

Towards on the conservation of rare species *Iris glaucescens* (Iridaceae) in Novosibirsk oblast: ecoinformative multimodal analysis of the area

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Abstract. Multimodal ecoinformation analysis as a modern computational approach to geospatial investigation of biodiversity structure is performed on maximum entropy method for local populations of *Iris glaucescens* – rare species of vascular plants that is included in Red Book of Novosibirsk Oblast. The most informative environmental variables were ranged and examined in detail. According to obtained results, trio of the most important variables in the scale of 1/12 arc-degree (5.0 arc-minutes) global model, includes: 1) maximum average diurnal temperature of surface air in the warmest period of a year (bio5) – 32.7%, annual mean temperature of surface air (bio1) – 11.2%, and maximum average diurnal temperature of surface air in July (tmax7) – 9.0%. Three of the most important variables in the scale of 1/60 arc-degree (1.0 arc-minutes) regional model (Zone_18) are: maximum average diurnal temperature of surface air in the warmest period of a year (bio5) – 35.7%, maximum average diurnal temperature of surface air in June (tmax6) – 23.1%, minimum average diurnal temperature of surface air in October (tmin10) – 7.7%. Therefore, climatic variables that influence on the amount of heat in the warmest period of a year, may be taken into account as factors, limiting population size of *I. glaucescens*.

1 Introduction

Modelling of a geospatial pattern for any chosen biological taxa is the actual task in rational nature using and bioresources saving, because for effective conservation of any rare and endangered species we need at first to see in what climatic conditions it prefers to live, and what are its specific requirements for survival, its ecological niche [1, 2].

Iris glaucescens Bunge is the rare species of vascular plants included in the Red List of the Novosibirsk region.

According to the published data [3, 4], the climatic factors limiting the number of populations of this species on territories of Novosibirsk oblast are not defined still.

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The purpose of this scientific research is the ecoinformative multimodal assessment of the general (total) environmental situation in the area of *Iris glaucescens* in Novosibirsk Oblast, with determination the set of the most influential climatic variables limiting its distribution on this territory, and quantitative analysis of variables position in climatic spectra.

To achieve this goal, the following tasks were set: 1) build global and regional models of an area of the species in different scales; 2) develop the protocol for assessing the level of favorable environmental conditions in and around the locality; 3) build climate spectra for each obtained model; 4) range the most influential climate variables and quantify them in different models; 5) determine the factors limiting the distribution of the species on the territory of Novosibirsk region.

2 Material and methods

Data on this species locations on the territory of Novosibirsk Oblast are received from the published sources [3, 4] and verified with the scientific collection and bioresources database of Central Siberian Botanical Garden, Siberian Branch of Russian Academy of Science «Herbarium of vascular plants, lichens and fungi (NS, NSK)», available at the address <http://herb.csbg.nsc.ru:8081/>. Herbarium specimens were tested in according to the stable combination of diagnostic features for *Iris glaucescens*: crescently curvated external leaves, slightly leaf venation and the thicked rhizome covered with the split remains of leaves [5]. This combination of diagnostic characters makes exactly distinguishing this species from closely related *Iris ludwigii* [6].

The study was performed for four local populations: 1) the vicinity of Nadyr swamp in Karasuk district of Novosibirsk Oblast (specimen NS0027297), with coordinates 077.60E, 53.49N; 2) the vicinity of Astrodym village in Karasuk district of Novosibirsk Oblast [3, 4], with coordinates 077.76E, 53.65N; 3) the vicinity of Rasskasovo in Karasuk district of Novosibirsk Oblast [3, 4], with coordinates 077.95E, 53.66N; 4) the vicinity of Eretnaya village in Ordynskoe district of Novosibirsk Oblast [3, 4], with coordinates 082.09E, 54.34N.

Probabilistic models for the distribution of the species in Novosibirsk Oblast are constructed on climate layers imported from WorldClim, an international database of world climate, available at <http://www.worldclim.org>. Climatic layers in WorldClim are generated on the direct measurements of near 60 000 meteorostations through all the world [7], and only stations with a full range of observations of at least 30 years were selected. In the study, climatic data for 1970-2000 years were taken, including the period of *Iris glaucescens* registration. According to experimental data and their expert assessment, the most informative models can be constructed with complete set of all available climatic variables. We have excluded from regional modelling only altitude indicator which not climatic factor, but can significantly change the spathial pattern of a model. Simuration was run in MAXENT computer program based on maximum entropy method [8].

