# Ecological and biological justification of the creation of tree-shrub and herbaceous compositions at sites of historical and cultural significance

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**Abstract.** Ancient manors are objects of historical and cultural significance. Modern research shows the importance of manor gardens and parks for the conservation of biodiversity. The purpose of the study is to conduct an ecological and biological substantiation of plant compositions for manor landscapes using the example of the Khvalevskoye estate in the Vologda region. Generally accepted methods of botanical gardens were used: phenological observations, assessment of the success of introduction and sustainability, assessment of ornamental plants; agrochemical methods of soil research. The study has been conducted in the Khvalevskoye estate in the Vologda region of the Russian Federation since 2015. The reconstruction and landscaping were carried out while preserving the elements of classical landscape design and the historical appearance of the parterre area. Compositions of flower beds and tree and shrub groups have been developed. Coniferous trees and shrubs (9 varieties), ornamental shrubs (6 varieties) and perennial herbaceous plants (36 varieties) were used in the landscaping process. The main criteria for selecting specific species and varieties were ecological and biological characteristics, decorative properties, flowering phenology, climatic and soil conditions, requirements for agrotechnical maintenance, as well as potential susceptibility to diseases and pests. The plants were planted in mixed borders, flower beds and in strips. A plant flowering calendar has been developed. Thus, the created flower beds convey the historical appearance of the estate, while giving a landscape to the historical and cultural object and contribute to the conservation of biodiversity.

## 1 Introduction

Modern landscaping of historical landscape architecture sites is a highly complex and specific task. There arises a need to adapt the historical territory to contemporary tasks and needs without disrupting the historical appearance of the site [1, 2]. When landscaping and

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urban greening historical sites, special attention is paid to architectural design, park areas, gardens, and alleys [3].

Modern research includes the study of the historical composition of tree plantations, their current phytosanitary condition, the identification of lost species, and the possibilities of replacing them with modern analogues [4]. In the reconstruction and improvement of estates, the main task is to preserve the historical appearance of the territory, including the arrangement of the parterre zone.

Some scientists have conducted studies of ancient manor gardens and parks. Daphne Langguth [5] has researched multiproximal approaches in archaeology. The most effective methods include microbotanical methods such as palynological and phytolytic analyses, as well as the study of macrobotanical residues, including wood, charcoal, seeds and fruits. The main focus is on the ancient gardens of the Mediterranean and the Middle East, but the approaches discussed and the conclusions drawn are applicable to ancient gardens around the world. After reconstructing the flora of a particular garden using various archaeobotanical methods, it becomes possible to recreate the sensory experience of its visitors.

Studies have been conducted in Estonia and the Czech Republic that provide insight into the importance of manor gardens and parks for the conservation of biodiversity.

Jaan Liiraa et al. [6] concluded that old rural manor parks provide an ecosystem service for nature conservation by harbouring forest biodiversity, and should be considered as potential refugium habitats.

Markéta Šantrůčkováa et al. [7] concluded that nature friendly managed manor gardens can provide a conservation function of local natural habitats and their biodiversity especially in intensively managed landscapes.

It is general practice, the parterre zone of many estates is occupied by flowerbeds and ornamental shrubs. The assortment of vegetation used in landscaping should be selected in accordance with the characteristics of each plant. Knowledge of the assortment of tree, shrub, and herbaceous species, forms, and cultivars suitable for the ecological and geographical conditions of a particular settlement is essential.

In urban landscaping, the most widely used plants are single-season species, primarily flowering annuals and ornamental foliage plants. In the floral-decorative design of recreational areas, perennial species with pronounced volumetric characteristics dominate, including woody shrubs and trees.

It is crucial to select an appropriate range of flowering plants that satisfy both aesthetic criteria and the environmental conditions of the intended cultivation site. Optimal results in ornamental planting are achieved through extensive utilization of perennial flowering-decorative species. By carefully selecting suitable plant assortments while accounting for flowering phenology, prolonged bloom continuity can be maintained from early spring through late autumn [8].

Liwen Zhang et al. [9, 10] ascertain how do flower colour combinations affect emotional response and influence therapeutic landscape design.

Findings Naixia Moua et al. [11] revealed that there is an association between flowers and visitor volumes to urban parks, with a noticeable increase in the frequency of visits to parks especially in spring (i.e., during flowering), different types of flowers have varying appeal to attract visitors.

Kapitonova R.A. et al. (2017) conducted an ecological justification for the selection of ornamental perennials for urban greening and identified nine rules:

1. The plants shall be suitable for the climatic features of this region;
2. Preference is given to true perennials;
3. Perennials that are resistant to diseases and pets are recommended;

4. The basis of the assortment should consist of consistently decorative species and varieties;

5. Preference is given to plants that are difficult to dig up and proligerous;

6. It is not advisable to use exclusive species and varieties;

7. Plants that are hazardous to health are not recommended;

8. The use of groundcover plants that are labor-intensive and poorly competitive against weeds should be limited;

9. In public urban flower beds, the cultivation of plants requiring annual digging is not recommended.

The specified regulations can be applied not only to urban landscaping but also to the greening of parks, gardens, squares in small settlements, curtilage areas, sanatoriums, and estates. In estate landscaping, the proper selection of shrub and herbaceous plant assortments, along with the high-quality and timely execution of agro-technical measures, is of particular importance.

