წაბლის (Castanea sativa Mill.) ბუნებრივი პოპულაციების გენეტიკური მრავალფეროვნება სამხრეთ კავკასიაში და კონსერვაციული პრიორიტეტები

Genetic diversity of *Castanea sativa* Mill. natural populations and conservation prioritization in the South Caucasus

ბერიკა ბერიძე, ირინა დანელია, კატაჟინა სენკევიჩი, ლუკაშ ვალასი, მონიკა დერინგი

Berika Beridze, Irina Danelia, Katarzyna Sękiewicz, Łukasz Walas, Monika Dering

თბილისი 2024

Tbilisi

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Reconstruction of the evolutionary history of the Caucasian forests:

comparative phylogeography of six forest tree species

(grant no 2017/26/E/NZ8/01049)

NATIONAL SCIENCE CENTRE
POLAND

INSTYTUT DENDROLOGII PAN
W KÓRNIKU

Evolutionary history and conservation genetics of *Castanea sativa* Mill. in the South Caucasus

Beridze B, Sękiewicz K, Walas Ł, Thomas PA, Danelia I, Kvartskhava G, Farzaliyev V, Bruch AA, Dering M. 2023. Evolutionary history of *Castanea sativa* Mill. in the Caucasus driven by Middle and Late Pleistocene palaeoenvironmental changes. ***AoB Plants***, *15*: plad059.

IF: 2.9

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IF: 2.6

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IF: 0.9

შესავალი
Introduction

The Hundred-Horse Chestnut
The tree in a gouache by Jean-Pierre Houël, around 1777. Public Domain

Castanea sativa Mill.

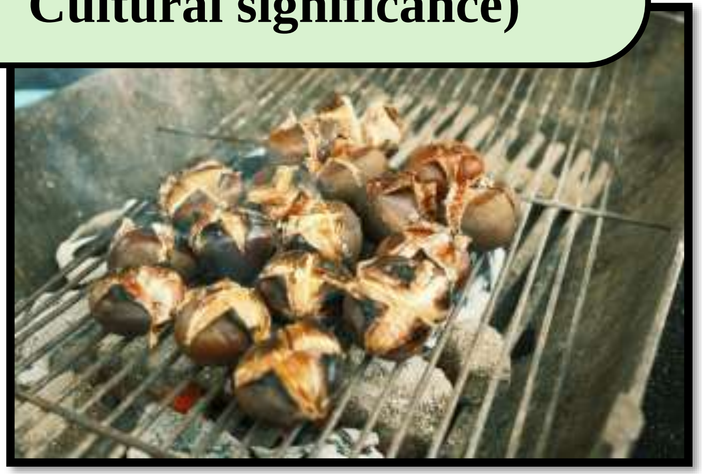
EN Chestnut, European Chestnut
GE წაბლი, ჭუბური, გვიჯ/გვიჯრა
AZ Adi şabalıd

ეკონომიკურად მნიშვნელოვანი სახეობა ევროპაში
(Ecological, Economic, and Cultural significance)

წაბლი – საქართველოს ტყეების
Chestnut – Georgian forests

2.1%

- წაბლი (Chestnut)
- წაბლი + წიფელი (Chestnut + Becch)
- წაბლი + წიფელი + რცხილა (Chestnut, Beech, Hornbeam)



