



BIOCLIMATIC MODELING RESULTS FOR *INULA GRANDIS*

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Abstract. In this article Based on *MaxEnt* modeling, a species bioclimatic model for the *Inula grandis* Schrenk ex Fisch. & C.A.Mey. was developed for the using random algorithms with 19 bioclimatic variables.

Key words. *Inula grandis*, area, climate factors, *MaxEnt* modeling, plantation.

Аннотация. В данной статье на основе моделирования *MaxEnt* была разработана биоклиматическая модель вида *Inula grandis* Schrenk ex Fisch. & C.A.Mey. с использованием случайных алгоритмов с 19 биоклиматическими переменными.

Ключевые слова. *Inula grandis*, площадь, климатические факторы, моделирование *MaxEnt*, плантация.

Аннотация. Ushbu maqolada *MaxEnt* modellashtirish asosida *Inula grandis* Schrenk ex Fisch & C.A.Mey. turi uchun bioiqlim modeli va 19 ta bioiqlim o'zgaruvchi parametrlar bilan tasodifiy algoritmlar yordamida ishlab chiqilgan.

Kalit so'zlar. *Inula grandis*, hudud, iqlim omillari, *MaxEnt* modellashtirish, plantatsiya, qulay ekologik muhit.

I. grandis are multifaceted and comprehensive. They include various aspects of assessing the species' distribution, understanding its ecological requirements, and developing strategies for its sustainable management.

This research geoforensic data reflecting the distribution of *I. grandis* species in the preparation of the work, field research an), Plants and lichens of Russia and neighboring countries: open online galleries and plant identification guide (<https://www.plantarium.ru>) online databases were used.

In general 20 geoforensics data of *I. grandis* (Yellow elecampane) have been downloaded. Bioclimatic data downloaded from the World Clim database (<http://www.worldclim.org>) for species distribution modeling included nineteen climate factors (Table 1). Data from the World Soil Database (82 soil parameters) were combined with bioclimatic data (19 climate factors) to better represent the potential distribution of *I. grandis*. ArcGIS 10.8 software using the layer tool was used to crop and extract the climate data data, maintain the desired data range, and finally convert it to ASCII format. Geoforensic data were loaded into *MaxEnt* 3.4.4 [1,2] and evaluated using the Jackknife test with bioclimate, soil and elevation data. T

he resulting models were calibrated using 75% of the available data for each species as training (calibration) data, and the remaining 25% were used for model validation as test data. The bootstrap method was performed with 10 replicates, a maximum of 5000 replicates, and default selected parameters. Model performance was evaluated by calculating the area under the receiver operator curve (AUC), where models with an AUC value greater than 0.7 were considered satisfactory for our study [1,2].

MaxEnt is a multivariate approach that evaluates species distribution by finding the probability distribution of maximum entropy, taking into account the constraints that represent our incomplete information about distribution. In general, $AUC < 0.7$ indicates low accuracy of the model, the prediction results are acceptable when AUC is 0.7-0.9, and $AUC > 0.9$ indicates that the prediction results are very accurate, for further analysis can be used.

Future climate scenarios. In its fifth report (AR5), the Intergovernmental Panel on Climate Change (IPCC, 2013) presented two Representative Concentration Pathway (RCP) climate scenarios (RCP 8.5) for 2050, downloaded from the WorldClim online database (www.worldclim.org).



Table 1.

Bioclimatic factors

Code	Trends in bioclimatic variability	Notes	Unity
BIO1	Average annual temperature		°C
BIO2	Average interval of the day		°C
BIO3	Isothermal	$BIO1 / BIO7 * 100$	%
BIO4	Seasonality of temperature	Coefficient of variation	
BIO5	Maximum temperature of the hottest month		°C
BIO6	The minimum temperature of the coldest month		°C
BIO7	Annual temperature range	$BIO5 - BIO6$	°C
BIO8	Average temperature of the warm quarter		°C
BIO9	Average temperature of the dry quarter		°C
BIO10	Average temperature of the warmest quarter		°C
BIO11	Average temperature of the cold quarter		°C
BIO12	Annual precipitation		mm
BIO13	Precipitation in the hottest month .		mm
BIO14	Rainfall in a dry month		mm
BIO15	Seasonality of precipitation	Coefficient of variation	1
BIO16	Precipitation in the Wet Quarter		mm
BIO17	Precipitation in the dry quarter		mm
BIO18	Precipitation in the warmest quarter		mm
BIO19	Precipitation in the coldest quarter		mm

A species bioclimatic model was conducted for the Yellow Elecampane using random algorithms with 19 bioclimatic variables . To determine the main climatic factors determining the range of the yellow elecampane, we used a jackknife test with variable significance in a trained random model.