The objective of the study is to conduct an ecological and biological justification of plant compositions for estate landscapes, using the example of the Khvalevskoye estate in the Vologda region.

## 2 Objects and methods

The research object is the woody-shrub and herbaceous vegetation of the parterre zone of the Khvalevskoye estate in the Vologda region. The study has been conducted since 2015.

Khvalevskoye Estate is located in the northwest of the Vologda region, in the village of Borisovo-Sudskoe. It is one of the historical noble estates in the Vologda region. The estate served as the main ancestral home of the ancient Russian noble families of Kachalov and Dolgovo-Saburov. It was built between 1854 and 1856 by N.A. Kachalov, a Privy Councillor, Governor of Arkhangelsk (1869–1870), and head of the Russian Empire's Customs. Since 2009, the Kachalov family descendants have undertaken restoration and reconstruction of the estate and its surrounding territory. In 2014–2015, landscaping of the estate’s park and parterre zone was carried out. The reconstruction and landscaping were performed while preserving elements of classical landscape design and the historical appearance of the parterre zone. A selection of woody-shrub and herbaceous plants was made for the landscaping.

When landscaping the estate, it was essential to consider its historical significance and design. The Khvalevskoye estate has preserved historical records only about the trees that were planted, such as the 170-year-old pedunculate oak (Quercus robur) growing on the estate.

At the same time, there are no detailed records on the arrangement of the parterre zone with shrubs and flower beds, or they are only partially described or depicted in photographs. This makes it challenging to select suitable species and varieties of woody-shrub and herbaceous plants that fit into the historical concept of the estate. However, this also allows for the introduction of new species and varieties of shrubs and flowers into the plant compositions.

The goal of landscaping the parterre zone of Khvalevskoye Estate was to create flower beds with continuous blooming. When selecting the plant assortment, natural and climatic conditions and the ecological and biological characteristics of shrubs and herbaceous plants were considered. This included flowering periods and duration, longevity in plantings, stability in maintaining decorative appeal, ensuring continuous blooming, and other factors. The plants were arranged in mixed borders, flower beds, and ribbon plantings.

Before planting, soil studies were conducted. Using the "Agrochemist" test system, soil acidity was measured. The estate’s soil was found to be close to neutral or neutral (pH =

6.5), making it suitable for creating most floral compositions from the selected plant assortment.

## 3 Results

Available from the research, the species composition of woody, shrub, and herbaceous vegetation in the Khvalevskoye estate of the Vologda region was identified. The landscaping process incorporated coniferous trees and shrubs, ornamental shrubs, and perennial herbaceous plants. The primary criteria for selecting specific species and cultivars included ecological and biological characteristics, ornamental properties, flowering phenology, agro-technical maintenance requirements, as well as potential susceptibility to diseases and pests.

Conifers trees and shrubs are frequently utilized in landscaping as focal elements. Their primary advantage lies in their year-round ornamental appeal, as they belong to the category of evergreen perennials. These plants are relatively low-maintenance, well-tolerant of pruning, frost-resistant, and long-lived. A wide range of cultivars exists, varying in size—from dwarf forms to large trees—and shape, including pyramidal, spherical, conical, narrow, and spreading forms. Additionally, they exhibit a variety of colors and shades. Coniferous species harmonize well with ornamental shrubs and flowering plants (Figure 1):

**Fig. 1.** The combination of coniferous and decorative shrubs at the Khvalevskoe estate.

In urban greening of the Khvalevskoe estate, the following coniferous trees and shrubs were used: Picea pungens Koster, Thuja occidentalis Rheingold, Pinus mugo Mops, Pinus mugo Mughus, Pinus mugo Winter Gold, Juniperus horizontalisGolden Carpet, Juniperus squamata Blue Spider, Thuja occidentalis Globosa (Table 1).