შესავალი
Introduction

შესავალი
Introduction

დაავადებული პოპულაციები

Affected populations

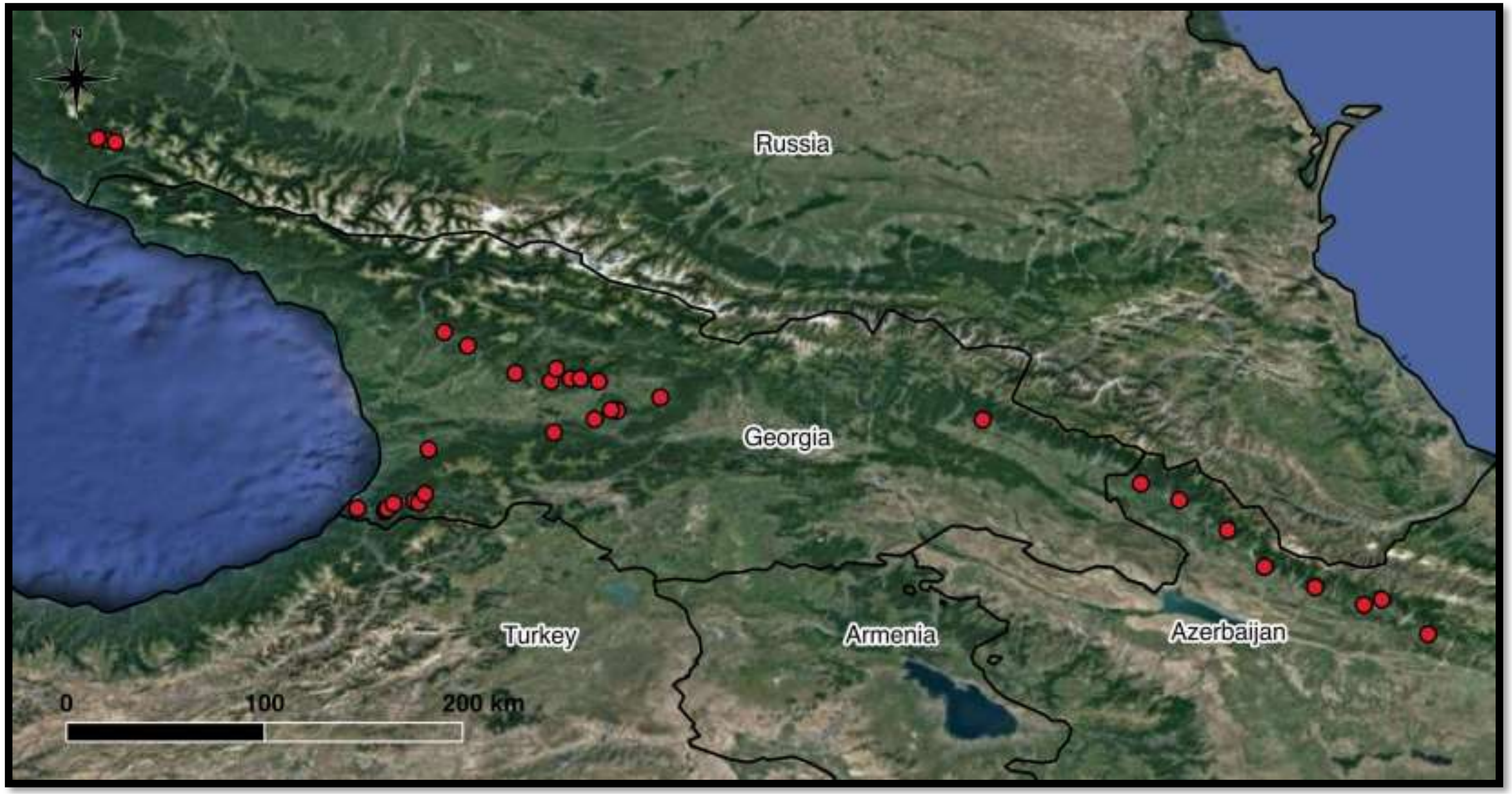
- გადაჭარბებული ძოვება

  Overgrazing
- არალეგალური ჭრა

  Illegal cuttings
- სოკოვანი დაავადება

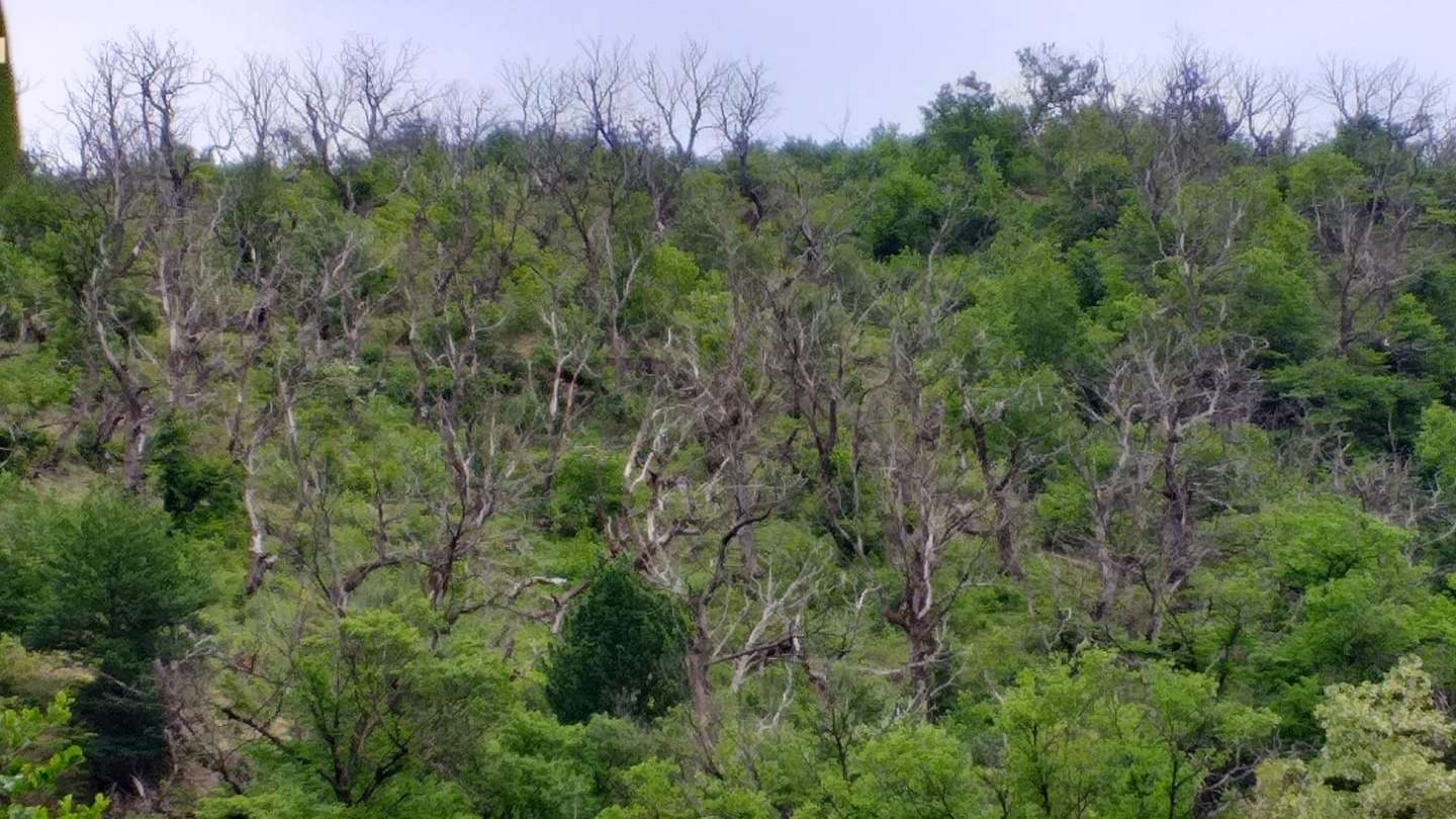
  Cryphonectria parasitica

- **LC** – globally (IUCN)
- **VU** – GE (IUCN unassessed)
- შესულია საქართველოსა და აზერბაიჯანის „წითელ ნუსხაში“ და „წითელ წიგნში“



Prospero et al., 2013; Rigling & Prospero, 2018; Aghayeva et al., 2017; Stauber et al., 2021; Tavadze et al., 2013; Cech and Hoch, 2018; Dumbafze et al., 2018; Pridnya et al., 1996.



შესწავლილი პოპულაციები
Studied populations

კვლევა
Study

21 – პოპულაცია (Population)

GE – 17, AZ – 4

653 – ინდივიდი (Individual)

9 – მიკროსატელიტური ბირთვული მარკერი (nSSRs)

