VYTAUTAS MAGNUS UNIVERSITY
FACULTY OF FOREST SCIENCE AND ECOLOGY

Tree species: resilience to future climate change and biodiversity conservation - Hemiboreal forest perspective

GEDIMINAS BRAZAITIS

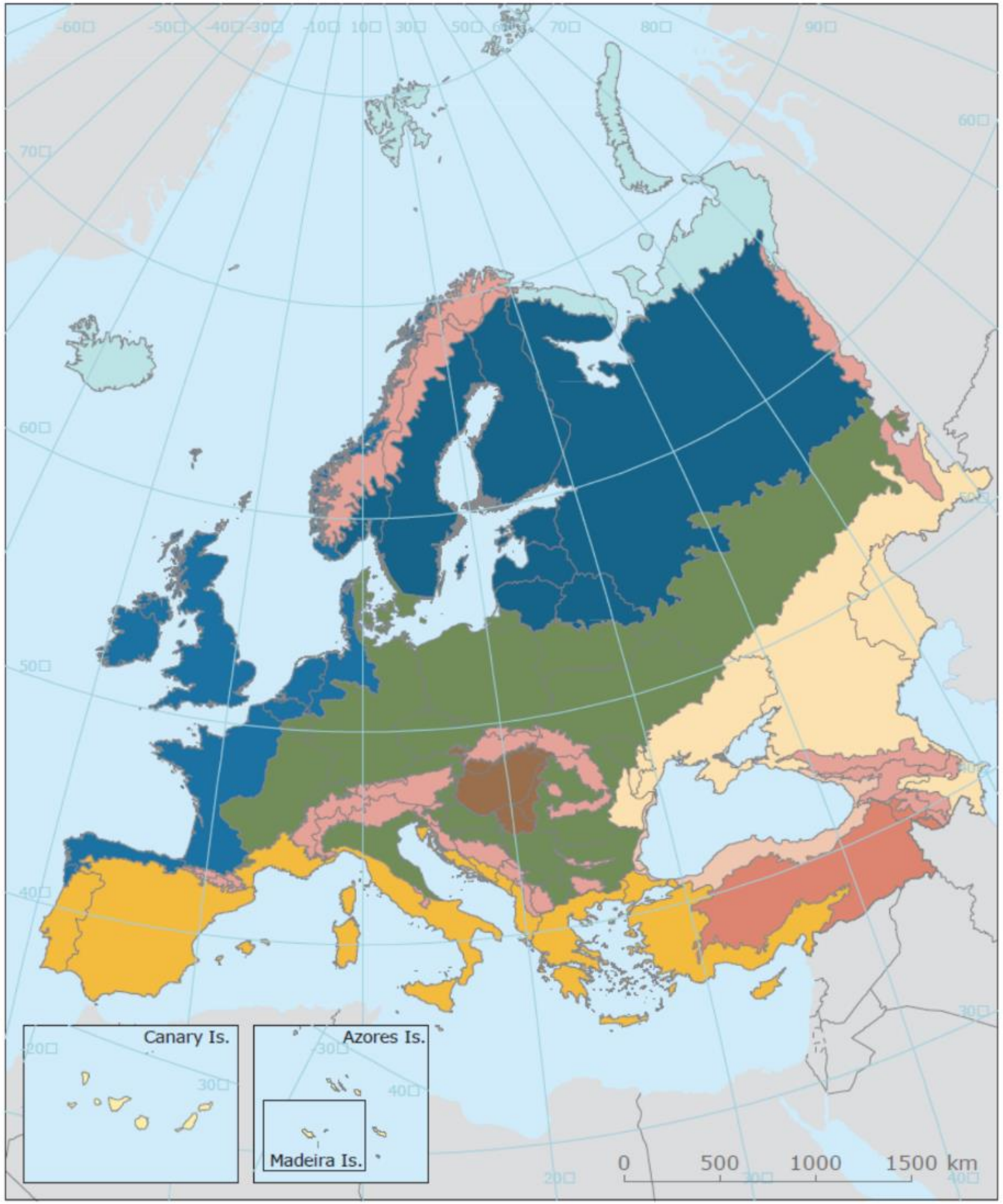
2025-01-28

Climate change and biodiversity conservation

We are faced in two global crisis

Often forest management ideas support mitigation of climate change, however suggested solutions might reduce biodiversity status;

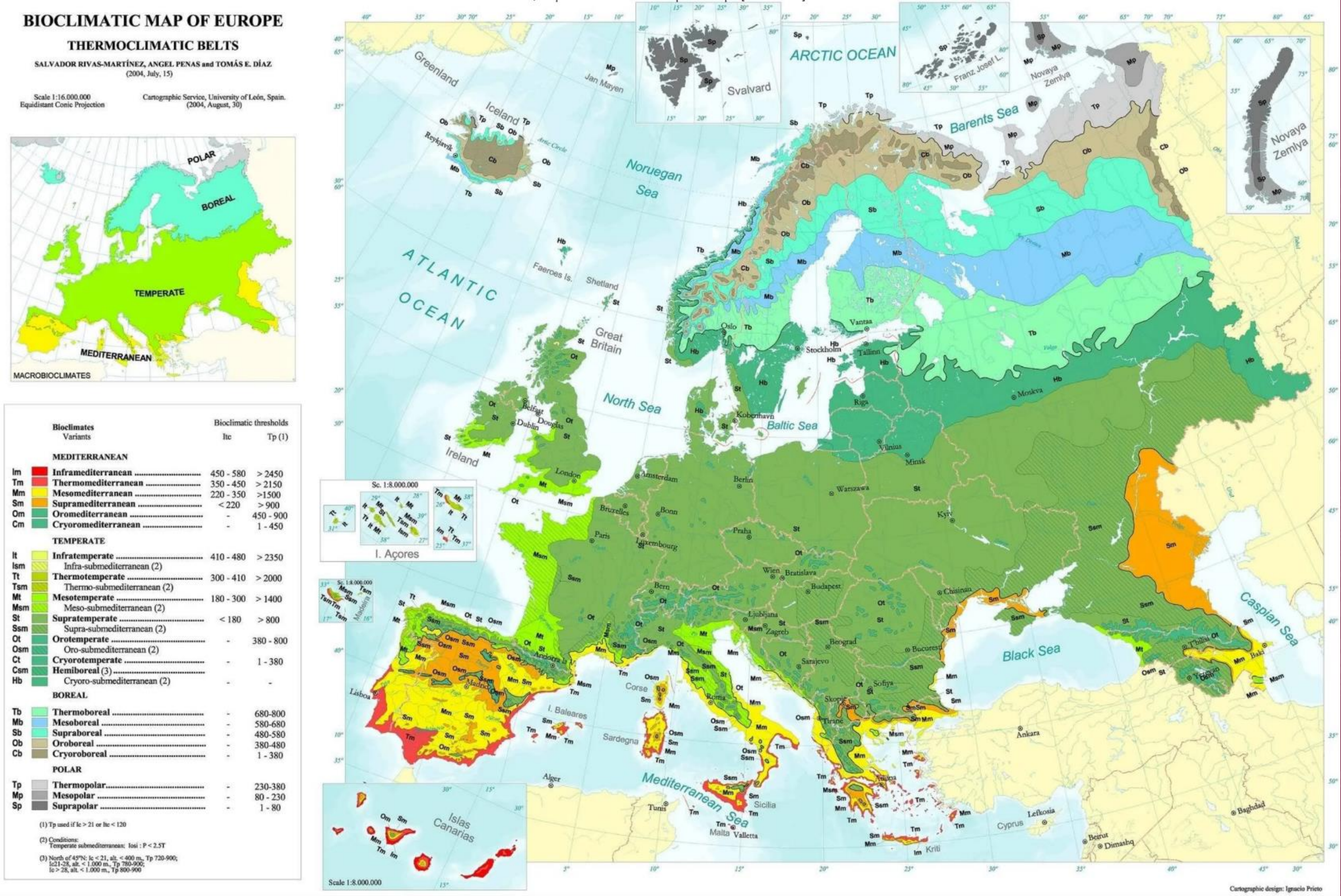
Need to find solutions to solve both crises simultaneously.

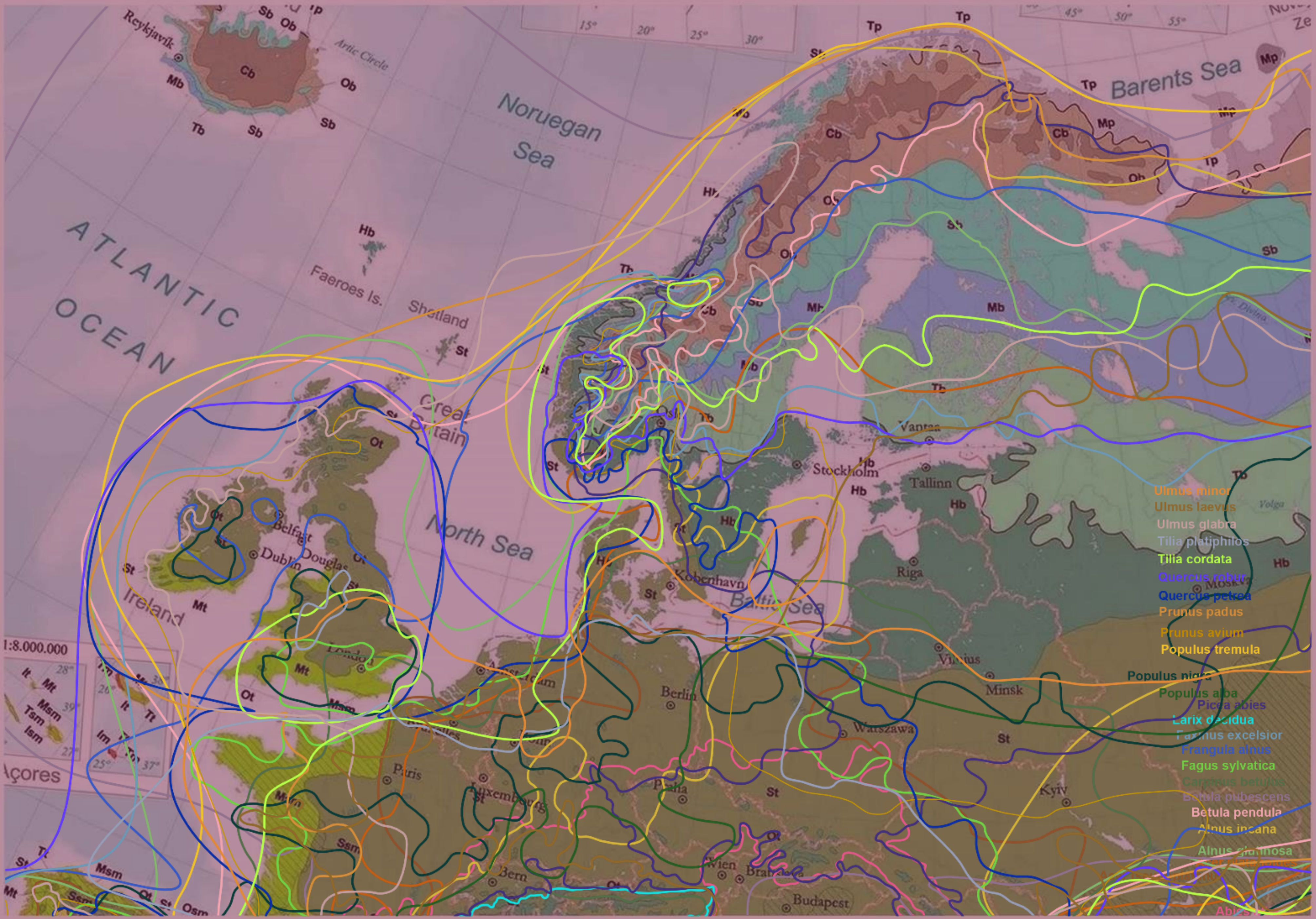


Biogeographical regions in Europe, 2016

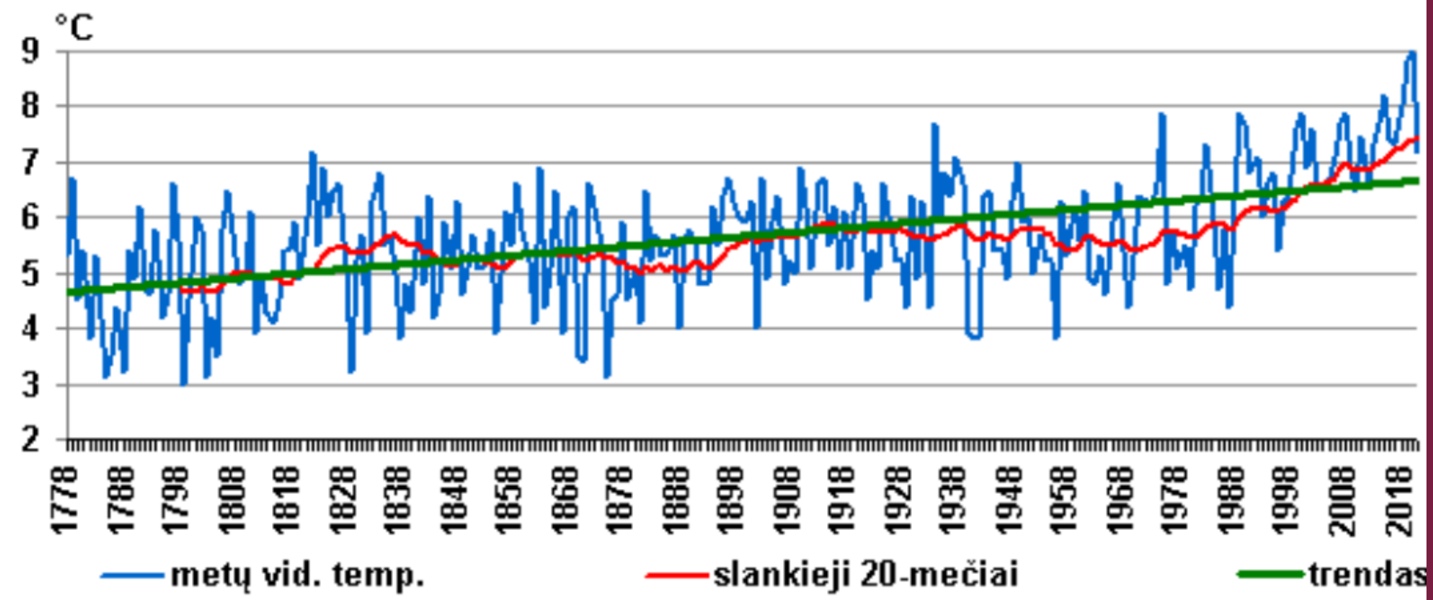
- Alpine
- Anatolian
- Arctic
- Atlantic
- Black Sea
- Boreal
- Continental
- Macaronesia
- Mediterranean
- Pannonian
- Steppic
- Outside data coverage