**Table 1**: The assortment of coniferous trees and shrubs at the Khvalevskoe estate

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| *Picea pungens* Koste | - Evergreen plant<br>- Bluish needle color with silver, white, or green undertones<br>- Tall-growing with a dense, symmetrically conical crown<br>- Immature cones exhibit shades of purple, green, blue, red, or pink, gradually turning brown with age<br>- Ornamental appeal maintained throughout the year | - Prefers a sunny location<br>- Temperate watering (once every two weeks) during the first year, then only during drought periods<br>- Does not require fertilization<br>- Sanitary pruning twice a year | Pine-leaf cast<br>Root Rot<br>Spruce Aphid<br>Spruce Spider Mite |
| *Thuja occidentalis* Rheingold | - Evergreen plant<br>- Dwarf growth habit<br>- Young specimens have a globular crown, which matures | - Prefers a sunny location<br>- Temperate watering (once every two weeks)<br>- Fertilization at planting, | Fungal disease<br>Thuya aphid<br>Parthenolecanium fletcheri |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| | into a broad-conical or ovoid shape<br>- Golden-yellow needles, acquiring a bronze hue in winter<br>- Ornamental appeal maintained throughout the year | then twice per season starting from the fourth year: specialized fertilizers for the Cupressaceaefamily in spring and organic fertilizers in July<br>- Periodic sanitary pruning | Leaf miner moth |
| *Pinus mugo* Mops | - Evergreen dwarf plant<br>- Dense, globular green crown<br>- Cones range in color from light brown to dark brown, depending on the season<br>- Ornamental appeal maintained throughout the year | - Prefers a sunny location<br>- Regular watering for young plants; mature specimens do not require additional irrigation<br>- Fertilization with mineral supplements during the first two years<br>- Does not require pruning | Scleroderris canker<br>Pine-leaf cast<br>Aphid<br>Pine needle scale |
| *Pinus mugo* Mughus | - Evergreen dwarf plant.<br>- Crown is creeping and cushion-shaped in youth, later developing a pyramidal form with upward-growing branches<br>- Cones are yellow-brown initially, gradually turning a cinnamon<br>- Ornamental appeal maintained throughout the year. | - Prefers a sunny location<br>- Regular watering is required for young plants; mature specimens do not need additional irrigation<br>- Mineral fertilization during the first two years<br>- Does not require pruning | Scleroderris canker<br>Pine-leaf cast<br>Aphid<br>Pine needle scale |
| *Pinus mugo* Winter Gol d | - Evergreen dwarf plant.<br>- Dense, globular crown, light green in summer and golden-yellow in winter<br>- Brownish-red cones<br>- Ornamental appeal maintained throughout the year. | - Prefers a sunny location<br>- Regular watering for young plants mature specimens require no supplemental irrigation<br>- Fertilize with mineral fertilizer during the first two years<br>- Pruning unnecessary | Scleroderris canker<br>Pine-leaf cast<br>Aphid<br>Pine needle scale |
| *Juniperus h orizontalis* Golden Car pet | - Evergreen dwarf plant.<br>- Dense spreading crown groundcover form<br>- Bright yellow foliage on upper surfaces greenish-yellow within the crown interior<br>- Dark blue berry-like cones<br>- Ornamental appeal maintained throughout the year. | - Prefers a sunny location, partial shade<br>- Temperate watering for young plants mature specimens require no supplemental irrigation<br>- Fertilize with mineral fertilizer in spring | Rust disease, Pine-leaf cast<br>Biatorella canker<br>Aphid<br>Spruce spider mite<br>Gall midges Sawflies<br>Pine shoot moth |
| *Juniperus s quamata* Blue Spider | - Evergreen dwarf plant.<br>- Dense wide-spreading crown groundcover form<br>- Bright silver-blue foliage<br>- Dark blue berry-like cones - Ornamental appeal maintained throughout the year. | - Prefers a sunny location, partial shade<br>- Temperate watering young plants mature plants during drought periods<br>- Fertilize with mineral fertilizer in spring potassium-phosphorus fertilizer in autumn | Rust disease Vascular wilt Spider mite<br>Scale insect Aphid<br>Leaf miner mot |
| *Thuja occidentalis* Globosa | Evergreen dwarf shrub<br>- Globular form<br>- Dense scale-like foliage transitions seasonally from light green in spring to brown in winter | - Prefers a sunny location, partial shade<br>- Regular watering once a week<br>- Annual fertilization commencing in the third | Phytophthora<br>Arborvitae soft scale<br>Rust disease<br>Pine-leaf cast |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| | - Summer foliage coloration dark green<br>- Ornamental appeal maintained throughout the year. | year post-planting<br>- Spring pruning | |

Decorative shrubs are widely used in landscaping residential areas. They are low-maintenance, visually appealing, bloom beautifully, and boast great diversity, as well as sufficient frost resistance. They are employed for creating hedges, solitary plantings, and group compositions. Agrotechnical care involves timely watering, soil aeration, mulching, fertilization, formative and sanitary pruning, which aids in disease prevention and enhances resistance to pests.

In the landscaping of the estate's parterre zone, the following were used: Spiraea bumalda Froebelii, Bérberis Berberis thunbergii Admiration, Philadelphus tenuifolius, Cornus alba Crataegus sanguinea, Rosa rugosa «Hansa» (Table 2).