- დემოგრაფიული ისტორია, ისტორიული ბიოგეოგრაფია

  Demographic history, Historical biogeography (Divergence patterns)

- პოპულაციის დემოგრაფია

  Population demography (Bottleneck, Genetic drift, Genetic differentiation, Effective population size)

- ლანდშაფტური გენეტიკა (გენეტიკური დიფერენცირების მიზეზები: კლიმატი და მანძილი)

  Landscape Genetics (Drivers of genetic differentiation: climate and geographical distance)

- გენეტიკური მრავალფეროვნება და კონსერვაციული გენეტიკა

  Genetic diversity and conservation genetics

- წაბლის გავრცელების არეალის მოდელირება

  Modelling the distributional are of *C. sativa* in the:

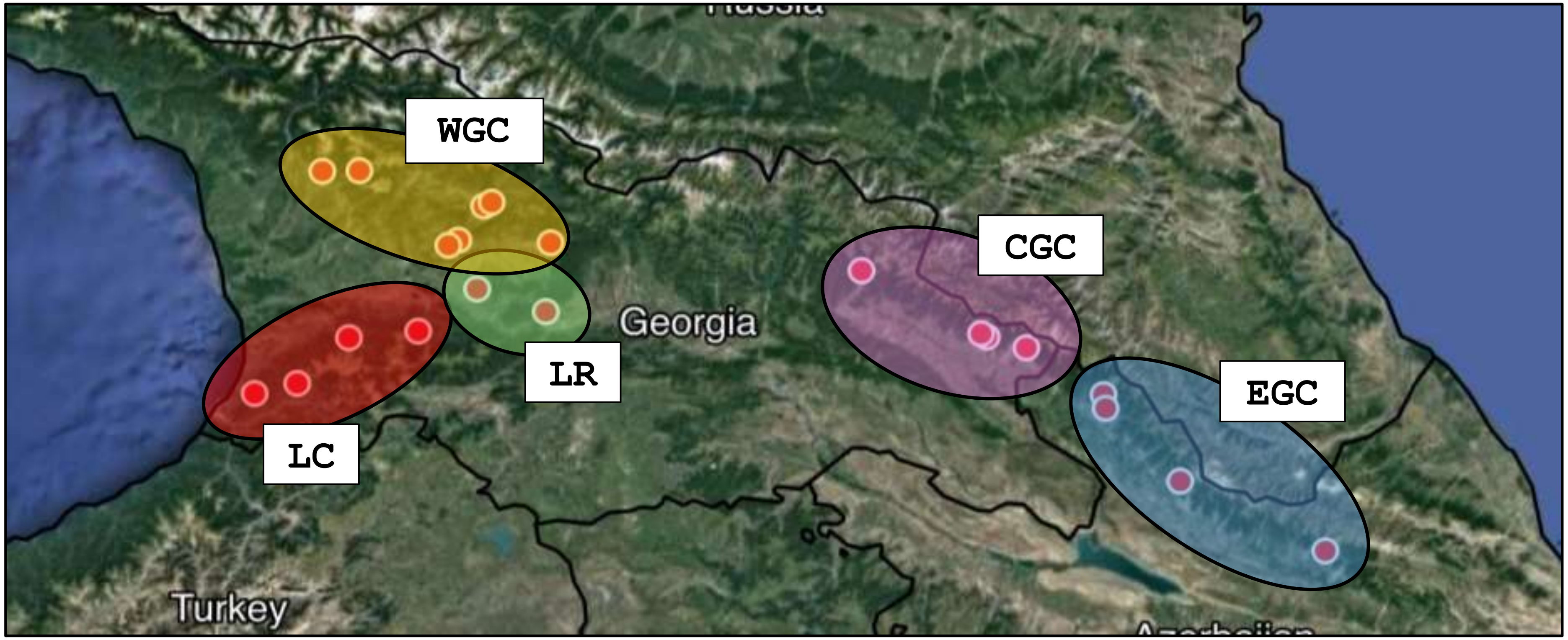
  - წარსულში **(Past)**
  - აწმყოში **(Present)**
  - მომვალაში კლიმატის ცვლილების გათვალისწინებით **(Future)**

