Experience in the use of GIS tools in plant conservation

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- GIS technologies can be used in 3 different sites:
- A Mapping
- B Niche modeling and research
- C Species distribution modeling

Mapping

ArcGIS -- ArcGIS (ESRI) URL: http://www.esri.com
DIVA-GIS -- Hijmans R.J., Guarino L., Jarvis A. et. al. DIVA-GIS, version 5.2. Manual. 2005

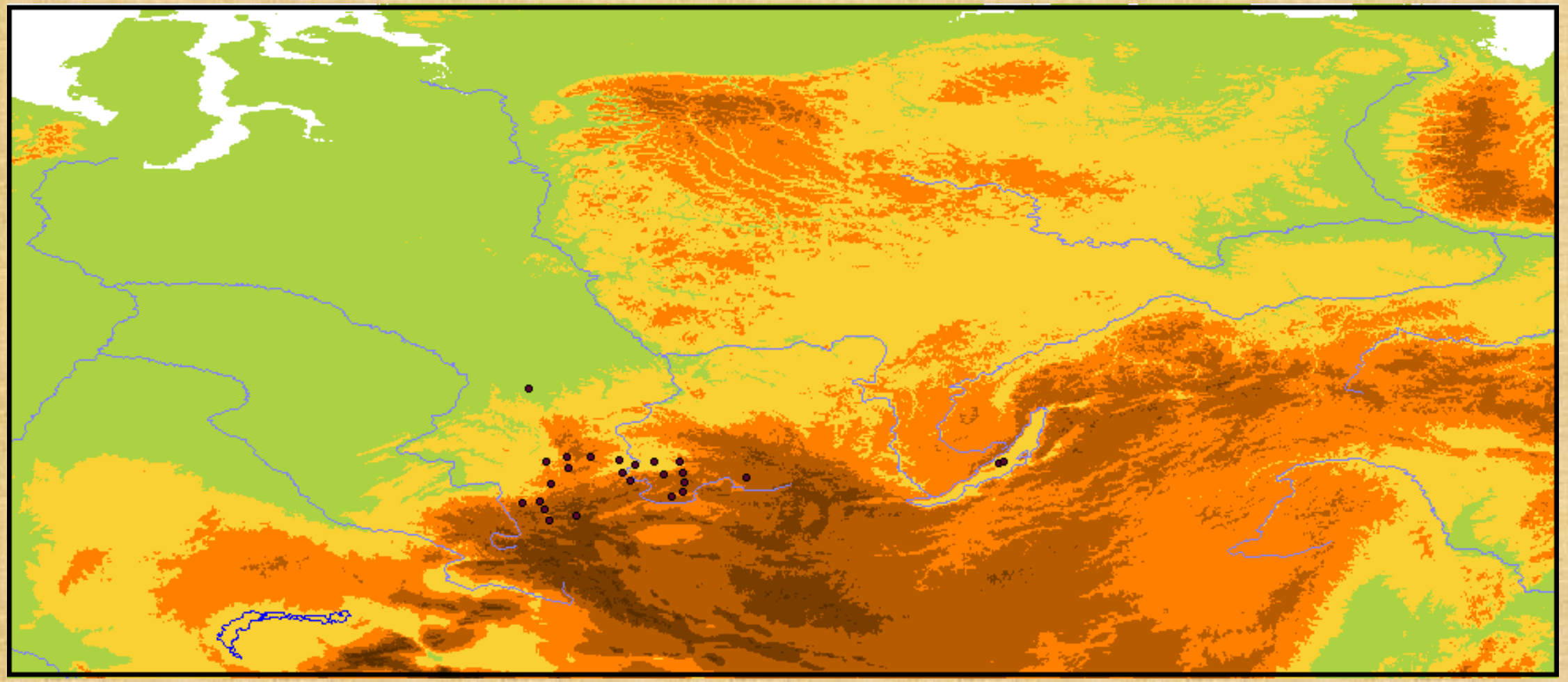
The data have to be prepared specially. From (from excell to attributive table of ArcGIS)

fx 1210

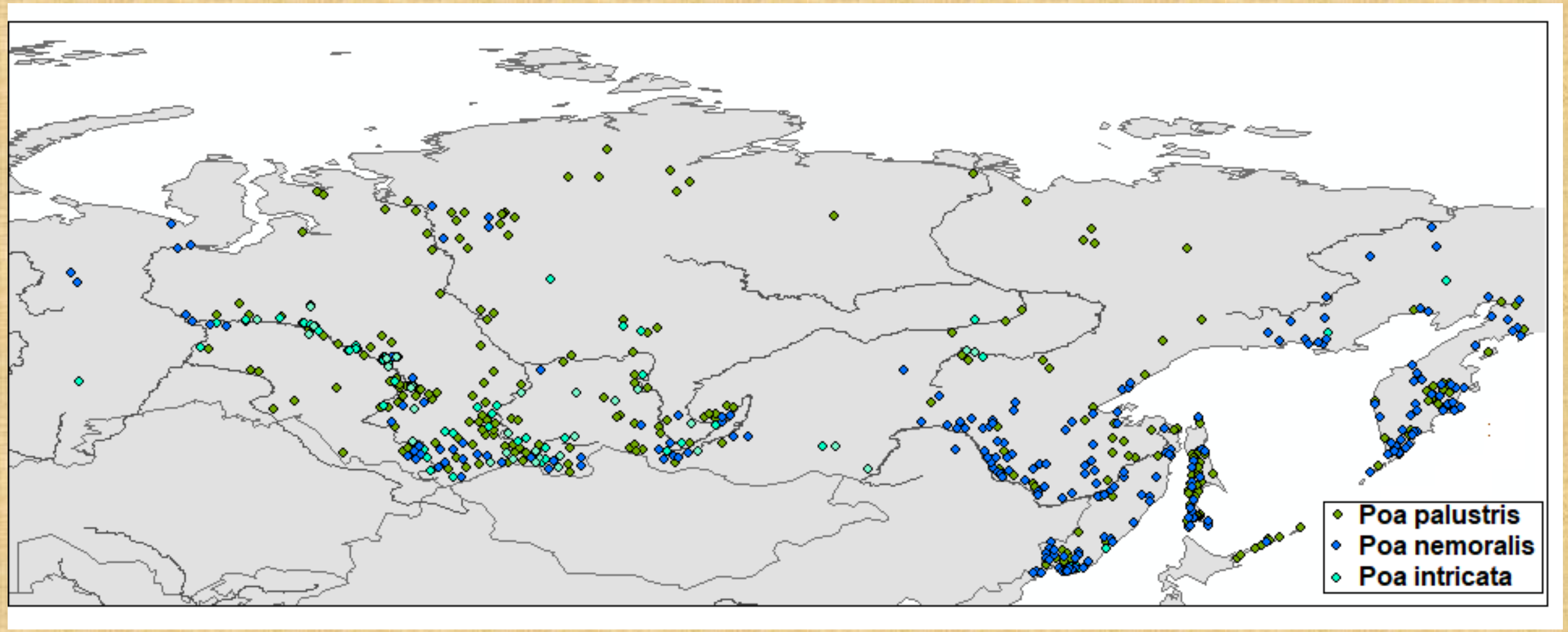
D	E	F	G	H	I	J	K	L	
species	longit	latid	alt	level	rachilla	callus	betw_veins	ligule	lor
nemor	85,094	57,061	142,0000	1	2	2	1	1	1
nemor	85,882	55,264	201,0000	1	2	2	1	1	2
nemor	85,126	51,670	845,0000	1	2	2	1	1	1
nemor	84,747	51,260	965,0000	1	2	2	1	1	1
nemor	85,252	51,071	1248,0000	1	2	2	1	1	2
nemor	85,662	51,386	858,0000	1	2	2	1	1	3
nemor	85,536	52,017	327,0000	1	2	2	1	1	5
nemor	87,112	51,796	537,0000	1	2	2	1	1	5
nemor	87,994	51,796	1365,0000	1	2	2	1	1	5
nemor	88,782	52,238	1185,0000	1	2	2	1	1	1
nemor	87,017	50,504	1926,0000	1	2	2	1	1	1
nemor	90,485	51,323	1397,0000	1	2	2	1	1	2
nemor	91,556	50,882	1670,0000	1	2	2	1	1	2
nemor	94,457	57,596	254,0000	1	2	2	1	1	2
nemor	93,795	51,166	1044,0000	1	2	2	1	1	1

Set of molecu-lar markers

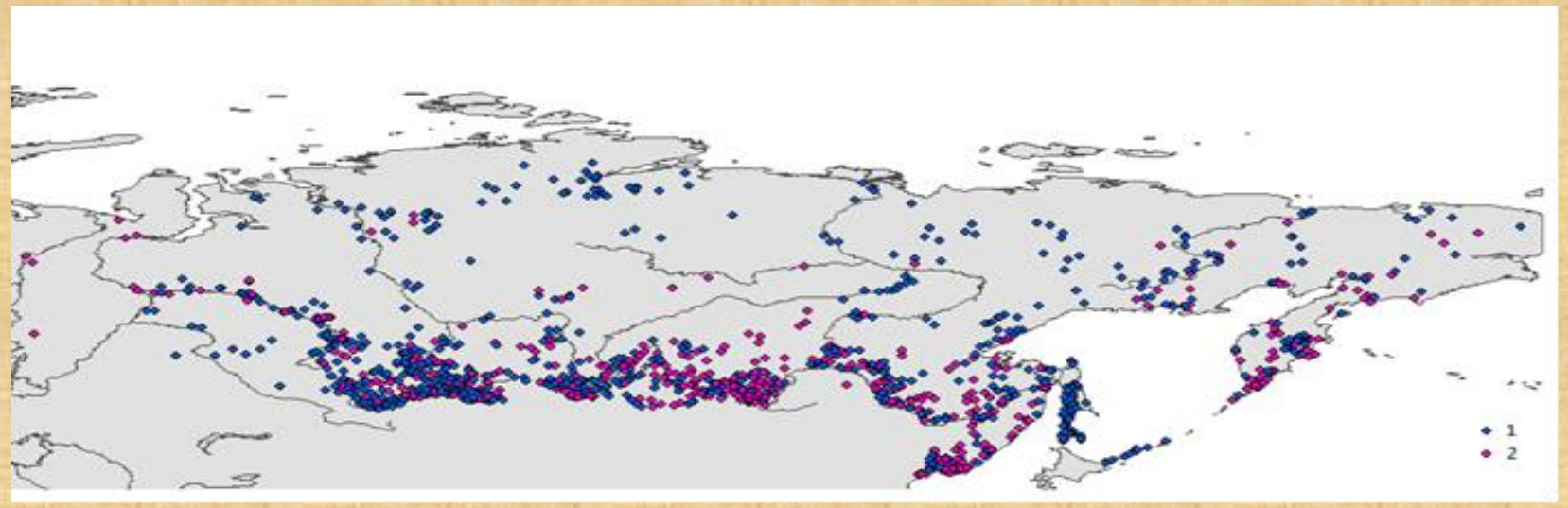
The distribution of *Brunnera sibirica*



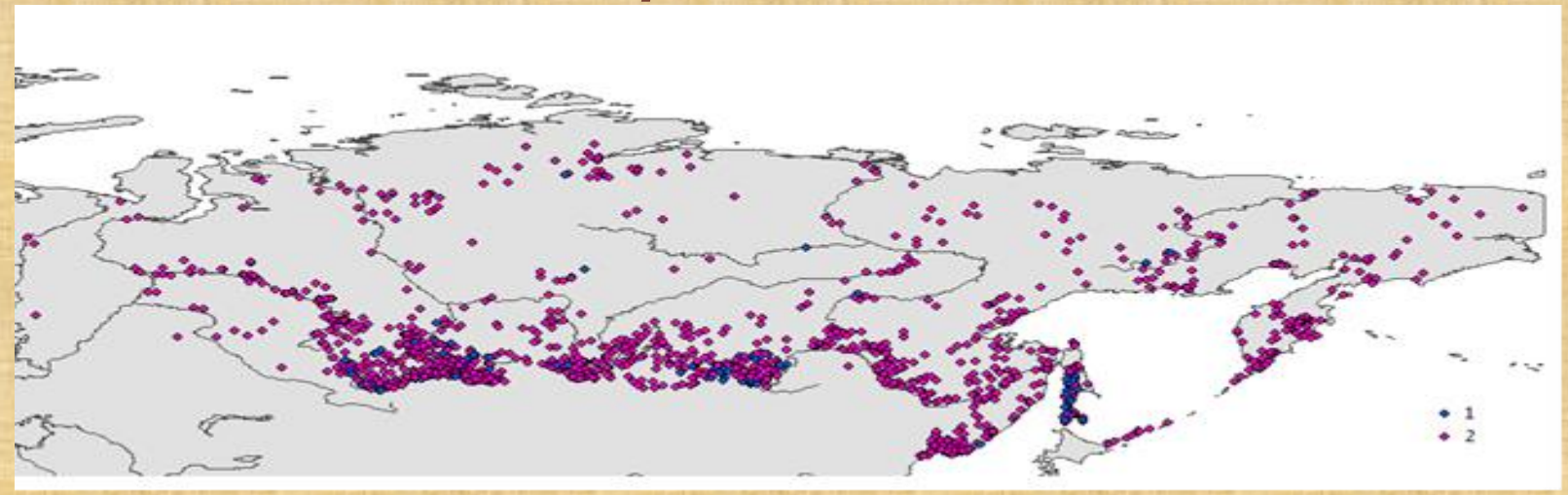
The distribution of 3 species in Asian Russia