Rosa rugosa is planted in a row in front of the house's porch and, due to its lush and prolonged flowering, remains ornamental throughout the summer and part of autumn (Figure 2). The remaining shrubs are planted in mixed borders near the house, with Spiraea bumalda Froebelii also planted along the pathways and Philadelphus tenuifolius along the fence. The shrubs' flowering period begins in May and continues throughout the summer. After flowering, they retain ornamental value through foliage coloration (Cornus alba, Bérberis Berberis thunbergii Admiration) or serve as a green backdrop for perennial flowers.

**Fig. 2:** Ornamental shrubs at the Khvalevskoe estate.

**Table 2** Assortment of ornamental shrubs at the Khvalevskoe estate

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| *Spiraea bumalda* Froebelii | - Dense spherical bush shape.<br>- Arching branches.<br>- Dark green leaves.<br>- Deep magenta inflorescences. | - Sunny or partially shaded locations.<br>- Temperate watering.<br>- Fertilization during planting.<br>- Spring pruning for crown shaping. | - Leaf spot<br>- Powdery mildew<br>- Verticillium wilt<br>- Spider mite<br>- Aphid |
| *Berberis thunbergii* Admiration | - Low-growing shrub.<br>- Dense spherical form<br>- Small yellow-red flowers<br>- Seasonal leaf coloration: orange (spring), red (summer), red-orange (autumn)<br>- Bright red berries | - Sunny locations<br>- Regular watering<br>- Fertilization every 3–4 years<br>- Sanitary pruning | - Powdery mildew<br>- Rust disease<br>- Tracheomycosis wilt.<br>- Shoot dieback.<br>- Berberis aphid. |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| | persisting until mid-winter | | |
| *Philadelphus tenuifolius* | Abundant white flowers in racemose inflorescences. Fragrant aroma. | - Sunny locations<br>- Regular watering<br>- Fertilization twice a year<br>- Sanitary pruning | - Spider mite<br>- Bean aphid<br>- Green leaf weevil |
| *Cornus alba* | - Bushy shrub with dense crown.<br>- Large green leaves with burgundy edges in autumn.<br>- Bright red bark in winter. | - Partial shade or shade.<br>- Temperate watering.<br>- Fertilization once a year.<br>- Annual pruning starting from four year | - Aphid<br>- Scale insect<br>- Powdery mildew |
| *Crataegus sanguinea* | - Green foliage with reddish tint in autumn.<br>- White flowers in clusters.<br>- Red fruits persisting through winter. | - Sunny location<br>- No watering required.<br>- Fertilization twice a year:<br>- Spring: manure tea.<br>- Autumn: phosphorus-potassium fertilizer (no nitrogen). | - Powdery mildew<br>- Rust disease<br>- Leaf spot<br>- Apple aphid<br>- Leaf roller<br>- Fruit weevils |
| *Rosa rugosa* Hansa | - Abundant flowering<br>- Large pink-purple buds<br>-Strong clove-like fragrance<br>An intense fragrance with pronounced clove aroma<br>- Decorative appeal from spring to late autumn | - Sunny or partially shaded locations.<br>- No additional watering required.<br>- Organic fertilization twice a year (spring and autumn). | - Aphid<br>- Leafhoppers<br>- Powdery mildew |

Perennials with continuous flowering are not commonly used in the landscaping of parks and squares in urban areas; however, they are well-suited for the landscaping of private plots, gardens, as well as for creating mixed borders and flower beds with continuous bloom.

When creating flower beds from perennial herbaceous plants, many factors must be taken into account. Firstly, the size of the flowering plants: low-growing (up to 30 cm), medium-sized (30–80 cm), and tall-growing (over 80 cm), as well as the width of the bush as it spreads. Secondly, the timing and duration of flowering: early-blooming, mid-blooming, and late-blooming species. Within one species, there may be varieties with different flowering periods. Thirdly, the shape, size, and color of the leaves and flowers.

Among perennials, there are decorative-leaved and flowering plants. The main decorative characteristics of decorative-leaved plants are the shape, texture, and color of the leaves. In addition to plants with green leaves of various shades, there are plants with blue-gray, yellow, silver, or other-colored leaves. These plants provide the opportunity to create bright decorative compositions against the backdrop of the greenery of uniform plantings. One of the most common decorative-leaved plants is Hosta.

Flowering plants are characterized by the bright color of their flowers and the large number of inflorescences. Flowering plants may have small and inconspicuous flowers in their inflorescences, or large and brightly colored flowers, with either regular or irregular shapes. Individual parts of the flower may differ in size, color, and shape (see Figure 3).

