Cenopopulation dynamics of Cisbaikalia medicinal plants

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Abstract. The article provides information on the study of the dynamic processes occurring in cenopopulations of 16 species of medicinal plants used both in scientific and folk medicine (Achillea asiatica Serg., Artemisia frigida Willd., Chamaenerion angustifolium (L.) Holub, Comarum palustre L., Geranium pratense L., Dasiphora fruticosa (L.) Rydb., Fragaria orientalis Losinsk., Mentha arvensis L., Pulmonaria mollis Wulfen ex Hornem., Potentilla anserina L., Potentilla bifurca L., Ribes spicatum E. Robson, Rosa majalis Herrm., Rubus matsumuranus Levl. Et Vaniot, Spiraea salicifolia L., Vaccinium uliginosum L.): age coefficient, recovery index, development rate. Identification of the population confinement of species to existing ecological and coenotic conditions, determination of demographic parameters, study of the development dynamics, methods of self-maintenance and survival strategies serve as the basis for the rational use of plant resources. The stable and dynamically developing medicinal plant cenopopulations, with a high recovery index, with a tendency to develop towards rejuvenation, include the cenopopulations of Geranium pratense of the Ziminsky region, Pulmonaria mollis of the Alar and Irkutsk regions, Rubus matsumuranus of the Irkutsk region. The results of the analysis of the cenopopulation dynamics of the studied species made it possible to identify stable, dynamically developing cenopopulations and recommend them for use.

1 Introduction

The study of plant resources of Baikal Siberia for the purpose of their rational use and protection remains one of the main tasks of modern biology and medicine. The development of resource industries in the pharmaceutical and food industries implies the expansion of the range of medicinal types, taking into account the experience of traditional and Tibetan medicine. The search for new medicinal and food plants requires a comprehensive study of flora and vegetation, comprehensive ecological and biological
research on the basis of generalization, clarification and addition of theoretical, methodological and practical recommendations.

Population studies can be considered one of the priority areas of ecological and biological research. Identification of the population confinement of species to existing ecological and coenotic conditions, determination of demographic parameters, study of the development dynamics, methods of self-maintenance and survival strategies serve as the basis for the rational use of plant resources.

The work of many authors is devoted to the study of medicinal plants used in scientific and folk medicine. Resource science, ontogenetic and cenopopulation, introduction studies, identification of thickets of industrial importance, recommendations on scientifically grounded volumes of raw materials procurement, ecological-biological, biochemical and pharmacognostic studies, study of the technology of drying and processing of plant materials while preserving the maximum amount of biologically active substances, study the impact of recreational activities on the components of biocomplexes and other aspects considered by the authors will help to solve the problem of biodiversity conservation [1-24].

When developing the problems of preserving the biological diversity of wild-growing medicinal plants, the question inevitably arises about the criteria for an approach to the procurement of raw materials for valuable plant species. The dynamic structure of cenopopulations of medicinal plants, as a rule, is not taken into account when collecting and preparing raw materials. In this connection, the aim of our research was to study the dynamic structure of wild medicinal plant cenopopulations in the conditions of Cisbaikalia.

2 Materials and Methods

Study of cenopopulations of 16 species of medicinal plants (Achillea asiatica Serg., Artemisia frigida Willd., Chamaenerion angustifolium (L.) Holub, Comarum palustre L., Geranium pratense L., Dasiphora fruticosa (L.) Rydb., Fragaria orientalis Losinsk., Mentha arvensis L., Pulmonaria mollis Wulfen ex Hornem., Potentilla anserina L., Potentilla bifurca L., Ribes spicatum E. Robson, Rosa majalis Herrm., Rubus matsumuranus Lev. et Vaniot, Spiraea salicifolia L., Vaccinium uliginosum L.) conducted by us on the territory of Cisbaikalia (Alar, Bokhansky, Ziminsky, Irkutsk, Nizhneudinsky, Olkhonsky regions) from 1999-2012.

