species listed in the Red Book provides justification for the creation of new SPNA.

15.7.4 Environmental Education and Upbringing

The threat of a global environmental crisis on the cusp of the twentieth and twenty-first centuries determines the necessity to develop strategies for building optimum relationships between man and nature. The United Nations Conference on Environment and Development (Rio de Janeiro, 1992) made several important decisions related to the environment. Many countries, including Russia, signed the Convention on Biological Diversity. These events marked the key boundary in the history of human civilization. Almost 30 years have passed since that momentous forum held in Rio de Janeiro, but there has been no significant paradigm change from the extensive to intensive economic management yet. The attempt to combat global warming through a global concerted effort of mankind focused on the implementation of treaties was not a success as the Kyoto Protocol (1997) did not lead to the desired results, and the 2009 Copenhagen accord also failed.

The reason for such slow progress toward greening, energy saving, and the modernization of both technologies and lifestyles is in the first place the human factor. Economic, political, and national interests are of secondary importance. The human egocentric world view prevents the "resetting" of people's morality. There are too few proponents of environmental ethics and environmental morality; they do not constitute a critical mass capable of changing the existing paradigm. The necessity to engage in environmental and botanical education and upbringing is determined by the position of botanical gardens between the research into fundamental processes in plants and the activity that is open to the public and whose results are shown to society.

Shaping an environmental worldview is a complex, multifaceted process that, in principle, must begin at an early age. It is based on the following three pillars: environmental pragmatism and practicability, environmental ethics, and environmental local history education. The principle of environmental local history education rests on several axioms: you cannot love what you do not know; you cannot save what you do not love; you cannot save nature globally. Thus, the understanding of the global nature of the processes taking place on the planet should be balanced with the responsibility for the environmental well-being of a particular person's place of residence. The botanical garden staff developed an environmental and local history methodology of environmental education and upbringing. It is based on the axioms mentioned earlier.

The environmental and local history methodology involves the maximum proximity of biological objects under study to the real place of students' residence. The clarification of general biological and environmental laws should be based on specific plants and animals living in students' residence.

The implementation of a large-scale project aimed at the introduction of this method was undertaken in Tashtagolsky and Belovsky districts of Kuzbass through the preparation and publication of a textbook for the regional component. For relatively small areas, *The Red Book (rare and endangered plants and animals of the Belovsky district of the Kemerovo region,* 2001) and *The Red Book (rare and endangered plants and animals of the Tashtagolsky district of the Kemerovo region,* 2014), textbooks on Botany (*Travelling with Plants Around Mountainous Shoria*, *The Green World of the Steppe Kuzbass*), textbooks on Ecology (*My House Mountainous Shoria*, *The Steppe Kuzbass Environment*), and textbooks on tourism, as well as posters and handouts for the aforementioned textbooks, were published and distributed to schools.

The botanical garden traditionally hosts ecological and biological excursions and runs sessions with school students on its premises.

Over the past 15 years, about 480,000 residents of six municipal districts participated in the experiment on the introduction of the environmental and local history methodology in the Kemerovo region, which is 18% of the total number of residents. The work was carried out within the framework of the United Nations Development Program and the Global Environment Facility (UNDP/GEF) "Conservation of biodiversity in the Russian part of the Altai-Sayan Ecoregion." Testing of students' knowledge at the end of the experiment showed the high effectiveness of this method. The students' level of knowledge about biological diversity increased by 1.7 points (from 2.1 to 3.8 points on a five-point scale).

15.7.5 Revegetation on Rock Dumps

The Kuzbass Botanical Garden is located within the area of the Kuznetsk Basin, which is one of the most extensive coal deposits in the world with estimated overall coal reserves of about 580 billion tons. Despite the progress of the "green economy," coal production is steadily growing and amounts to 230–250 million tons per year. About 9 billion tons of coal have been mined from the bowels of the Kuznetsk Basin over the whole period of mining in the area.

The downside of the coal industry development in the Kuznetsk Basin and of the increase in the share of open-pit coal mining is a rise in the area of disturbed lands. At present, they comprise 150,000 hectares. Such territories are characterized by a completely changed general profile of the earth surface and entirely or partly destroyed biological diversity.

The paradigm of sustained development of human civilization changed at the end of the twentieth century. The state of biodiversity and its conservation were chosen as the basic criterion for the necessary development. The pragmatic technologies of the fertility restoration of disturbed lands are being replaced by nature-like technologies that aim at the following: the restoration of the ecological functions of rock dumps; the restoration of the high level of biological diversity on rock dumps; the introduction of the environmental approach to natural resources management; and the creation of new nature-like technologies for the restoration of the vegetation cover of disturbed lands. To restore the biodiversity of waste rock dumps, nature-like technologies for the reconstruction and restoration of the vegetation cover on rock dumps were introduced. Such technologies accelerate the natural processes of the overgrowth of rock dumps; they ensure the creation of multi-species plant communities that approach natural communities in a short period (3–6 years).