https://www.eea.europa.eu

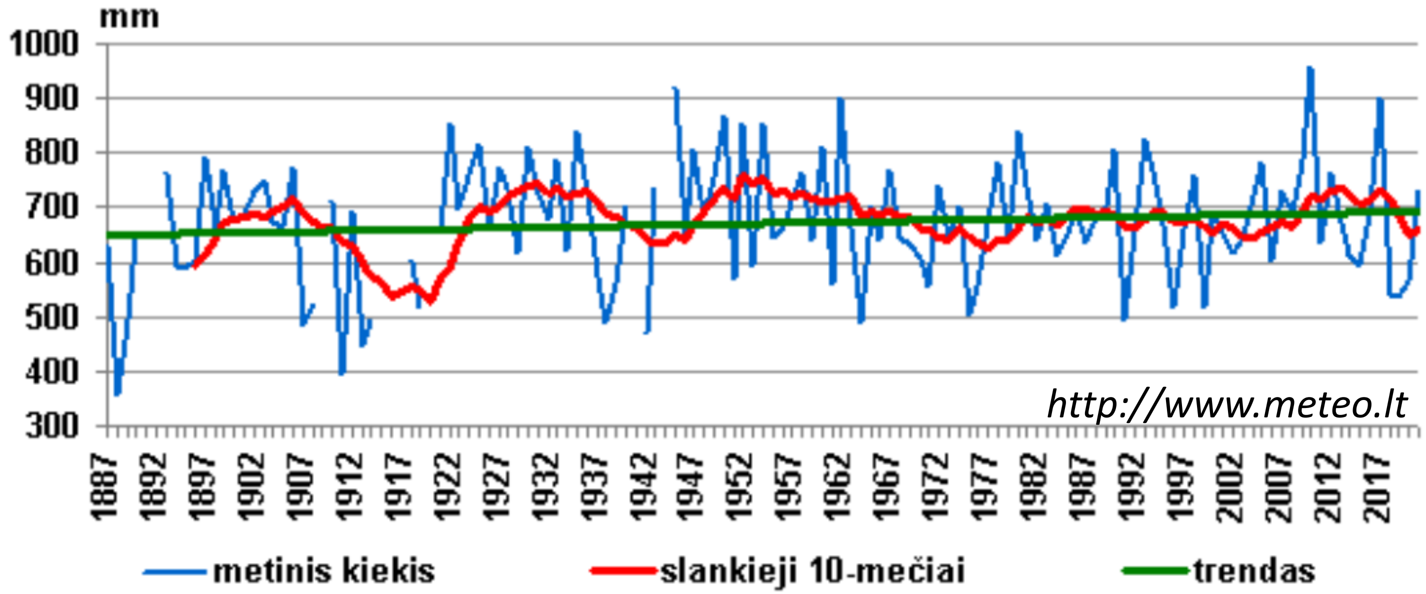

BIOCLIMATIC MAP OF EUROPE
THERMOCLIMATIC BELTS
SALVADOR RIVAS-MARTÍNEZ, ANGEL PENAS and TOMÁS E. DÍAZ
(2004, July, 15)
Scale 1:16.000.000
Equidistant Conic Projection
Cartographic Service, University of León, Spain.
(2004, August, 30)
POLAR
BOREAL
TEMPERATE
MEDITERRANEAN
MACROBIOCLIMATES
Bioclimates
Variants
Bioclimatic thresholds
Itc
Tp (1)
MEDITERRANEAN
Im Inframediterranean 450 - 580 > 2450
Tm Thermomediterranean 350 - 450 > 2150
Mm Mesomediterranean 220 - 350 >1500
Sm Supramediterranean < 220 > 900
Om Oromediterranean - 450 - 900
Cm Cryoromediterranean - 1 - 450
TEMPERATE
It Infratemperate 410 - 480 > 2350
Ism Infra-submediterranean (2)
Tt Thermotemperate 300 - 410 > 2000
Tsm Thermo-submediterranean (2)
Mt Mesotemperate 180 - 300 > 1400
Msm Meso-submediterranean (2)
St Supratemperate < 180 > 800
Ssm Supra-submediterranean (2)
Ot Orotemperate - 380 - 800
Osm Oro-submediterranean (2)
Ct Cryorotemperate - 1 - 380
Csm Hemiboreal (3)
Hb Cryoro-submediterranean (2) - -
BOREAL
Tb Thermoboreal - 680-800
Mb Mesoboreal - 580-680
Sb Supraboreal - 480-580
Ob Oroboreal - 380-480
Cb Cryoroboreal - 1 - 380
POLAR
Tp Thermopolar - 230-380
Mp Mesopolar - 80 - 230
Sp Suprapolar - 1 - 80
(1) Tp used if Ic > 21 or Itc < 120
(2) Conditions: Temperate submediterranean; Iosi : P < 2.5T
ARCTIC OCEAN
Svalvard
Franz Josef L.
Novaya Zemlya
Barents Sea
Greenland
Jan Mayen
Iceland
Reykjavik
Noruegan Sea
ATLANTIC OCEAN
Faeroes Is.
Shetland
Great Britain
North Sea
Baltic Sea
Ireland
Belfast
Dublin
Douglas
London
Amsterdam
Berlin
Warszawa
Oslo
Stockholm
Vantaa
Tallinn
Moskva
Riga
Vilnius
Minsk
Kobenhavn
Bruxelles
Bonn
Paris
Luxembourg
Praha
Kyiv
Wien
Bratislava
Budapest
Chisinau
Bern
Ljubljana
Zagreb
Beograd
Bucuresti
Sarajevo
Sofiya
Skopje
Tirane
Roma
Andorra la V.
Madrid
Lisboa
Corse
Sardegna
I. Baleares
Sicilia
Malta
Valletta
Tunis
Alger
Mediterranean Sea
Black Sea
Caspian Sea
Tbilisi
Baki
Ankara
Lefkosia
Cyprus
Kriti
Beirut
Dimashq
Baghdad
I. Açores
Sc. 1:8.000.000
Madeira
Islas Canarias
Scale 1:8.000.000
Cartographic design: Ignacio Prieto


Ulmus minor
Ulmus laevus
Ulmus glabra
Tilia platiphilos
Tilia cordata
Quercus robur
Quercus petrea
Prunus padus
Prunus avium
Populus tremula
Populus nigra
Populus alba
Picea abies
Larix decidua
Fagus sylvatica
Carpinus betulus
Betula pubescens
Betula pendula
Alnus incana
Alnus glutinosa
Barents Sea
Noruegan Sea
ATLANTIC OCEAN
North Sea
Baltic Sea
Great Britain
Ireland
Faeroes Is.
Shetland
Reykjavik
Artic Circle
Belfast
Dublin
Douglas
Stockholm
Tallinn
Riga
Vilnius
Minsk
Moskva
Kyiv
København
Berlin
Warszawa
Praha
Wien
Bratislava
Budapest
Paris
Luxembourg
Bern
Volga
Açores
1:8.000.000

Mean annual temperature in Vilnius 1778-2021 yrs.



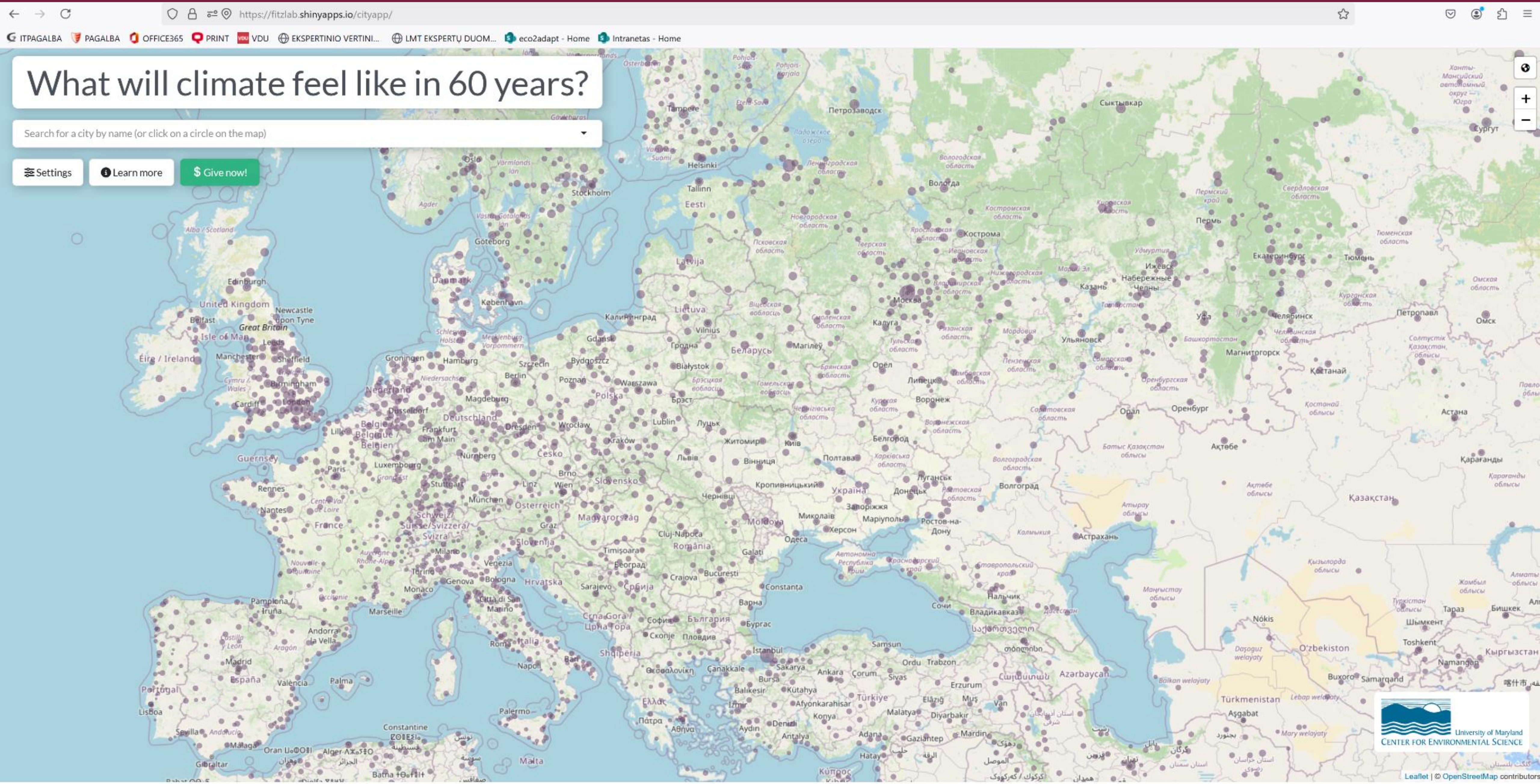
Mean annual precipitation in Vilnius 1887-2021 yrs.



DE MARTONNE ARIDITY INDEX IN LITHUANIA:

1981-2010 – 41,3

1991-2020 – 39,9


https://fitzlab.shinyapps.io/cityapp/
ITPAGALBA
PAGALBA
OFFICE365
PRINT
VDU
EKSPERTINIO VERTINI...
LMT EKSPERTŲ DUOM...
eco2adapt - Home
Intranetas - Home
What will climate feel like in 60 years?
Search for a city by name (or click on a circle on the map)
Settings
Learn more
$ Give now!
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
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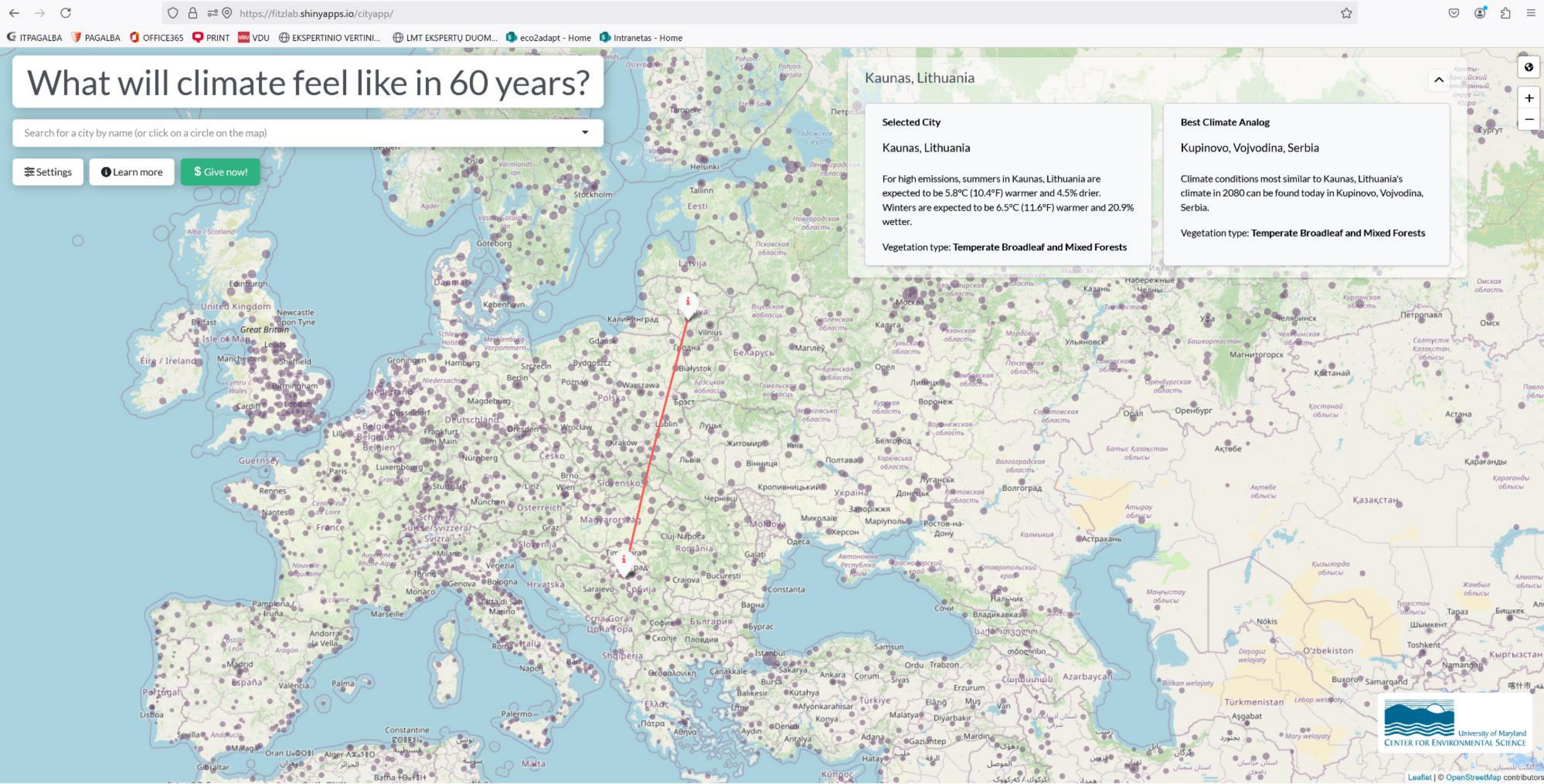
https://fitzlab.shinyapps.io/cityapp/
ITPAGALBA
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LMT EKSPERTŲ DUOM...
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What will climate feel like in 60 years?
Search for a city by name (or click on a circle on the map)
Settings
Learn more
$ Give now!
Kaunas, Lithuania
Selected City
Kaunas, Lithuania
For high emissions, summers in Kaunas, Lithuania are expected to be 5.8°C (10.4°F) warmer and 4.5% drier. Winters are expected to be 6.5°C (11.6°F) warmer and 20.9% wetter.
Vegetation type: Temperate Broadleaf and Mixed Forests
Best Climate Analog
Kupinovo, Vojvodina, Serbia
Climate conditions most similar to Kaunas, Lithuania's climate in 2080 can be found today in Kupinovo, Vojvodina, Serbia.
Vegetation type: Temperate Broadleaf and Mixed Forests
University of Maryland
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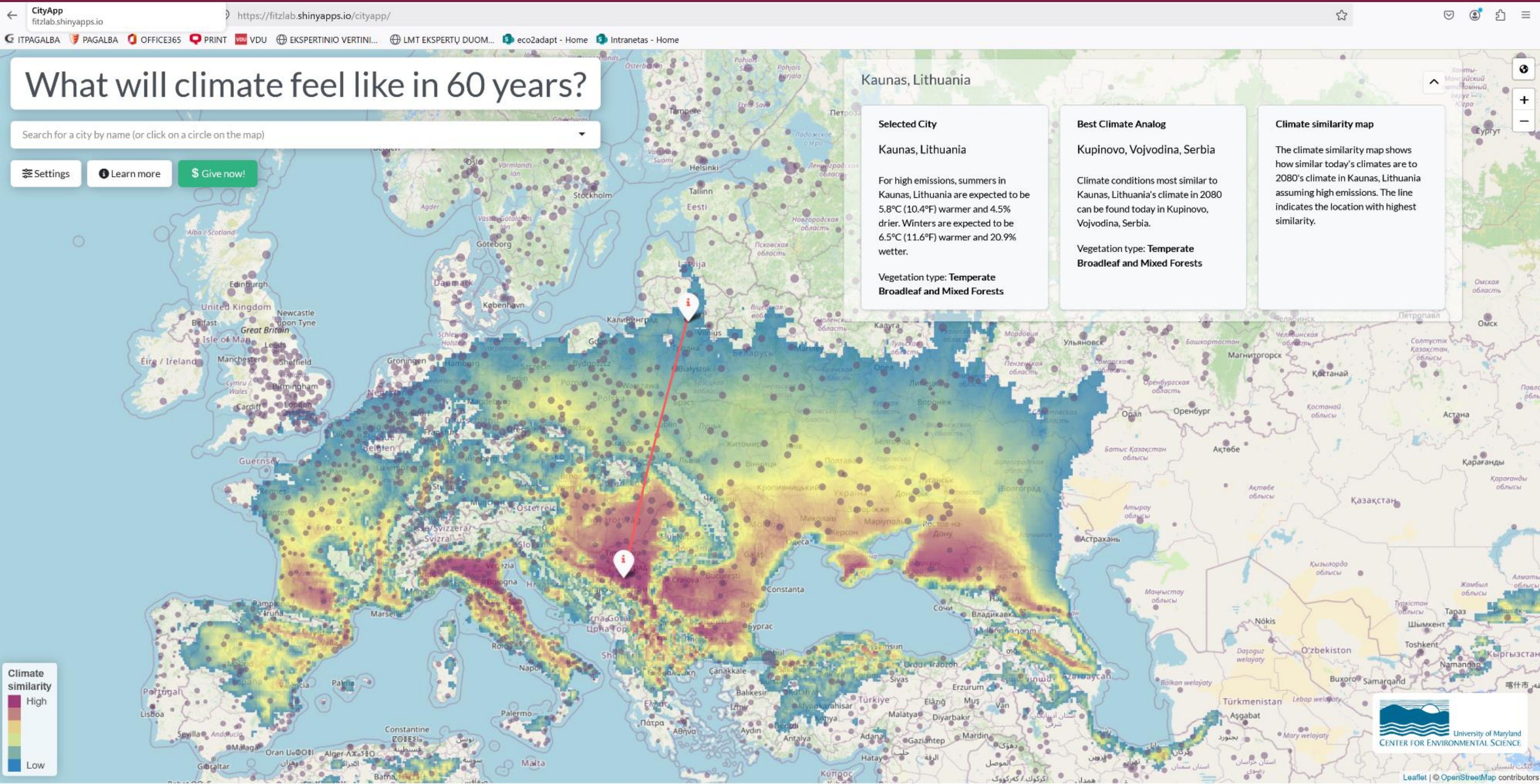
CityApp
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https://fitzlab.shinyapps.io/cityapp/
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Climate similarity map
The climate similarity map shows how similar today's climates are to 2080's climate in Kaunas, Lithuania assuming high emissions. The line indicates the location with highest similarity.
Climate similarity
High
Low
University of Maryland
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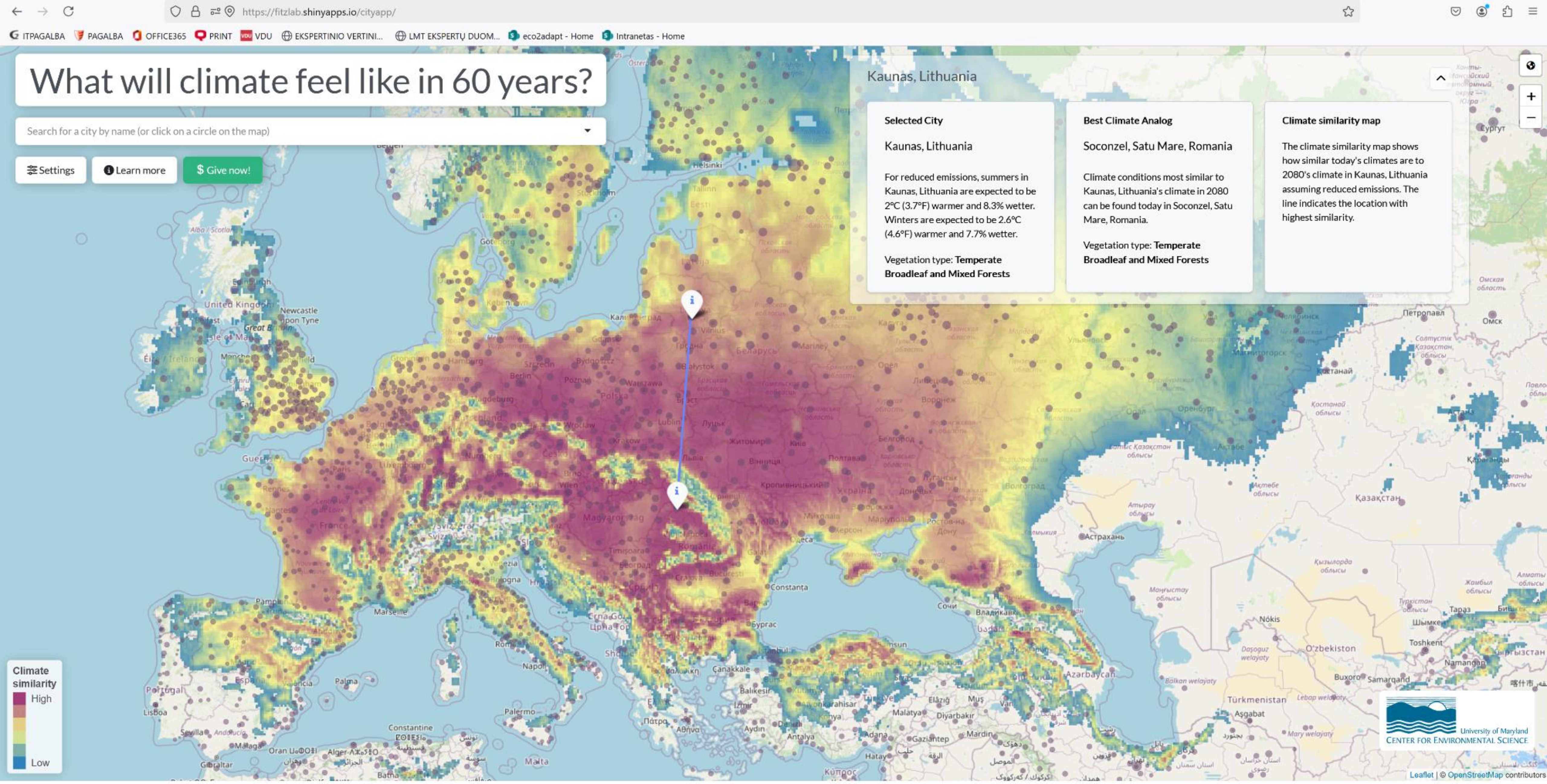
https://fitzlab.shinyapps.io/cityapp/
What will climate feel like in 60 years?
Search for a city by name (or click on a circle on the map)
Settings
Learn more
$ Give now!
Kaunas, Lithuania
Selected City
Kaunas, Lithuania
For reduced emissions, summers in Kaunas, Lithuania are expected to be 2°C (3.7°F) warmer and 8.3% wetter. Winters are expected to be 2.6°C (4.6°F) warmer and 7.7% wetter.
Vegetation type: Temperate Broadleaf and Mixed Forests
Best Climate Analog
Soconzel, Satu Mare, Romania
Climate conditions most similar to Kaunas, Lithuania's climate in 2080 can be found today in Soconzel, Satu Mare, Romania.
Vegetation type: Temperate Broadleaf and Mixed Forests
Climate similarity map
The climate similarity map shows how similar today's climates are to 2080's climate in Kaunas, Lithuania assuming reduced emissions. The line indicates the location with highest similarity.
Climate similarity
High
Low
University of Maryland
Center for Environmental Science
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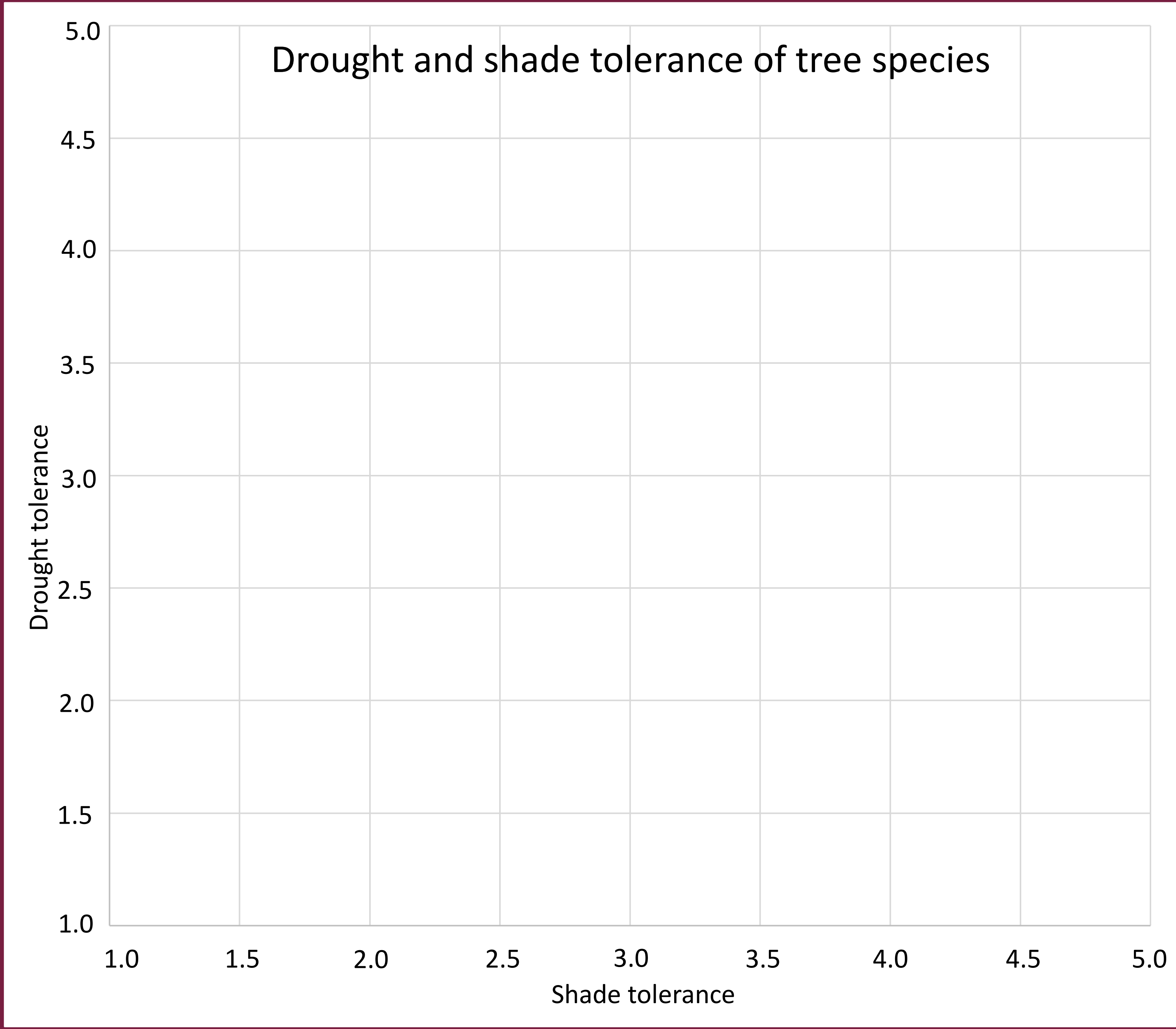
Climate change and biodiversity conservation