The determination of the age composition and number of cenopopulations of medicinal plants was carried out in accordance with the method of T.A. Rabotnov, taking into account the methodology for studying the age structure of the populations that make up the community of V.D. Aleksandrova, criteria for identifying age states and features of the course of ontogenesis in plants of various biomorphs of L.I. Vorontsova, L.E. Gatsuk, V.N. Egorova and others, L.B. Zaugolnova, L.A. Zhukova, A.S. Komar, O.V. Smirnova, as well as the principles and methods of studying the age structure of cenopopulations by Yu.A. Zlobina, E.L. Nukhimovsky [25].

When assessing each age state, three groups of features were taken into account (according to the classification of life forms of Rabotnov-Uranov): a) morphostructure of individuals and its change in ontogenesis; b) the state of integration of elements; c) the sequence of passing the stages of morphogenesis. The age state was determined mainly by the aboveground parts: the number, shape and size of leaves, the number and length of shoots, the presence of flowers and fruits. Sometimes, to clarify the age state, they dug up individual shoots or dug up the whole plant [25].

Individuals belonging to the same age state were combined into one age group. The selection of age groups of individuals was carried out in accordance with the classification of age states of T.A. Rabotnov, indexes of age states were proposed by A.A. Uranov [25].
When assessing the dynamic structure of cenopopulations, we relied on the theory of A.A. Uranova, L.A. Zhukova, including with co-authors, according to which the dynamic processes occurring in populations reflect the age coefficients, recovery index, development rate [25]. The age index was determined by the formula:

$$\Delta = \Sigma \frac{ki}{mi}$$, where

ki is the size of each age group,

mi is the “weight” of the age of one individual in each age group:

$$mi = \frac{1}{1+e^{-x}}$$,

The development rate of cenopopulations was determined by the formula proposed by L.A. Zhukova:

$$U\Delta = \Delta_2 - \Delta_1 / t_2 - t_1$$, where

$\Delta_1$ is initial age, $\Delta_2$ is final age, $t_2 - t_1$ is time interval.

The recovery index ($J_{R, \%}$) was calculated to characterize the dynamics of self-maintenance:

$$J_{B} = \Sigma j \rightarrow \nu / \Sigma g1 \rightarrow g3 \times 100\%.$$  

### 3 Results

Cisbaikalia is a region of the south of Eastern Siberia, located in the center of the Asian continent. The territory of Cisbaikalia, according to the botanical-geographical zoning, belongs to the Eurasian coniferous-forest region, the Euro-Siberian subregion and is characterized by a plain or plateau relief, the predominance of pine forests. Dark coniferous forests with the participation of spruce, cedar, fir and larch are located in elevated areas. Birch and aspen forests, as well as mixed forests with the participation of small-leaved species, are common at the site of fires.

The results of the ontogenetic structure studies of cenopopulations of the studied medicinal plants are shown in Table 1.

According to theory of A.A. Uranova and L.A. Zhukova, the dynamic processes taking place in populations reflect the age coefficients, recovery index and development rate (Table 2).

The plant communities of medicinal plants in all regions were identical, and therefore, the experimental data on the studied cenopopulations of 16 species were summarized by us and presented for the studied regions of the study.