**Fig. 3.** Flower bed continuously flowering plants at the Khvalevskoe estate.

The following perennials were used in the creation of continuous flowering beds on the estate: Hosta Green Fountain,. Hosta hybride Climax, Hosta Lancifolia, Monarda didyma, Monarda hybrida Kardinal, Delphinium consolida, Dianthus caryophyllus var. Schabaud, Dianthus barbatus, Diánthus deltoids, Dianthus caryophyllus, Calla Picasso, Lotus Pure, Lotus Vetto, Lilium Zambesi, Paeonia Oslo, Paeonia After Glow, Louis Van Houtte, Phlox paniculata, Phlox paniculata, Helenium hybr. 'Sombrero Elit', Gaillardia Arizona Sun, Gaillardia x hybrida, Armeria martima 'Rosea', Rosa groundcover "The Fairy", Rósa Nina Weibull, Rosa floribunda Jubile De St. Petersbourg, Rosa floribunda Red Leonardo da Vinci, Sedum Autumn Fire, Sedum 'Frosted Fire', Sedum Pinky, Allium Millennium, Polygonatum x hybridum Grace Barker, Astilbe arendsii Color Flash, Campanula carpatica, Iris L., Iris sibirica (Table 3).

**Table 3:** The Assortment of Perennial Herbaceous Plants at the "Khvalevskoye" Estate

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| *Hosta* Green Fountain | - Large green leaves.<br>- Lavender-colored flowers. | - Partial shade.<br>- Frequent watering.<br>- Fertilize 3 times per season until mid-July.<br>- Mulching with peat, pine needles, or grass clippings.<br>- Autumn pruning to 10 cm. | - Phyllosticta leaf spot<br>- Gray mold<br>- Sclerotinia<br>- Slugs<br>- Stem nematodes |
| *Hosta hybride* Climax | - Strongly ribbed, dark green leaves with golden margins<br>- Lavender flowers | - Sunny locations.<br>- Frequent watering.<br>- Fertilize 3 times per season until mid-July.<br>- Mulching with peat, pine needles, or grass clippings.<br>- Autumn pruning to 10 cm. | - Phyllosticta leaf spot.<br>- Gray mold.<br>- Sclerotinia.<br>- Slugs.<br>- Stem nematodes. |
| *Hosta lancifolia* | - Ovate-lanceolate, dense, glossy green leaves.<br>- Purple flowers with dark stripes on the inner petal base. | - Partial shade.<br>- Frequent watering.<br>- Fertilize 3 times per season until mid-July.<br>- Mulching with peat, pine needles, or grass clippings.<br>- Autumn pruning to 10 cm. | - Phyllosticta leaf spot.<br>- Gray mold.<br>- Sclerotinia.<br>- Slugs.<br>- Stem nematodes. |
| *Astilbe arendsii* | - Delicate small flowers in apical inflorescences.<br>- Flowers in red, pink, white, lilac, or purple.<br>- Rhombic, paniculate, or pyramidal inflorescences. | - Partial shade.<br>- Regular watering.<br>- Fertilize 3 times per summer. | - Root-knot nematodes.<br>- Strawberry root nematodes.<br>- Spittlebugs |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| *Monarda didyma* | - Small tubular flowers in dense capitate inflorescences.<br>- Colors: bright red, pink, purple, white.<br>- Leaves and stems emit a bergamot-like aroma. | - Sunny or partially shaded locations.<br>- Regular watering. | - Powdery mildew.<br>- Rust disease. |
| *Monarda hybrida* Kardinal | - Small tubular flowers in dense capitate inflorescences.<br>- Purple flowers.<br>- Dark green wavy leaves with lemon-mint aroma. | - Sunny or partially shaded locations.<br>- Regular watering. | - Powdery mildew.<br>- Rust disease. |
| *Delphínium consolida* | - Tall stems with numerous flowers.<br>- Colors: blue, purple, pink, white. | - Sunny or partially shaded locations.<br>- Regular watering.<br>- Drought-tolerant.<br>- Fertilize at the beginning and end of flowering. | - Powdery mildew.<br>- Leaf spot.<br>- Fungal diseases.<br>- Aphids. |
| *Dianthus caryophyllus* var. Schabaud | - Large flowers in soft pink, white, yellow, bright red, or purple.<br>- Pronounced fragrance. | - Sunny locations.<br>- Temperate watering. | - Alternaria blight.<br>- Rust disease.<br>- Aphids.<br>- Mites.<br>- Thrips. |
| *Dianthus barbatus* | - Bright flowers in lush inflorescences.<br>- Petal colors: white, pink, red.<br>- Bicolor contrast.<br>- Pronounced fragrance. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize at bud formation. | - Fusarium wilt.<br>- Fungal diseases. |
| *Diánthus deltoides* | - Groundcover with small pink or lilac flowers.<br>- Pronounced fragrance. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize with complex fertilizer in spring. | - Alternaria blight.<br>- Rust disease.<br>- Fungal diseases.<br>- Mole crickets.<br>- Earwigs. |
| *Dianthus caryophyllus* | - Large flowers in soft pink, bright red, or purple.<br>- Pronounced fragrance. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize at bud formation. | - Alternaria blight.<br>- Fusarium wilt.<br>- Rust disease. |
| *Lotus* Pure | - Large white lotus-shaped flowers with crimson speckles.<br>- Persistent sweet fragrance. | - Sunny or partially shaded locations.<br>- Temperate watering.<br>- Fertilize with complex mineral fertilizers in early spring, during budding, mid- and late summer. | - Gray mold.<br>- Rust disease.<br>- Spider mites.<br>- Leaf beetles. |
| *Lotus* Vetto | - Large flowers with pointed petals and wavy edges.<br>- Pink hue with thin white margins and small brown speckles. | - Sunny or partially shaded locations.<br>- Temperate watering.<br>- Fertilize with complex mineral fertilizers in early spring, during budding, mid- and late summer. | - Gray mold.<br>- Rust disease.<br>- Spider mites.<br>- Leaf beetles. |
| *Lilium* Zambesi | Large white flowers with a yellow-green star- | - Sunny or partially shaded locations. | - Gray mold.<br>- Rust disease. |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| | shaped center.<br>Pleasant fragrance. | - Temperate watering.<br>- Fertilize with complex mineral fertilizers in early spring, mid- and late summer. | - Spider mites.<br>- Leaf beetles. |