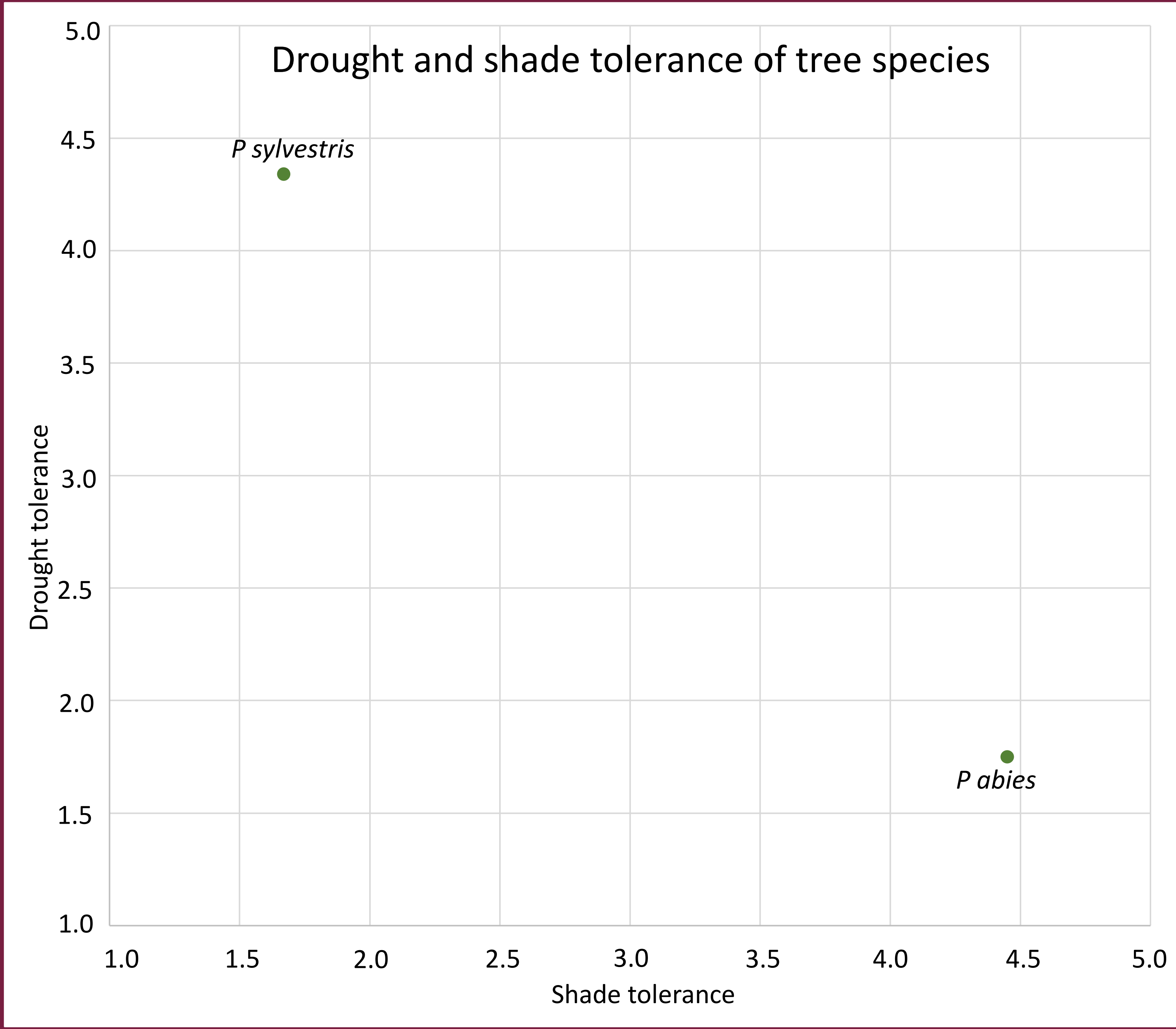
Special focus on tree species

Tools suggested for closer-to-nature forestry adapting climate change:

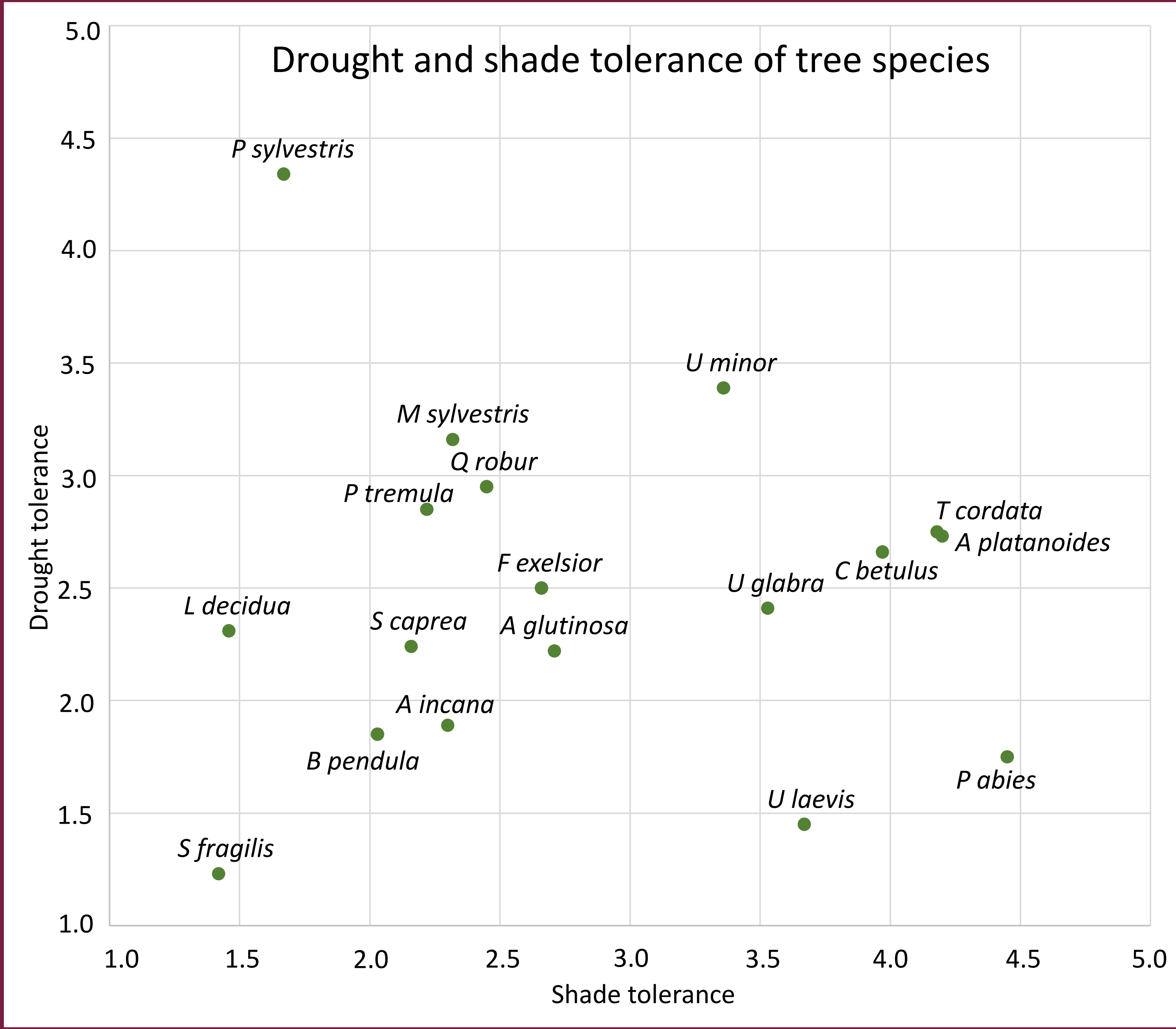
- Increase tree species richness (native, mid European)
- Increase stand structural diversity (enabling space for tree species diversity)
- Maintain and increase genetic variation within tree species