3 Results

In the global model of 1/12 arc-degree resolution (near 50,76 sq. km per a cell), the top 10 of the most informormative factors is, in decrease order (Table): (1) maximum average diurnal temperature of surface air in the warmest period of an year (bio5) – 32.7%; (2) annual average temperature of surface air (bio1) – 11.2%; (3) maximum average diurnal tempreature of surface air in July (tmax7) – 9.0%; (4) minimum average diurnal tempreature of surface air in October (tmin10) – 7.7%; (5) maximum average diurnal

temperature of surface air in June (tmax6) – 5.9%; (6) maximum average diurnal temperature of surface air in April (tmax4) – 5.3%; (7) minimum average diurnal temperature of surface air in February (tmin2) – 4.8%; (8) maximum average diurnal temperature of surface air in August (tmax8) – 4.0%; (9) average monthly temperature of surface air in October (tmean10) – 3.9%; and (10) maximum average diurnal temperature of surface air in October (tmax10) – 3.0%. Other factors have input less than 3.0%.

Table. The most informative variables in the global and the regional climatic spectra for the area of *Iris glaucescens* in Novosibirsk Oblast

Spathial scale (in a degree)	Jackknife		Jackknife		Average rank
	1/12	1/12	1/60	1/60	
Climatic variables and its ranks					
bio5 / bio5_18	1	1	1	1–2	1,125
bio1 / bio1_18	2	3	4	4	3,25
tmax7 / tmax7_18	3	2	(15)	1–2	5,375
tmin10 / tmin10_18	4	–	3	6	–
tmax6 / tmax6_18	5	–	2	3	–
tmax4 / tmax4_18	6	–	10	–	–
tmin2 / tmin2_18	7	4	(14)	–	–
tmax8 / tmax8_18	8	–	(20)	5	–
tmean10 / tmean10_18	9	7	–	8–9	–
tmax10 / tmax10_18	10	–	–	–	–
tmin1 / tmin1_18	(13)	5	7–8	–	–
bio6 / bio6_18	(11)	6	–	–	–
tmean12 / tmean12_18	(24)	–	5	–	–
tmean4 / tmean4_18	(16)	8	9	8–9	–
tmin5 / tmin5_18	–	9	–	–	–
tmin9 / tmin9_18	–	10	–	–	–
tmin4 / tmin4_18	–	–	7–8	7	–
bio3 / bio3_18	(23)	–	–	10	–
tmax1 / tmax1_18	–	–	6	–	–

Jackknife test on the world level produces the other top 10 of the climatic spectrum, in decrease order (see Table): (1) maximum average diurnal temperature of surface air in the warmest period of an year (bio5) – near 4.0 points RTG (regularized training gain) of total 7.181, (2) maximum average diurnal temperature of surface air in July (tmax7) – 3.7; (3) average annual temperature of surface air (bio1) – 2.6; (4) minimum average diurnal temperature of surface air in February (tmin2) – 2.5; (5) minimum average diurnal temperature of surface air in January (tmin1) – some less than 2.5; (6) minimum average diurnal temperature of surface air in coldest period of a year (bio6) – 2.3; (7) average monthly temperature of surface air in October (tmean10) – 2.1; (8) average monthly temperature of surface air in April (tmean4) – 1.9; (9) minimum average diurnal

temperature of surface air in May (tmin5) – 1.8; and (10) minimum average diurnal temperature of surface air in September (tmin9) – 1.7. Other factors have input less than 1.7 points of RTG.

In the regional model (climatic cluster Zone_18) of 1/60 arc-degree resolution (near 2,026 sq. km per a cell), we get the next climatic spectre of influence variables, in decrease order (see Table): (1) maximum average diurnal temperature of surface air in the warmest period of a year (bio5_18) – 35.7%; (2) maximum average diurnal temperature of surface air in June (tmax6_18) – 23.1%; (3) minimum average diurnal temperature of surface air in October (tmin10_18) – 7.7%; (4) average annual temperature of surface air (bio1_18) – 7.4%; (5) average monthly temperature of surface air in December (tmean12_18) – 5.2%; (6) maximum average diurnal temperature of surface air in January (tmax1_18) – 2.8%; (7–8) minimum average diurnal temperature of surface air in April (tmin4_18) – 2.8%; (7–8) minimum average diurnal temperature of surface air in January (tmin1_18) – 2.7%; (9) average monthly temperature of surface air in April (tmean4_18) – 2.6%; and (10) maximum average diurnal temperature of surface air in April (tmax4_18) – 1.9%. Other variables have input less than 1.6%.