The Jackknife test systematically evaluates the contribution of each variable to the predictive performance of the model by repeatedly training each variable with and without each variable at random. The results of the Jackknife test, calculated on the predictive performance independent test data set, revealed four bioclimatic variables with high multivariate significance for the Yellow Elecampane (Figure 1).

1. Bio5 (maximum temperature of the hottest month)
2. Bio10 (average temperature of the warmest quarter)
3. Bio13 (precipitation in the warmest month)
4. Bio16 (Wet Quarter Precipitation)

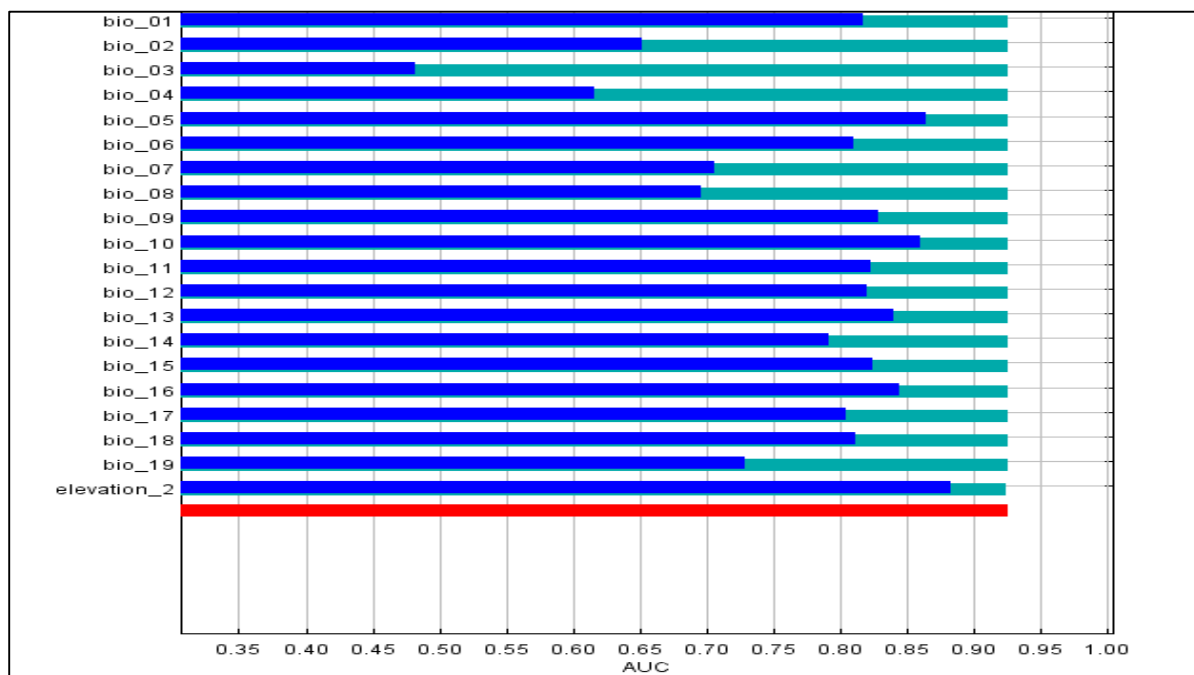


Figure 1 . Jackknife test results significance of bioclimatic factors for the yellow elecampane.

When each of these four variables was excluded from the model individually, the resulting AUC scores were significantly lower than in models where the other variables were excluded. This shows that the maximum and average temperatures in the warmest periods, and the precipitation in the warmest and wettest intervals provide informative signals about the climatic boundaries of the yellow elecampane. Most notably, these important variables describe temperature and humidity conditions during the extremes of the warm season. Yellow Elecampane refers to its physiological tolerance and habitat requirements, which depend on high heat tolerance and sufficient rainfall during active growth. The identification of these four bioclimatic factors as key drivers of the potential distribution of the yellow elecampane confirms their ecological importance and provides insight into the climatic controls that shape its range limits. Further research is planned based on the above results to understand and potentially project how yellow elecampane will respond to future climate change.

References:

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