Niinemets and Valladares, 2006



Niinemets and Valladares, 2006

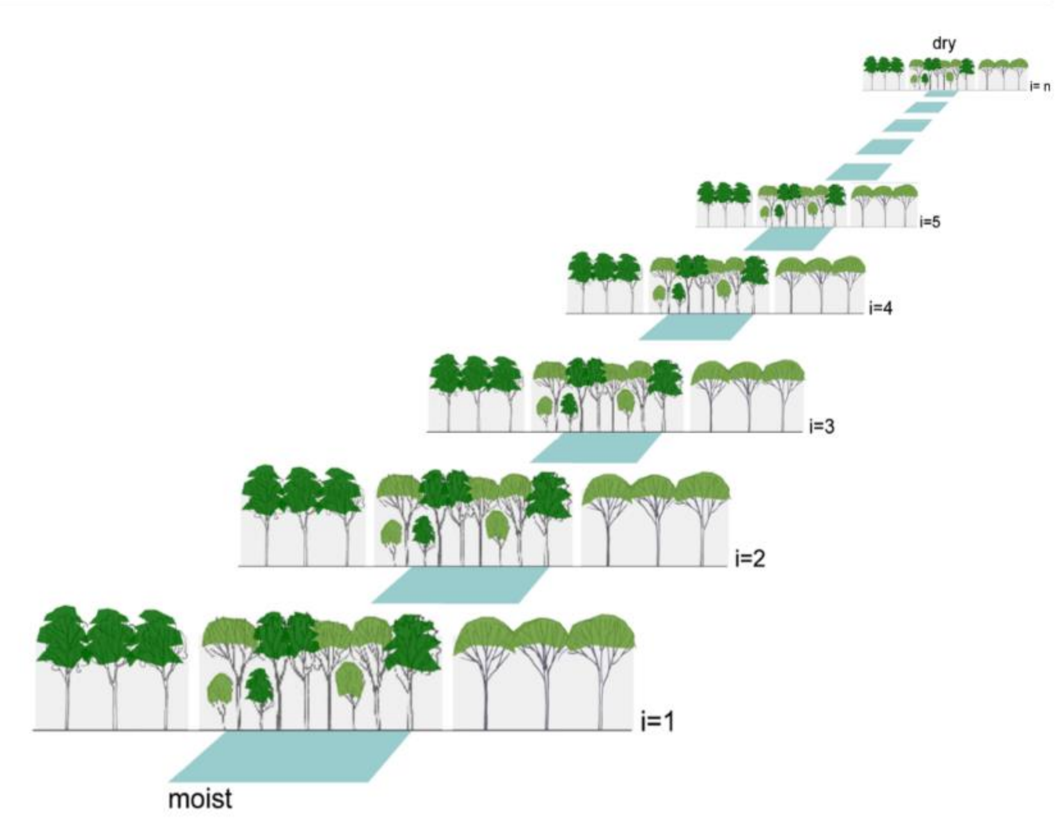


Niinemets and Valladares, 2006

Mixed forests

Monospecific (1 species) vs. Mixed forest (2 and more species)

Mixed forest – often studied two species stands



Pretzsch et al. 2015

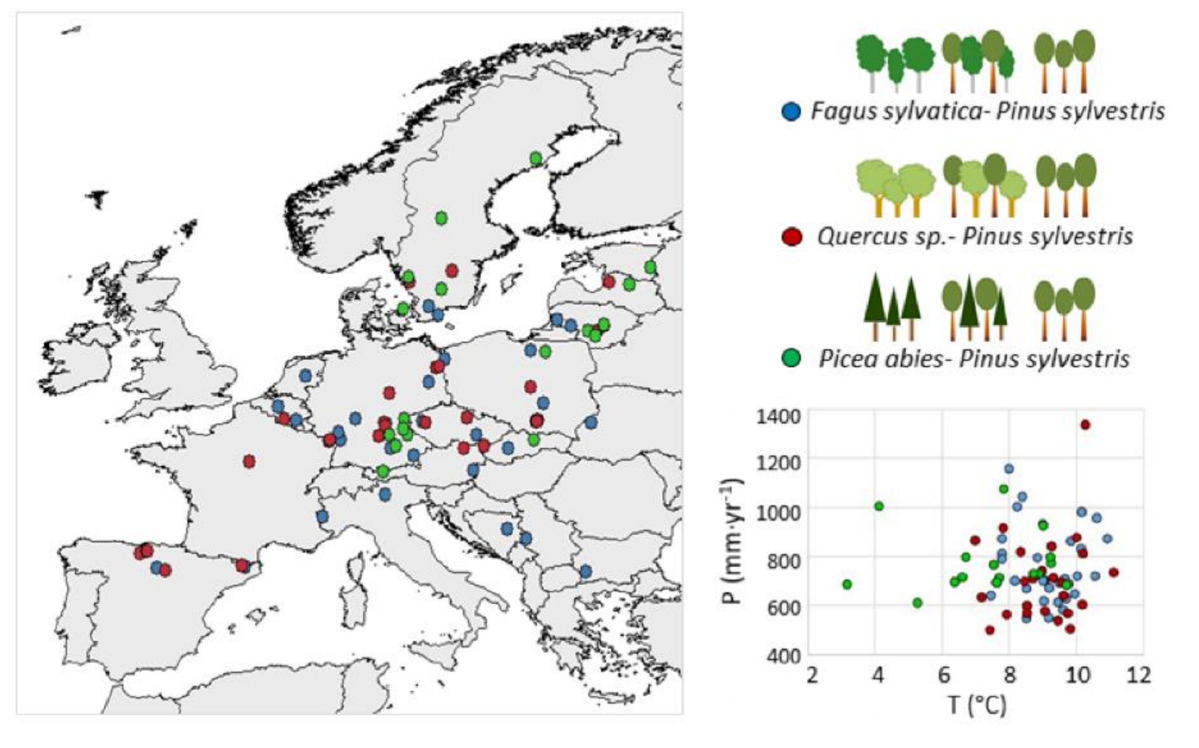


FIGURE 2 Location of the 87 triplets corresponding to the three transects: beech–pine, oak–pine (red), spruce–pine (green). Bottom-right panel shows the distribution of triplets by average site temperature (axis *x*) and precipitation (axis *y*).

Del Rio et al. 2022

Mixed forests

Different than monospecific in processes, growth, resilience and require more complex management;

The effect depends on complementarity of species, more efficient use recourses such as light and water;

Stands has higher structural complexity that positively associated with higher biodiversity;

Stands often more productive, especially in sites with higher water availability;

More resistant to droughts, however more severe droughts decrease positive effect;

No 100% guarantee, many depends on local management, site conditions, land use history, etc.

Mixed forests

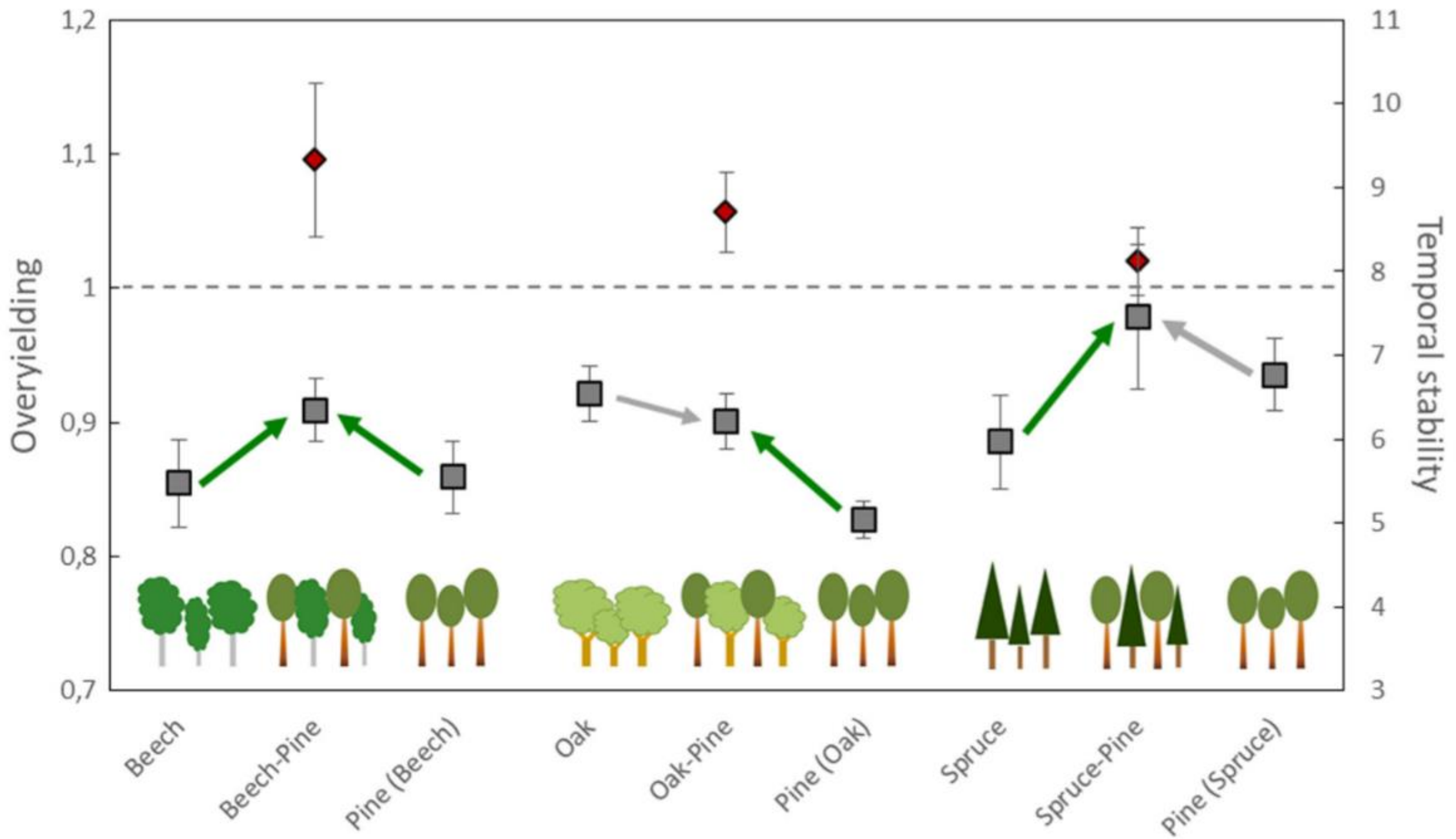


FIGURE 3 Overyielding (red diamonds) and temporal stability of stand growth (grey quadrats) for the three types of mixtures: beech–pine, oak–pine, spruce–pine (mean and standard error). Temporal stability is given for monospecific and mixed stands. Green arrows indicate significant stabilizing effects by mixing species, and grey arrows indicate nonsignificant effects (Table S4).

Del Rio, M. et al. 2022

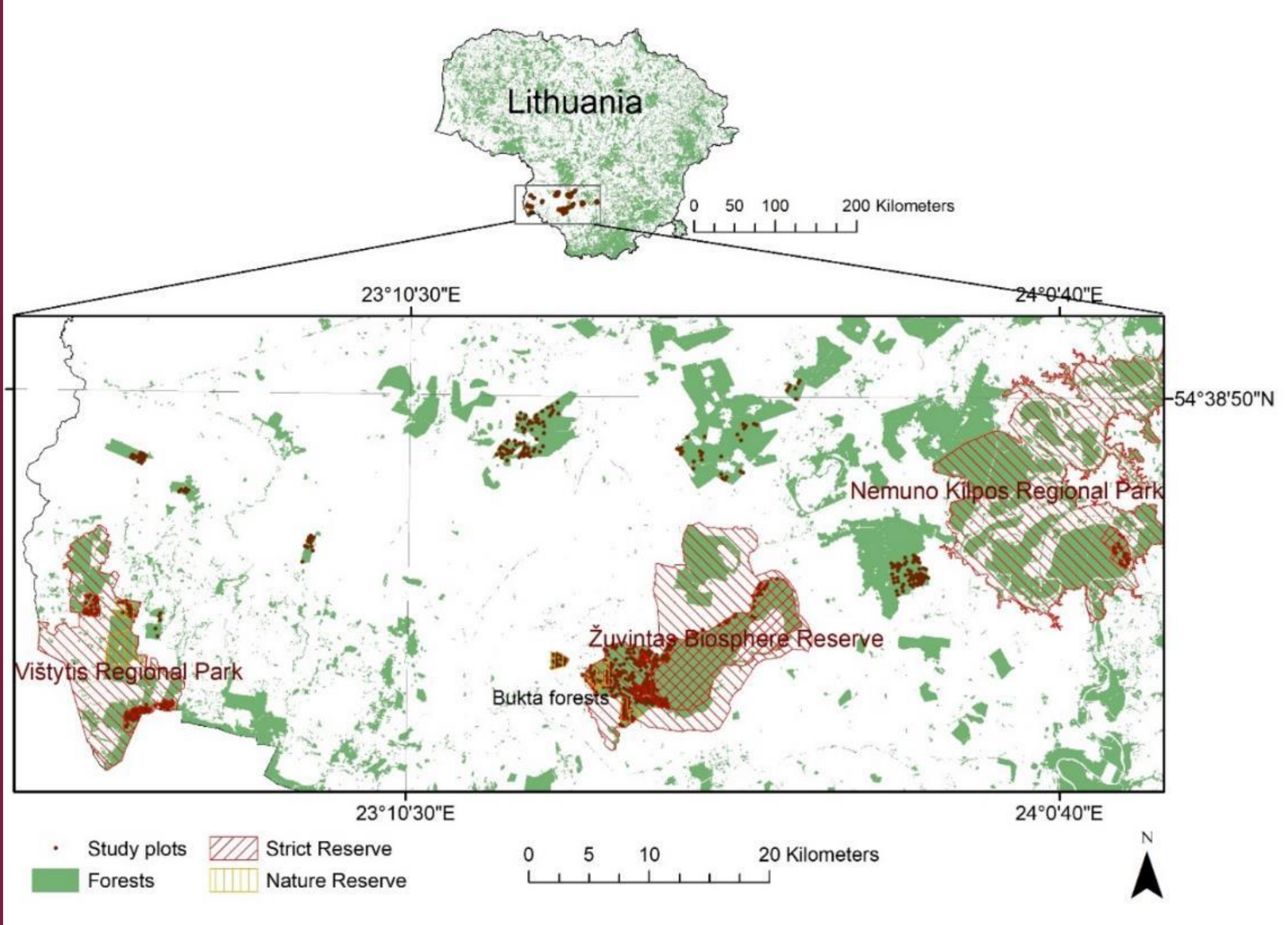
Mixed forests

Lots of studies of two species mixtures;

Semi-natural forests often consist of >2 species;

Lack of multi-species stand studies as such complex structures were avoided and eliminated by long-lasting forest management;

Study in SW Lithuania of protected forests.



Mixed forests – stand characteristics

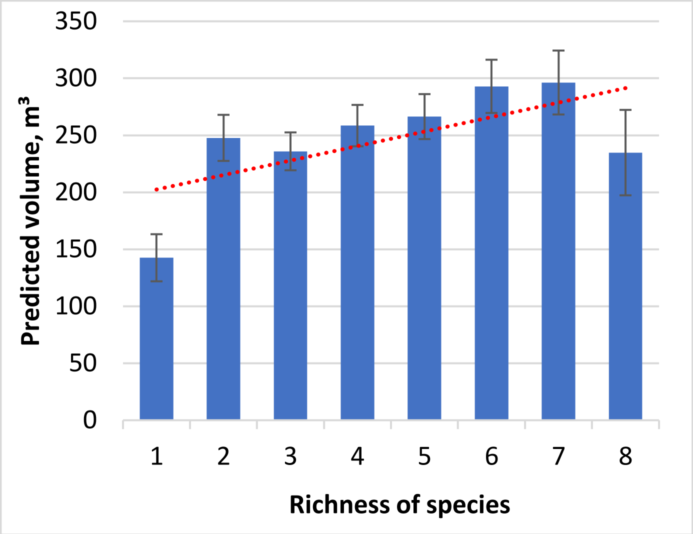
Totally inventoried 16 tree species (total area - 29.1ha),

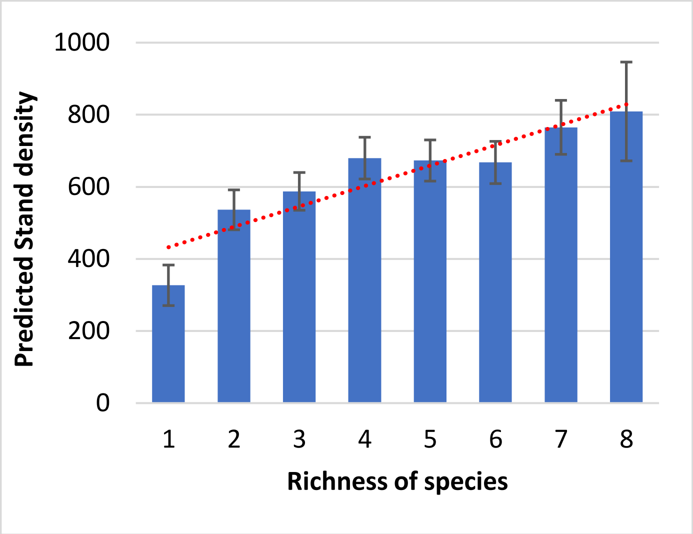
Maximal number of species per plot – 10 tree species (DBH>10 cm);