#### Table 1. Dynamics of raw material stocks and age structure of medicinal plant cenopopulations.

| View       | Research area | Plant Communities        | Year  | p     | j1    | j2    | im    | \(v\) | \(g1\) | \(g2\) | \(g3\) | ss | s  |
|------------|---------------|--------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|----|
| Achillea   | Alar          | Pine-birch forest, forb, forb meadow | 2005  | 0.1   | 0.2   | 1.4   | 3.8   | 12.5  | 29.0  | 38.3  | 13.6  | 1.1 | -  |
|            |               |                          | 2011  | 0.3   | 0.3   | 0.6   | 1.5   | 13.0  | 20.1  | 37.6  | 24.3  | 2.3 | -  |
|            | Irkutsk       |                          | 2005  | 0.8   | 1.0   | 1.2   | 1.5   | 16.0  | 32.5  | 30.1  | 15.9  | 1.0 | -  |
|            | Ziminsky      |                          | 2010  | 0.4   | 0.2   | 0.5   | 1.1   | 27.0  | 28.9  | 23.4  | 17.5  | 1.0 | -  |
|            | Nizhneudinsky |                          | 2005  | 0.3   | 0.9   | 1.1   | 1.9   | 10.0  | 50.6  | 30.2  | 4.7   | 0.3 | -  |
|            |               |                          | 2011  | 0.3   | 1.4   | 0.5   | 1.7   | 7.6   | 67.3  | 18.4  | 1.3   | 1.5 | -  |
| Artemisia  | Olkhonsky     | Grass-forb real steps    | 2000  | 1.2   | 1.6   | 1.6   | 2.0   | 2.3   | 51.2  | 25.2  | 10.2  | 4.7 | -  |
|            |               |                          | 2011  | 0.2   | 0.3   | 0.4   | 0.7   | 0.8   | 29.5  | 29.7  | 28.9  | 9.5 | -  |
| Chamaener  | Irkutsk       | Bereznyak,               | 2000  | 0.6   | 2.0   | 6.5   | 10.3  | 13.2  | 18.4  | 40.0  | 7.0   | 2.0 | -  |
| View | Research area | Plant Communities | Year | Ontogenetic structure,% |
|------|---------------|-------------------|------|------------------------|
| | | mixed fireweed forest, grass-fireweed meadow | 2006 | 1.0 4.6 8.8 9.2 9.7 26.9 33.8 5.0 - 1.0 |
| | | | 2011 | 0.9 3.8 8.5 8.7 10.4 20.0 42.4 4.2 - 1.1 |
| Comarum palustre | Irkutsk | Bereznjak rotational, horsetail; soddy sedge meadow | 2006 | 0.6 0.6 0.8 4.4 11.0 23.2 30.6 25.9 2.3 0.6 |
| | | | 2012 | 0.6 0.6 0.6 2.3 3.3 9.7 42.5 35.4 4.0 1.0 |
| | | Yernik forb | 2005 | 1.4 1.6 2.0 3.2 8.0 46.1 35.8 1.3 0.6 - |
| | | | 2012 | 2.1 2.4 3.8 5.6 6.3 41.1 37.6 0.7 0.4 - |
| | | Yernik forb | 1999 | 0.1 0.5 0.3 3.7 15.0 40.2 36.9 2.4 0.9 - |
| Dipsophora fruticosa | Irkutsk | Yernik forb | 2005 | 0.2 0.7 2.3 5.0 12.4 39.8 35.5 2.5 1.6 - |
| | Olkhonsky | Yernik forb | 2011 | 0.3 0.3 1.1 3.6 10.7 38.2 40.4 3.6 1.8 - |
| | | Yernik forb | 2006 | 0.1 0.2 1.6 2.8 5.2 40.6 39.3 7.7 2.5 - |
| | | | 2011 | 0.6 1.3 1.3 2.2 31.8 47.8 9.6 3.2 - |
| Fragaria orientalis | Alar | Grass-strawberry-forb meadow | 2000 | 1.0 1.8 2.5 3.8 6.4 29.5 48.6 3.7 2.0 0.7 |
| | Ziminsky | Grass-strawberry-forb meadow | 2005 | 1.3 1.5 1.7 1.5 10.2 32.0 40.4 6.5 3.7 1.2 |
| | | Grass-strawberry-forb meadow | 2012 | 0.8 1.0 1.2 1.4 1.8 34.7 38.0 0.8 0.2 0.1 |
| | Olkhonsky | Grass-strawberry-forb meadow | 2005 | 0.6 1.3 2.0 2.5 4.5 22.2 45.5 10.9 10.3 0.2 |
| | | Grass-strawberry-forb meadow | 2011 | 0.1 0.5 0.6 0.9 1.1 19.2 43.0 18.6 15.0 1.0 |
| | | | 2005 | 0.5 0.8 1.4 2.1 8.2 53.3 27.7 5.0 1.0 - |
| | | | 2010 | 0.3 1.0 1.0 1.3 3.7 52.4 29.5 9.5 1.7 - |
| Geranium pratense | Alar | Grain-geranium-forb meadow | 2000 | 1.5 4.2 5.0 1.33 27.9 40.1 16.9 2.4 0.6 - |
| | Ziminsky | Grain-geranium-forb meadow | 2005 | 1.0 2.8 3.5 16.5 20.4 31.0 20.0 4.0 0.8 - |
| | | Grain-geranium-forb meadow | 2012 | 4.4 2.6 4.4 14.8 16.5 27.4 19.1 9.0 1.7 0.1 |
| | Olkhonsky | Grain-geranium-forb meadow | 2005 | 0.6 0.9 8.3 0.4 25.2 30.7 30.2 3.4 0.3 - |
| | | Grain-geranium-forb meadow | 2011 | 1.3 2.0 15.6 3.7 17.3 36.5 16.3 6.5 0.8 - |
| | | | 2000 | 1.7 3.4 6.7 9.9 14.4 38.8 22.0 1.6 1.5 - |
| | | | 2005 | 3.0 4.6 6.3 1.5 9.3 38.1 30.2 5.8 1.2 - |
| | | | 2010 | 6.2 9.3 3.1 5.2 17.0 33.4 22.5 2.9 0.3 0.1 |
| Mentha arvensis | Alar Yernik forb | Yernik forb, sedge-horsetail meadow | 2005 | 0.3 1.5 1.4 1.7 7.6 56.3 26.0 3.5 1.7 - |
| | | | 2012 | 1.4 2.3 2.7 3.6 4.1 52.2 23.9 5.8 4.0 - |
| | | Yernik forb, sedge-horsetail meadow | 2006 | 0.8 0.9 3.1 8.8 30.3 45.6 8.6 1.4 0.5 - |
| | Olkhonsky | Yernik forb, sedge-horsetail meadow | 2010 | 0.4 1.6 4.5 1.2 5.8 47.4 38.5 2.8 0.8 - |
| | | | 2006 | 0.1 0.1 0.6 1.7 9.3 58.4 27.9 1.6 0.3 - |
| | | | 2011 | 1.0 2.0 4.0 4.0 67.5 50.5 26.0 4.8 1.0 - |
| Potentilla anserina | Irkutsk | Grass-geese-leaved meadow | 2001 | 0.02 1.2 1.2 4.88 29.4 24.4 24.4 12.2 2.3 - |
| | | | 2010 | 0.02 0.05 0.06 0.85 10.6 43.3 24.3 23.6 13.6 - |
| Potentilla bifurca | Olkhonsky | Forb-cold wormwood mountain steppes | 2006 | 0.1 0.1 0.3 4.7 8.0 39.0 43.0 4.0 0.8 - |
| | | | 2011 | 0.2 0.5 1.6 2.9 5.6 35.2 46.2 6.5 1.3 - |
| Pulmonaria mollis | Alar | Bereznjak forb | 2005 | 0.3 1.9 2.8 11.6 17.5 38.0 23.9 3.0 - 1.0 |
| | Ziminsky | Bereznjak forb | 2012 | 0.4 4.0 5.0 9.9 21.5 30.0 22.0 5.5 - 1.7 |
| | | Bereznjak forb | 2005 | 0.6 2.0 1.8 3.8 29.2 22.6 22.4 16.2 - 1.4 |
| | | Bereznjak forb | 2011 | 0.2 1.1 1.6 2.5 28.7 26.0 19.7 18.0 - 2.2 |
| | | Bereznjak forb | 1999 | 0.5 2.7 3.2 16.9 14.2 37.2 23.1 2.0 - 0.2 |
| | | Bereznjak forb | 2005 | 0.8 3.0 6.6 13.5 15.2 33.8 25.2 1.7 - 0.2 |
| | | Bereznjak forb | 2010 | 0.9 5.1 8.3 14.1 8.9 38.4 21.5 2.3 - 0.5 |
| Ribes spicatum | Alar | Yernik forb | 2005 | 0.3 3.5 7.2 10.2 10.4 27.8 33.0 7.0 0.6 - |
| | | Yernik forb | 2012 | 0.6 1.3 4.6 5.3 6.0 19.9 56.3 5.3 0.7 - |
Table 2. Dynamics of medicinal plant cenopopulations.

