Modeling potential ranges of non-indigenous species: land snails as a case study

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Biological invasions – i.e., the spread of organisms accidentally or deliberately introduced to geographic regions outside their native range (IUCN, 2000) .

Native range

Non-native range

The main feature of invasive species: 2 ranges

Land snails in Eastern Europe in as a case study

- *Arianta arbustorum* Linnaeus, 1758;
- *Brephulopsis cylindrica* Menke, 1828;
- *Caucasotachea vindobonensis* C. Pfeiffer, 1828;
- *Harmozica ravergiensis* Férussac, 1835;
- *Helix lucorum* Linnaeus, 1758;
- *Helix pomatia* Linnaeus, 1758;
- *Monacha cartusiana* O.F.Müller, 1774;
- *Xeropicta derbentina* Krynicki, 1836;
- *Xeropicta krynickii* Krynicki, 1833.

Harmozica ravergiensis, Rostoy am Don, Russland

Arianta arbustorum

The study area
66° N to 40° N, from 20° E to 60° E

Xeropicta derbentina, Rostoy on Don, Russland

Helix pomatia

1. Occurrences

Species/ Native range	Occurrences number					
	Author's collection	Lit	ZM MSU	ZIN RAS	GBIF	**Total**
A. arbustorum N-W, C Europe	3	47	6	17	177	**250**
B. cylindrica Crimea	30	45	8	15	4	**102**
C. vindobonensis C, S-E Europe, Caucasus, Crimea	18	121	10	68	2	**219**
H. ravergiensis Caucasus	33	9	8	80	0	**130**
H. lucorum S Europe, Crimea, Caucasus	15	19	15	39	0	**88**
H. pomatia C, S-E Europe	16	91	14	25	16	**162**
M. cartusiana S Europe, Crimea, Caucasus	14	41	13	27	0	**95**
X. derbentina Caucasus, Crimea, Asia Minor	59	107	25	142	1	**334**
X. krynickii Caucasus, Crimea, Asia Minor	8	35	12	23	2	**80**

Dataset Acquisition and Preparation

1. Spatial Thinning of Records
spThin package in R, 5–10 km

2. **Random background points**

Point layers with presence and pseudo-absence points for each species

2. Predictor Variables

19 **bioclimatic variables**
WorldClim 2.1
2.5 arcmin
VIF = 10

'bio1' Average annual temperature,
'bio2' Average daily temperature range,
'bio4' Seasonal temperature,
'bio8' Average temperature of the wettest quarter,
'bio9' Average temperature of the driest quarter,
'bio15' Variation coefficient of precipitation,
'bio18' Precipitation of the warmest quarter,
'bio19' Precipitation of the coldest quarter

Moderate Resolution Imaging Spectroradiometer (MODIS)

land cover/land use type,

EVI (enhanced vegetation index)

Land cover types are identified in accordance with the classification of the International Geosphere-Biosphere Programme

3. Modeling

- generalized linear model, GLM
- random forest, RF
- MaxEnt

k-fold cross validation
original sample was divided into
training (75%)
test (25%)