- **Assisted Gene Flow possibility between European and the Caucasian populations**

Pop	Locality	Latitude	Longitude	Altitude	*N*	*A*	*Pa*	*Ar*	*Ho*	*uHe*	*Fis*	*Null*
LC1	**Lesser Caucasus**	41.6843	41.8345	187	30	6.67	3	5.86	0.526	0.588	0.062	
LC2		41.7287	42.0781	971	30	6.44	2	5.51	0.548	0.594	0.029	0.051
LC3		41.9293	42.3735	465	33	6.56	1	5.60	0.529	0.584	*0.030**	0.014
LC4		41.9581	42.7697	582	31	6.67	1	5.62	0.479	0.565	*0.111**	0.052
Average						**6.59**	**1.75**	**5.65**	**0.521**	**0.583**	**0.058**	**0.045**
LR1	**Likhi Range**	42.0437	43.4988	899	30	5.22	1	5.60	0.474	0.546	*0.086**	0.050
LR2		42.1429	43.1068	365	30	5.78	0	4.42	0.483	0.587	0.081	0.057
Average						**5.50**	**0.50**	**5.01**	**0.479**	**0.567**	**0.084**	**0.054**
WGC1	**Western Greater Caucasus**	42.3441	43.5264	595	30	5.33	2	4.62	0.506	0.530	0.025	0.040
WGC2		42.5205	43.1896	756	29	5.00	0	4.58	0.492	0.539	0.018	0.055
WGC3		42.5038	43.1462	775	33	5.56	0	4.80	0.529	0.546	0.033	0.017
WGC4		42.3557	42.9991	574	31	4.78	0	4.20	0.503	0.554	0.029	0.077
WGC5		42.3329	42.9421	537	28	6.44	5	5.64	0.583	0.562	0.021	0.018
WGC6		42.6569	42.4341	913	29	5.78	0	4.92	0.437	0.533	*0.131**	0.077
WGC7		42.6548	42.2216	343	31	6.22	0	5.39	0.482	0.518	*0.073**	0.024
Average						**5.59**	**1.0**	**4.88**	**0.505**	**0.540**	**0.047**	**0.044**
CGC1	**Central Greater Caucasus**	42.2226	45.3037	806	18	4.67	2	4.64	0.549	0.532	0.030	0.017
CGC2		41.9472	45.9865	679	30	4.44	0	3.88	0.456	0.471	0.029	0.020
CGC3		41.9326	46.0194	559	27	5.00	0	4.38	0.413	0.511	*0.136**	0.060
CGC4		41.8854	46.2457	691	22	3.56	0	3.65	0.433	0.415	0.026	0.005
Average						**4.42**	**0.50**	**4.14**	**0.463**	**0.482**	**0.055**	**0.026**
EGC1	**Eastern Greater Caucasus**	41.6796	46.6864	963	33	4.56	0	3.85	0.473	0.499	*0.084**	0.027
EGC2		41.6194	46.6990	670	31	4.11	0	3.66	0.436	0.510	0.082	0.044
EGC3		41.2976	47.1249	852	29	3.56	0	3.20	0.481	0.491	0.019	0.046
EGC4		40.9883	47.9544	1058	41	3.89	1	3.24	0.473	0.491	0.030	0.022

Group of populations	*Mean He*	*Mean Ar*	*Mean F_{IS}*	*Mean F_{ST}*
LC/LR/WGC/CGC/EGC	**0.610/0.599/ 0.561/0.512/0.505**	**5.65/5.01/4.88/4.14/3.49**	0.041/0.089/-0.002/0.016/-0.010	0.024/0.023/0.053/0.101/0.083
LC/WGC	0.610/0.561	5.65/4.88	0.041/-0.002	0.024/0.053
(LC, WGC)/CGC/(EGC	**0.579/0.512/0.505**	**5.16/4.14/3.49**	0.014/0.016/-0.010	0.050/ 0.101/0.083
(LC, LR, WGC)/(CGC, EGC)	**0.582/0.508**	**5.14/3.81**	0.026/0.001	0.046/0.095

Bolded are significant differences at $p<0.001$; LC = Lesser Caucasus, WGC – West Greater Caucasus, CGC – Central Greater Caucasus, ECG – East Greater Caucasus