| Research area | Age of cenopopulation, A | Recovery index, $J_R$ | Development rate, $U$ |
|---------------|--------------------------|-----------------------|----------------------|
|               | 2000 | 2005 | 2010-2011 | 2000 | 2005 | 2010-2011 | 2000-2011 |
| Achillea asiatica | | | | | | | |
| Alar          | -    | 0.396 | 0.456 | -    | 22.1 | 18.8 | 1.00 |
| Ziminsky      | -    | 0.335 | 0.314 | -    | 16.1 | 12.8 | -0.35 |
| Irkutsk       | -    | 0.385 | 0.375 | -    | 25.6 | 41.4 | -0.22 |
| Nizhneudinsky | -    | 0.337 | 0.319 | -    | 28.5 | 40.4 | -0.30 |
| Artemisia frigida | | | | | | | |
| Olkhonsky     | 0.385 | -    | 0.526 | 8.6  | -    | 2.4  | 1.28 |
| Chamaenerion angustifolium | | | | | | | |
| Irkutsk       | 0.343 | 0.434 | 0.399 | 49.6 | 50.5 | 48.5 | 0.50 |
| Comarum palustre | | | | | | | |
| Olkhonsky     | 0.385 | -    | 0.526 | 8.6  | -    | 2.4  | 1.28 |

