

Pomen modeliranja razširjenosti in habitatne ustreznosti vrst pri upravljanju z gozdovi, ogroženimi vrstami in habitatami

Andrej Rozman



Univerza v Ljubljani
Biotehniška fakulteta
Oddelek za gozdarstvo
in obnovljive gozdne vire

MODELIRANJE VRST, ZDRUŽB, NJIHOVE HABITATNE USTREZNOSTI TER PROSTORSKE RAZŠIRJENOSTI

Kaj je model razširjenosti vrst in habitatov?

Kaj modeliramo?

Katere podatke potrebujemo?

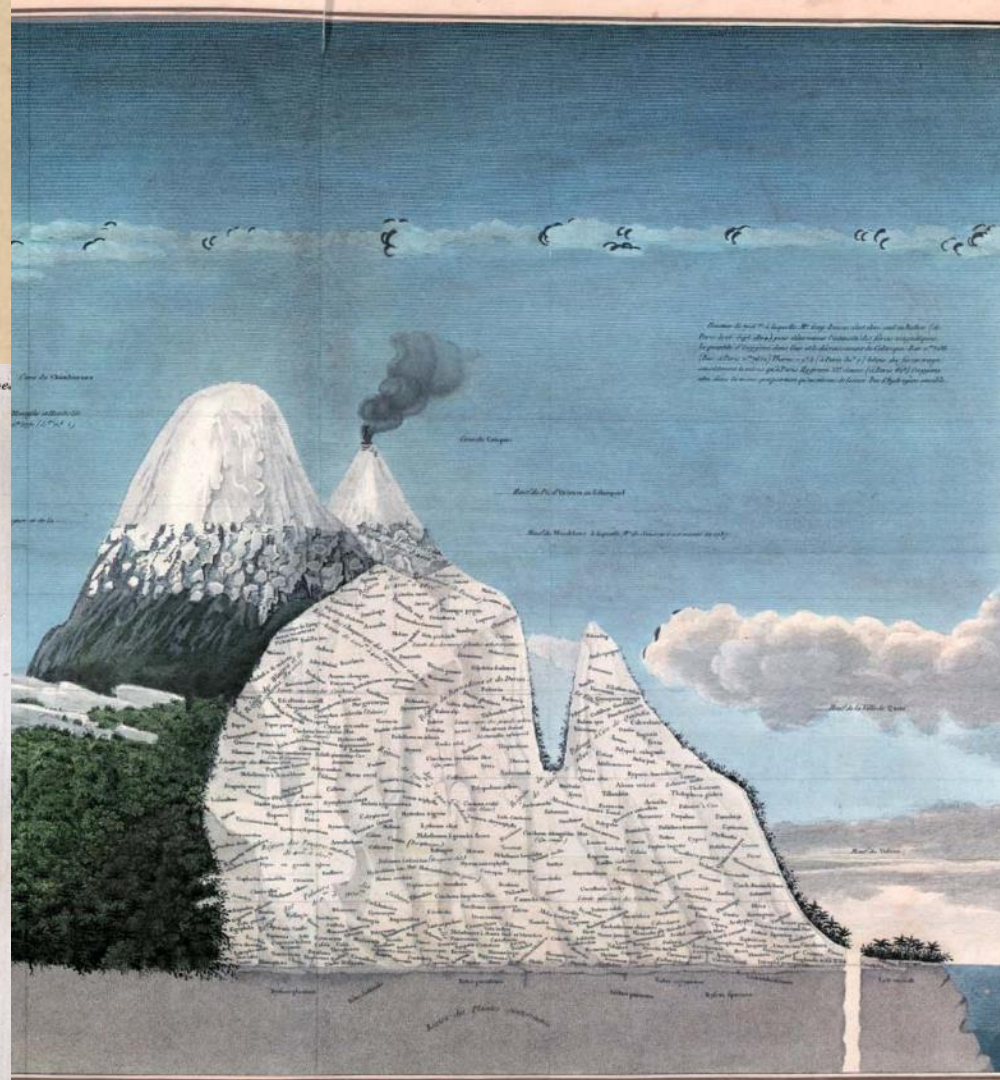
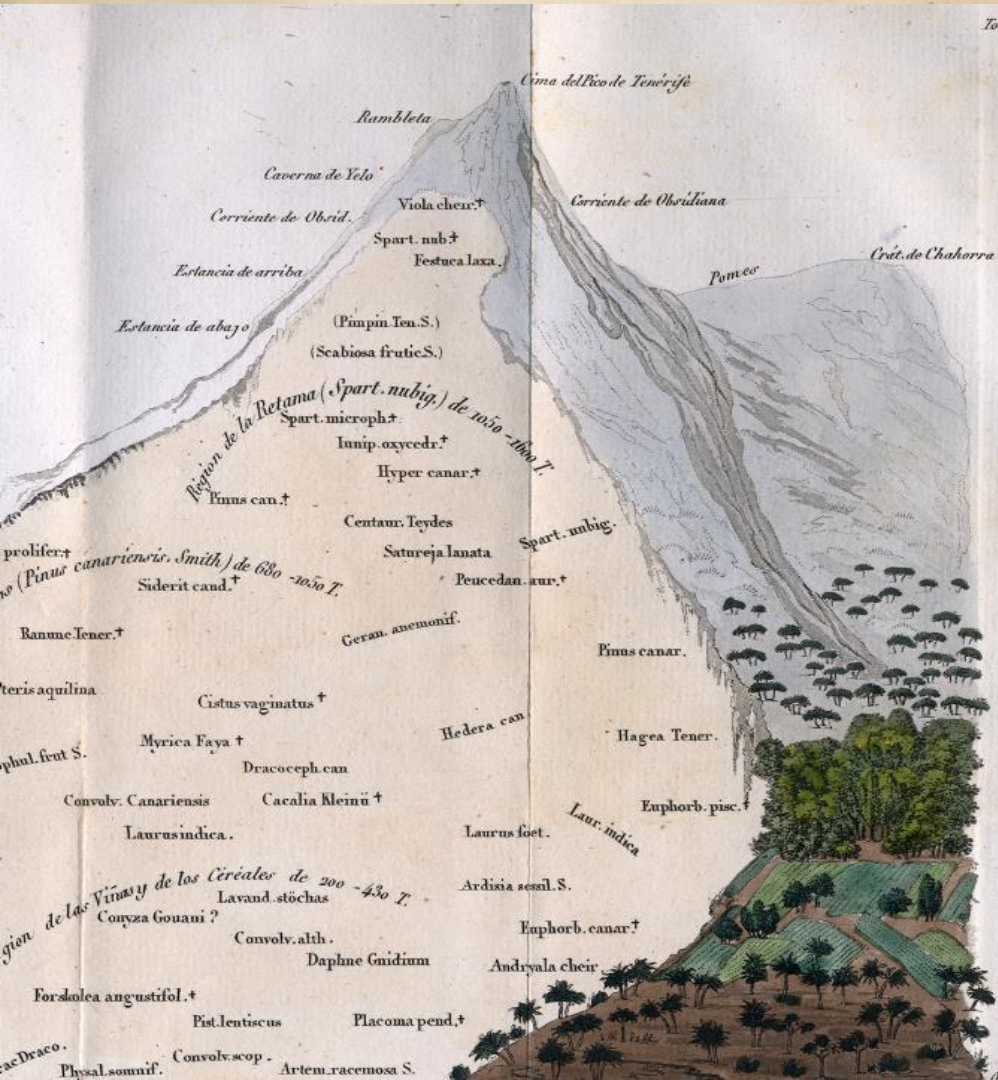
Katere metode se pri modeliranju uporabljajo?