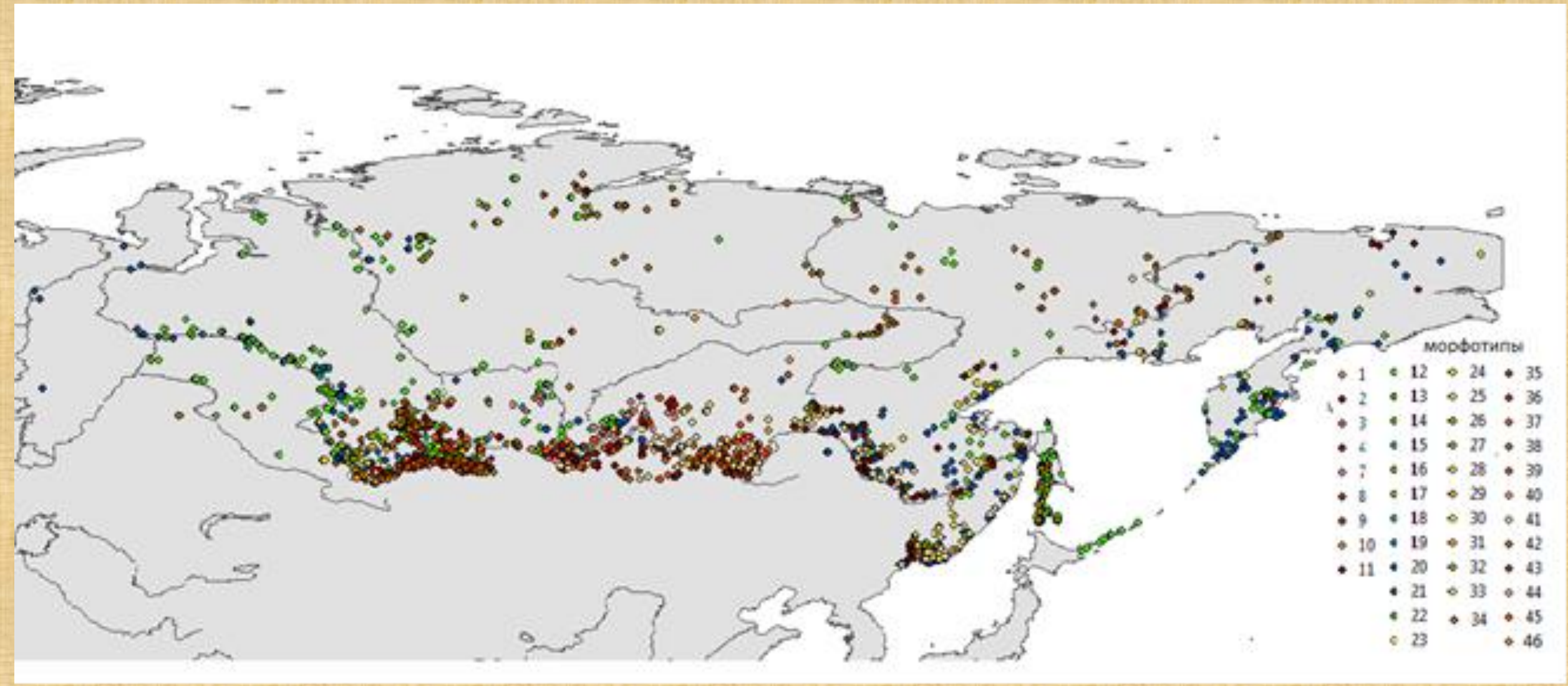
The distribution of rachilla pubescence within the Bluegrasses section in Asian Russia



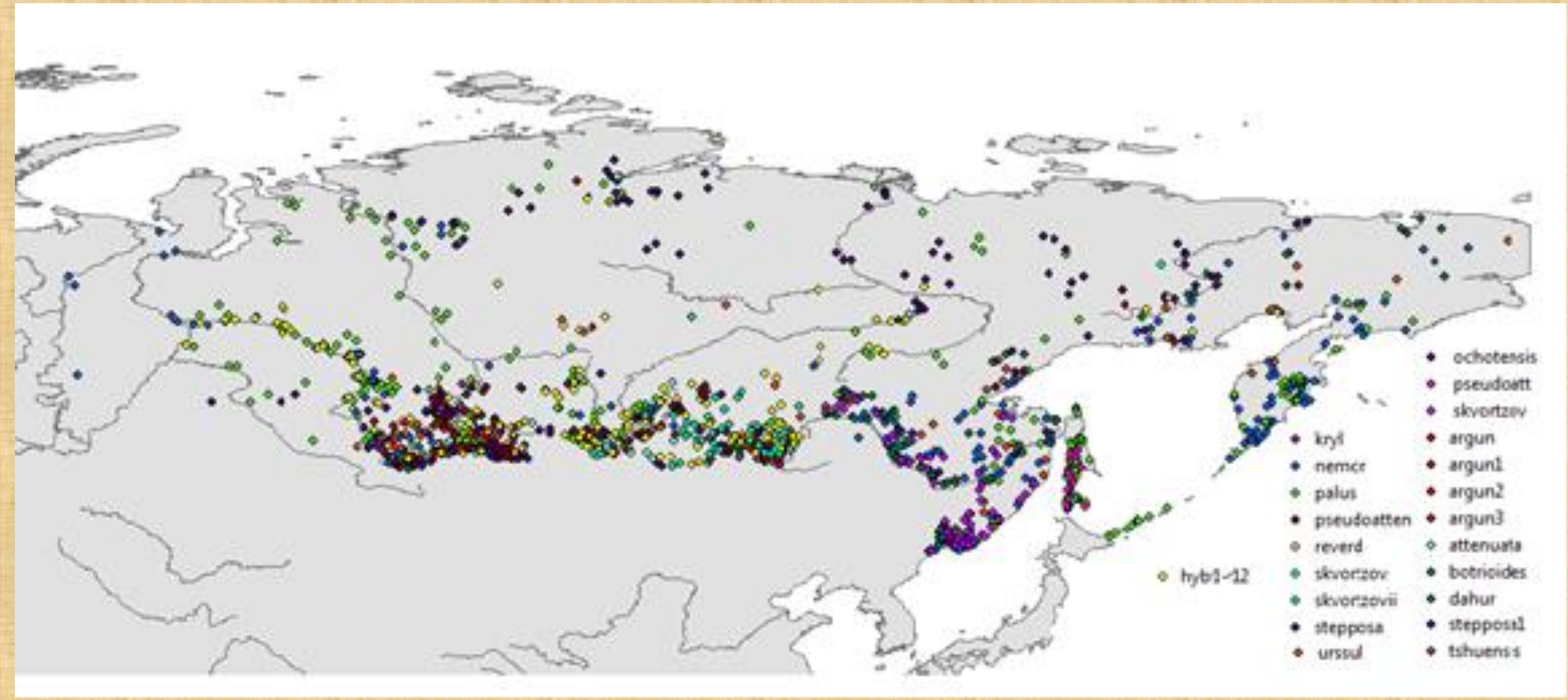
The distribution of callus pubescence within the Bluegrasses section *Stenopoa* in Asian Russia



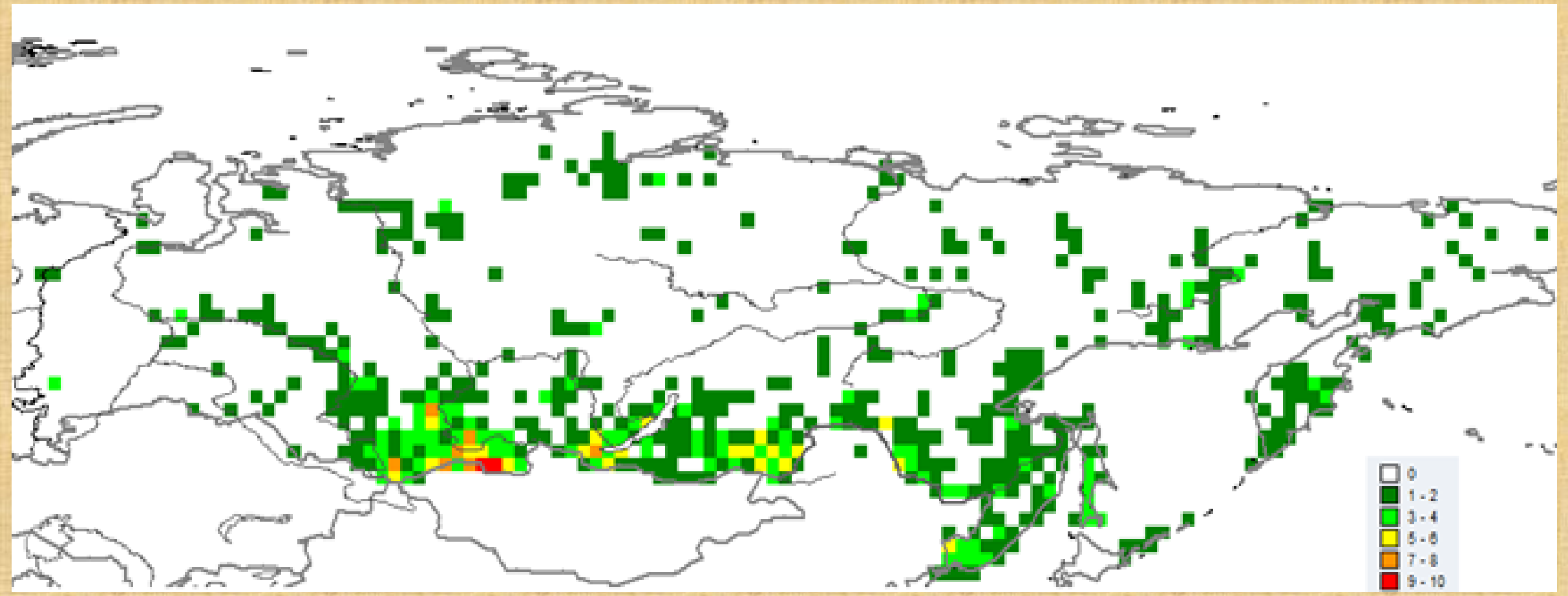
The distribution of different morphotypes of the same species in Asian Russia basing 5 basic characters



The distribution of putative hybrid morphs of *Stenopoa* Bluegrasses in Asian Russia



The richness of Asian Russia with morphotypes of Blugrasses section *Stenopoa*



Ecologo-climatic niche research and modeling

DIVA GIS

Hijmans R.J., Guarino L., Jarvis A. et. al. DIVA-GIS, version 5.2. Manual. 2011. URL: http://www.diva-gis.org/docs/DIVAGIS5_manual.pdf