The botanical garden staff members are developing nature-like technologies to restore the natural vegetation cover on coal mine rock dumps (Kopytov and Kupriyanov, 2019). The technology used to restore vegetation cover consists in applying a grass-seed mixture to a dump. Such mixtures are collected in areas of native vegetation similar to zonal steppe vegetation and are applied to the surface of a dump. When this method is employed, 30–40 zonal meadow-steppe species settle on the experimental site, including typical steppe species: *Artemisia austriaca*, *Dianthus versicolor*, *Elisanthe noctiflora*, *Galium verum*, *Goniolimon speciosum*, *Gypsophila patrinii*, *Hedysarum gmelinii*, *Medicago falcata*, *Seseli ledebourii*, and *Stipa capillata*. A nature-like plant community is formed in six years. By contrast, a similar community is only formed in several decades in case of natural vegetation overgrowth.

The technology employed to reconstruct vegetation cover consists in applying a soil layer containing plant seeds and rhizomes to a dump. Such soil layers are removed during quarrying for coal and are not kept in storage clamps for long. Implementing this technology makes it possible to create a nature-like plant community with rich species diversity (30–50 species) on a dump, which cannot be achieved within several decades in the case of self-organized vegetation. The development of such technologies is in accord with the global agenda to conserve biodiversity (Kupriyanov et al., 2021).

Two patents (Ufimtsev et al., 2019, Ufimtsev, 2020) have been obtained for the development of new nature-like technologies for restoring floral diversity in landfills, which are actively used by coal companies. The results of the restoration of the dumps of the coal company are presented in Figure 15.6

15.8 CONCLUSION

The role of botanical gardens in the twenty-first century will become even more critical. The global challenges include the search for new plants to cure new diseases, the development of new technologies to accelerate carbon dioxide sequestration and combat global warming, and the conservation of floristic diversity *in situ* and *ex situ*. In the context of global urbanization, the role of botanical gardens is also becoming more significant in environmental education and upbringing.

The Kuzbass Botanical Garden is one of the youngest academic botanical gardens in Russia. Thirty years of evolution is a short time for a botanical garden. Nevertheless, the challenges the Kuzbass Botanical Garden is embracing are extremely significant. They concern the study of the Siberian flora, the introduction of plants of the natural flora of southern Siberia, the digitization of

A B

FIGURE 15.6 Reconstruction of meadow-steppe plant communities on dumps: (A) 2014; (B) 2020.

the herbarium collections, the development of nature-like technologies to restore the vegetation cover of waste rock dumps, the *in situ* and *ex situ* conservation of plants, and the environmental education and upbringing of the population.

REFERENCES

Anderson, S. 2003. Identifying Important Plant Areas: A Site Selection Manual for Europe, and a Basis for Developing Guidelines for Other Regions of the World. M. *Izd-vo Predstavitel'stva Vsemirnogo soyuza okhrany prirody (IUSN) dlya Rossiii stran SNG* [In Russian].

Biological Biodiversity of the Altai-Sayan Ecoregion. 2003. Russian Representative Office of the WWF. (Sci. ed. A. Kupriyanov). Kemerovo. [In Russian].

The Black Book of the Flora of Siberia. 2016. (edited by Yu. Vinogradova & A. Kupriyanov). Novosibirsk. 440 p. [In Russian].

Buko T., S. Sheremetova, N. Lashchinsky et al. 2009. *Key Botanical Territories of the Kemerovo Region*. Kemerovo. [In Russian].

Convention on Biological Diversity. Rio de Janeiro, 5 June 1992. Convention on Biological Diversity.

Global Strategy for Plant Conservation. 2011–2020. Global Strategy for Plant Conservation: 2011–2020. Botanic Gardens Conservation International, Richmond, UK.

Klimova, O.A., V.A. Latokhin and A.N. Kupriyanov. 2021. Preservation of rare and endangered plants in conditions of intensive coal mining. *Problems of Industrial Botany of Industrially Developed Regions*. Kemerovo, pp. 53–56 [In Russian].

Kopytov, A.I. and A.N. Kupriyanov. 2019. A new strategy for the development of the coal industry in Kuzbass and solving environmental problems. *Coal*. 11: 89–93. [In Russian].

Kupriyanov, A.N. 2020. Synopsis of the flora of the Kazakh Upland. Novosibirsk. 423 p. [In Russian].

Kupriyanov, A.N., A.L. Ebel, N.N. Laschinsky and B.M. Moshkalov. 2017a. Floristic diversity of Boroldai. Shymkent. 237 p. [In Russian].

Kupriyanov, A.N., I.A. Khrustaleva, S.M. Adekenov and E.M. Gabidullin. 2017b. *Flora of Big Ulutau*. Novosibirsk. 184 p. [In Russian].