Vrednotenje in napovedi modelov

Uporaba modelov prostorske razširjenosti vrst in habitatov

Essay on the Geography of Plants

ALEXANDER VON HUMBOLDT
AND AIMÉ BONPLAND



DES PLANTES ÉQUINOXIALES
Physique des Andes et Pays voisins
dans & des Mesures prises sur les lieux depuis le 10. degré de latitude boréale
et 10. de latitude australe en 1799, 1800, 1801, 1802 et 1803.

LIGNES ou MÉTRES	DIRECTION de l'Air dominant à l'époque de l'année	HAUTEUR de la montagne de la cime de la colline	ÉCHELLE de la hauteur de la cime de la colline	MÉTRES de la hauteur de la cime de la colline	VUES	
					Géologiques	
1000						
2000						
3000						
4000						
5000						
6000						
7000						
8000						
9000						
10000						



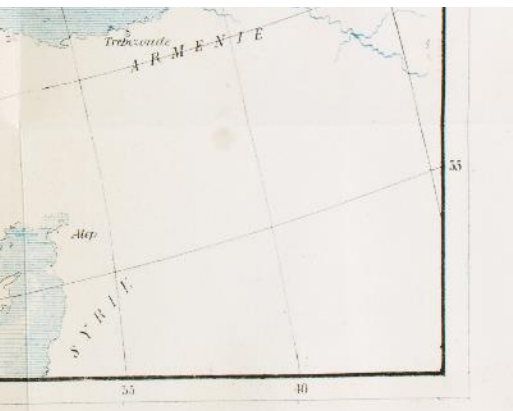
LIMITES POLAIRES DE QUELQUES ESPECES.



- 1. *Missum calcearum* L.
 - 2. *Succowia balcarica* Medic.
 - 3. *Radiola linoides* Grmel.
 - 4. *Atractylis cancellata* L.
 - 5. *Campanula Erinus* L.
- Esèces annuelles
tracées en rouge
- 6. *Aquilegia vulgaris* L.
 - 7. *Dianthus carthusianorum* L.
 - 8. *Helleborus foetidus* L.
 - 9. *Peperum Harmala* L.
- Esèces vivaces
tracées en noir.
- 10. *Ilex Aquifolium* L.
 - 11. *Evonymus Europaeus* L.
 - 12. *Daboecia polifolia* Don.
 - 13. *Amygdalus nana* Pull.
 - 14. *Chamaecyparis humilis* L.
 - 15. *Fagus sylvatica* L.
- Esèces ligneuses
tracées en bleu.



De Candolle, *Limites polaires de quelques espèces* (1855)