| *Paeonia* Oslo | - Low-growing with single large crimson flowers and yellow centers. | - Sunny or partially shaded locations.<br>- Temperate watering.<br>- Fertilize during flowering. | - Gray mold.<br>- Powdery mildew.<br>- Rust disease. |
| *Paeonia* After Glow | - Semi-double pink flowers. | - Sunny or partially shaded locations.<br>- Temperate watering.<br>- Fertilize during flowering. | - Gray mold.<br>- Powdery mildew.<br>- Rust disease.<br>- Aphids |
| *Paeonia* Louis Van Houtte | - Semi-double pink-crimson flowers with a silvery sheen. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize with mineral fertilizers 3 times per season. | Gray mold.<br>Powdery mildew.<br>Rust disease.<br>Aphids. |
| *Phlox paniculata* | - Dense spherical inflorescences.<br>- Wide color range.<br>- Strong fragrance.<br>- Prolonged flowering. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize in spring and during flowering. | - Powdery mildew.<br>- Rust disease.<br>- Leaf spot.<br>- Caterpillars.<br>- Slugs.<br>- Spittlebugs. |
| *Phlox paniculata* Koko Shanel | - Dwarf habit.<br>- Peach-colored flowers.<br>- Prolonged flowering. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize in spring and during flowering | - Powdery mildew.<br>- Rust disease.<br>- Leaf spot.<br>- Caterpillars.<br>- Slugs.<br>- Spittlebugs. |
| *Helenium hybr.* Sombrero Elit | - Daisy-like flowers in brown, red, purple, orange, or yellow. | - Sunny locations.<br>- Regular watering.<br>- Fertilize 3 times per year. | - Snails. |
| *Gaillardia* Arizona Sun | - Large red, orange, or yellow daisy-like flowers with serrated edges.<br>- Spiky seed heads post-flowering.<br>- Ornamental throughout the season. | - Sunny locations.<br>- Infrequent watering.<br>- Fertilize 3 times per season: early spring, during budding, and before frost. | - Powdery mildew.<br>- Gray mold.<br>- Aphids. |
| *Gaillardia x hybrida* | - Large red, orange, or yellow daisy-like flowers with serrated edges.<br>- Spiky seed heads post-flowering. | - Sunny locations.<br>- Infrequent watering.<br>- Fertilize 3 times per season: early spring, during budding, and before frost. | - Powdery mildew.<br>- Gray mold.<br>- Aphids. |
| *Armeria martima* Rosea | - Evergreen low-growing plant.<br>- Dark green cushion-like foliage in winter.<br>- White, pink, or red flowers. | - Sunny locations.<br>- Infrequent watering.<br>- No fertilization needed. | - Leaf spot.<br>- Root rot. |
| *Rósa* Nina Weibull | - Dark red double flowers. | - Sunny locations.<br>- Temperate watering. | - Leaf spot.<br>- Scale insects. |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| | - Fragrant aroma. | - Fertilize with nitrogen (spring), phosphorus, and potassium (summer).<br>- Winter protection recommended. | - Thrips.<br>- Spittlebugs. |
| *Rosa floribunda* Jubile De St. Petersbourg | - Bicolor white and crimson buds with smooth color transition .-Subtle sweet fragrance. | - Sunny or partially shaded locations.<br>- Regular watering.<br>- Fertilize 3 times per year: nitrogen in spring, phosphorus and potassium in autumn.<br>- Winter protection recommended. | - Powdery mildew.<br>- Black spot.<br>- Rust disease.<br>- Gray mold.<br>- Mole crickets.<br>- Spittlebugs. |
| *Rosa floribunda* Red Leonardo da Vinci | - Dark red double flowers.<br>- Mild fruity aroma. | - Sunny or partially shaded locations.<br>- Regular watering.<br>- Fertilize up to 6 times per season (compost, humus, mineral blends). | - Black spot.<br>- Chlorosis.<br>- Scale insects.<br>- Thrips.<br>- Spittlebugs. |
| *Sedum* Autumn Fire | - Large pink-copper inflorescences.<br>- Foliage and flowers remain attractive in winter. | - Sunny locations.<br>- Water only during extreme drought.<br>- No fertilization needed. | - Sawflies.<br>- Aphids.<br>- Spider mites.<br>- Leaf rollers. |
| *Sedum* Frosted Fire | - Light green leaves with white margins.<br>- Large white-pink inflorescences.<br>- Winter-persistent foliage and flowers. | - Sunny locations.<br>- Water only during extreme drought.<br>- No fertilization required. | - Sawflies.<br>- Aphids.<br>- Spider mites.<br>- Leaf rollers |
| *Sedum* Pinky | - Low-growing habit.<br>- Green leaves with gray-pink edges.<br>- Large pink inflorescences.<br>- Decorative until frost. | - Sunny locations.<br>- Temperate watering.<br>- No fertilization required. | - Sawflies.<br>- Aphids.<br>- Spider mites.<br>- Leaf rollers |
| *Allium* Millennium | - Abundant flowering ornamental onion.<br>- Purple spherical inflorescences. | - Sunny locations.<br>- Temperate watering.<br>- No fertilization needed. | - White rot.<br>- Downy mildew.<br>- Onion fly.<br>- Slugs.<br>- Leaf miners. |
| *Polygonatum x hybridum* Grace Barker (*Striatum*) | - Bluish-green, slightly curly leaves with characteristic creamy stripes.<br>- White bell-shaped flowers<br>- Arrangement of flowers on the stem. | - Partial shade or shade.<br>- Temperate watering.<br>- No fertilization required | - Snails.<br>- Sawfly larvae. |
| *Astilbe arendsii* Color Flash | - The leaves are yellow-green with a purple edge in the first half of summer, darken during the flowering period, and then lighten in the center, with dark green edges remaining.<br>- Inflorescence – a large lavender panicle. | - Partial shade.<br>- Regular watering.<br>- Fertilize 4 times per year: nitrogen in spring, potassium pre-flowering, phosphorus post-flowering, compost in autumn. | - Fusarium wilt.<br>- Aphids.<br>- Root-knot nematodes.<br>- Spittlebugs. |