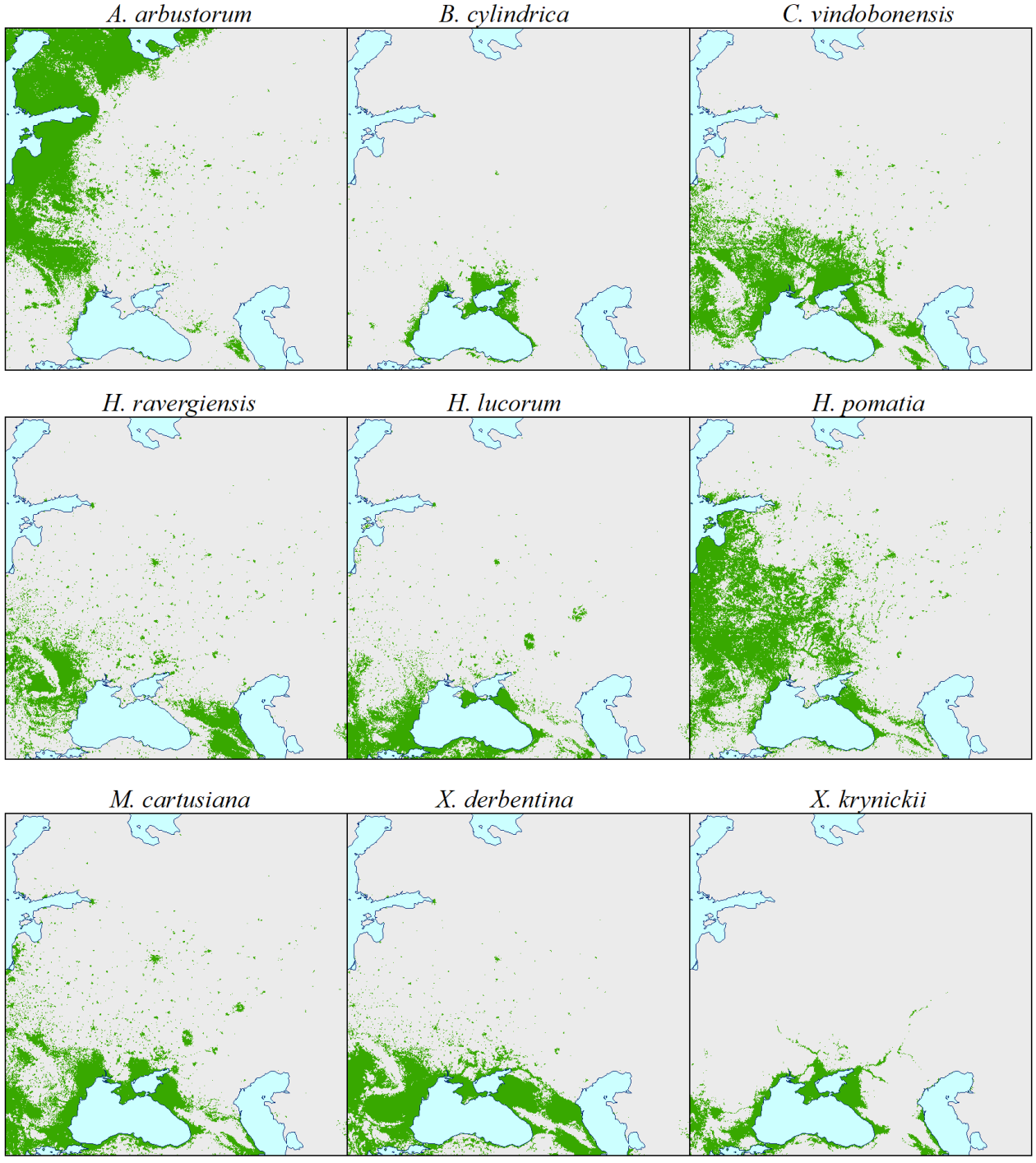
Models with
AUC ≥ 0,85

Ensemble models

Threshold –
maximizing the sum of sensitivity
and specificity (maxSSS)