MaxEnt

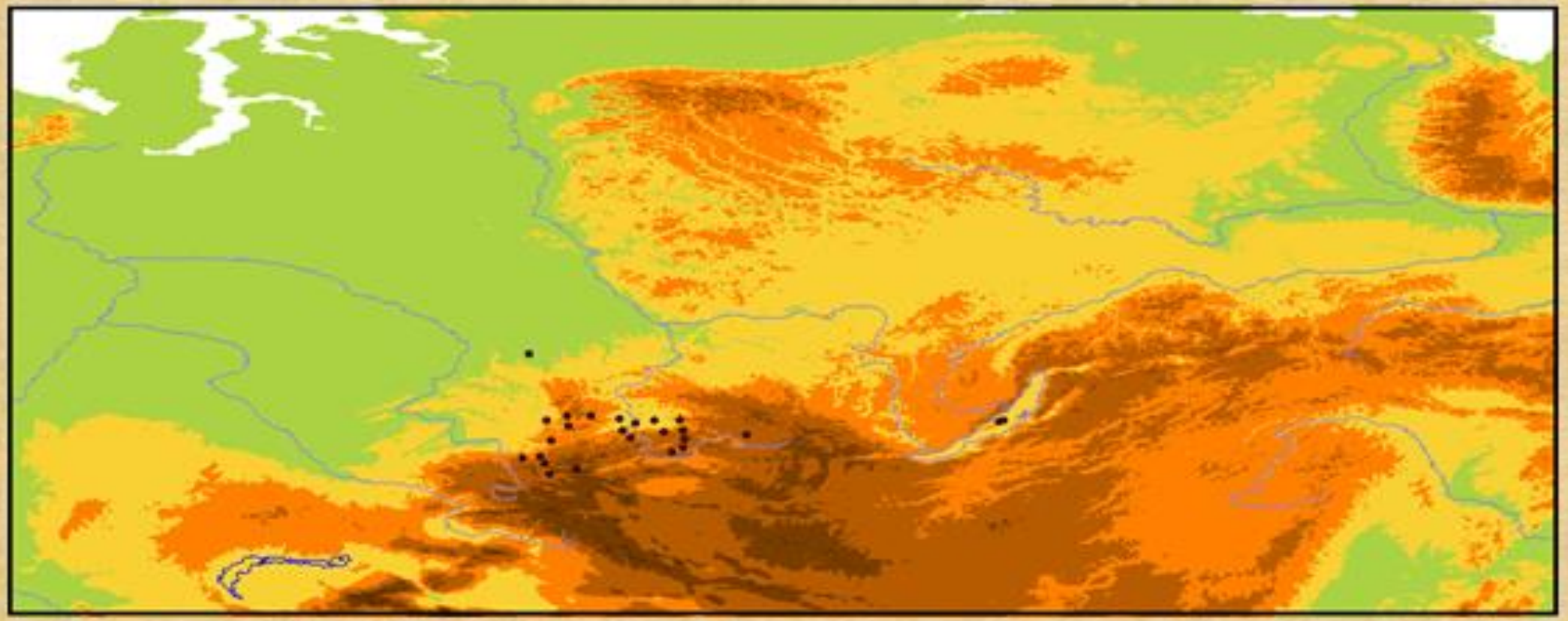
Philips S.J., Anderson R.P., Schapire R.E. Maximum entropy modeling of species geographic distributions // Ecological Modelling. 2006. Vol. 190. P. 231–259.

Uses occurrence and climatic data

- There are several methods of bioclimatic modeling at present, but among ones, which are satisfied with data about the presence of species only, the MaxEnt algorithm is the most popular currently.
- This application is based on the identification of the climatic niche of the species under study, which is established by combining the data of the geographical distribution of species and the climatic characteristics of these points, which are freely available on the internet (Worldclim database).
- If desired, and with the availability of data, you can add other indicators - for example, such as slope, salinity, chemical composition of soils and so on.

Data of occurrence

The distribution of Brunnera sibirica



The Worldclim database (Hijmans et al, 2004). Biologically significant variables

BIO1 = Annual mean temperature
BIO2 = Mean diurnal range (max temp – min temp) (monthly average)
BIO3 = Isothermality (BIO1/BIO7) * 100
BIO4 = Temperature Seasonality (Coefficient of Variation)
BIO5 = Max Temperature of Warmest Period
BIO6 = Min Temperature of Coldest Period
BIO7 = Temperature Annual Range (BIO5-BIO6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter

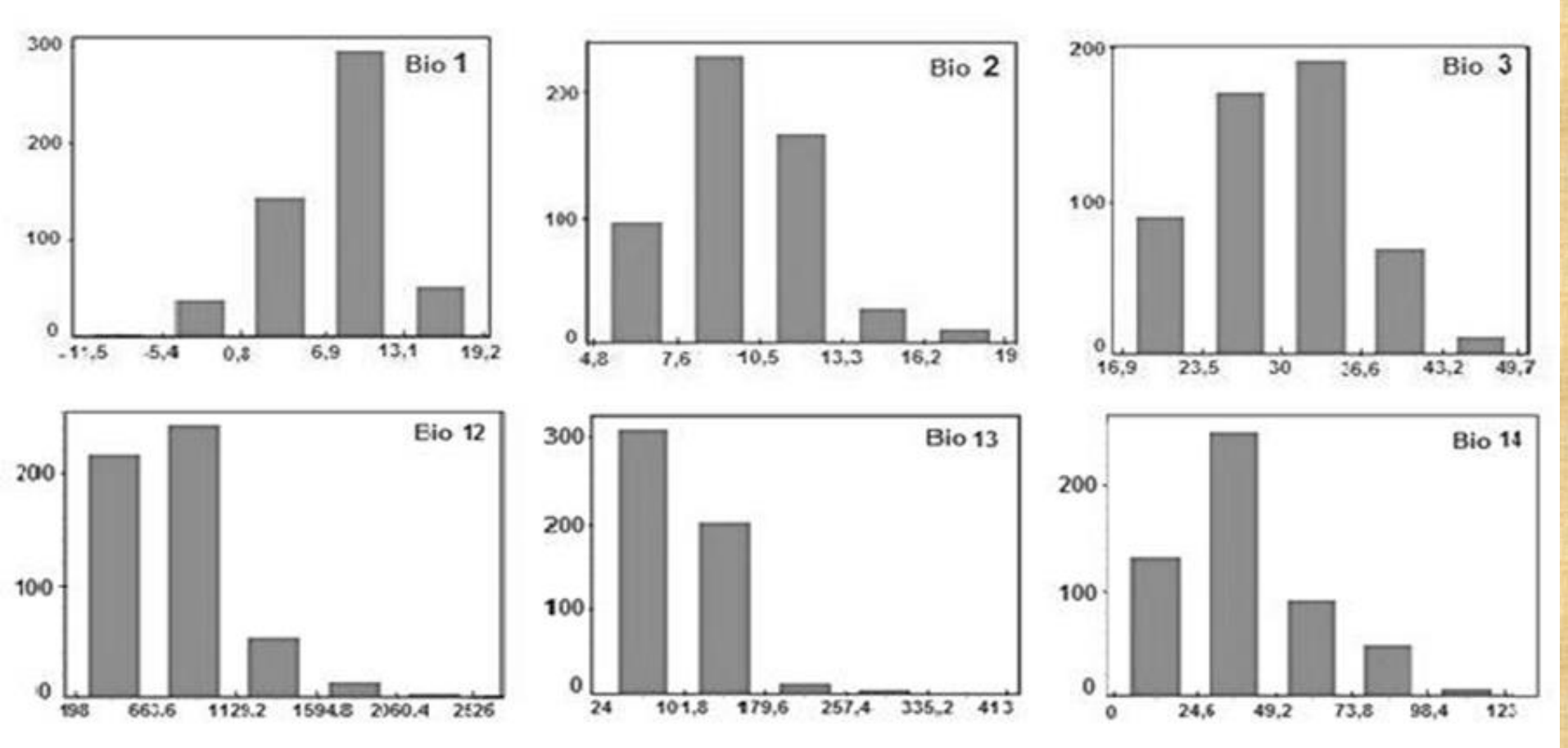
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Period
BIO14 = Precipitation of Driest Period
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter

The DIVA-GIS program allows you to determine the bioclimatic parameters of each point where a species was recorded, then, build various histograms, and conduct multivariate analyses of data.

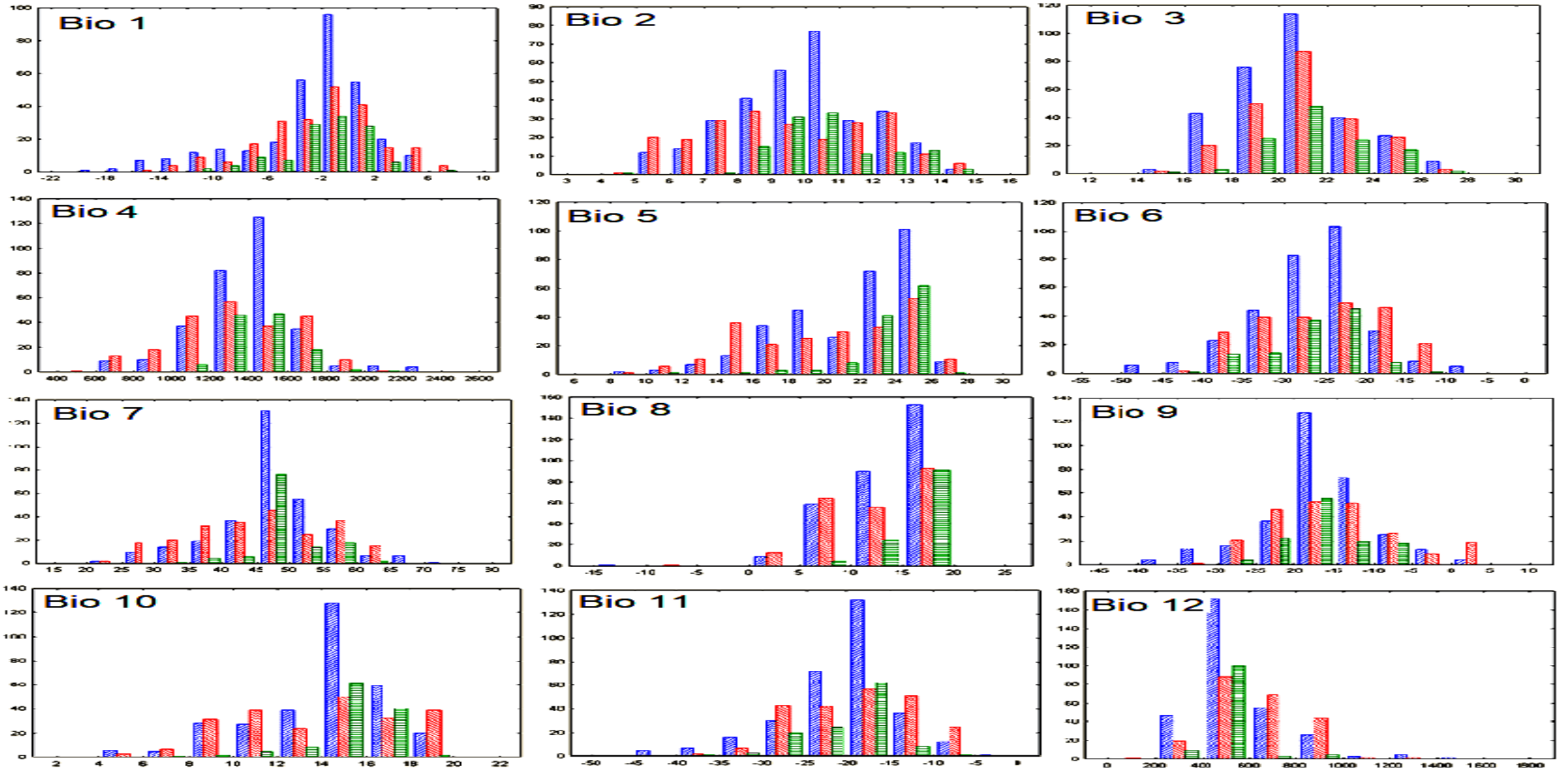
DIVA-GIS allows to obtain the bioclimatic profile of one species