| Culture | Ornamental characteristics | Plant care | Diseases and pests |
|---|---|---|---|
| Campanula carpatica (*Campanula carpatica*) | - Bell-shaped large flowers in light blue, blue with a purple tint, or white. | - Sunny location.<br>- Watering during dry periods.<br>- Fertilizing twice a year. In late March – nitrogen fertilizers. During the flowering period – organic fertilizers for flowering plants. | - Fungal diseases.<br>- Snails.<br>- Slugs.<br>- Spittlebugs. |
| *Rosa groundcover* The Fairy | - Double pink flowers, fading to pale pink, sometimes almost white.<br>- Abundant blooming.<br>- Delicate fragrance with apple notes | - Sunny or partially shaded locations.<br>- Temperate watering.<br>- Fertilize twice: nitrogen in spring, phosphorus and potassium during budding.<br>- Winter protection. | - Powdery mildew.<br>- Gray mold.<br>- Nematodes.<br>- Aphids.<br>- Spider mites. |
| *Iris sibirica* | - Flowers in lilac, blue, white, or yellow. | - Sunny locations.<br>- Temperate watering.<br>- Fertilize twice per season: early spring and pre-/post-flowering. | - Alternaria blight.<br>- Ascochyta blight.<br>- Heterosporiosis.<br>- Root rot.<br>- Bacterial soft rot.<br>- Fusarium wilt.<br>- Onion mite.<br>- Nematodes.<br>- Iris fly.<br>- Thrips.<br>- Cutworms. |
| *Iris L.* | - Low-growing habit.<br>- Flowers in purple, lilac, or yellow | - Sunny locations.<br>- Temperate watering.<br>- Fertilize twice: nitrogen-potassium in early spring, phosphorus-nitrogen 20 days later, minerals during flowering. | - Alternaria blight.<br>- Ascochyta blight.<br>- Heterosporiosis.<br>- Root rot.<br>- Bacterial soft rot.<br>- Fusarium wilt.<br>- Onion mite.<br>- Nematodes.<br>- Iris fly.<br>- Thrips.<br>- Cutworms. |

Perennial flowers are planted in mixed borders, flower beds, and ribbon beds, considering the height of the plants: tall ones (Delphinium, Polygonatum, Phlox) are placed in the background, while low-growing and ground-covering plants (Campanula carpatica, Sedum, Armeria, Gaillardia) are positioned at the front or in groups.