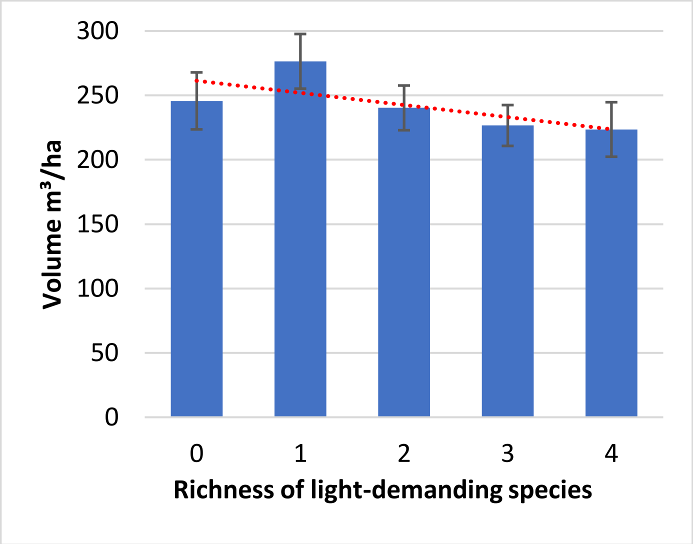
Mostly common mixtures 3-5(6) tree species (plot area - 500m^2)

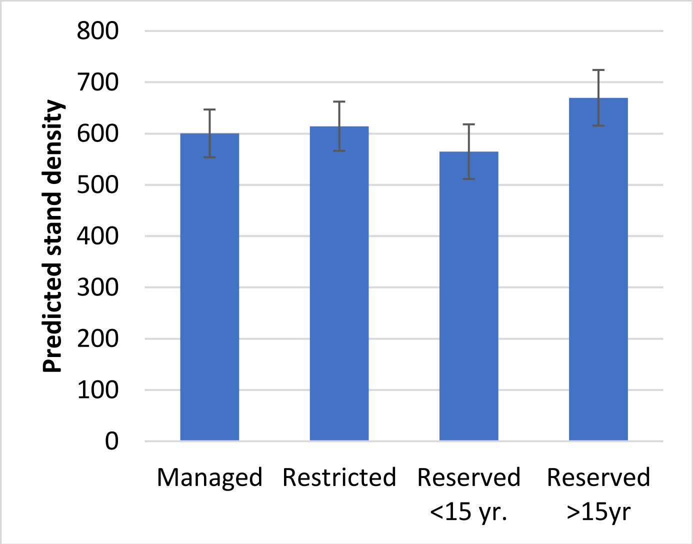
N. of tree species in plot	N. of plots	Tree species																
		Total N.	Pic abi	Bet spp.	Car bet	Qur rob	Aln glu	Fra exe	Pop tre	Til cor	Ace pla	Ulm min	Sal cap	Mal syl	Pin syl	Sor auc	Pru pad	Sal fra
1	8	8		1	1		5	1										
2	46	92	18	15	12	10	18	4	6	8					1			
3	134	402	89	66	48	49	55	21	27	38	1	1	1	1	1	1	1	2
4	164	656	130	105	79	69	70	58	47	61	15	5	4	3	7	3		
5	129	645	114	98	75	83	60	61	58	46	14	20	5	4	4	2	1	
6	67	402	62	57	42	46	36	46	43	29	13	15	4	5		2	1	1
7	28	196	24	25	23	20	14	22	24	16	7	7	5	4		2	2	1
8	5	40	5	5	4	5	3	3	4	2	3	2	1	1		2		
10	1	10	1	1	1	1	1	1			1	1	1				1	
Totally:	582	2451	443	373	285	283	262	217	209	200	54	51	21	18	13	12	6	4

Mixed forests – stand characteristics



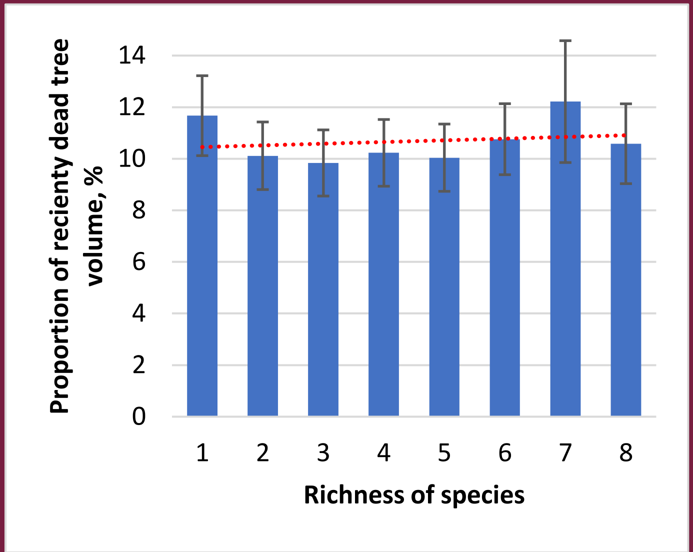


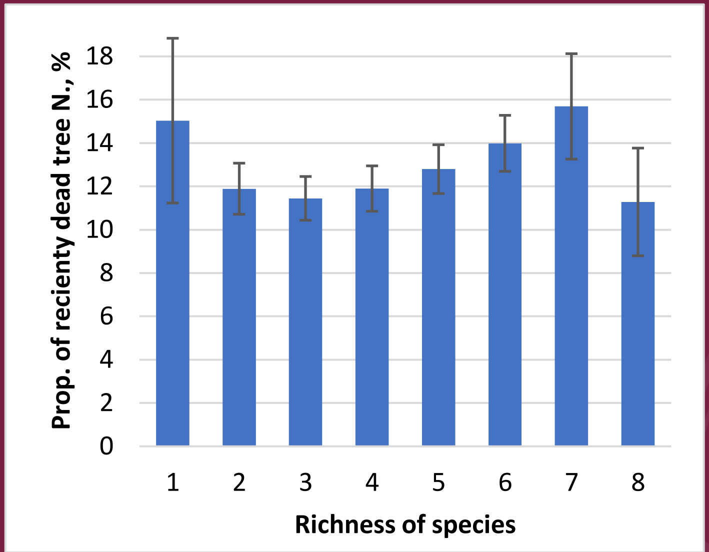


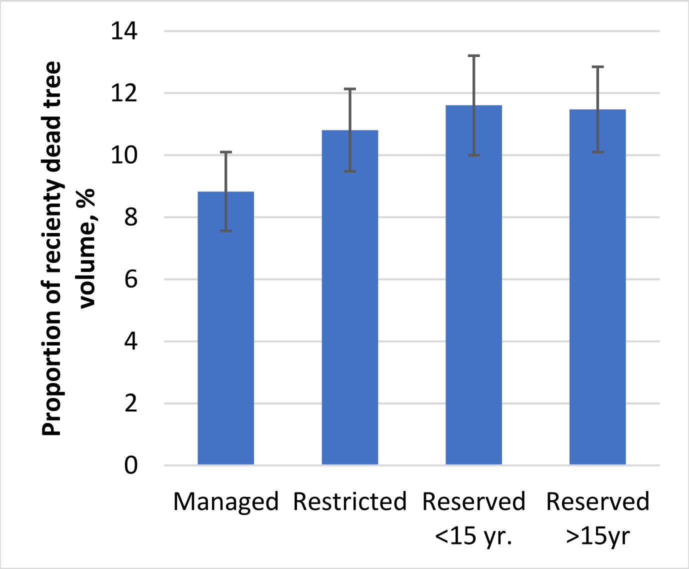


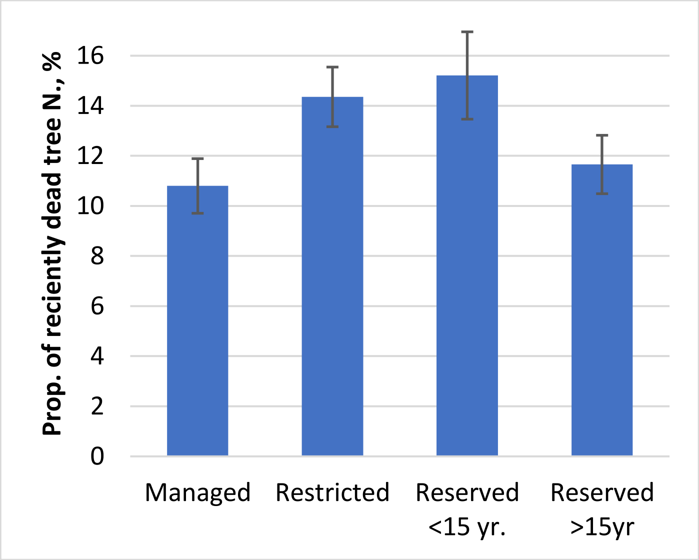
Estimated means of the Richness of species in stand (top), the Dominating tree species (mid) and the Richness of light-demanding species (bottom) in GLMM predicting stand volume. Continuous predictors were set at the following values: Equitability=0.687; Age=83,29.

Mixed forests – stand characteristics









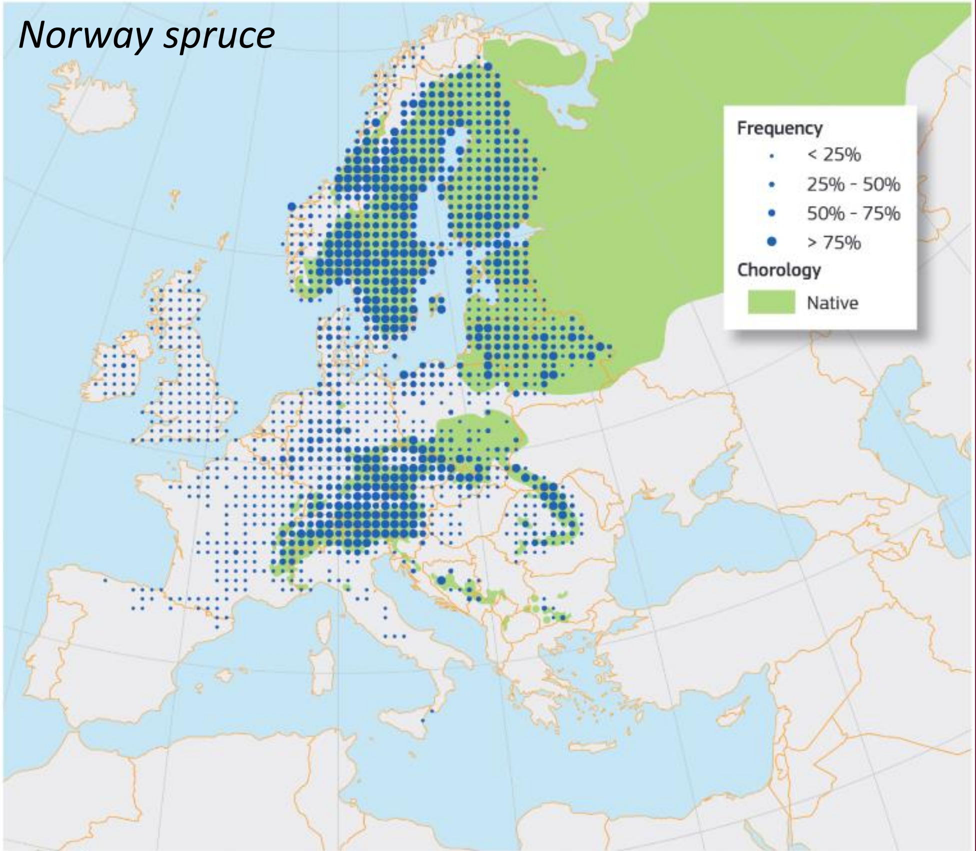
Left: Estimated means of fixed effects in GLMM evaluating the proportion of recently eliminated tree volume. Continuous predictors were set at the following values: Equitability=0.748; Basal area=27.88

Right: Estimated means of fixed effects in GLMM evaluating the proportion of recently eliminated tree number. Continuous predictors were set at the following values: Equitability=0.748, Basal area=27.88; Age=83.29

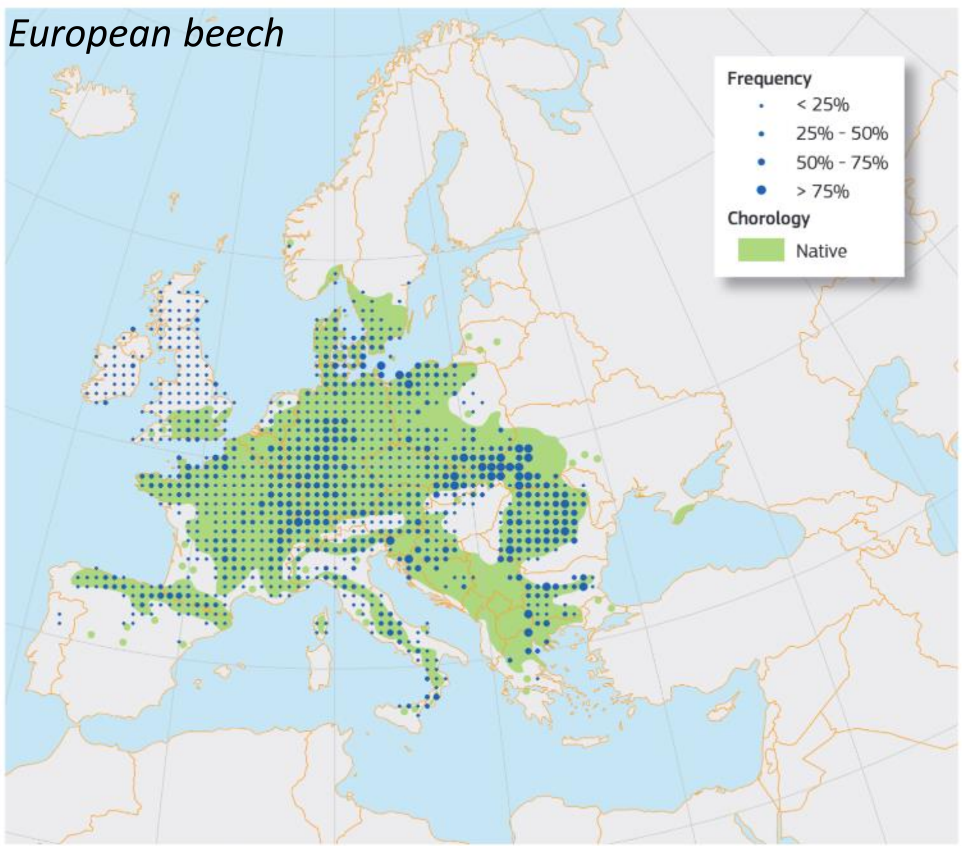
INCREASE TREE SPECIES RICHNESS

We need to increase shade tolerant tree species diversity

Two shade-tolerant key tree species in Europe



Map 1: Plot distribution and simplified chorology map for *Picea abies*.
Caption: Frequency of *Picea abies* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *P. abies* is derived after EUFORGEN[39].



Map 1: Plot distribution and simplified chorology map for *Fagus sylvatica*.
Frequency of *Fagus sylvatica* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *F. sylvatica* is derived after Meusel and Jäger, and EUFORGEN[27, 28].

https://www.euforgen.org/

Norway spruce problematic

Czech, Šumava National Park, 2022

Norway spruce problematic

Immediate attacked spruce neutralization – debarking

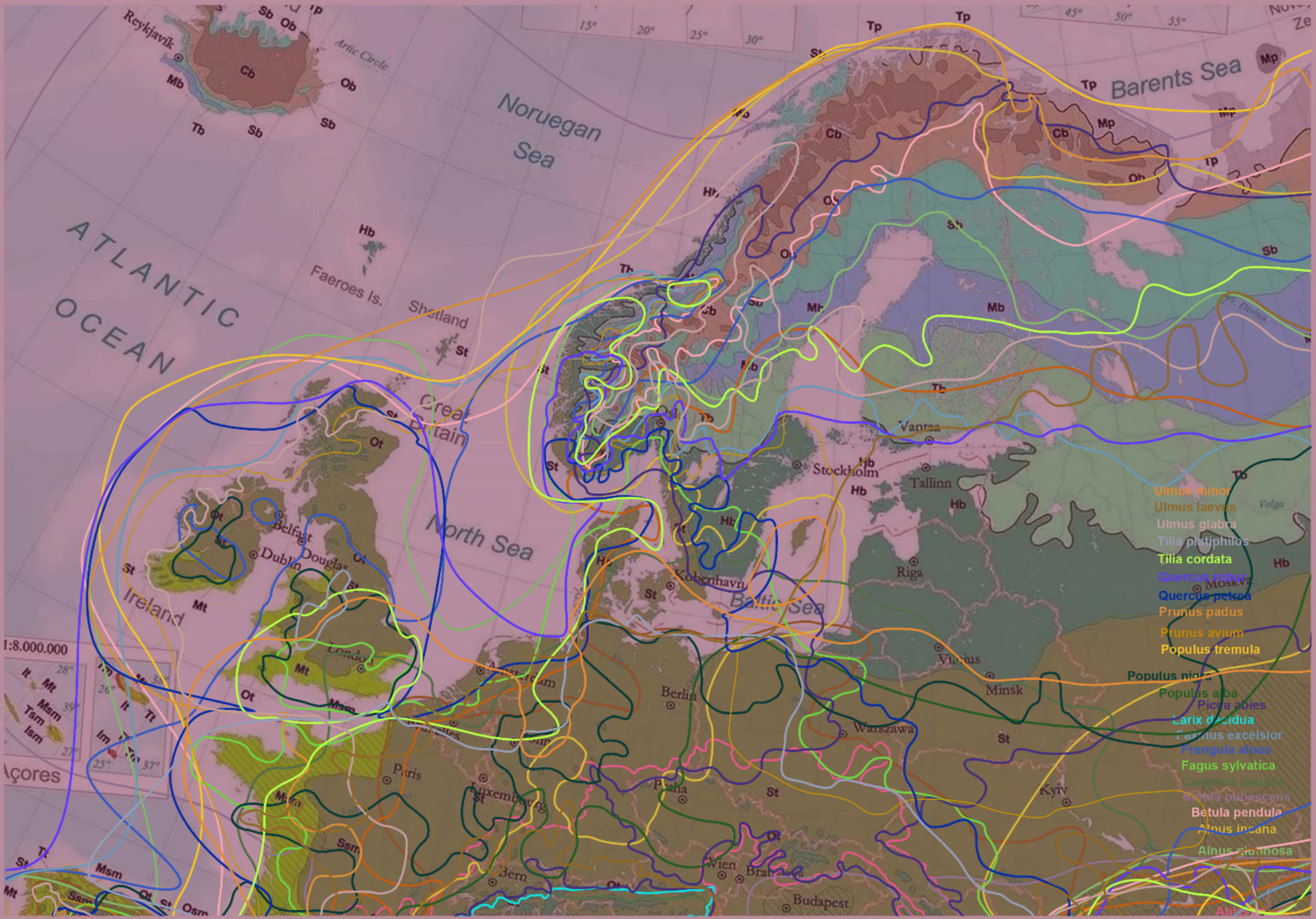
Expensive and time-consuming action, could be applied in limited extent