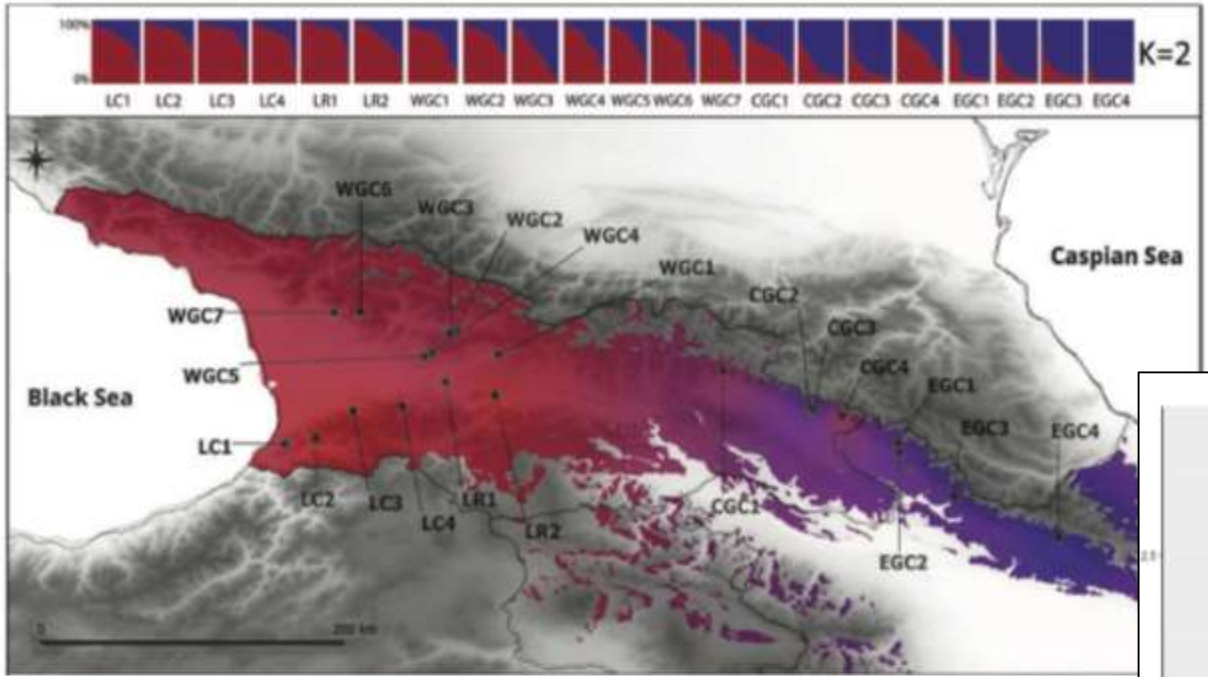
LC – Lesser Caucasus

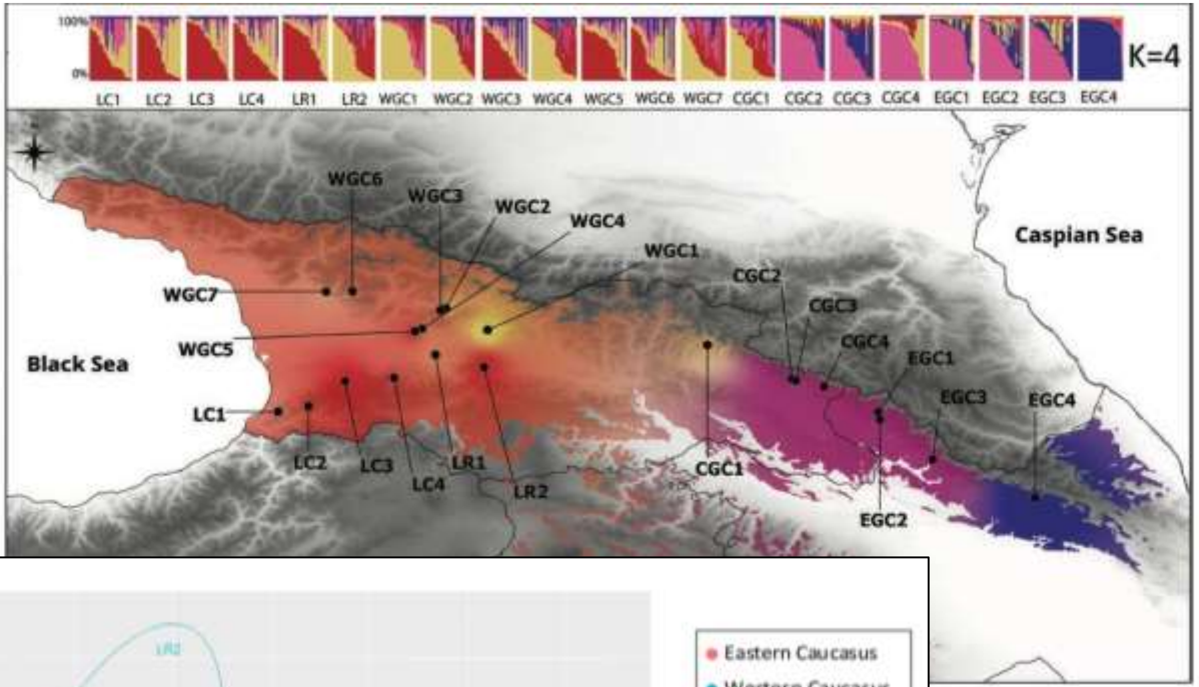
LR – Likhi Range

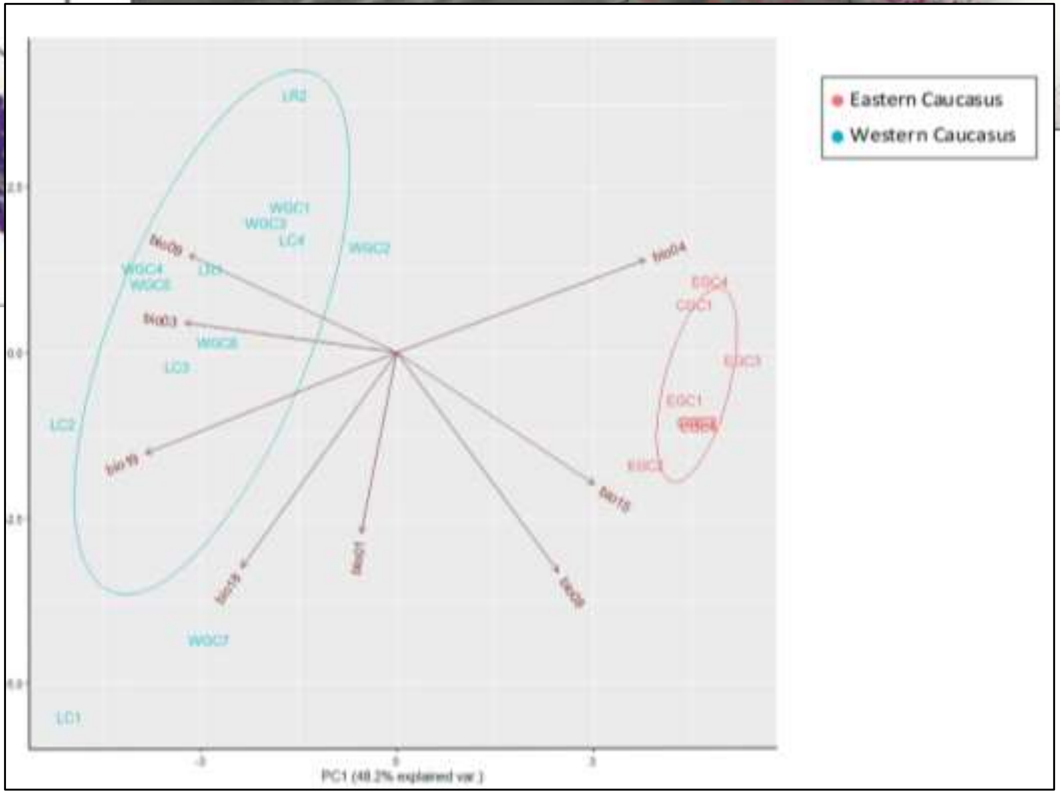
WGC – West Greater Caucasus

CGC – Central Greater Caucasus