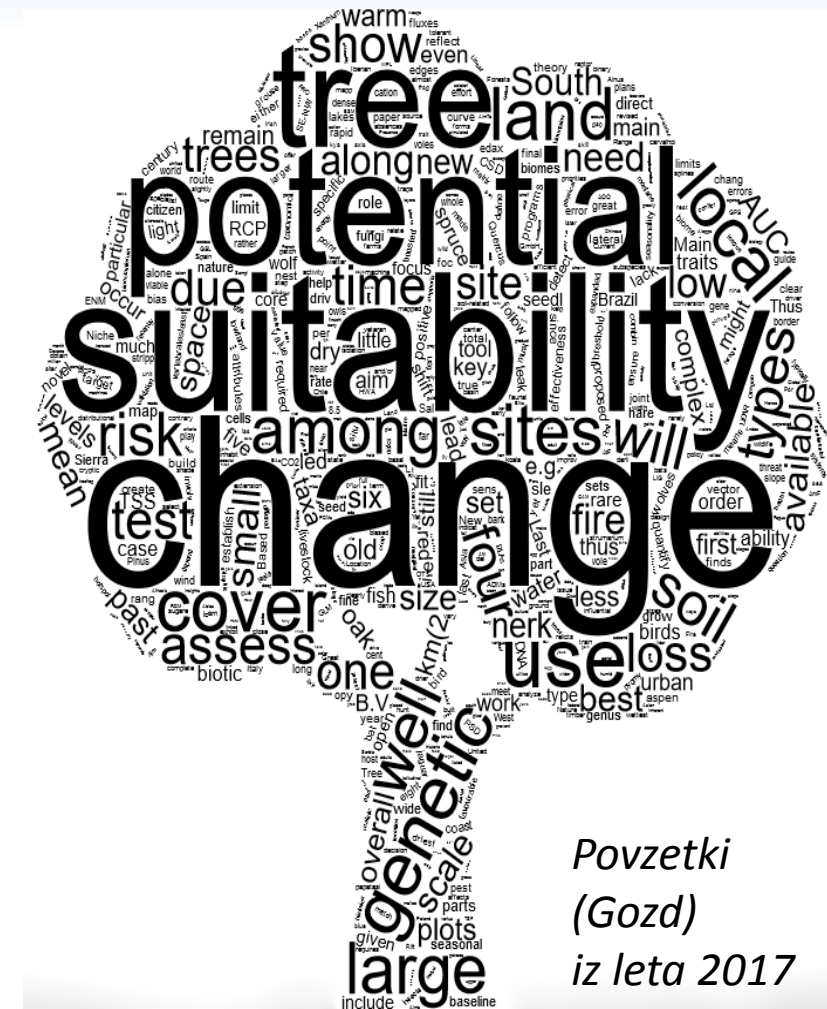
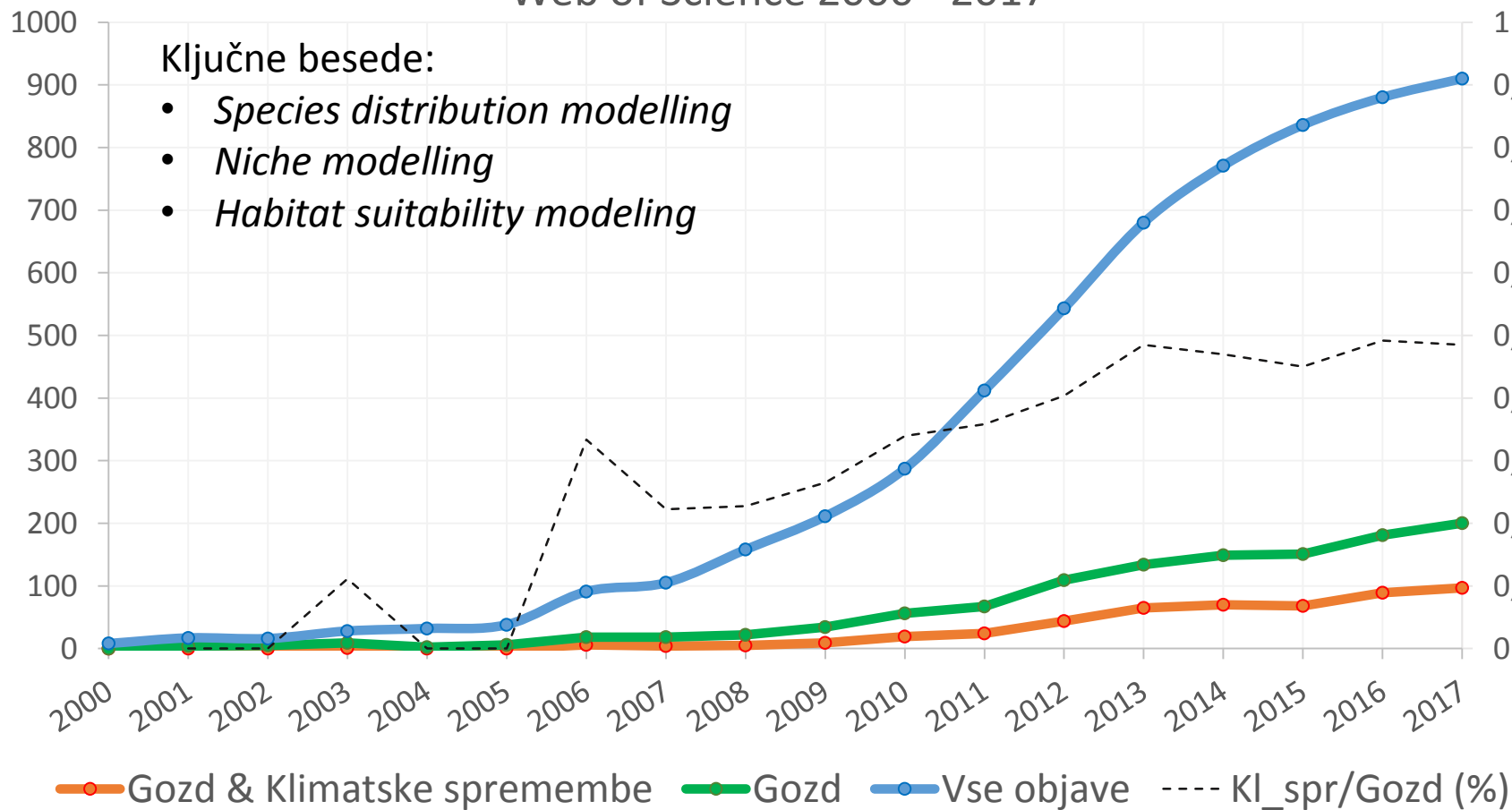


MODELIRANJE VRST, ZDRUŽB, NJIHOVE HABITATNE USTREZNOSTI TER PROSTORSKE RAZŠIRJENOSTI

Web of Science 2000 - 2017

Ključne besede:

- *Species distribution modelling*
- *Niche modelling*
- *Habitat suitability modeling*



KAJ JE MODEL RAZŠIRJENOSTI VRST IN HABITATOV?