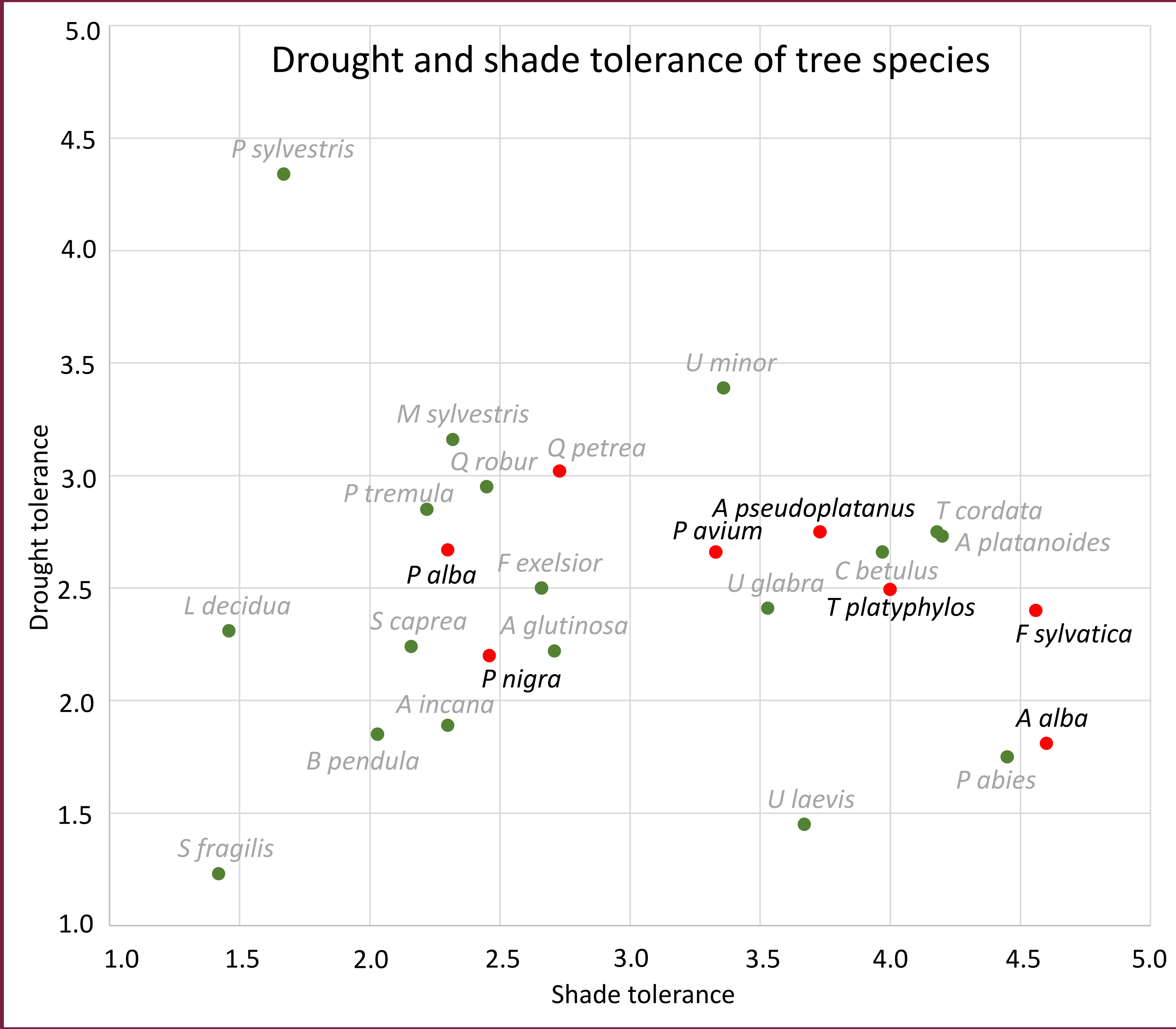
Norway spruce problematic - solutions

Decreasing rotation age is not solution.

Mixed uneven age stands with proportion of trees with the risk age <20%.

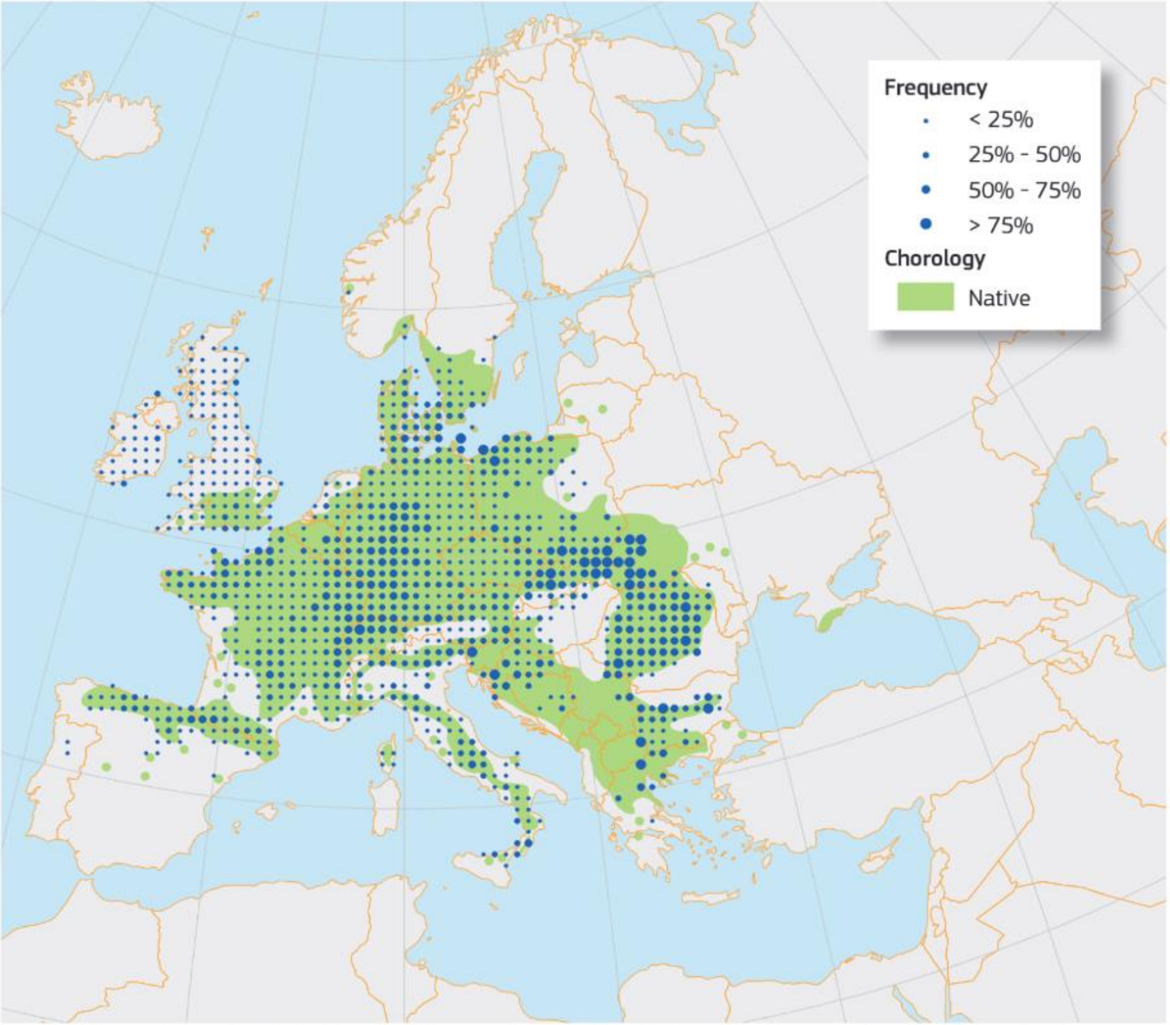
Poland, Bialowieza forest


Ulmus minor
Ulmus laevus
Ulmus glabra
Tilia platiphilos
Tilia cordata
Quercus robur
Quercus petrea
Prunus padus
Prunus avium
Populus tremula
Populus nigra
Populus alba
Picea abies
Larix decidua
Fraxinus excelsior
Frangula alnus
Fagus sylvatica
Carpinus betulus
Betula pubescens
Betula pendula
Alnus incana
Alnus glutinosa



Niinemets and Valladares, 2006

Fagus sylvatica



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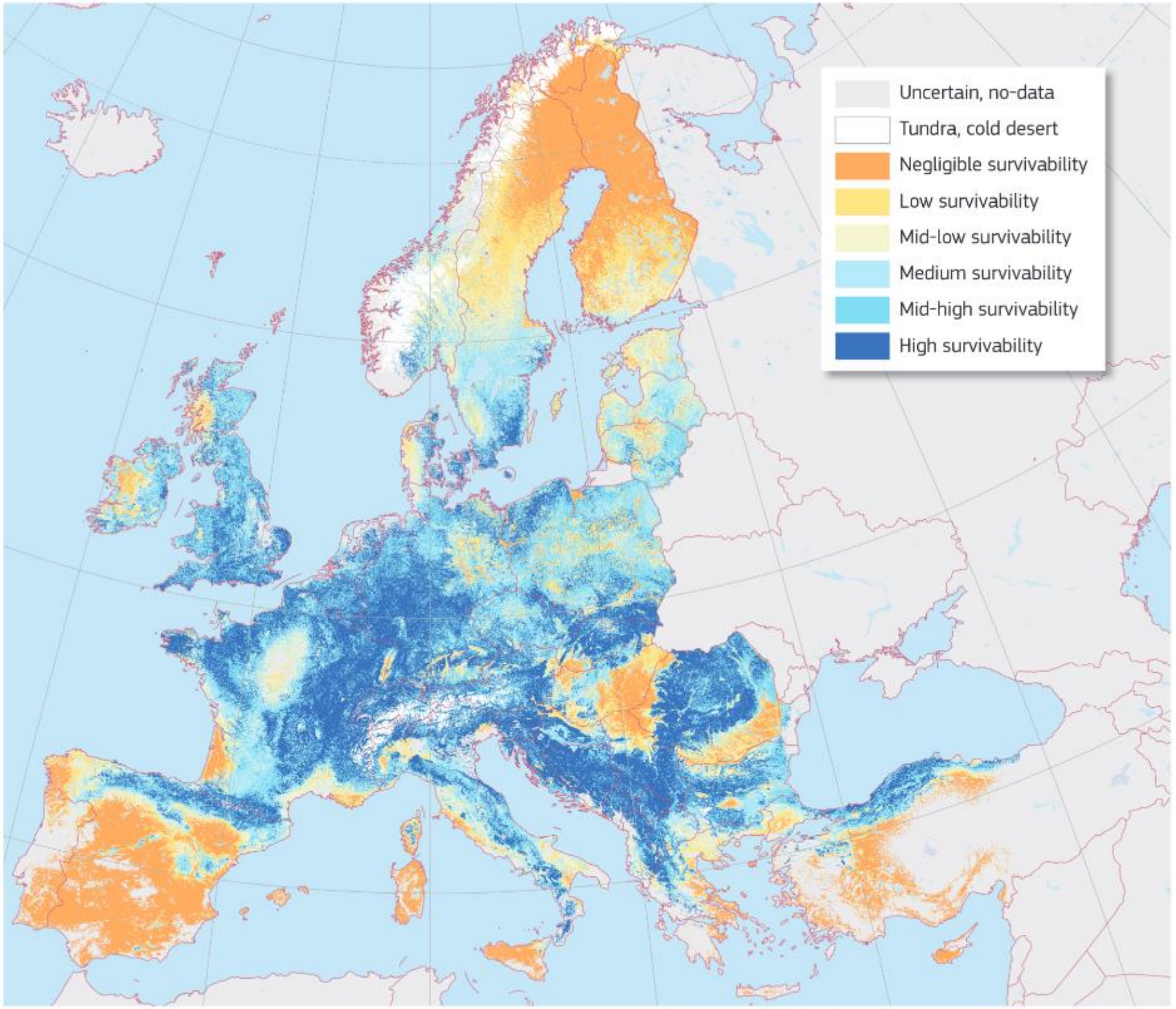
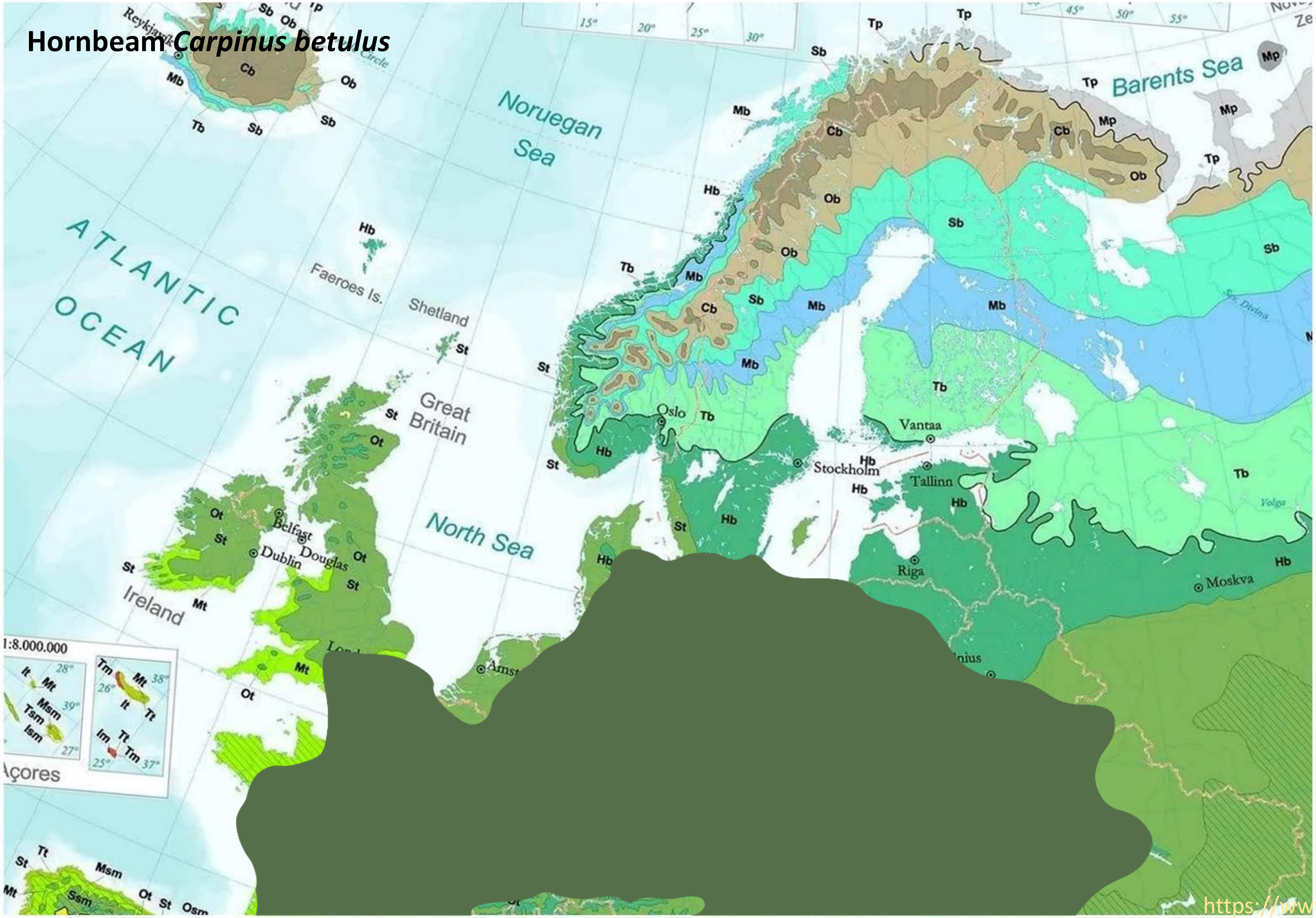
Frequency of *Fagus sylvatica* occurrences within the field observations as reported by the National Forest Inventories. The chorology of the native spatial range for *F. sylvatica* is derived after Meusel and Jäger, and EUFORGEN[27, 28].



Map 3: High resolution map estimating the maximum habitat suitability.