EGC – East Greater Caucasus







Global *Fst* — 0.073 (95% *CI* 0.052–0.092)

კონსერვაციული პრიორიტეტიზაცია

Conservation prioritization

1. **Reserve selection**

   (ალელური მრავალფეროვნება

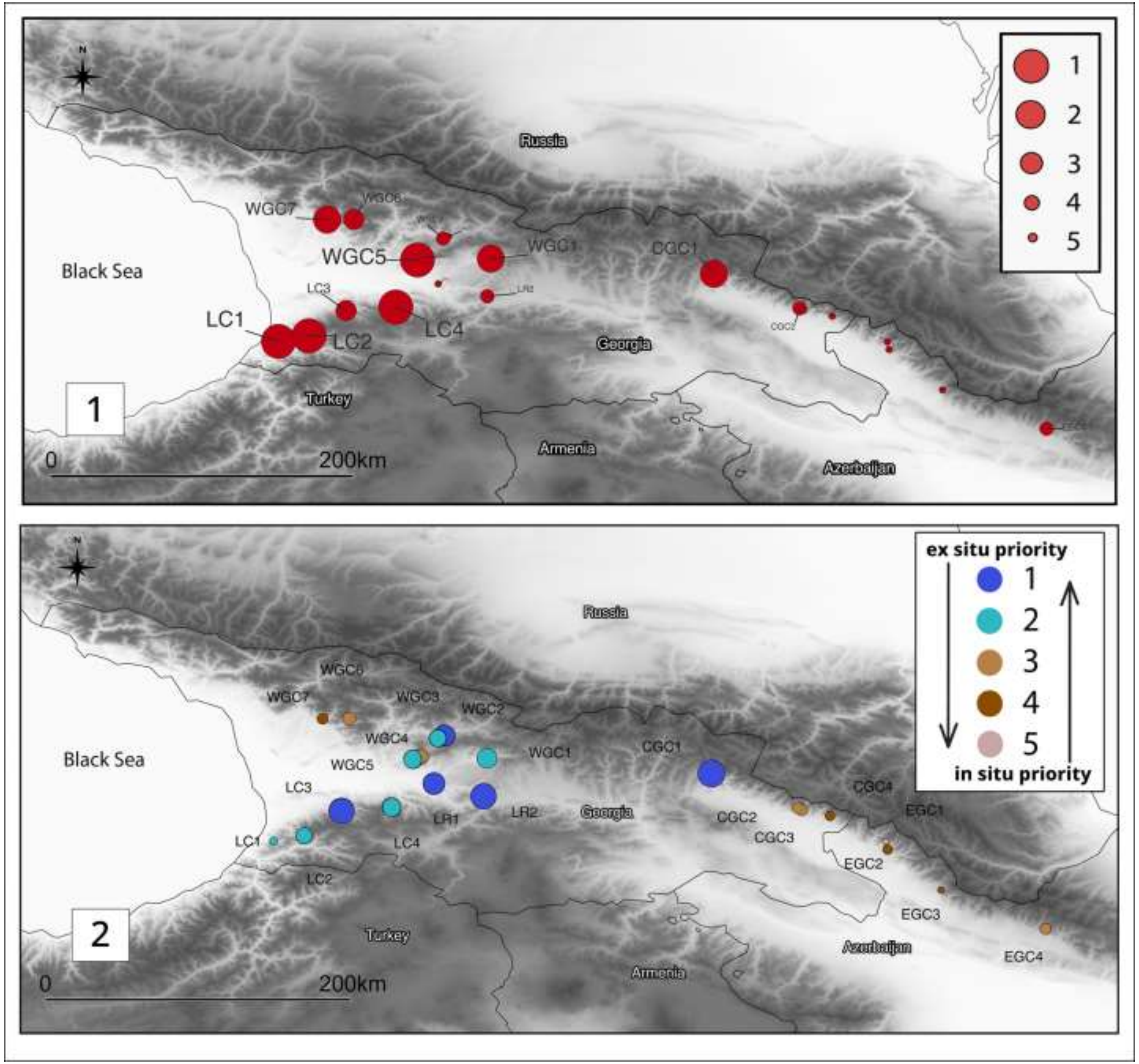
   Allelic diversity)