Kupriyanov, A.N., I.A. Khrustaleva, Yu. A. Manakov and S.M. Adekenov. 2008. *Plant Determinant of the Karkaraly National Park*. Karaganda. 264 p. [In Russian].

Kupriyanov, A.N., I.A. Khrustaleva, Yu. A. Manakov and S.M. Adekenov. 2013. *Determinant of Vascular Plants of Bayanaul National Park*. Novosibirsk. 215 p. [In Russian].

Kupriyanov, A.N., O.A. Kupriyanov, Yu. A. Manakov, V.I. Ufimtsev. 2021. Effects of the growth substrate on the restoration of *Stipa capillata* L. populations on refuse dumps. *Contemporary Problems of Ecology* 2021 (2): 193–200. DOI: 10.1134/S1995425521020062]. [In Russian].

Kupriyanov, A.N., O.A. Kupriyanov and A. Yu. Ovchinnikov. 2017c. Methodological recommendations for the conservation of rare plant species in the implementation of coal mining projects on the example of the conservation of *Glycyrrhiza uralensis* Fisch. and *Epipactis helleborine* (L.) Crantz. for subsequent introduction/reintroduction to places suitable for growth./Collection of methodological recommendations for the conservation and restoration of biological diversity in the implementation of economic activities of energy sector enterprises. United Nations Development Programme, Global Environment Facility: 1–12.

Kuzevanov, V. Ya. 2013. Botanic gardens and arboreta as ecological resources for sustainable development. *Role of the Arboretum and Botanical Garden against Climate Change of the East Asia (International Symposium)*, Seoul, KNA. 2013. p. 24. http://bogard.isu.ru/articles/2013_koreakuzevanov_korea_2013.pdf.

Kyoto Protocol to the United Nations Framework Convention on Climate Change. Adopted on December 11, 1997

The Red Book (rare and endangered plants and animals of the Belovsky district of the Kemerovo region) 2011. (Sci. ed. A. Kupriyanov). Kemerovo. 110 p. [In Russian].

The Red Book (rare and endangered plants and animals of the Tashtagolsky district of the Kemerovo region) 2014. (Sci. ed. A. Kupriyanov). Kemerovo. 120 p. [In Russian].

The Red Book of the Kemerovo Region – Kuzbass. Vol. 1. Rare and endangered species of plants and fungi. 2021. Kemerovo. 245 p. [In Russian].

The Red Book of the Kemerovo Region. Vol. 1. Rare and endangered species of plants and fungi. 2012. Kemerovo. 206 p. [In Russian].

The Red Book of the Russian Federation. (Plants and fungi). 2008. M. 855 p. [In Russian].

Sheremetova, S.A., I.A. Khrustaleva, A.N. Kupriyanov, T.O. Strelnikova, G.I. Yakovleva and E.B. Rotkina. 2021a. Additions to the flora of Kemerovo Region (2010–2020). *Bot. Zhurn*. 106(7): 696–702. [In Russian].

Sheremetova, S.A., I.A. Khrustaleva and P. Stieglbauer. 2021b. Biodiversity of vascular plants of Kuzbass. *Problems of Industrial Botany of Industrially Developed Regions*. Kemerovo. 2021. DOI: 10.1051/bioconf/20213100023

Sheremetova, S.A. and R.T. Sheremetov. 2020. The Tom River basin: Floristic and physico-geographical features. Novosibirsk 323 p. [In Russian].

Strategy and Action Plan for the conservation of biological diversity of the Russian Federation. 2014. M. 257 p. [In Russian].

Sultangazina, G.Zh., I.A. Khrustaleva, A.N. Kupriyanov and S.M. Adekenov. 2014. Flora of the National Natural Park "Burobai". Novosibirsk. 242 p. [In Russian].

Sultangazina, G.Zh. and A.N. Kupriyanov. 2017. Pyrogenic successions in the pine forests of the Kokshetau upland after fires. Novosibirsk. 174 p. [In Russian].

Sultangazina, G.Zh., A.N. Kupriyanov and S.V. Boronnikova (eds.). 2020. Rare plant species of Northern Kazakhstan. Kostanay. 2020. 260 p. [In Russian].

The system of specially protected natural territories of the Altai-Sayan ecoregion. 2001. Russian Representative Office of the WWF. (Sci. ed. A. Kupriyanov). Kemerovo. 173 p. [In Russian].

Ufimtsev, V.I. 2020. A method for creating sustainable forest ecosystems on dumps formed during the development of open-pit coal deposits. *Patent of the Russian Federation*. № 12831345.

Ufimtsev, V.I., A.N. Kupriyanov, Yu. A. Manakov and O.A. Kupriyanov. 2019. A method for restoring ecosystems that were disrupted during the development of mineral deposits by an open method. *Patent of the Russian Federation*. №. 2862040.