maps of potential ranges

suitable, 1
unsuitable, 0



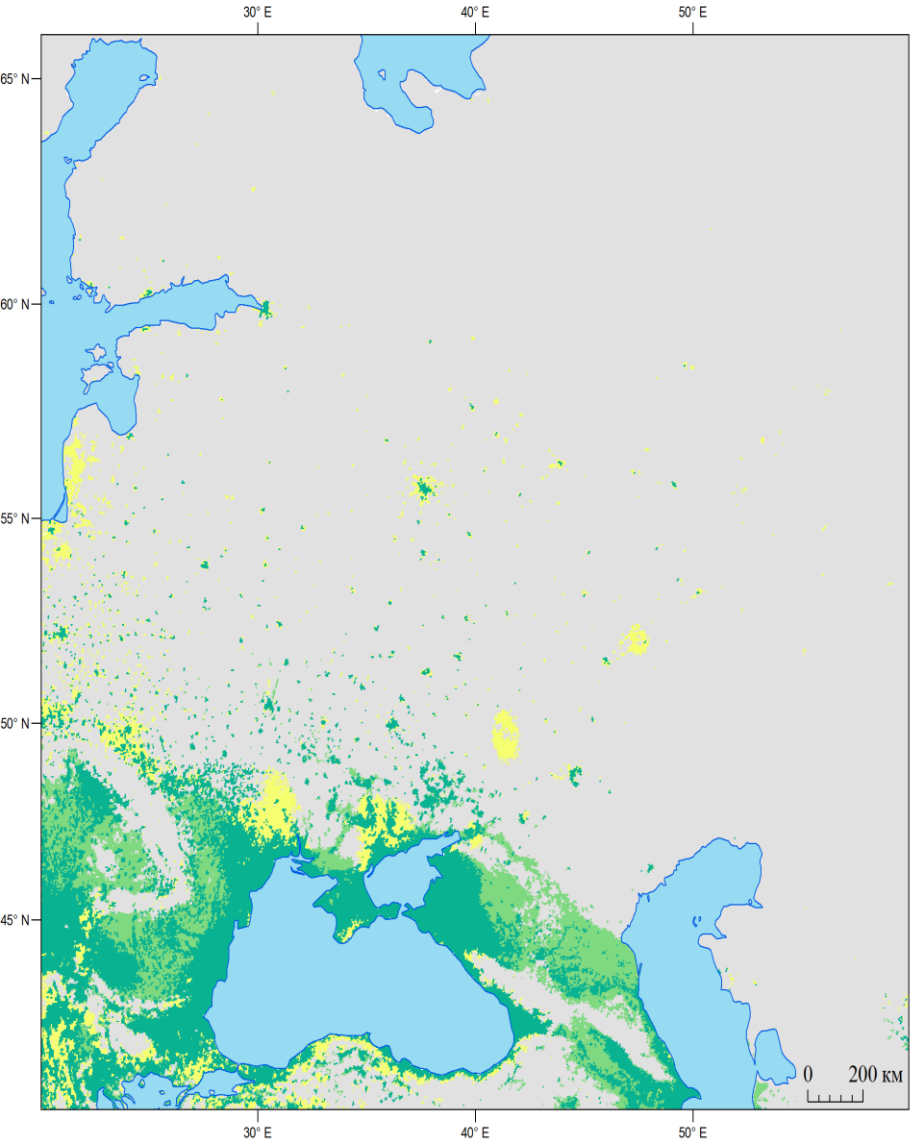
Пригодность территории для обитания

непригодная пригодная

Species	Sq km
A. arbustorum	**1 170 865.59**
B. cylindrica	210 956.85
C. vindobonensis	982 045.05
H. ravergiensis	645 009.13
H. lucorum	628 528.55
H. pomatia	**1 383 689.96**
M. cartusiana	946 436.76
X. derbentina	988 462.54
X. krynickii	559 092.30