2. **კონსერვაციული ინდექსი**

   Conservation index

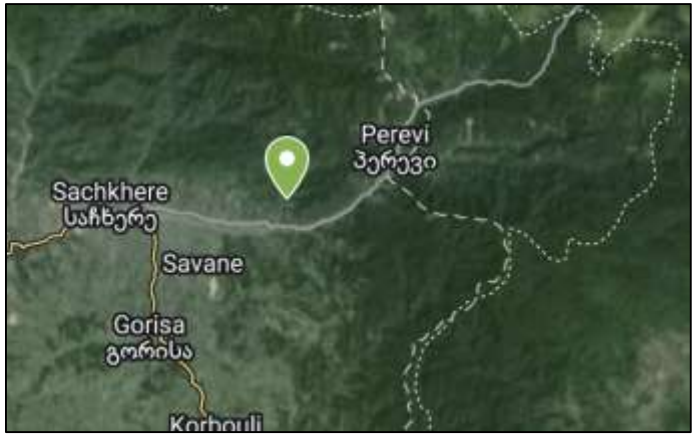
   (ალელური განაწილება და ეკოლოგიური ცვლადები

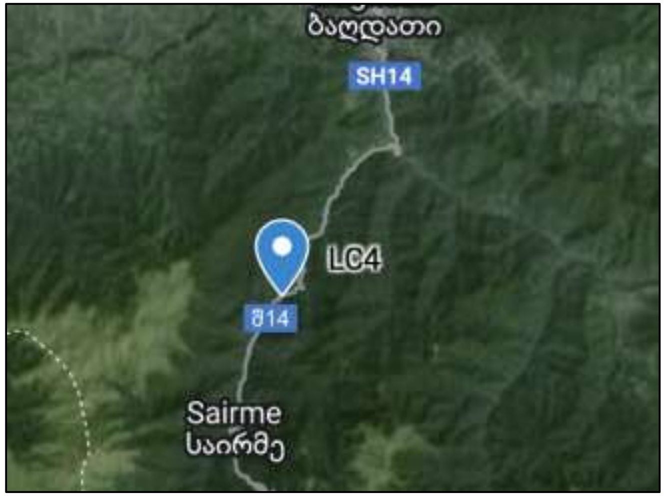
   Allelic diversity and ecological variables)

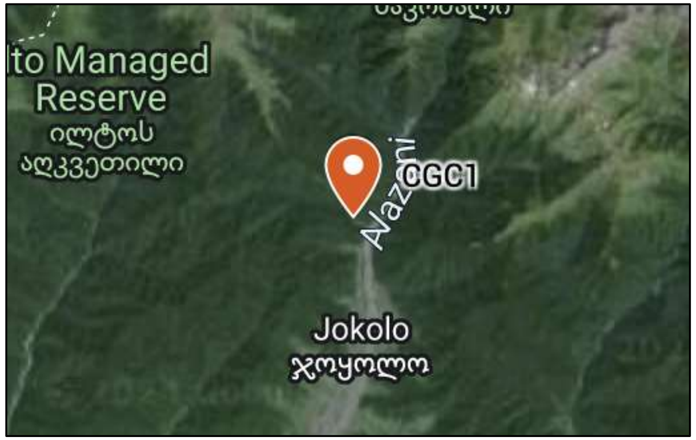



WGC4
WGC5
ტყიბული
Kursebi
კურსები
Tkibuli Reservoir
ტყიბულის წყალსაცავი
Dzevri


გეგმარებითი
ეროვნული
პარკი
WGC7
Mukhuri
მუხური
Kurzu
კურზუ
Khabume


Perevi
პერევი
Sachkhere
საჩხერე
Savane
Gorisa
გორისა


ბაღდათი
SH14
LC4
შ14
Sairme
საირმე


Reserve
ილტოს
აღკვეთილი
CGC1
Alazani
Jokolo
ჯოყოლო


Tsikhisdziri
ციხისძირი
Chakvi
ჩაქვი
LC2
Chaisubani
ჩაისუბანი
LC1
Mtirala
National Park
Akho
ახო