- Zanima nas, kje se vrste ter njihove združbe pojavljajo in zakaj prav tam?
- Kakšna je verjetnost pojavljanja vrste na nekem območju?

Statistični model: povezava med terenskim opažanjem vrst in okoljskimi razmerami



Ekološko ozadje: uspešnost vrste na gradientih posameznih okoljskih spremenljivk (klima, substrat, relief...)

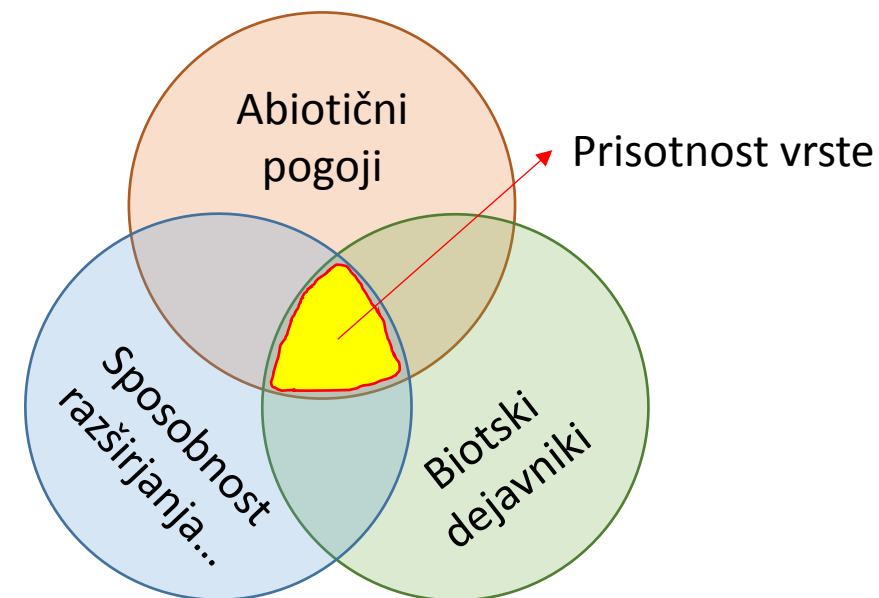
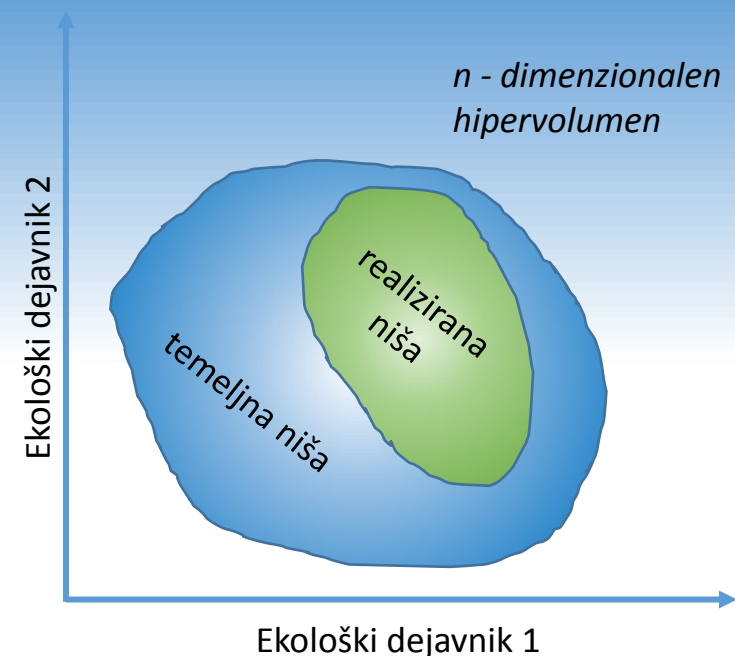


Prostorska napoved modela:
“verjetnost” pojavljanje vrste v prostoru
(karta habitatne ustreznosti)

KAJ MODELIRAMO?