Jackknife test on the region level produces the next climatic spectrum, in decrease order (see Table): (1–2) maximum average diurnal temperature of surface air in the warmest period of an year (bio5_18) and maximum average diurnal temperature of surface air in July (tmax7_18) – nearly 2.0 points RTG (regularized training gain) of total 3.374; (3) maximum average diurnal temperature of surface air in June (tmax6_18) – 1.3; (4) average annual temperature of surface air (bio1_18) – nearly 1.2; (5) maximum average diurnal temperature of surface air in August (tmax8_18) – 1.0; (6) minimum average diurnal temperature of surface air in October (tmin10_18) – 0.9; (7) minimum average diurnal temperature of surface air in April (tmin4_18) – 0.8; (8–9) average monthly temperature of surface air in April (tmean4_18) – 0.7; (8–9) average monthly temperature of surface air in October (tmean10_18) – 0.7; and (10) isothermality as a ratio of average diurnal range to temperature annual range (bio3_18) – 0.6. Other factors have input less than 0.6 points of RTG.

4 Discussion

Comparative analysis of two obtained spectra, at the global and regional levels, showed that maximum average diurnal temperature of surface air in the warmest period of an year is the most informative climatic variables in both cases: 35,7% of the total input in the regional model and 32,7% of the total input in the world model. The warmest period of an year consists of June, July, and August in the southern parts of the territory of Novosibirsk Oblast, and July is the most important among them. Leading role of maximum average diurnal temperature of surface air in the warmest period of an year is confirmed of results in both Jackknife tests (see Table), but on the regional level maximum average diurnal temperature of surface air in July has the same high value. As a result, the value of average rank for the factor bio5/bio5_18 calculated by four climatic spectra is 1,125.

Maximum average diurnal temperature of surface air in July (tmax7 / tmax7_18) has shared the 1–2 rank with bio5_18 in Jackknife test of a regional level, has 2th position in Jackknife test of a global level, 3th rank in the climatic spectrum of global level, and only 15th position in the climatic spectrum of regional level. As a result, the value of average rank for the factor tmax7 / tmax7_18 calculated by four climatic spectra is 5,375.

Position of average annual temperature of surface air (bio1 / bio1_18) show high stability in all four spectra: 2th in global model, 3th in Jackknife test of a global level, 4th in regional model and Jackknife test on a regional level. Of stability, this factor is like to

bio5 / bio5_18. The value of average rank for the factor bio1 / tmax1_18 calculated by four climatic spectra is 3,25, significantly higher than of tmax7 / tmax7_18.

Only three variables (bio5, bio1, and tmax7) have place in the top 10 of investigated spectra, some other important factors can be there three times or only twice. Maximum average diurnal temperature of surface air in June (tmax6 / tmax6_17) has the best position among them: 2th place in the regional model, 3th – in Jackknife test on a regional level, and 5th rank in the global model. The closest competitor is minimum average diurnal temperature of surface air in October (tmin10 / tmin10_18) having 3th rank in the regional model and 4th rank in the global modal, and 6th position in Jackknife test of a regional level.

Therefore, climatic variables that influence on the amount of heat in the warmest period of a year, namely maximum average diurnal temperature of surface air in the warmest period of an year (bio5 / bio5_18), maximum average diurnal temperature of surface air in July (tmax7 / tmax7_18) and in June (tmax6 / tmax6_18), may be taken into account as key factors, limiting population size of rare species *I. glaucescens* in the territory of Novosibirsk Oblast. The total input of three these variables is 59.6% in the regional model and 47.6% in the global model. The obtained results do not confirm the opinion of environmental experts that distribution of vascular plants in the steppe zone of Northern Asia is limited by the amount of precipitation. The total contribution of the variables determining the amount of precipitation is only 1.5% in the regional model (exclusively the variable bio15_18 – precipitation seasonality) and only 0.2% in the global model (exclusively the variable prec6 – amount of precipitation in June) of the distribution for *I. glaucescens*.

This work was performed within the framework of the state assignment of the CSBG SB RAS, on the topic AAAA-A17-117012610055-3. The methodical part of the experimental studies is supported by the grant of Novosibirsk State University (Russia) «Creation and development of the Laboratory for biogeomodeling and ecoinformatics of Faculty for Natural Sciences NSU» under the TOP-100 program. In preparing the publication, the scientific collection and bioresources database of Central Siberian Botanical Garden, Siberian Branch of Russian Academy of Science «Herbarium of vascular plants, lichens and fungi (NS, NSK)» USU 440537 were used.

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