Pop	*Ar*	*Fc*	*CI*	*Ci*
LR2	4.42	73.57	64.74	5.02
CGC1	4.64	51.81	51.59	4.66
LC3	5.60	69.63	84.54	4.61
WGC2	4.58	75.17	79.67	4.32
LR1	5.60	70.20	95.65	4.11
WGC1	4.62	63.16	76.16	3.83
WGC3	4.80	68.76	87.46	3.77
WGC5	5.64	81.10	121.60	3.76
LC4	5.62	65.05	100.87	3.62
LC2	5.51	89.15	158.05	3.11
WGC4	4.20	83.88	124.86	2.82
CGC3	4.38	38.44	67.97	2.48
WGC6	4.92	80.35	164.67	2.40
CGC2	3.88	39.73	69.79	2.21
EGC4	3.24	32.78	52.80	2.01
WGC7	5.39	73.55	198.64	1.99
CGC4	3.65	40.88	84.69	1.76
EGC2	3.66	49.11	108.67	1.65
LC1	5.86	60.98	268.90	1.33
EGC3	3.20	27.62	74.93	1.18
EGC1	3.85	27.50	109.54	0.97

Ar – ალელეური მრავალფეროვნება (Allelic diversity)

Fc – ტყის საფარი (Forest cover)

Cl* – აწმყოსა და მომავლის კლიმატის განსხვავება
(Differences between the present and future climate)

Ci^ – კონსერვაციული ინდექსი
(Conservation index)

***** – 2071-2100 წლების კლიმატი (Climate)
bio18 – precipitation of warmest quarter
bio19 – precipitation of coldest quarter

^ – მოდიფიცირებული (Modified) Ci
Cheddadi, R. and Khater, C., 2022. Guiding conservation for mountain tree species in Lebanon. *Forests*, *13*(5), p.711.

scientific reports

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OPEN

The evolutionary heritage and ecological uniqueness of Scots pine in the Caucasus ecoregion is at risk of climate changes

M. Dering[1,2], M. Baranowska[2], B. Beridze[1], I. J. Chybicki[3], I. Danelia[4], G. Iszkuło[1,5], G. Kvartskhava[4], P. Kosiński[1,2], G. Rączka[2], P. A. Thomas[6], D. Tomaszewski[1], Ł. Walas[1] & K. Sękiewicz[1]

Scots pine is one of the most widely occurring pines, but future projections suggest a large reduction in its range, mostly at the southern European limits. A significant part of its range is located in the Caucasus, a global hot-spot of diversity. Pine forests are an important reservoir of biodiversity and endemism in this region. We explored demographic and biogeographical processes that shaped the genetic diversity of Scots pine in the Caucasus ecoregion and its probable future distribution under different climate scenarios. We found that the high genetic variability of the Caucasian populations mirrors a complex glacial and postglacial history that had a unique evolutionary trajectory compared to the main range in Europe. Scots pine currently grows under a broad spectrum of climatic conditions in the Caucasus, which implies high adaptive potential in the past. However, the current genetic resources of Scots pine are under high pressure from climate change. From our predictions, over 90% of the current distribution of Scots pine may be lost in this century. By threatening the stability of the forest ecosystems, this would dramatically affect the biodiversity of the Caucasus hot-spot.

Pinus sylvestris L.

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RESEARCH ARTICLE

Ecology and Evolution WILEY

Past climatic refugia and landscape resistance explain spatial genetic structure in Oriental beech in the South Caucasus

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Funding information
National Science Centre, Grant/Award Number: 2017/26/E/NZ8/01049; Poznań University of Life Sciences; Institute of Dendrology, Polish Academy of Sciences

Abstract
Predicting species-level effects of climatic changes requires unraveling the factors affecting the spatial genetic composition. However, disentangling the relative contribution of historical and contemporary drivers is challenging. By applying landscape genetics and species distribution modeling, we investigated processes that shaped the neutral genetic structure of Oriental beech (*Fagus orientalis*), aiming to assess the potential risks involved due to possible future distribution changes in the species. Using nuclear microsatellites, we analyze 32 natural populations from the Georgia and Azerbaijan (South Caucasus). We found that the species colonization history is the most important driver of the genetic pattern. The detected west–east gradient of genetic differentiation corresponds strictly to the Colchis and Hyrcanian glacial refugia. A significant signal of associations to environmental variables suggests that the distinct genetic composition of the Azerbaijan and Hyrcanian stands might also be structured by the local climate. Oriental beech retains an overall high diversity; however, in the context of projected habitat loss, its genetic resources might be greatly impoverished. The most affected are the Azerbaijan and Hyrcanian populations, for which the detected genetic impoverishment may enhance their vulnerability to environmental change. Given the adaptive potential of range-edge populations, the loss of these populations may ultimately affect the specie's adaptation, and thus the stability and resilience of forest ecosystems in the Caucasus ecoregion. Our study is the first approximation of the potential risks involved, inducing far-reaching conclusions about the need of maintaining the genetic resources of Oriental beech for a species' capacity to cope with environmental change.

KEYWORDS
conservation genetics, *Fagus orientalis*, genetic structure, habitat stability, landscape genetics, species distribution modeling

TAXONOMY CLASSIFICATION
Population genetics

Fagus orientalis Lipsky

გმადლობთ

ყურადღებისათვის

Thanks!

სადოქტორო თეზისი

Ph.D. Thesis

berikaberidze7@gmail.com