Note: p - seedlings (shoots), j (j1, j2) - juvenile, im - immature, v - virginal (young vegetative, adult vegetative), g1 - young generative, g2 - middle-aged generative, g3 - old generative, ss - subsenile (old vegetative), s - senile.
| Research area       | Coefficients of cenopopulation dynamic |          |          |          |          |
|---------------------|----------------------------------------|----------|----------|----------|----------|
|                     | Age of cenopopulation, Δ               | Recovery index, J<sub>r</sub> | Development rate, U |
| Irkutsk             | -                                      | 0.446    | 0.366    | -        | 20.8     | 9.8     | 1.33    |
| Olkhonsky           | -                                      | 0.551    | 0.426    | -        | -        | 4.5     | 2.3     |

**Dasiphora fruticosa**

| Research year      | 1999 | 2005-2006 | 2011-2012 | 1999 | 2005-2006 | 2011-2012 |
|--------------------|------|-----------|-----------|------|-----------|-----------|
| Alar               | -    | 0.328     | 0.346     | -    | 19.8      | 25.4      | 0.25    |
| Irkutsk            | 0.128| 0.335     | 0.361     | 24.7 | 26.7      | 19.5      | 1.94    |
| Olkhonsky          | -    | 0.348     | 0.418     | -    | 15.2      | 11.4      | -2.48   |

**Fragaria orientalis**

| Research year      | 2000 | 2005     | 2010-2012 | 2000 | 2005     | 2010-2012 |
|--------------------|------|----------|-----------|------|----------|-----------|
| Alar               | 0.384| 0.394    | 0.396     | 17.9 | 18.9     | 5.8       | 0.10    |
| Ziminsky           | -    | 0.467    | 0.547     | -    | 13.3     | 3.8       | 1.33    |
| Irkutsk            | -    | 0.339    | 0.379     | -    | 14.5     | 7.2       | 0.78    |
| Nizhneudinsky      | -    | 0.348    | 0.418     | -    | 15.2     | 11.4      | 1.17    |

**Geranium pratense**

| Research year      | 2000 | 2005     | 2010-2012 | 2000 | 2005     | 2010-2012 |
|--------------------|------|----------|-----------|------|----------|-----------|
| Alar               | 0.252| 0.253    | 0.326     | 64.4 | 78.5     | 68.9      | 0.61    |
| Ziminsky           | -    | 0.294    | 0.259     | -    | 53.9     | 65.3      | -0.56   |
| Irkutsk            | 0.264| 0.316    | 0.253     | 55.2 | 29.7     | 58.6      | -0.11   |