Perennials offer several advantages: longevity, prolonged blooming throughout the warm season, and low maintenance. Many of them can thrive in full sun, partial shade, or even full shade and are resistant to diseases and pests. Agricultural care includes timely watering, fertilization, soil loosening, weeding, and pest and disease treatment. During the blooming period, it is essential to remove dry stems and flower heads. Additionally, it is necessary to ensure that some plants do not overgrow, overshadowing and displacing others. Some flowers require special winter preparation, such as covering Rosa shrubs with spruce branches.

When creating continuous-bloom flower beds, the blooming periods of plants and their decorative features before and after flowering were considered. A flowering calendar was developed for this purpose (Table 4). The table shows the flowering periods and flower color (F), as well as the foliage color of the plants (L).

**Table 4**: Flowering calendar of plants at the Khvalevskoye estate

| Culture | May | June | July | August | September | October |
|---|---|---|---|---|---|---|
| Ornamental shrubs | | | | | | |
| *Spiraea bumalda* Froebelii | L | L | F | F | F | L |
| *Berberis thunbergii* Admiration | F | F | L | L | L | L |
| *Philadelphus tenuifolius* | L | F | F | L | L | L |
| *Cornus alba* | L | F | F | L | L | L |
| *Crataegus sanguinea* | F | L | L | L | L | L |
| Rosa rugosa Hansa | L | F | F | F | F | L |
| Perennial flowers | | | | | | |
| *Hosta* Green Fountain | L | L | L | F | F | L |
| *Hosta hybride* Climax | L | L | F | L | L | L |
| *Hosta lancifolia* | L | L | | F | F | L |
| *Astilbe arendsii* | L | F | F | F | L | L |
| *Monarda didyma* | L | F | F | F | L | L |
| *Monarda hybrida* Kardinal | L | F | F | F | L | L |
| *Delphínium consolida* | L | F | F | F | L | L |
| *Dianthus caryophyllus* var. Schabaud | L | F | F | F | F | F |
| *Dianthus barbatus* | L | F | F | F | L | L |
| *Diánthus deltoídes* | L | F | F | L | L | L |
| *Dianthus caryophyllus* | L | F | F | F | F | F |
| *Lotus* Pure | L | L | F | F | L | L |
| *Lotus* Vetto | L | L | F | F | L | L |
| *Lilium* Zambesi | L | L | F | F | L | L |
| *Paeonia* Oslo | F | F | L | L | L | L |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Paeonia* After Glow | F | F | L | L | L | L |
| *Paeonia* Louis Van Houtte | L | F | L | L | L | L |
| *Phlox paniculata* | L | | F | F | F | L |
| *Phlox paniculata* Koko Shanel | L | F | F | F | F | L |
| *Helenium hy br.* Sombrero Elit | L | F | F | F | F | L |
| *Gaillardia* Arizona Sun | L | F | F | F | F | L |
| *Gaillardia x hybrida* | L | F | F | F | F | L |
| *Armeria martima* Rosea | F | F | L | L | L | L |
| *Rósa* Nina Weibull | L | F | F | F | F | L |
| *Rosa floribun da* Jubile De St. Petersbourg | L | F | F | F | F | F |
| *Rosa floribun da* Red Leon ardo da Vinci | L | F | F | F | F | F |
| *Sedum* Autumn Fire | L | L | F | F | F | F |
| *Sedum* Frosted Fire | L | L | F | F | L | L |
| *Sedum* Pinky | L | L | F | F | L | L |
| *Allium* Millennium | L | L | F | F | L | L |
| *Polygonatum x hybridum* Grace Barker (*Striatum*) | F | L | L | L | L | L |
| *Astilbe arend sii* Color Flash | L | L | F | F | F | L |
| *Campanula carpatica* | L | L | F | F | F | L |
| *Rosa groundcover* The Fairy | L | L | F | F | F | F |
| *Iris sibirica* | L | F | L | L | L | L |
| *Iris L.* | F | F | L | L | L | L |

Plants with different flowering periods create the effect of continuous blooming. At the same time, it is important that wilted plants do not spoil the overall appearance of the

flower bed with dried leaves and inflorescences. For this, plant varieties that retain their decorative appeal after flowering are used.

## 4 Discussion and conclusion

All woody-shrub and herbaceous plants used in the landscaping of the Khvalevskoye estate are perennial, frost-resistant, and require minimal agricultural maintenance. They are well-suited for landscaping in the temperate zone of Russia. The range of plants is selected taking into account environmental factors: plants are grouped in relation to light, moisture, heat and soil conditions.

The combination of shrubs and herbaceous plants in flower beds was selected according to their flowering periods and duration, ensuring decorative appeal and beauty throughout the warm season. The inclusion of evergreen coniferous trees and shrubs in the landscaping helps maintain the estate's visual attractiveness year-round.

Thus, when landscaping the estate territory, the main principles of creating an ecological garden were taken into account, which made it possible to preserve biodiversity and ecosystem stability.

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