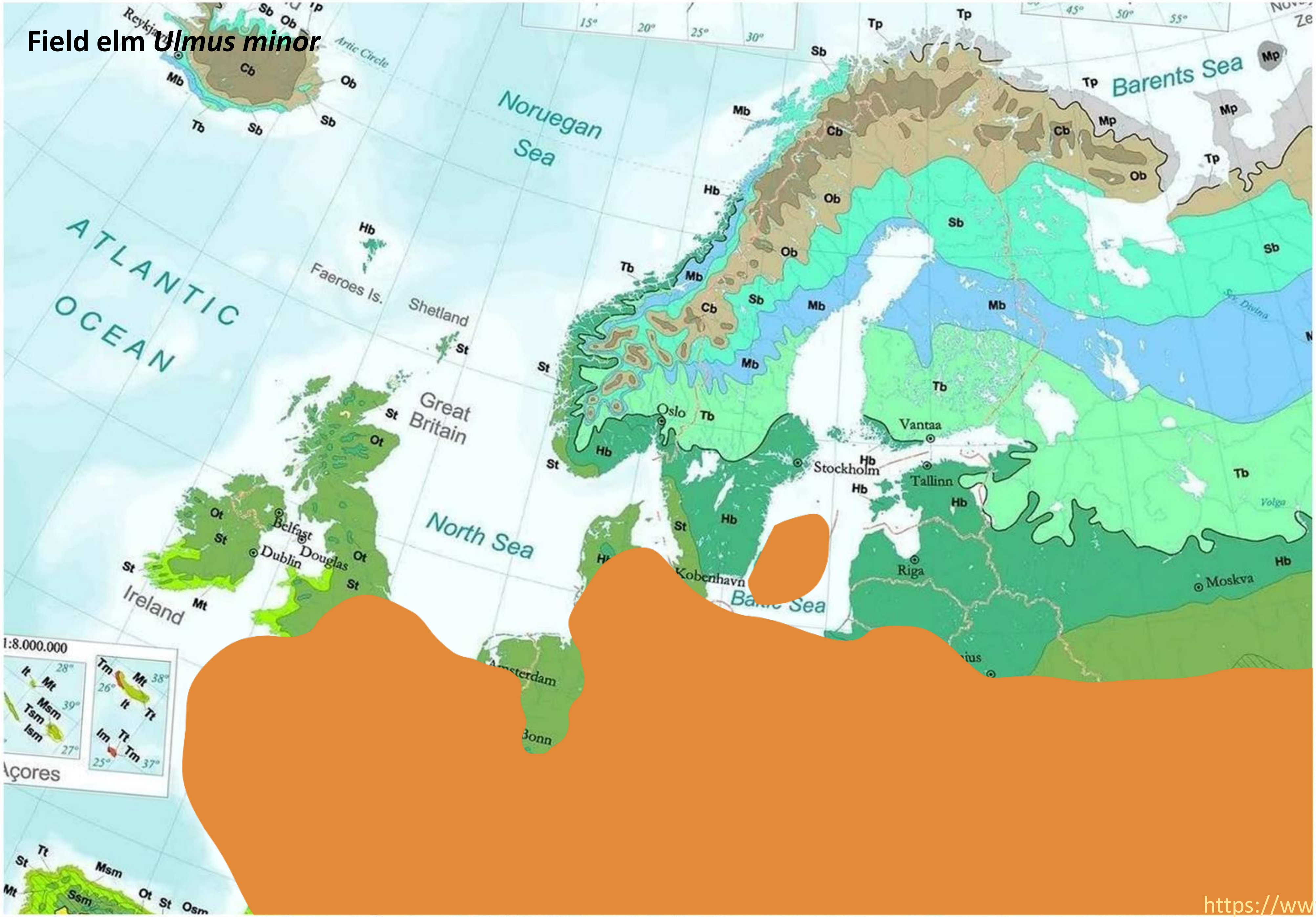
https://forest.jrc.ec.europa.eu/media/atlas/Fagus_sylvatica.pdf

Hornbeam *Carpinus betulus*



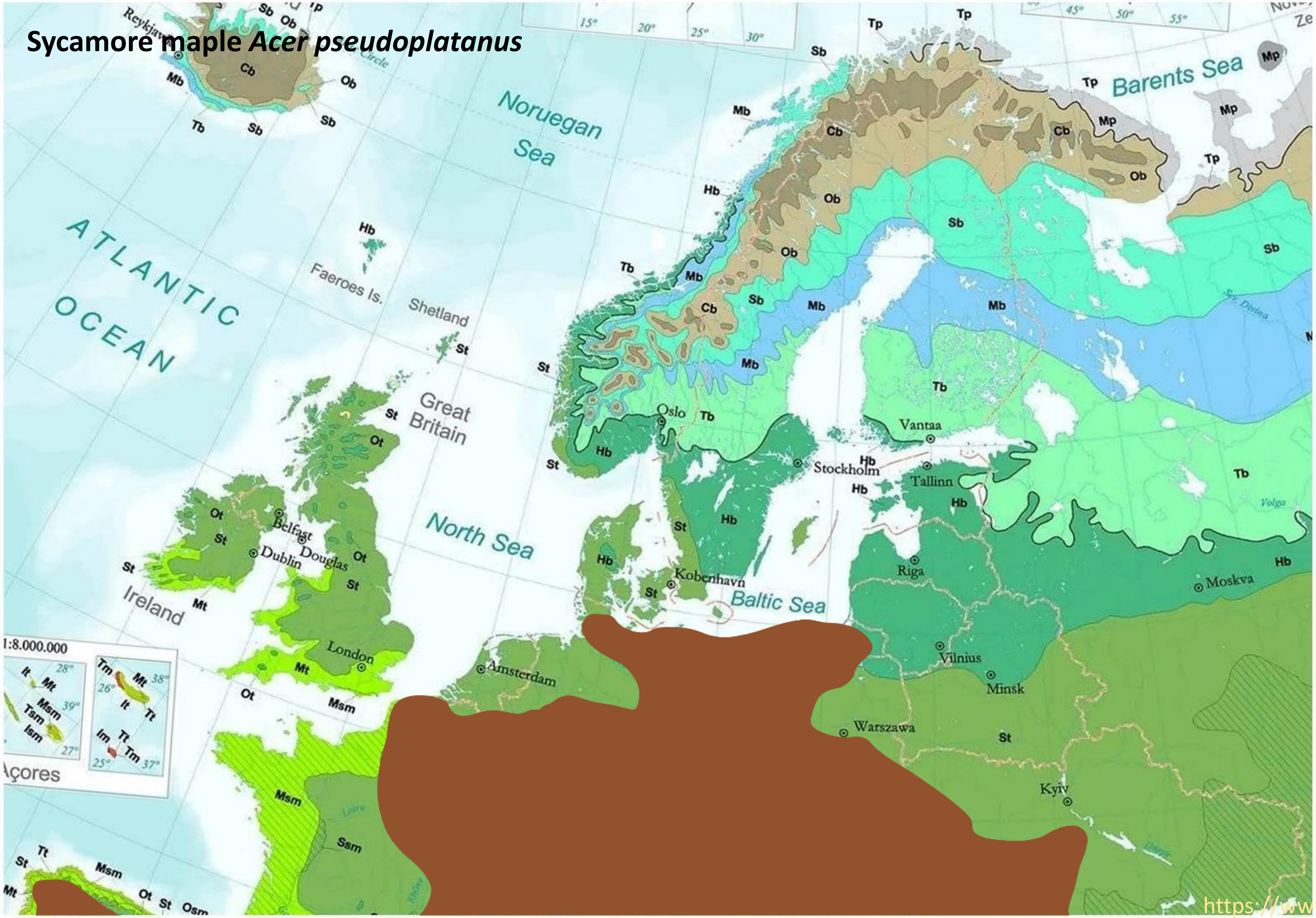
https://www.euforgen.org/

Field elm *Ulmus minor*



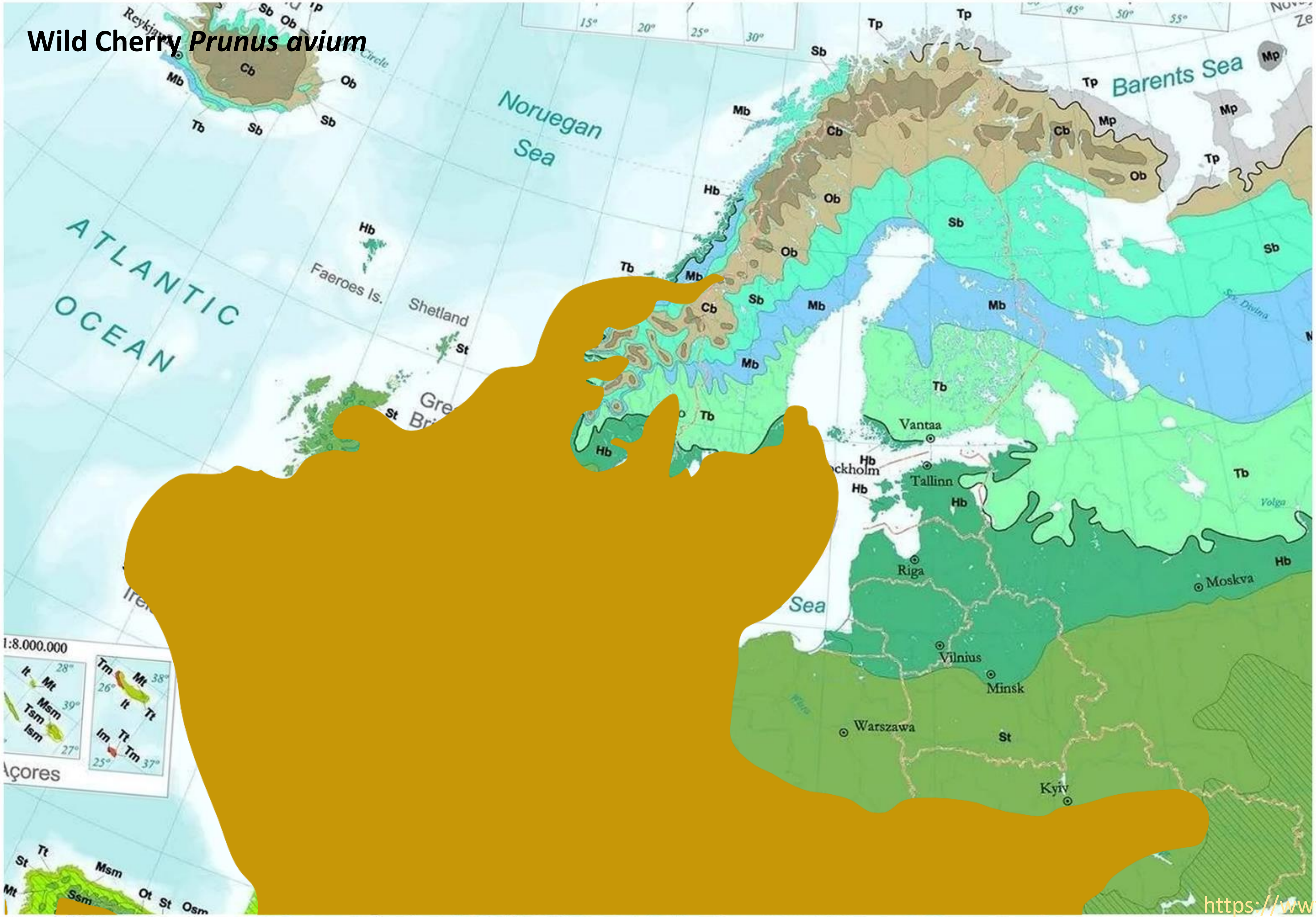
https://www.euforgen.org/

Sycamore maple *Acer pseudoplatanus*



https://www.euforgen.org/

Wild Cherry *Prunus avium*



https://www.euforgen.org/

Sessile oak *Quercus petrea*

https://www.euforgen.org/

Silver fir *Abies alba*

https://www.euforgen.org/

How to support translocation (assisted migration)

Slow process, long adaptation period with climatic extreme testing (winter temperatures).

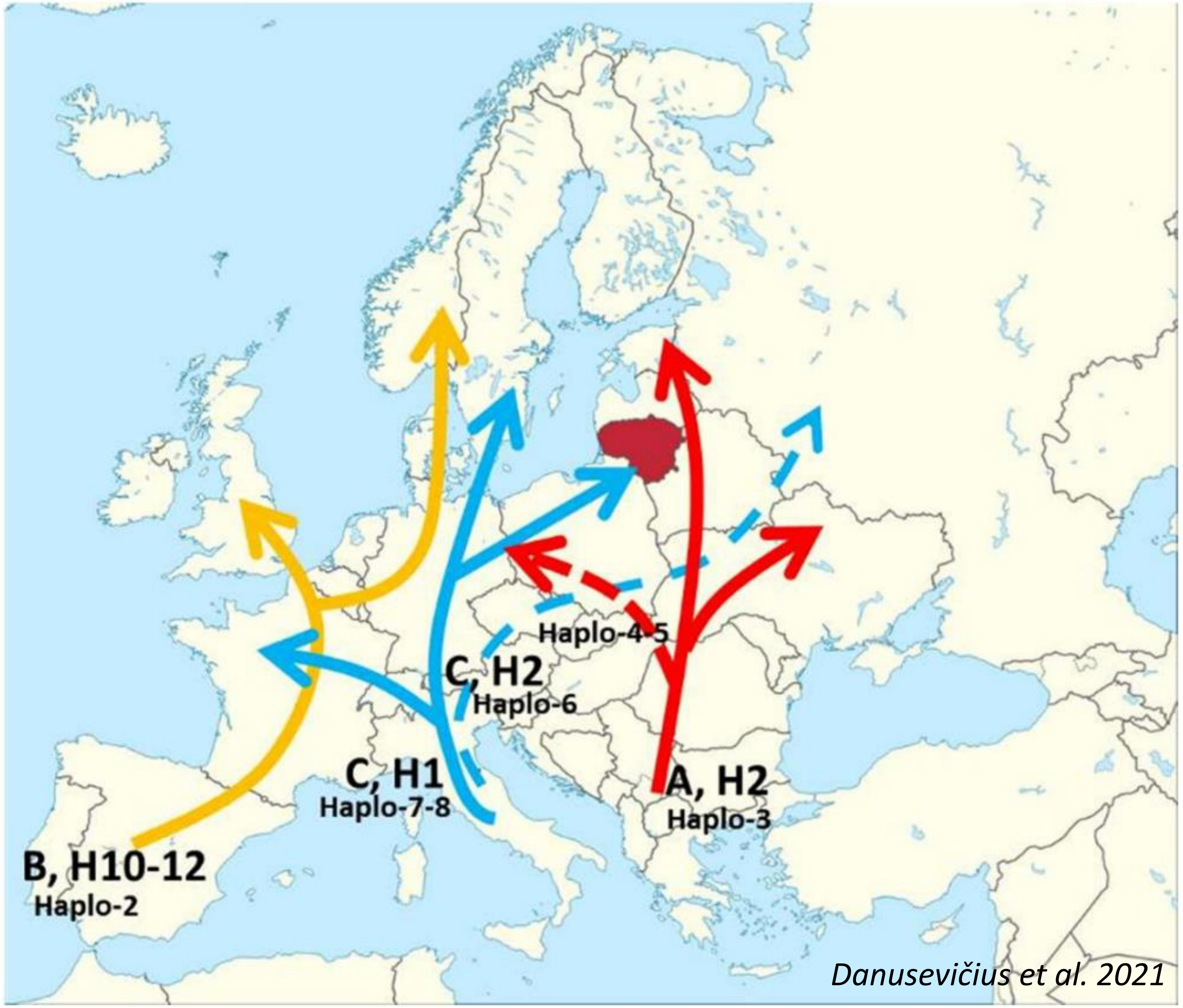
Mixing experiments:
Beech mixed with eight native tree species;
Established in 2021;
Two regions in Lithuania.