**Mentha arvensis**

| Research year      | 2000 | 2005-2006 | 2010-2012 | 2000 | 2005-2006 | 2010-2012 |
|--------------------|------|-----------|-----------|------|-----------|-----------|
| Alar               | -    | 0.333     | 0.346     | -    | 14.0      | 15.4      | 0.19    |
| Irkutsk            | -    | 0.258     | 0.353     | -    | 24.8      | 11.4      | 2.36    |
| Olkhonsky          | -    | 0.324     | 0.319     | -    | 13.7      | 20.0      | -0.09   |

**Potentilla bifurca**

| Research year      | 1999 | 2006     | 2011     | 1999 | 2006     | 2011     |
|--------------------|------|----------|----------|------|----------|----------|
| Irkutsk            | -    | 0.368    | 0.395    | -    | 15.0     | 11.9     | 0.52    |

**Potentilla anserina**

| Research year      | 2001 | 2005-2006 | 2010 | 2001 | 2005-2006 | 2010 | 2001-2010 |
|--------------------|------|-----------|------|------|-----------|------|-----------|
| Irkutsk            | 0.387| -         | 0.403| 60.0 | -         | 13.7 | 0.17      |

**Pulmonaria mollis**

| Research year      | 1999 | 2005     | 2010-2012 | 1999 | 2005     | 2010-2012 |
|--------------------|------|----------|-----------|------|----------|-----------|
| Alar               | -    | 0.281    | 0.280     | -    | 43.0     | 71.2      | -0.005   |
| Ziminsky           | -    | 0.328    | 0.359     | -    | 61.3     | 53.5      | 0.50     |
| Irkutsk            | 0.258| 0.257    | 0.252     | 58.2 | 64.4     | 60.0      | -0.02    |

**Ribes spicatum**

| Research year      | 2001 | 2005     | 2012 | 2001 | 2005     | 2012 | 2001-2012 |
|--------------------|------|----------|------|------|----------|------|-----------|
| Alar               | -    | 0.316    | 0.390 | -    | 46.4     | 21.1 | 1.05      |
| Irkutsk            | -    | 0.320    | 0.338 | -    | 43.4     | 34.8 | 0.25      |

**Rosa majalis**

| Research year      | 2000-2001 | 2005 | 2011-2012 | 2000-2001 | 2005 | 2011-2012 | 2000-2012 |
|--------------------|-----------|------|-----------|-----------|------|-----------|-----------|
| Alar               | 0.329     | 0.355| 0.470     | 68.4      | 40.5 | 14.5      | 1.27      |
| Ziminsky           | 0.481     | 0.564| 0.650     | 41.6      | 27.2 | 8.7       | 1.69      |
| Irkutsk            | 0.256     | 0.305| 0.322     | 73.9      | 51.0 | 52.9      | 0.59      |
| Nizhneudinsky      | 0.300     | 0.365| 0.399     | 57.2      | 42.0 | 32.9      | 0.82      |

**Rubus matsumuranus**
### Coefficients of cenopopulation dynamic

| Research area | Age of cenopopulation, Δ | Recovery index, \( J_r \) | Development rate, \( U \) |
|---------------|--------------------------|--------------------------|--------------------------|
|               | 2001 | 2005 | 2010 | 2001 | 2005 | 2010 | 2001 – 2010 |
| Alar          | 0.322 | -    | 0.410 | 68.7 | -    | 67.1 | 0.98        |
| Irkutsk       | 0.345 | -    | 0.309 | 41.0 | -    | 55.0 | -0.38       |

### Discussion

The results of the analysis of the cenopopulation dynamics of medicinal plants for the studied period from 1999 to 2012, showed that the cenopopulation of *Achillea asiatica* in the Alar region is normal, long-lived, but slowly developing, with a tendency towards aging \( (U = 1) \). Gradual aging is also observed in the cenopopulation of *Rubus matsumuranus* \( (U = 0.98) \) of the Alar region, *Fragaria orientalis, Rosa majalis* and *Spiraea salicifolia* \( (U = 0.005-0.65) \) \( (U = 0.59-1.69) \) of the Alar, Ziminsky, Irkutsk and Nizhnedinsky regions \( (U = 0.1-1.33) \); *Artemisia frigida* \( (U = 1.28) \) of the Olkhonsky region; *Comarum palustre* \( (U = 1.33) \), *Mentha arvensis* \( (U = 2.36) \), *Potentilla bifurca* \( (U = 0.52) \), *Potentilla anserina* \( (U = 0.17) \) of the Irkutsk region; *Pulmonaria mollis* \( (U = 0.50) \) of the Ziminsky region; *Ribes spicatum* \( (U = 0.25-1.05) \), *Rosa acicularis* \( (U = 0.30-1.29) \) of the Alar and Irkutsk regions; *Vaccinium uliginosum* \( (U = 0.50) \) of the Olkhonsky region.