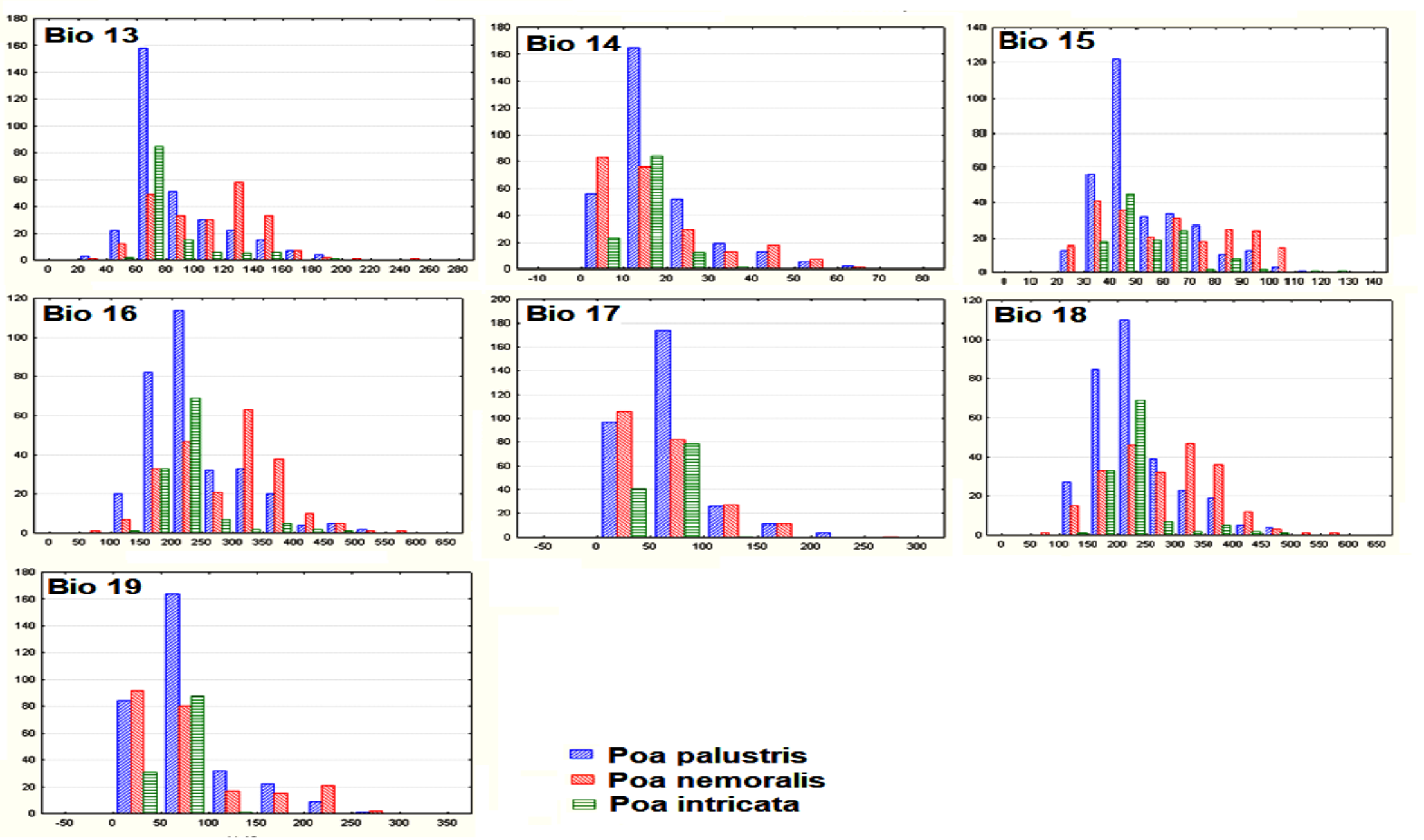
temperature

precipitation

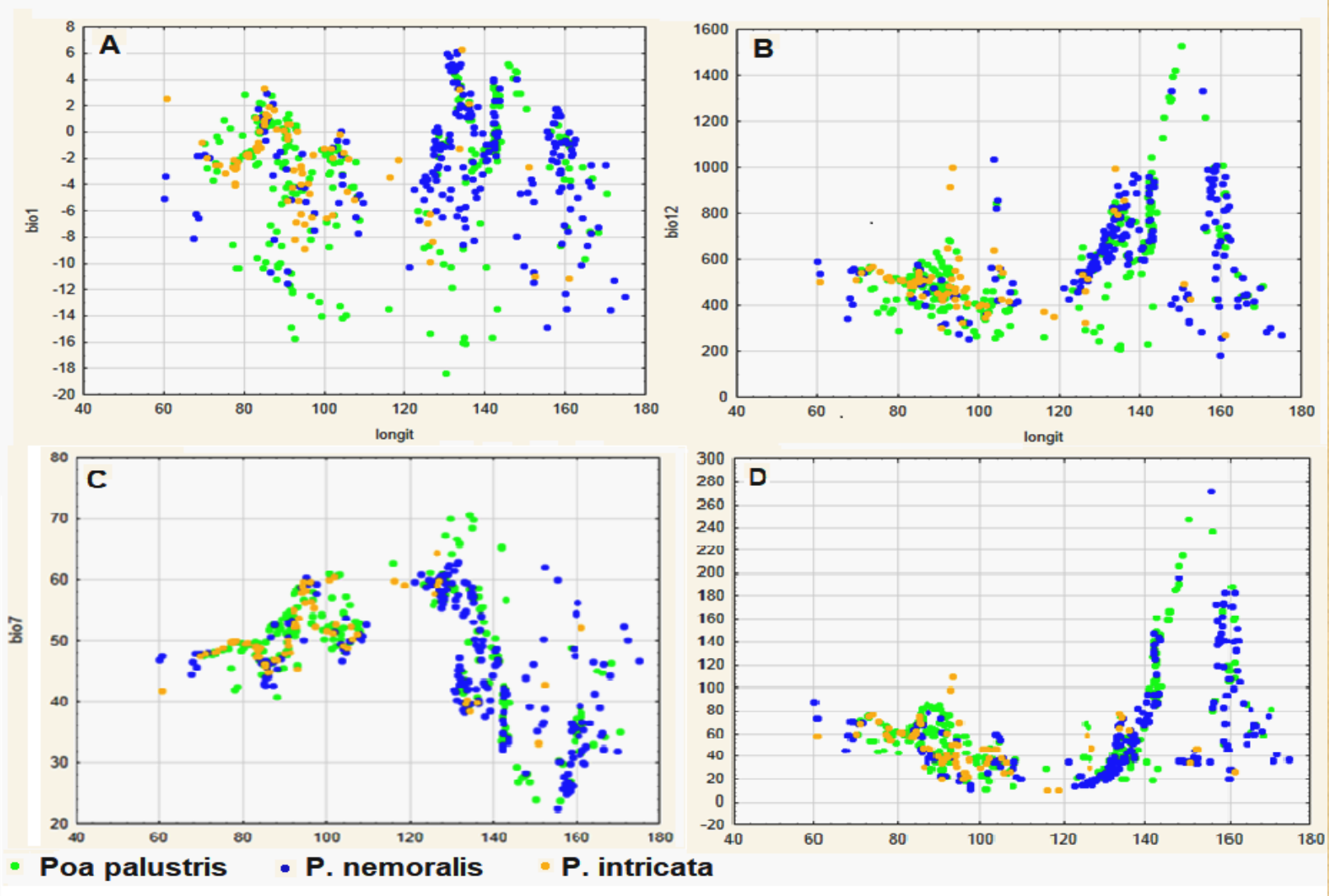


… To compare two bioclimatic outlines of *3* different relative species




Bio 13
Bio 14
Bio 15
Bio 16
Bio 17
Bio 18
Bio 19
Poa palustris
Poa nemoralis
Poa intricata

To reveal the dependence of distribution of 3 different relative species on longitude



A Annual mean temperature

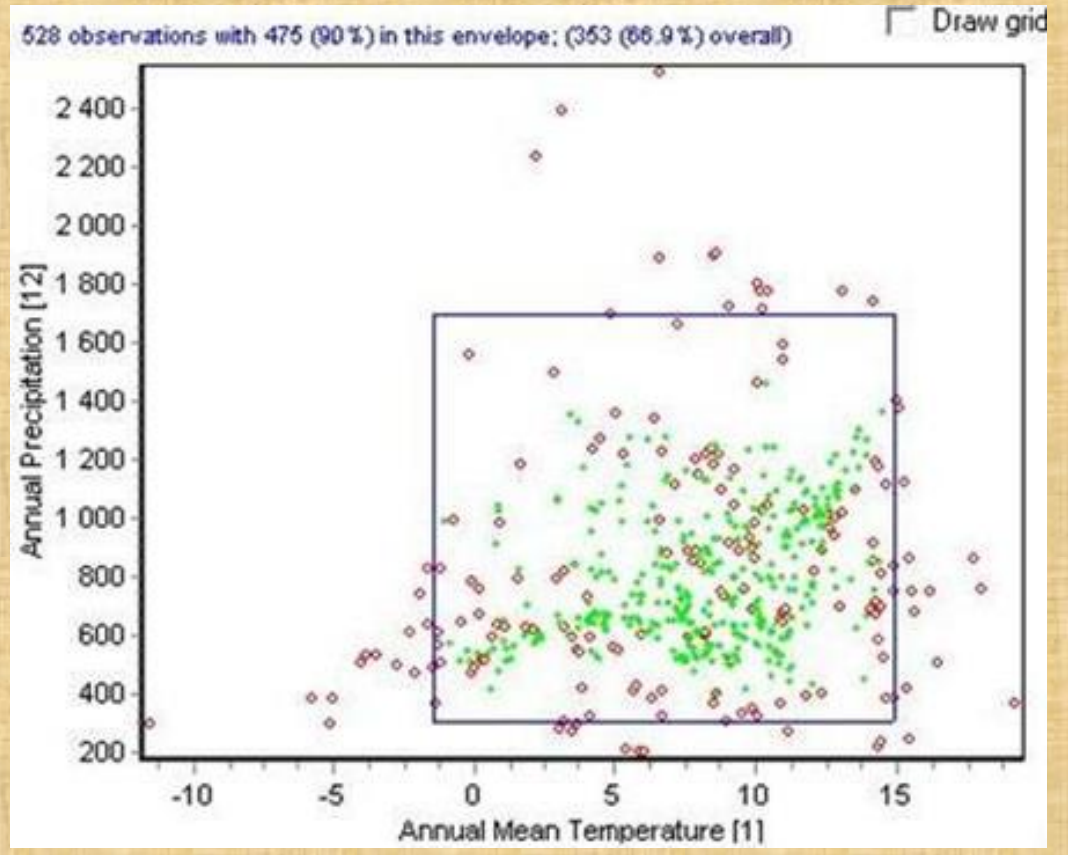
B Annual precipitation

C Temperature annual range

D Precipitation of wet-test period

… To obtain bioclimatic “envelope” for 2 climatic variable

Bio12



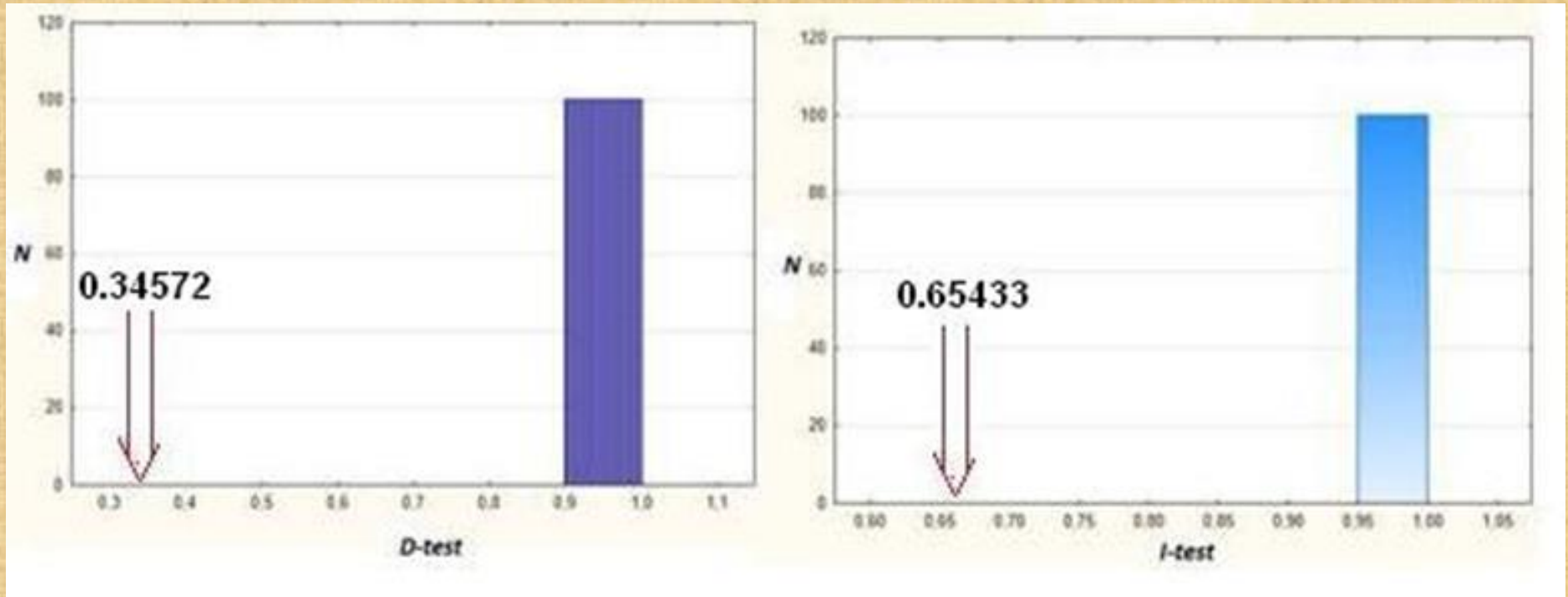
Bio1

MaxEnt, using the special additional soft, allows to measure and to compare obtained niches