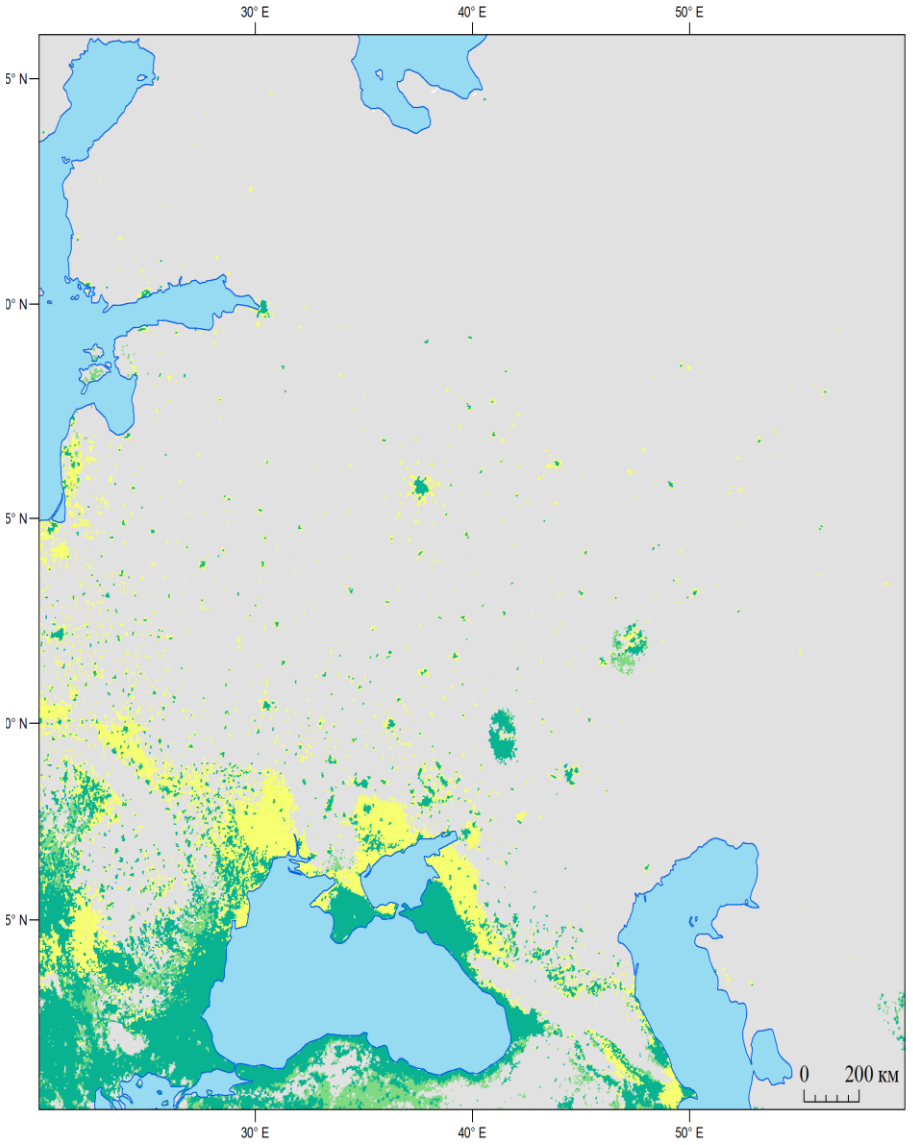
Relative contribution of variables (%) based on correlation metrics

	A. arbustorum	*B. cylindrica*	*C. vindobonensis*	*H. ravergiensis*	*H. lucorum*	*H. pomatia*	*M. cartusiana*	*X. derbentina*	*X. krynickii*
bio1	4.5*	16.8*	27.9*	9.3*	10.8*	16.1*	10.8*	33.7*	34.1*
bio2	29.7*	14.4*	10.8*		0.6	9.8*	4.2*		2.6
bio4	27.8*	3.7*		3	11.6*		2.8	8.7*	1.8
bio8			7,0*		10.1*		2.4*		
bio9	4.7*	8.5*			6.5*		5.4*		3.5*
bio15	1.3	3.4*		1.4			1.6		6.7*
bio18		6.6*	9.5*	6.2*	5.1*	8.5*	4.9*	9.9*	3.4*
bio19		7.9*		5*			0.8		2.2*
EVI	0.6	3.6*		5.1*	3.1*		0.8		
LU1				7.2*	7.8*		8.7*		
LU4	2*		1.4						
LU5	4	9.9*	12*	16.5*	6.1*	5.4*	3.7*	16.4*	13.7*
LU8	2.6	0.9						0.5	2.2*
LU9						4.1*			
LU10		1.8*		4.8*			0.7	2.9	2.4*
LU11		1.8*				0.6			1.5
LU12	2.9		3.2*		2.9*	2*	0.7		6.3*
LU13	14.0*	11.5*	11.8*	21.2*	18.2*	16.8*	12.2*	10.8*	