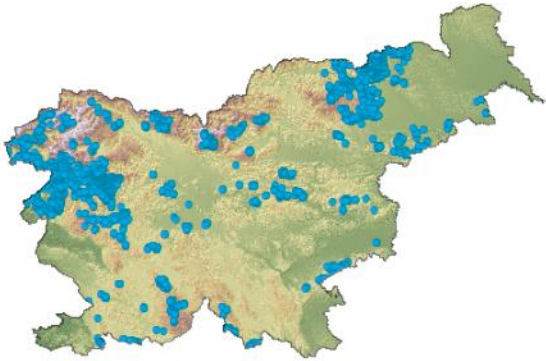
Ekološka niša

- vrsta se lahko pojavlja le v območjih, kjer so zanje okoljske razmere ugodne (**temeljna** ekološka niša), dejanska razširjenost znotraj teh območij (**realizirana** niša) pa je odvisna od kompeticijske sposobnosti vrste in od njene pretekle razširjenosti
- s prostorskimi modeli želimo ugotoviti območje **realizirane** ekološke niše vrst

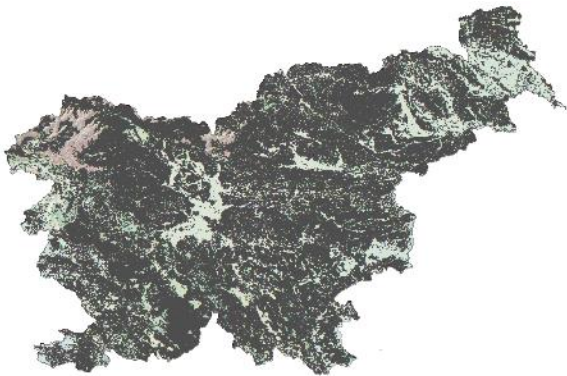


PODATKI

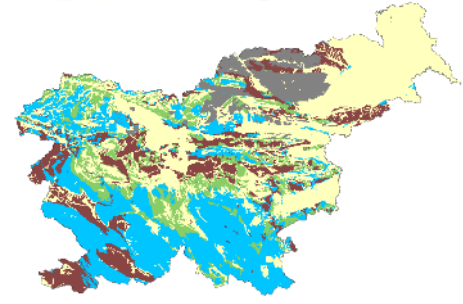
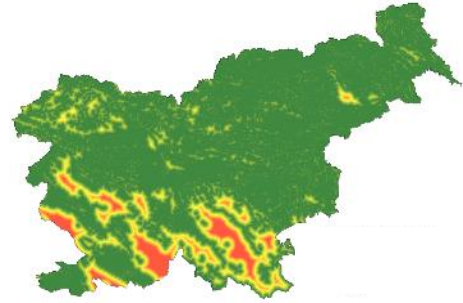
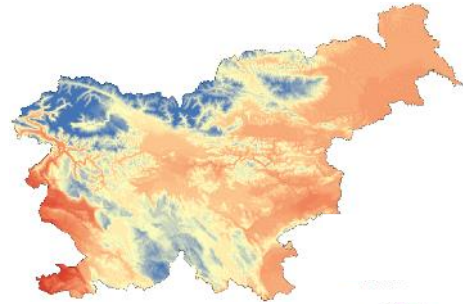
Pojavljanje vrste



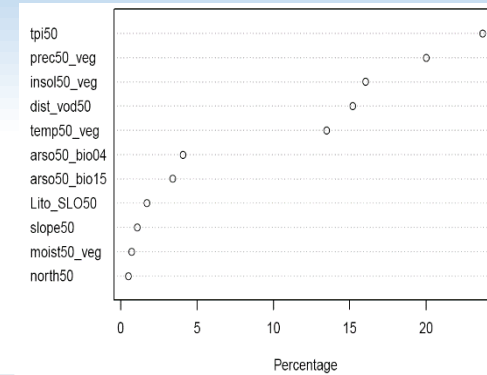
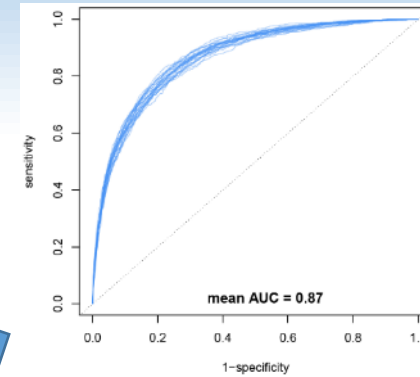
Odsotnost vrste