Warren et al., 2008,

ENVIRONMENTAL NICHE EQUIVALENCY VERSUS CONSERVATISM: QUANTITATIVE APPROACHES TO NICHE EVOLUTION. Evolution 62-11: 2868–2883

I-test – identity of ecologo-climatic niches of two relative spescies in Asian Russia (for overlapping ranges) via ENMtools (Warren et al., 2008, 2010)

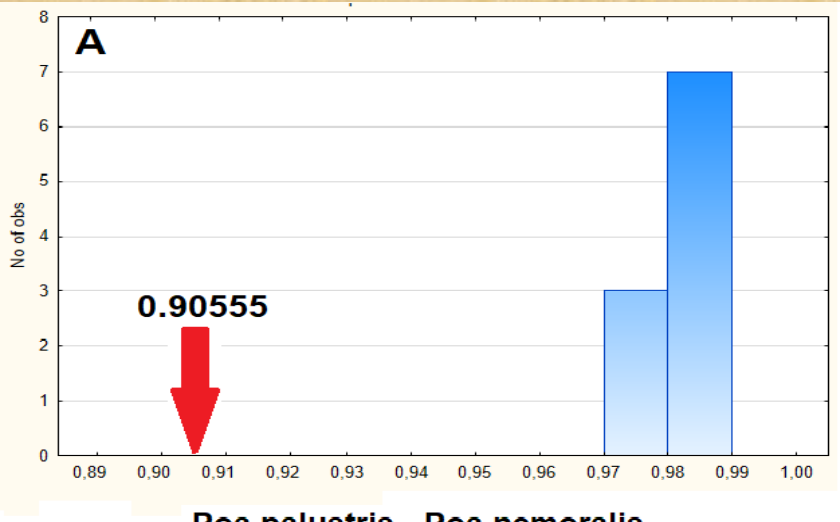


the standardized Hellinger distance

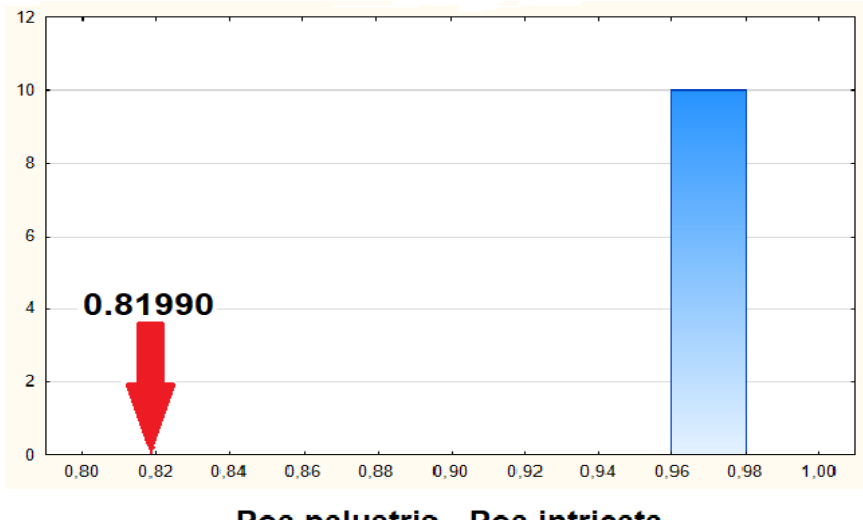
the Schöner index

Identity of ecologo-climatic niches of 3 relative species in Asian Russia

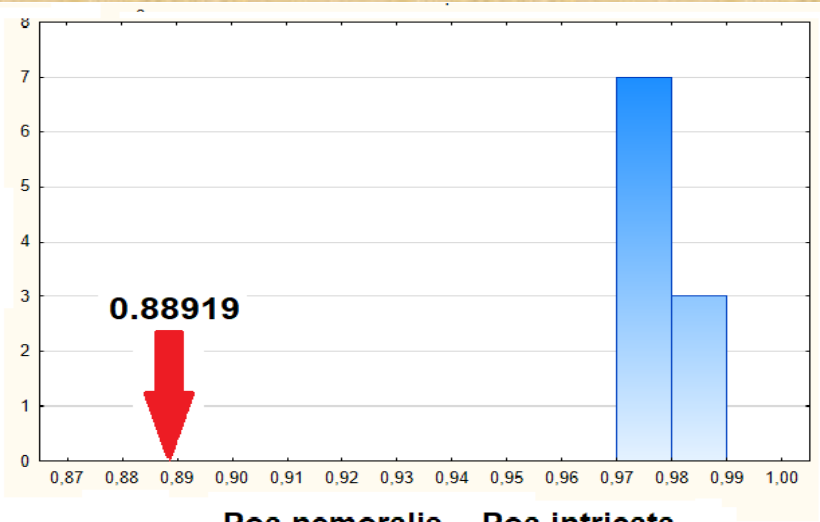
I-test



Poa palustris - Poa nemoralis

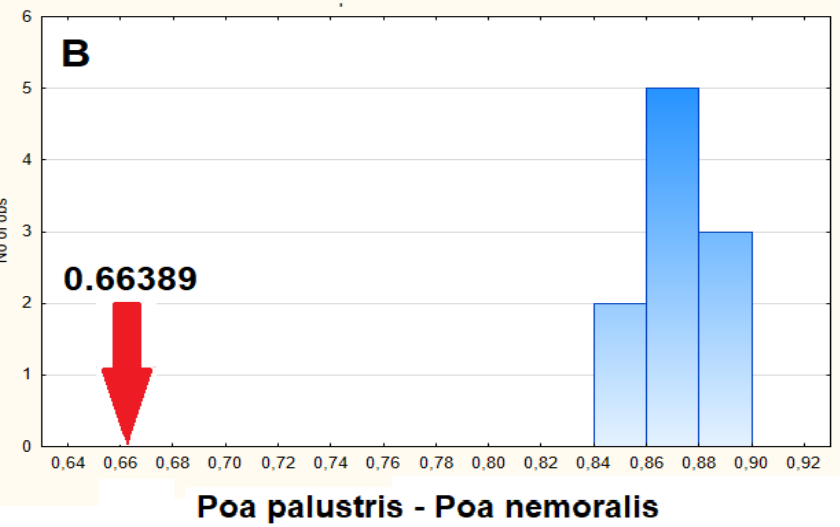


Poa palustris - Poa intricata

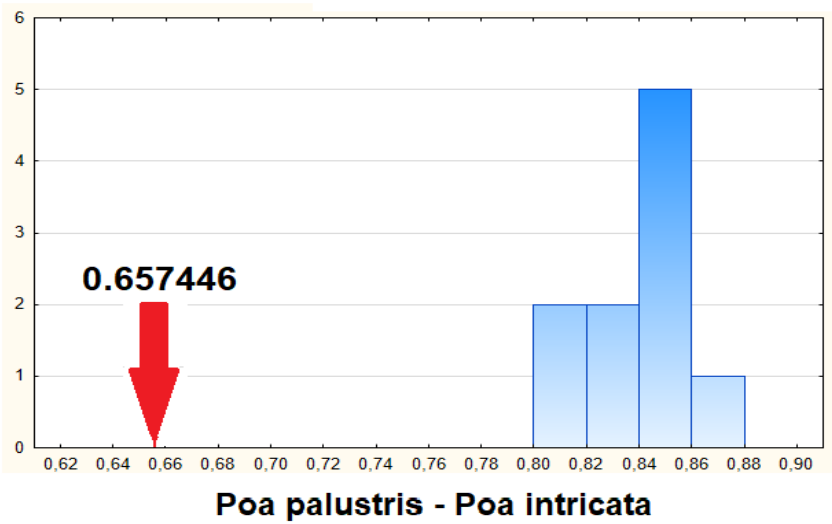


Poa nemoralis - Poa intricata

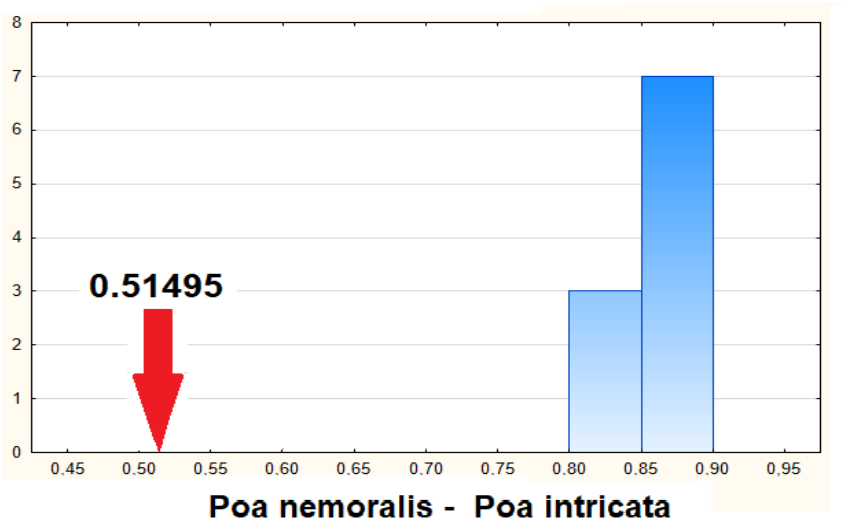
D-test



Poa palustris - Poa nemoralis



Poa palustris - Poa intricata



Poa nemoralis - Poa intricata

Background test provides another opportunity to confirm the niches divergence on genetic level