The cenopopulation of *Chamaenerion angustifolium* is stable and rapidly developing \( (J_r = 48.5 - 50.5) \), the species is regenerated both by seed and vegetative means. A high recovery index was also noted in *Pulmonaria mollis* \( (J_r = 43-71.2) \). Fluctuations in the dynamics of age and recovery index for *Geranium pratense* \( (J_r = 29.7-78.5) \), *Potentilla anserina* \( (J_r = 13.7-60) \), *Pulmonaria mollis* \( (J_r = 43-71.2) \), *Rosa majalis* \( (J_r = 8.7-73.9) \), *Rubus matsumuranus* \( (J_r = 41-68.7) \), *Spiraea salicifolia* \( (J_r = 27.8-58.2) \) and other species over the studied period of time, can be associated with biomorphological features of the species, for example, with the ability of the rhizomes of *Chamaenerion angustifolium* and other species to partially die off, fall out of the clone structure and quickly replace the fallen shoots with young vegetative particles, as well as with climatic features of the year (dry growing season), anthropogenic (irrational procurements of raw materials, pasture digestion) and pyrogenic factors.

The cenopopulation of *Dasiphora fruticosa* is quite stable, periodically renewing by seed. The moderately pronounced seed renewal of *Dasiphora fruticosa* \( (J_r = 6.5-26.7) \) is possibly associated with the weak ability of seeds to germinate in a dry climatic period. Development towards rejuvenation is observed in the Olkhonsky cenopopulation of *Dasiphora fruticosa* \( (U = - 2.48) \), a fairly young Alar cenopopulation \( (U = 0.25) \).

Gradual rejuvenation is also observed in the cenopopulation of *Achillea asiatica* of the Ziminsky, Irkutsk and Nizhnedinsky regions \( (U = - 0.22 - 0.35) \), *Geranium pratense* of the Ziminsky and Irkutsk regions \( (U = - 0.11-0.56) \), *Rubus matsumuranus* \( (U = - 0.38) \) of the Irkutsk region. The Irkutsk cenopopulations of *Vaccinium uliginosum* \( (U = - 0.30) \) and others stable and dynamically developing cenopopulations of *Pulmonaria mollis* are
developed with rejuvenation, while development towards rejuvenation, with good seed renewal, is observed in coenopopulations of *Pulmonaria mollis* of the Alar (*U* = - 0.005) and Irkutsk regions (*U* = - 0.02).

## 5 Conclusions

The stable and dynamically developing cenopopulations of medicinal plants, with a high recovery index (*J*$_R$ ≥ 50), with a tendency to develop towards rejuvenation, include the cenopopulations of *Geranium pratense* of the Ziminsky region; gradual rejuvenation is observed in the coenopopulations of *Pulmonaria mollis* of the Alar and Irkutsk regions, *Rubus matsumuranus* of the Irkutsk region. Irkutsk cenopopulations of *Chamaenerion angustifolium*, *Rosa majalis*, Ziminsky cenopopulations of *Pulmonaria mollis*, Alar cenopopulations of *Geranium pratense*, *Rubus matsumuranus*, *Spiraea salicifolia* develop with a tendency towards aging.

The results of the analysis of the cenopopulation dynamics of the studied species for the studied period of time (1999-2012) made it possible to identify stable, dynamically developing cenopopulations and recommend them for use. Determining the demographic parameters of useful plants, studying the dynamics of development, methods of self-maintenance and survival strategies of species serve as the basis for the rational use of plant resources.

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