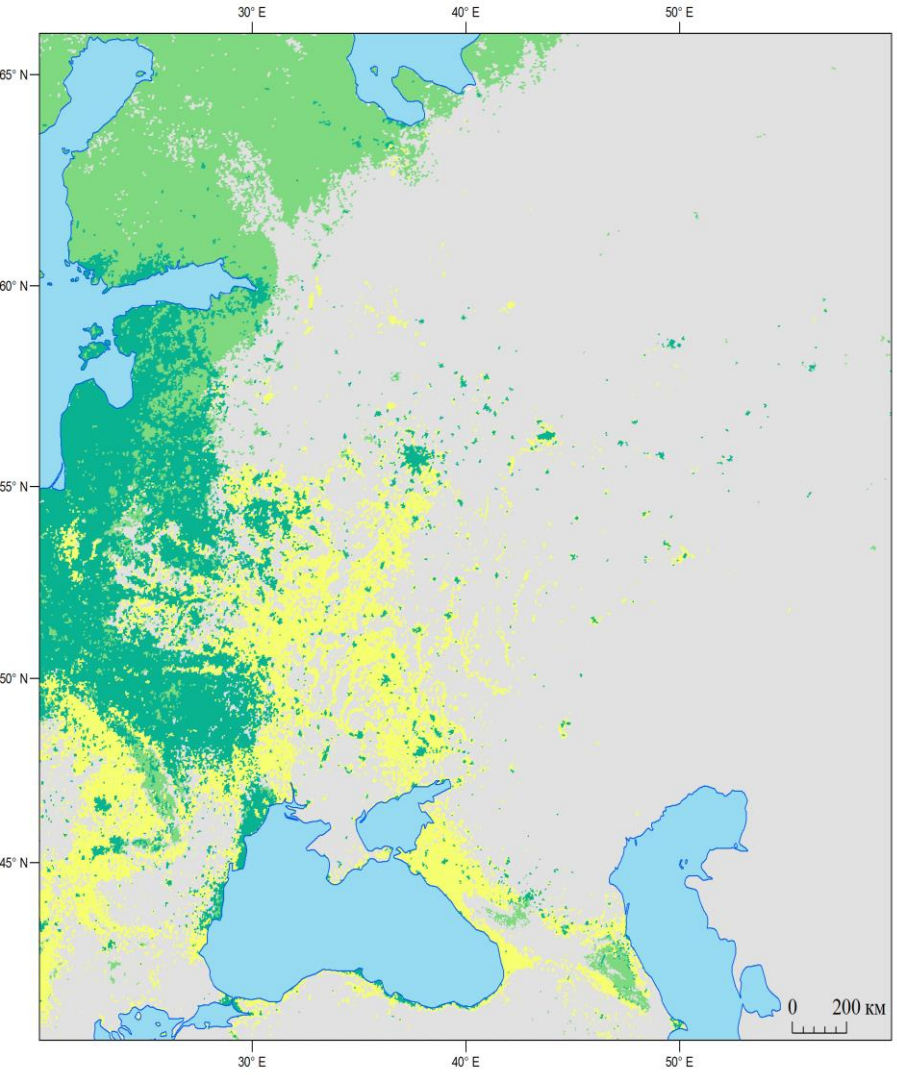
Пригодность территории для обитания

- непригодна для обоих видов
- пригодна для *X. derbentina*
- пригодна для *M. cartusiana*
- пригодна для обоих видов