Can be used for non-overlapping ranges

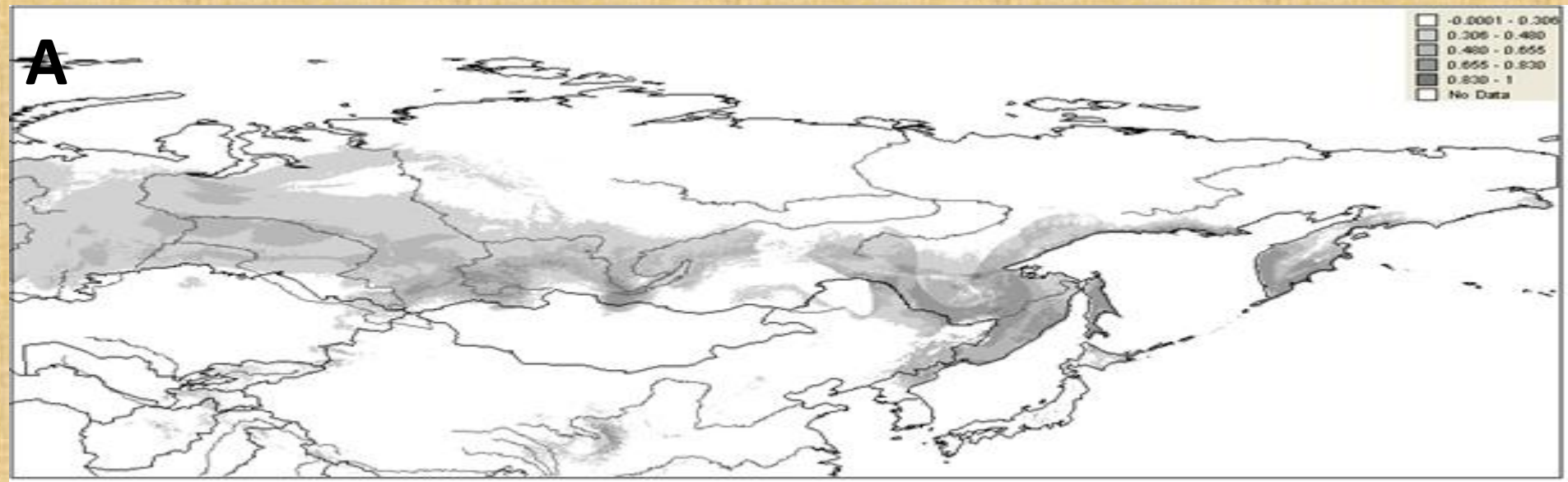
Species distribution modelling

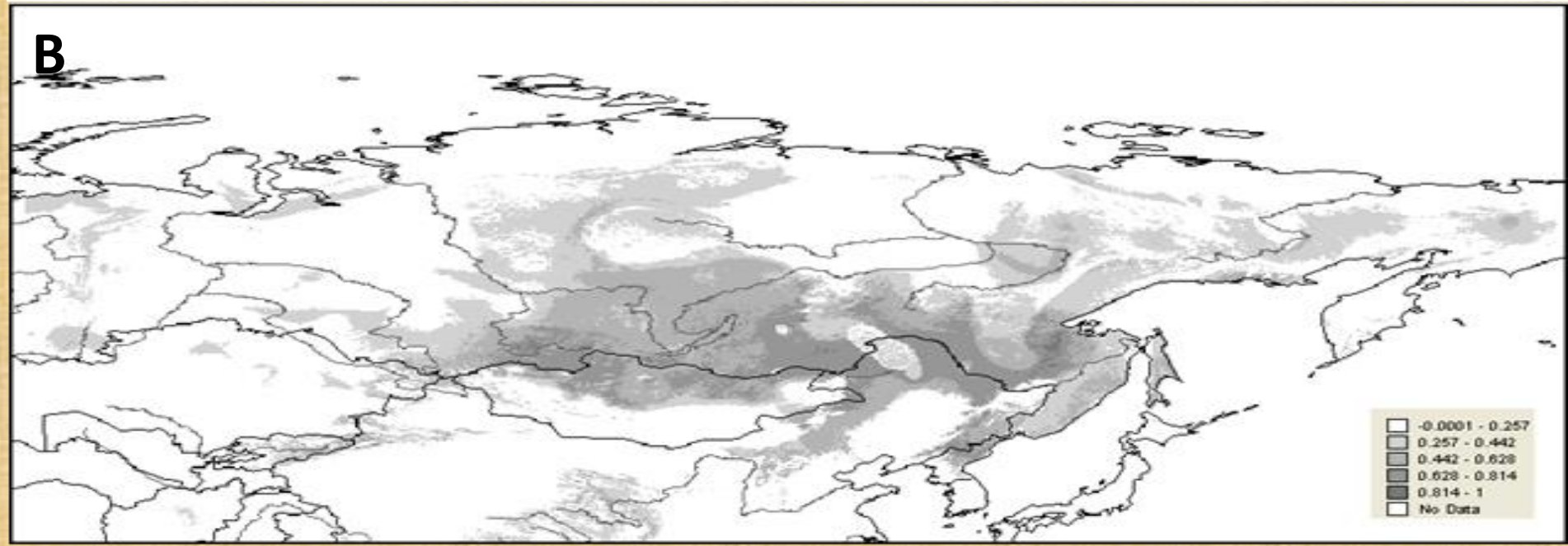
(MaxEnt)

Preparing data to minimize the omissions using SDMtools (Brown et all, 2014)

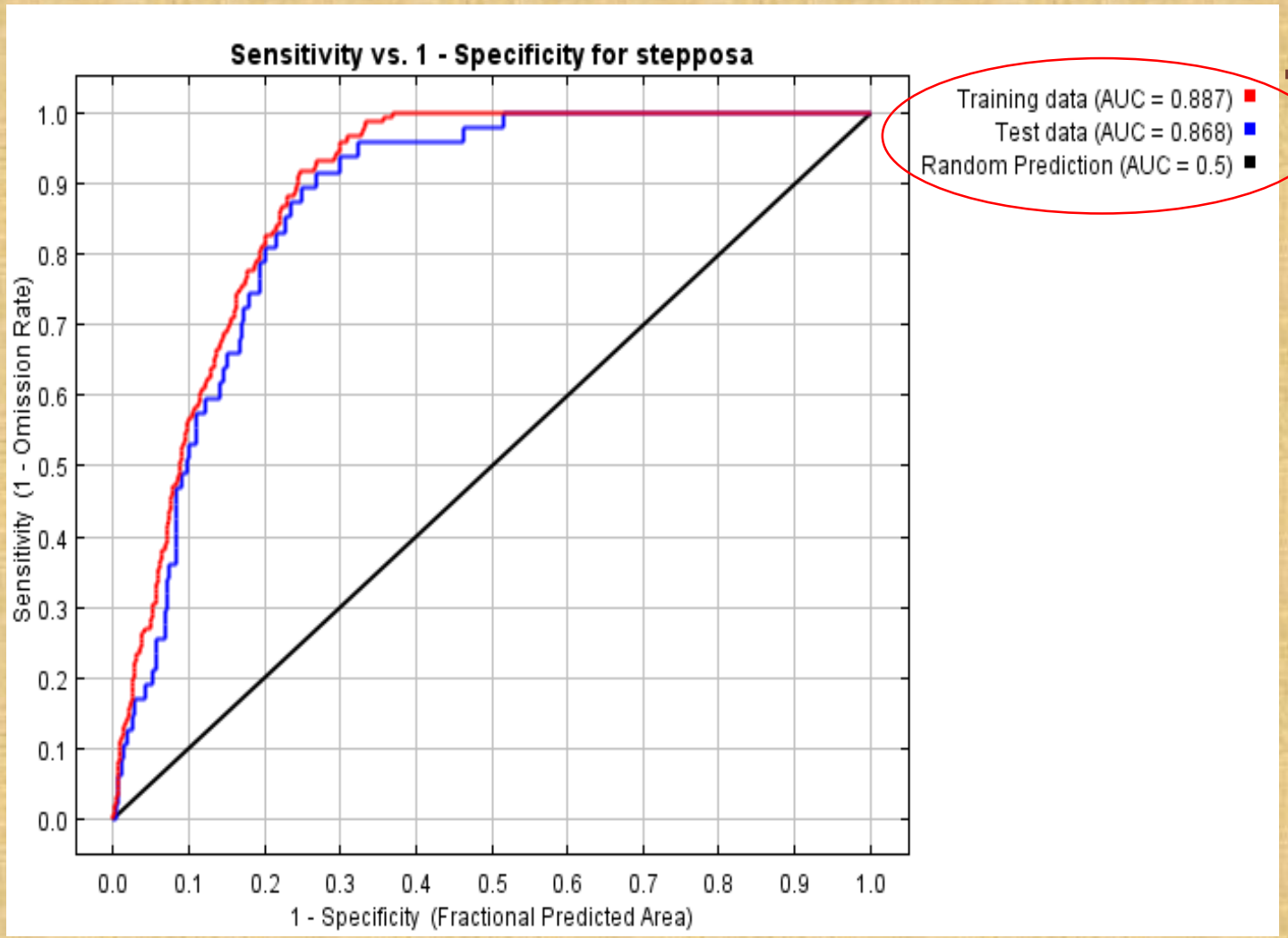
1. Delete the correlated bioclimatic data
2. Rarify occurrence data, taking into account
   a. latitudinal background
   b. climate and sampling heterogeneity

The models of distribution 2 relative species in Asian Russia (10 percentile threshold)



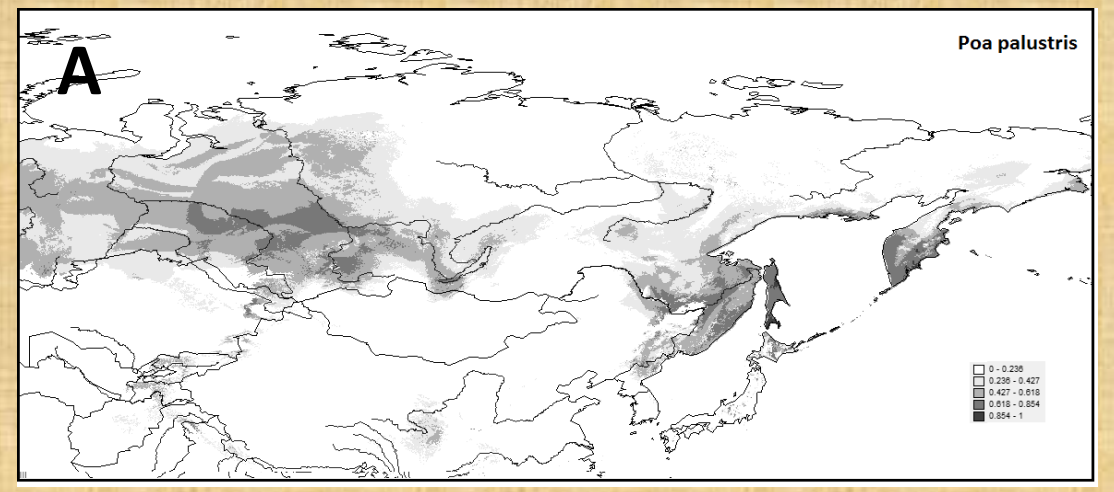


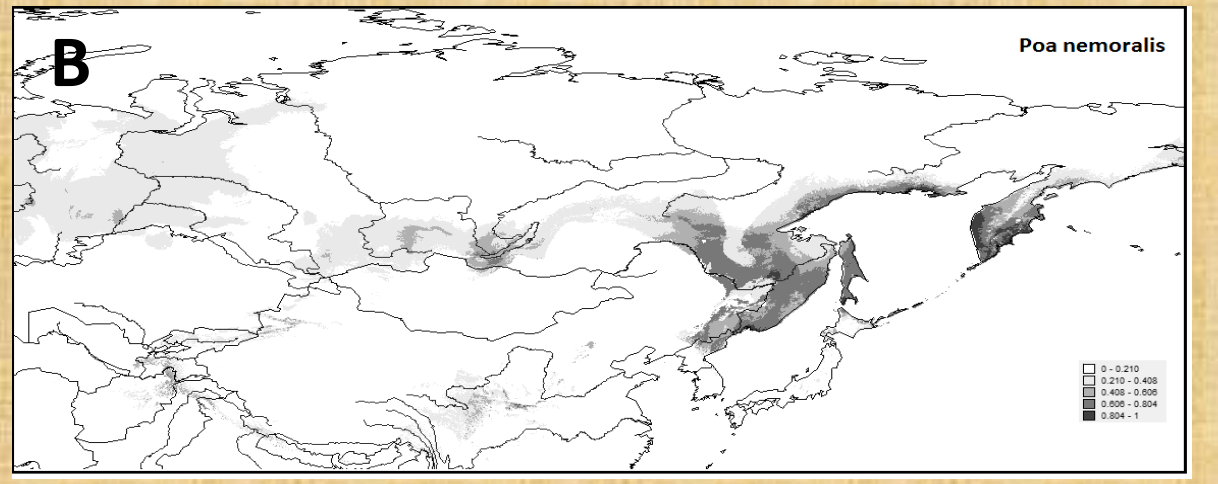
A – mesomorphic species
B - xeromorphic species

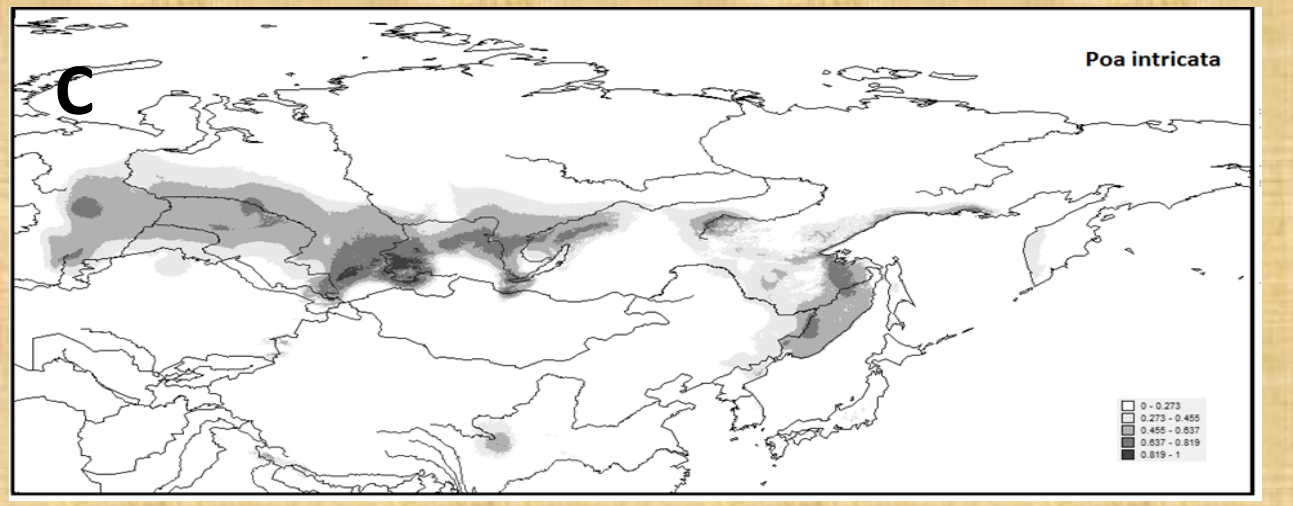


The MaxEnt algorithm allows not only to obtain a species distribution model, but also to evaluate it, using the AUC, showing the quality of prediction