	200								
25	P	P+Bu	A+Bu	A	J	J+Bu	M+Bu	M	
25	E	E+Bu	L+Bu	L	D	D+Bu	B+Bu	B	
25	M	M+Bu	1Bu	5Bu	XBu	2Bu	L+Bu	L	
25	B	B+Bu	3Bu	2Bu	3Bu	4Bu	J+Bu	J	
25	J	J+Bu	5Bu	1Bu	4Bu	1Bu	A+Bu	A	200
25	D	D+Bu	4Bu	2Bu	5Bu	3Bu	P+Bu	P	
25	A	A+Bu	B+Bu	B	M	M+Bu	E+Bu	E	
25	L	L+Bu	P+Bu	P	E	E+Bu	D+Bu	D	
	25	25	25	25	25	25	25	25	

MAINTAIN AND INCREASE GENETIC VARIATION

How to adopt *Quercus robur?*

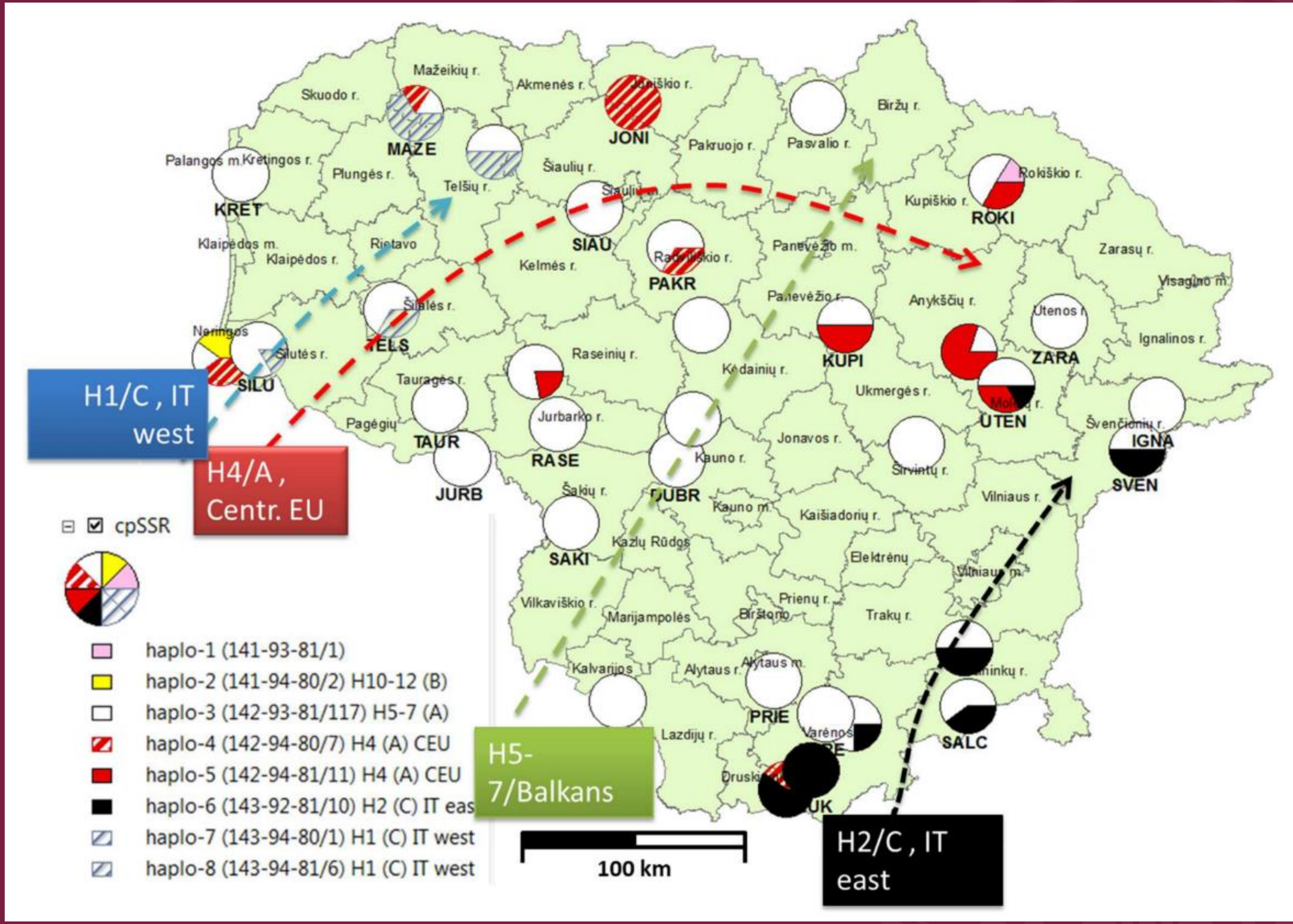
Often suggested “Climate envelope” method translocating seeds from the regions with similar current to forecasted future climatic conditions.



Danusevičius et al. 2021

MAINTAIN AND INCREASE GENETIC VARIATION

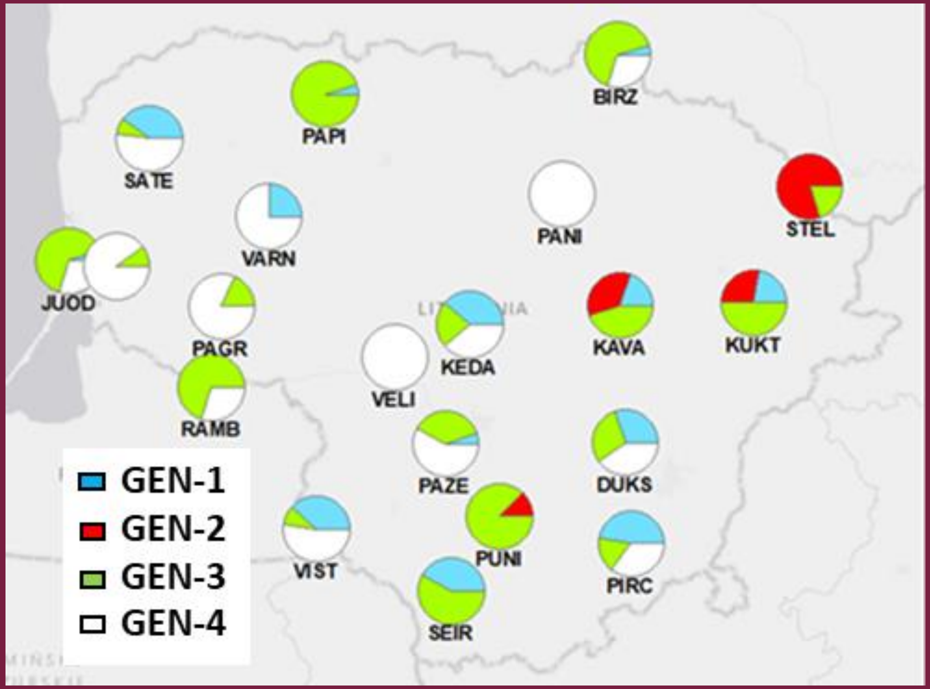
Genetic diversity of Quercus robur in Lithuania



Danusevičius et al. 2021

MAINTAIN AND INCREASE GENETIC VARIATION

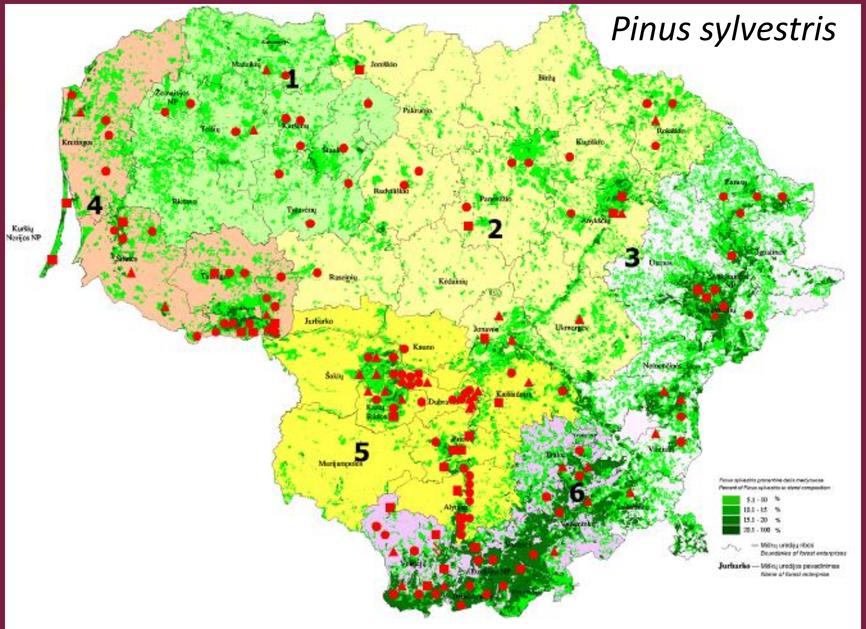
Genetic diversity of Norway maple *Acer platanoides* and genetic groups respond to precipitation, temperature and drought.

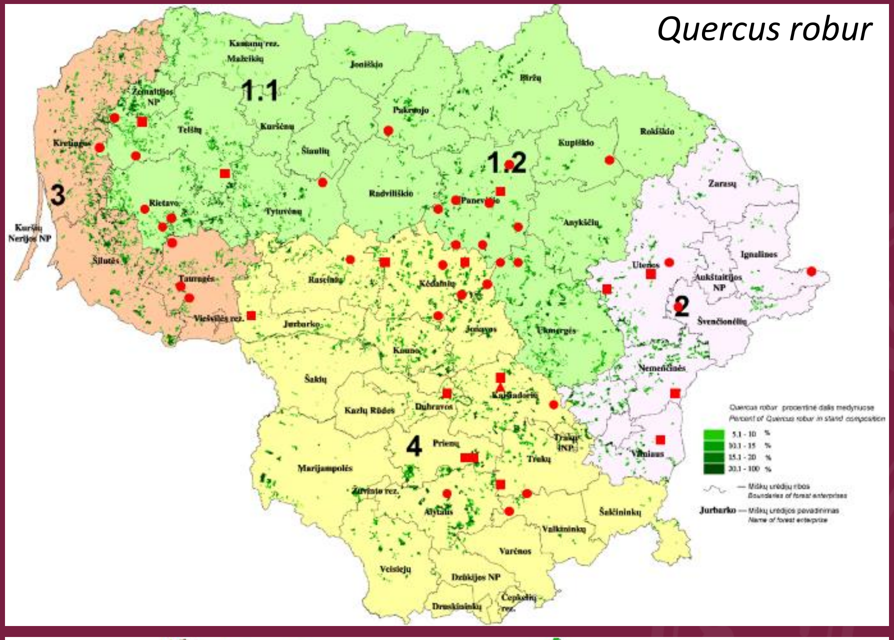


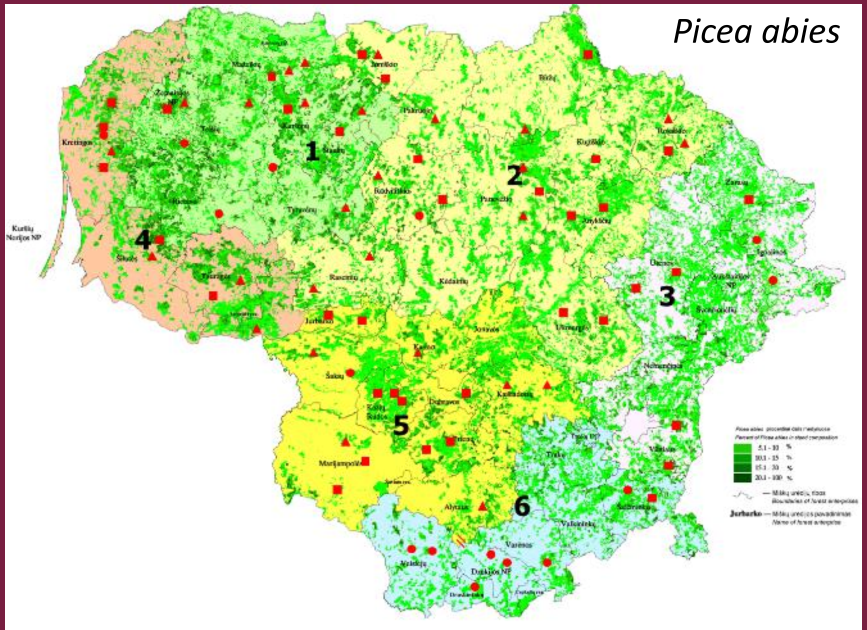
Factor	GEN	Month											
		10	11	12	1	2	3	4	5	6	7	8	9
Precipitation	1												
	2					1							
	3		1										
	4									2			
Temperature	1		3						1				
	2	2							6				
	3			3			2		5				
	4								3				
De Martonne index	1					2							
	2		3							5		4	
	3									4		6	
	4									1			4

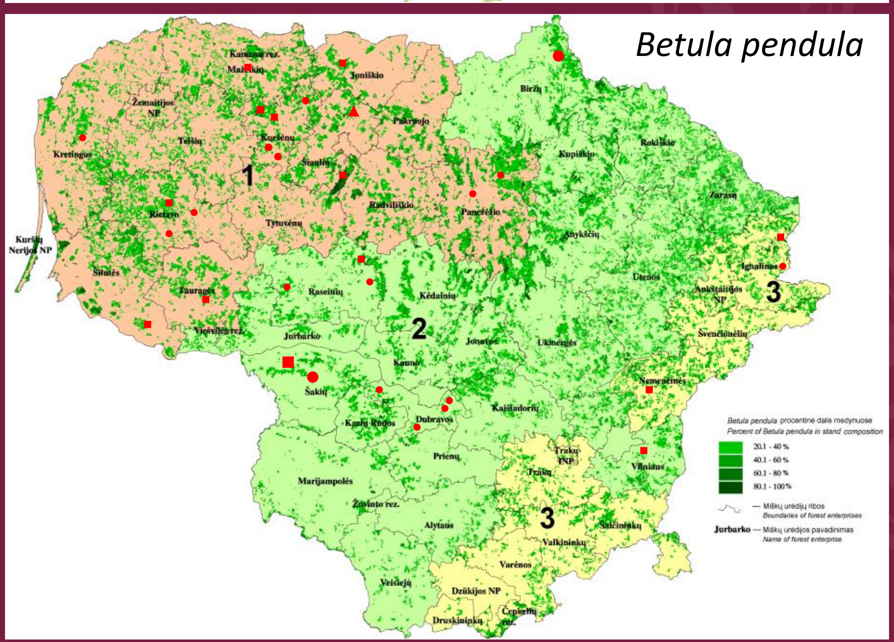
Developed GLMM models of *Acer platanoides* genetic group respond to climatic factors. The number corresponds priority inclusion into the model. Dark green – significant effect, light green – close to significant. Models selected using AIC criteria, step-wise forward modelling applied.

Genetic recourses zoning in Lithuania









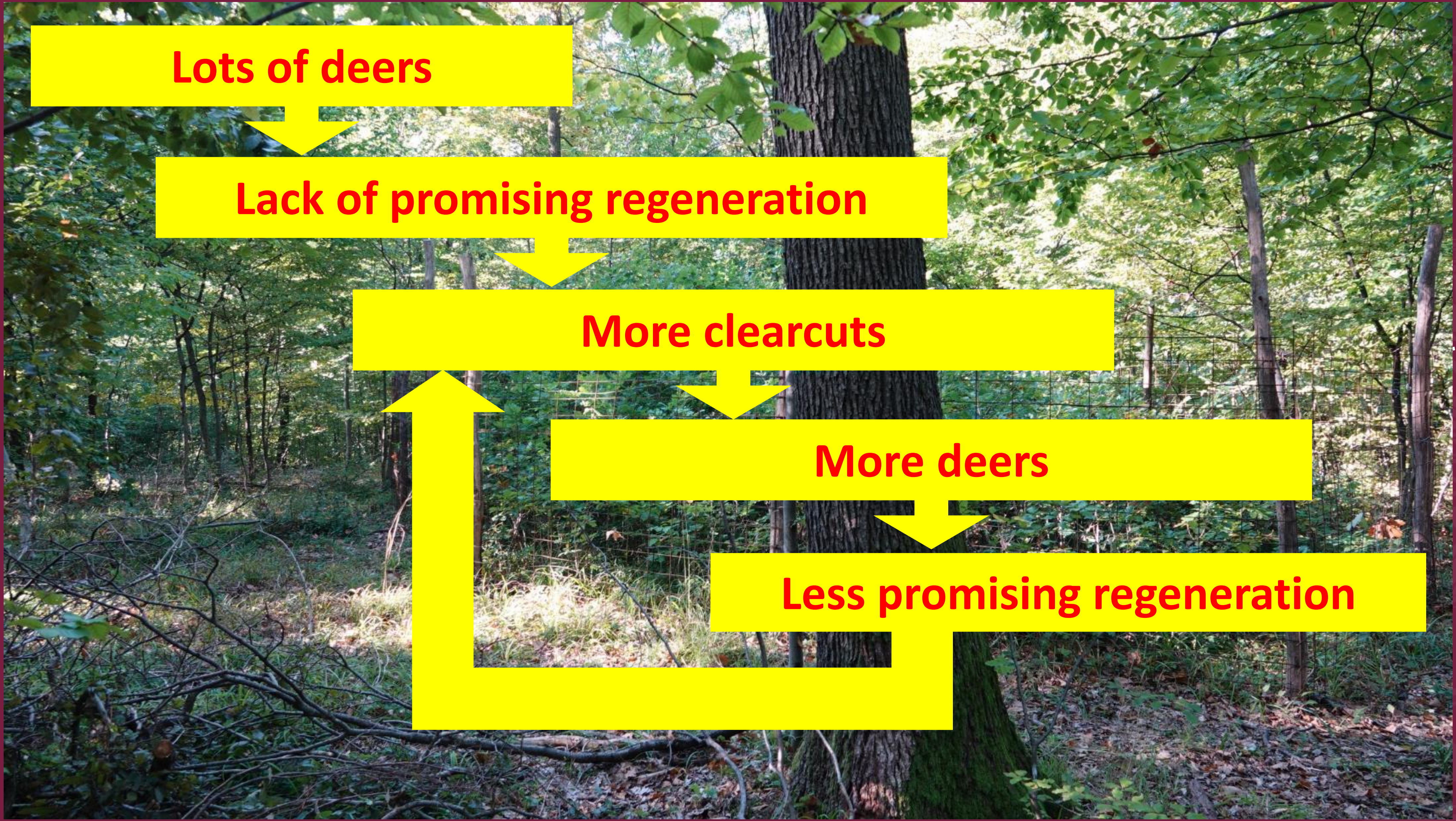
▲ Seed orchards
● Genetic reserves
■ Seed stands

The effect of overabundance of deer's

Short term effect

Long term effect

The effect of overabundance of deer's



Thank You!