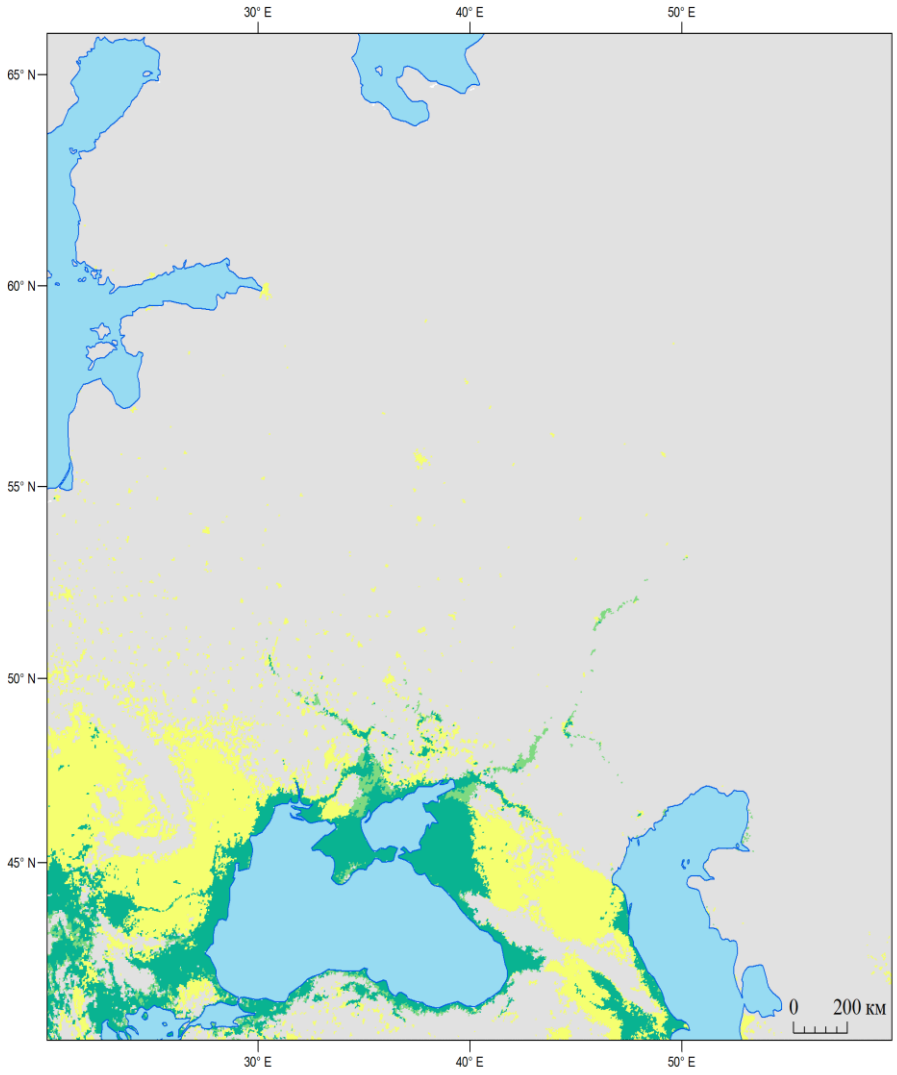
Пригодность территории для обитания

- непригодна для обоих видов
- пригодна для *H. lucorum*
- пригодна для *M. cartusiana*
- пригодна для обоих видов