The models of potential distribution of *3* relative species in Asian Russia, obtained using MaxEnt, based on Bio1, Bio2, Bio5, Bio7, Bio8, Bio12, Bio15 for current climate





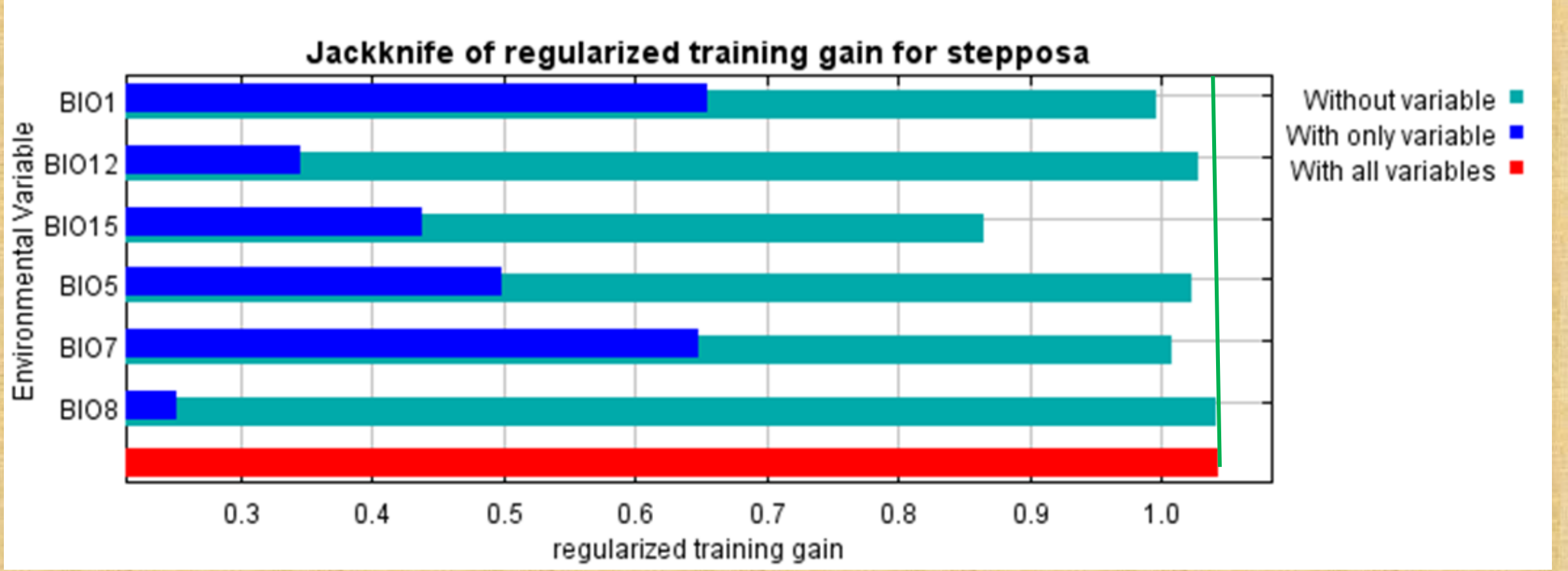


Correlated variables were deleted using SDMtools

The impact of variables can be evaluated in three independent ways:

a direct contribution (in percent)
b revaluation after permutation
c with jackknife test

jackknife algorithm



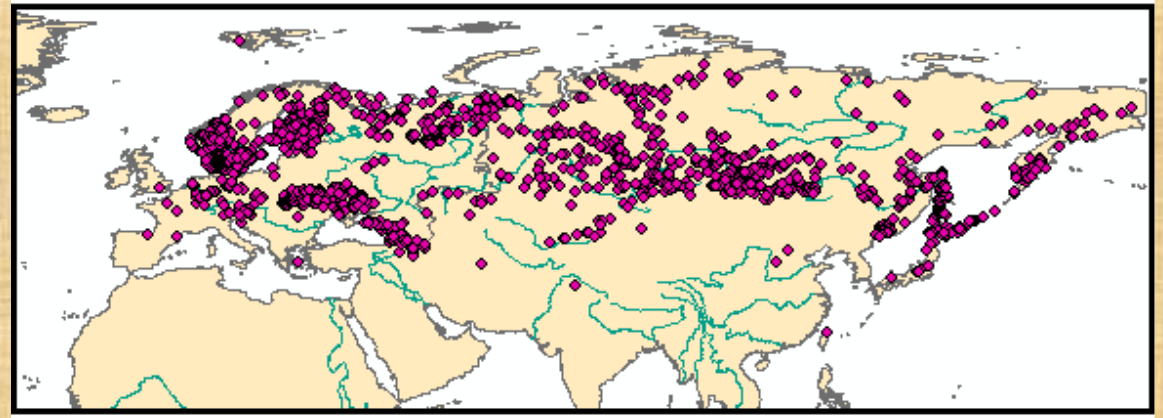
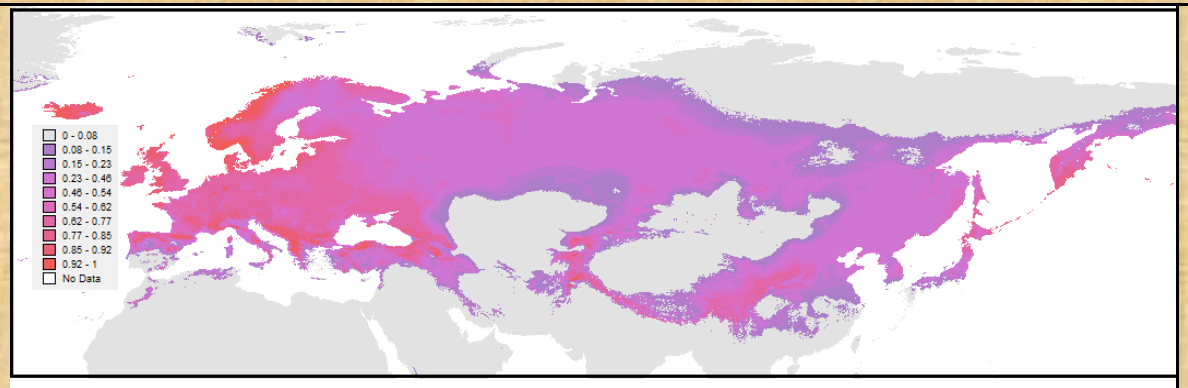
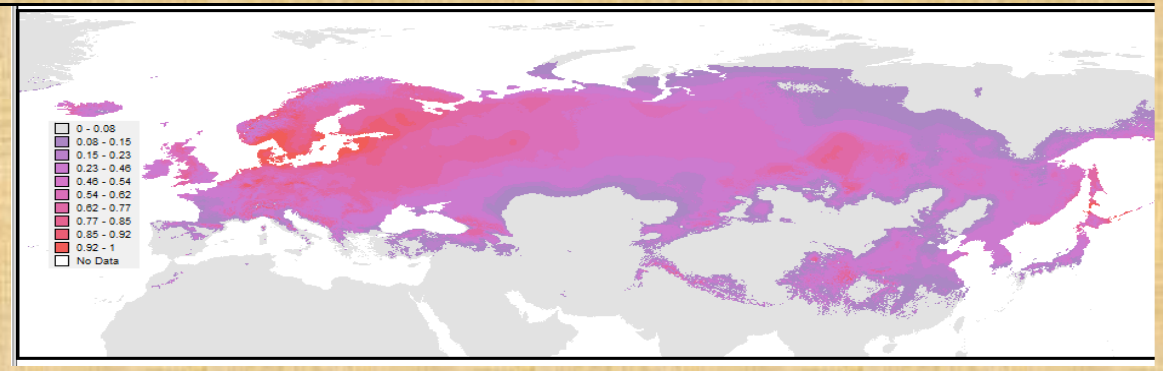
	1 speies = 290		2 species n = 229		3 species n = 97	
n tr/n tst	218/72		172/57		73/24	
AUCtr/AUCtst	0.887/0.871		0.920/0.902		0.922/0.884	
Standard deviation	0.016		0.020		0.036	
Logistic threshold	0.236		0.210		0.273	
Evaluation	% contribution	Permutation	% contribution	Permutation	% contribution	Permutation
	Bio12=32.6	Bio12=25.3	Bio12=42.7	Bio1=29.7	Bio12=36.8	Bio1=25.5
	Bio5=22.9	Bio1=23.6	Bio1=15.1	Bio2=24.1	Bio1=29.7	Bio15=22.2
	Bio1=20.5	Bio15=18.5	Bio5=13.5	Bio15=23.9	Bio15=22.1	Bio8=20.1
	Bio15=11.1	Bio5=14.6	Bio2=13.3	Bio5=7.3	Bio8=5.3	Bio12=17.7
AUCtr- AUC of training sampling; AUCtst – AUC of testing sampling						

Modelling for past and future

MaxEnt

GBIF

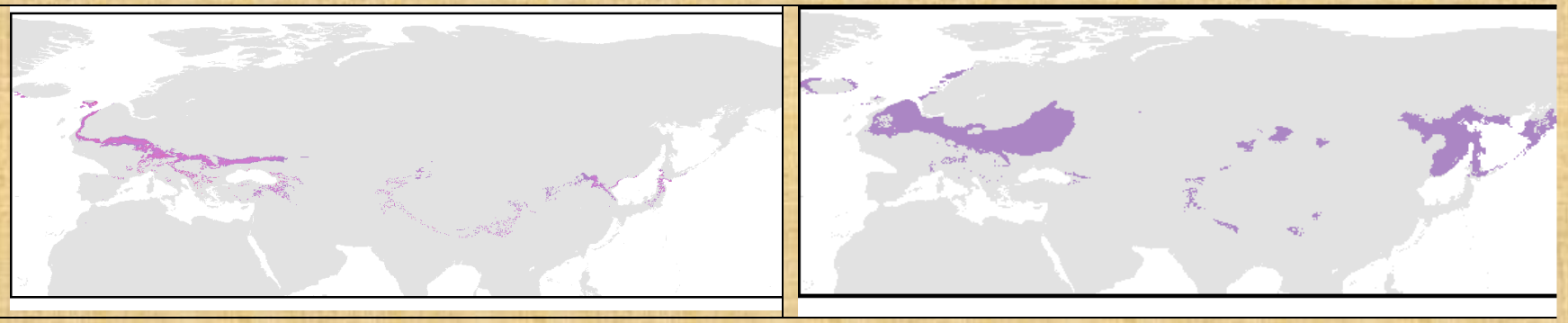
Modern distribution

P. nemoralis	*P. palustris*
	
	

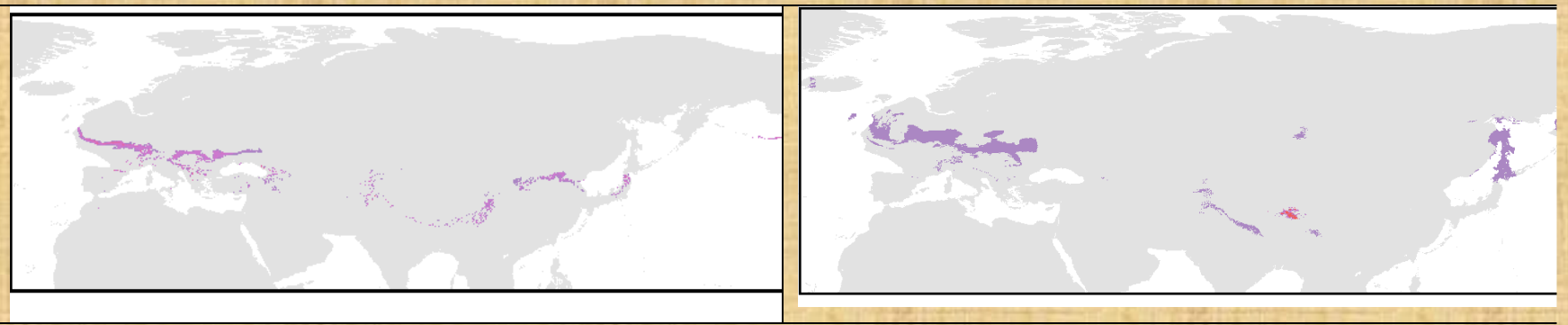
LGM

P. nemoralis *P. palustris*

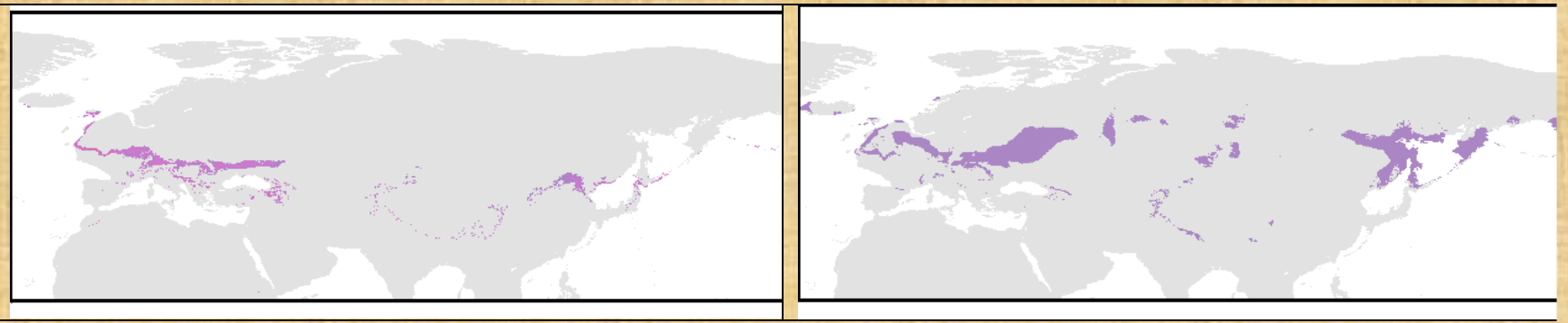
CCSM4



MIROC-ESM

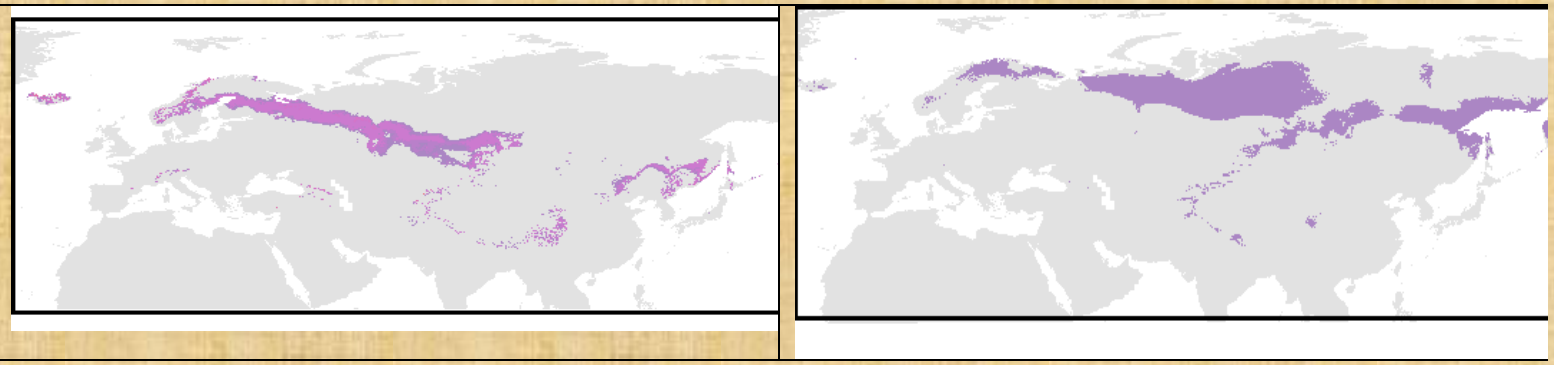


MPI-ESM

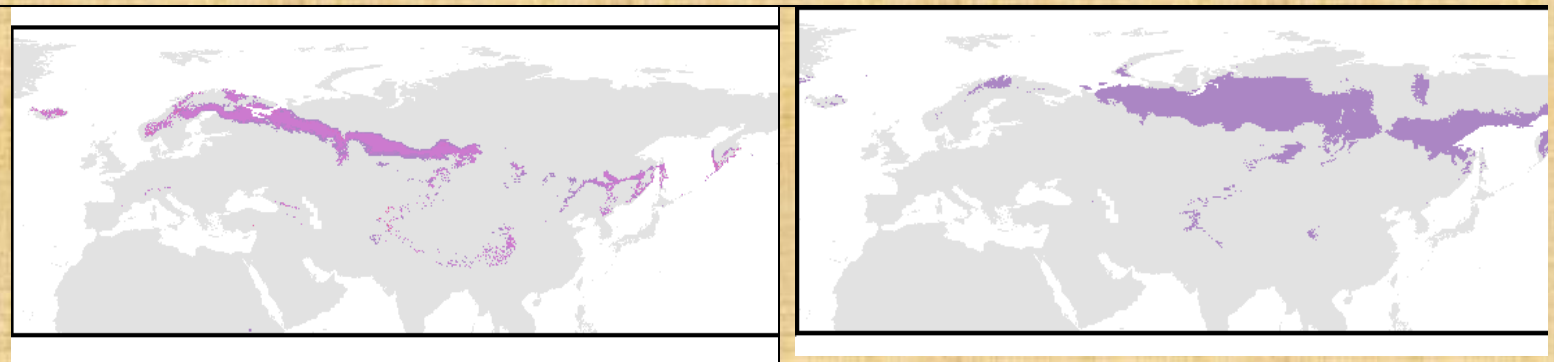


Middle Holocene

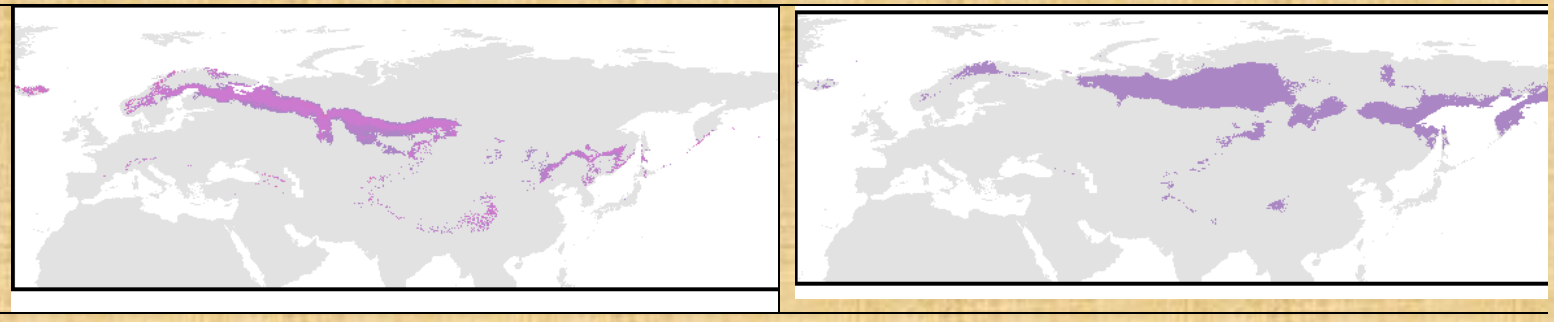
CCSM4



MIROC-ESM

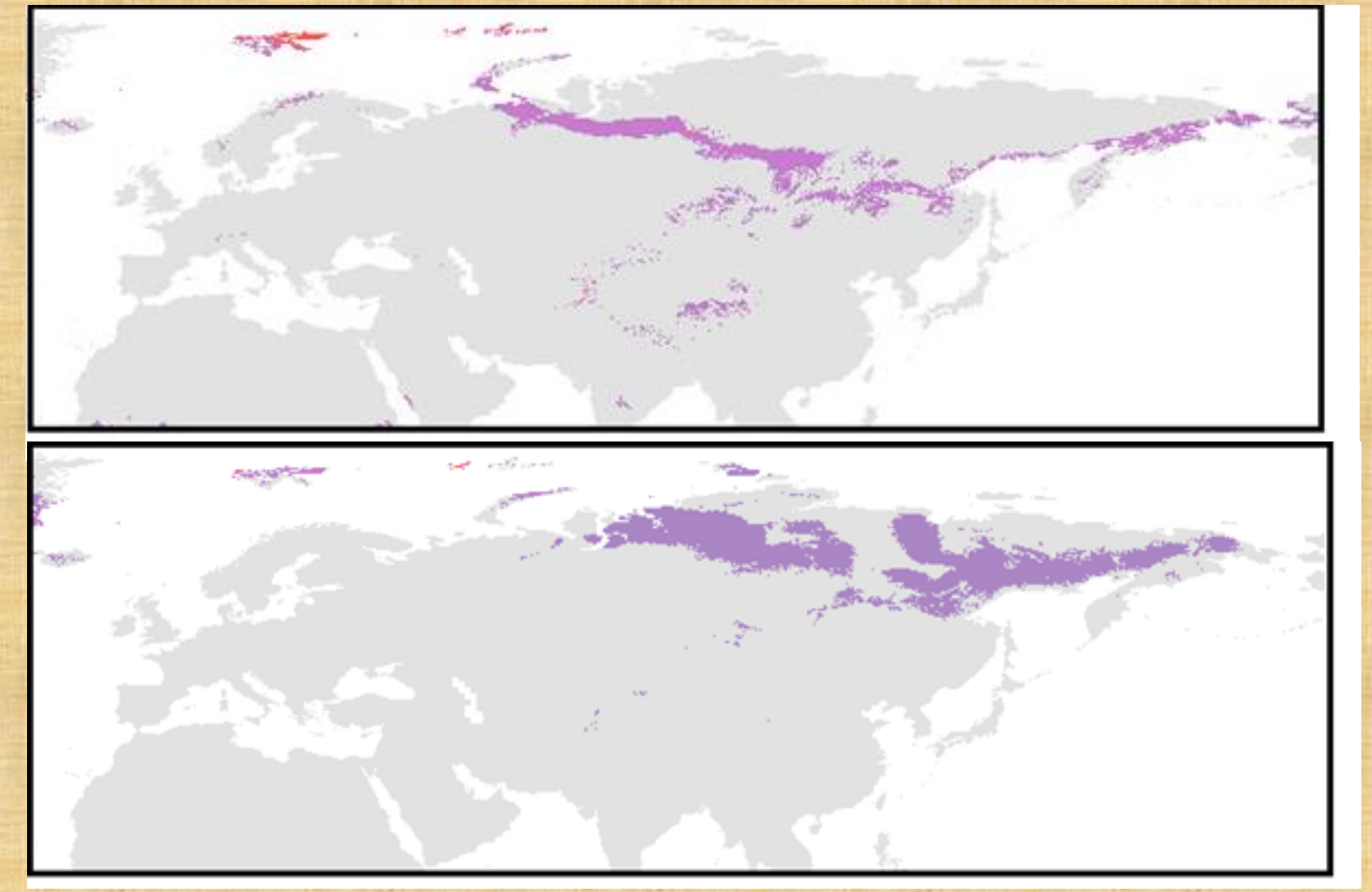


MPI-ESM



Models of distribution of *Poa nemoralis and P. palustris for 2080*

SCIRO scenario of emmission– A2a 2080



The models of potential species distribution, constructed on the basis of ecologo-climatical niches can be used not only for paleogeographical reconstructions, but also are of a great practical value.

They allow

A To predict the expansion of invasive species

B To reveal the possibility of the useful species introduction

C To predict probable dynamics of ranges in accordance with various scenarios of climate change in the future

D To reveal the possible locations of rare species.

Thank you for your attention

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