Пригодность территории для обитания

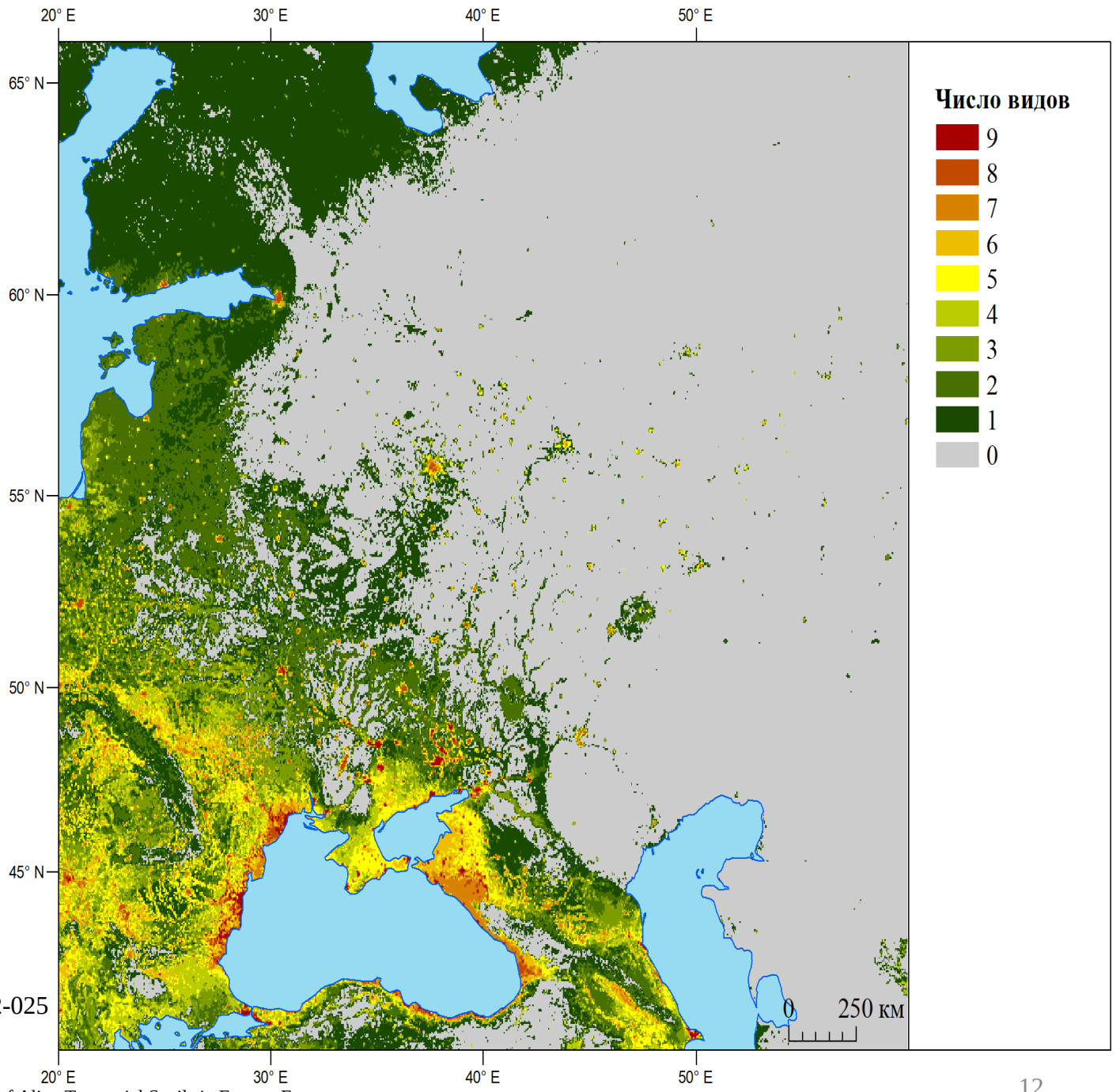
- непригодна для обоих видов
- пригодна для *A. arbustorum*
- пригодна для *H. pomatia*
- пригодна для обоих видов



Пригодность территории для обитания

- непригодна для обоих видов
- пригодна для *X. krynickii*
- пригодна для *X. derbentina*
- пригодна для обоих видов

Habitat suitability for different numbers of studied species



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Conclusions

All land snails species have the potential for expansion to new territories under the current climate conditions.

Modeling results confirmed the role of climate in the spread of land snails. In the eastern part of the study region current climatic conditions are not suitable for the species.

The anthropogenic biotopes contribution to the models was high but the real role in nonindigenous snails species ecology is discussible.