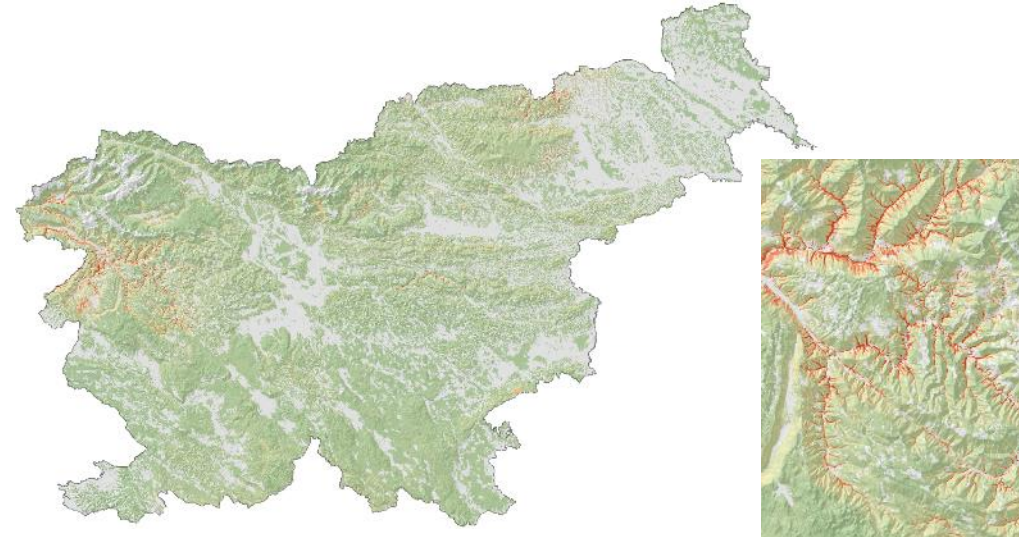
Ekološke razmere



Izdelava modela, vrednotenje



prostorska interpolacija/ekstrapolacija



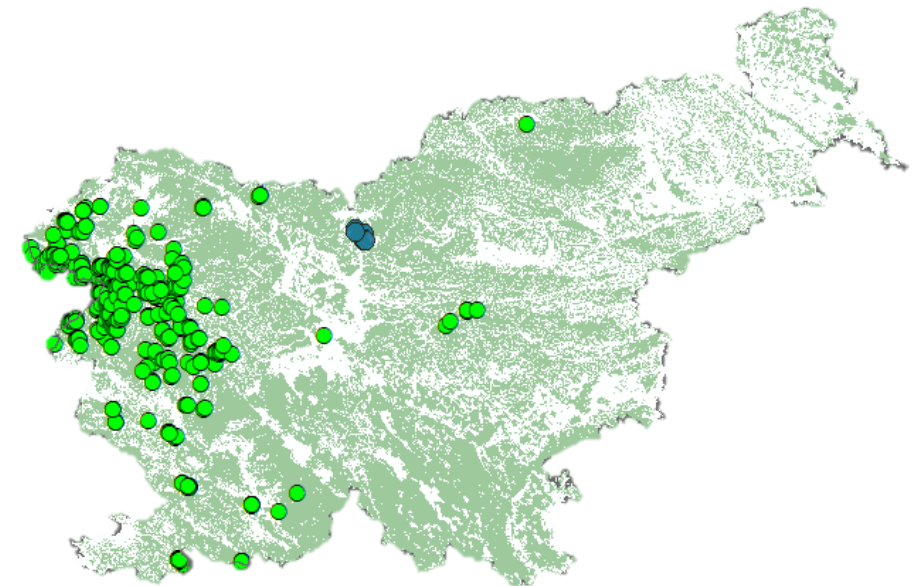
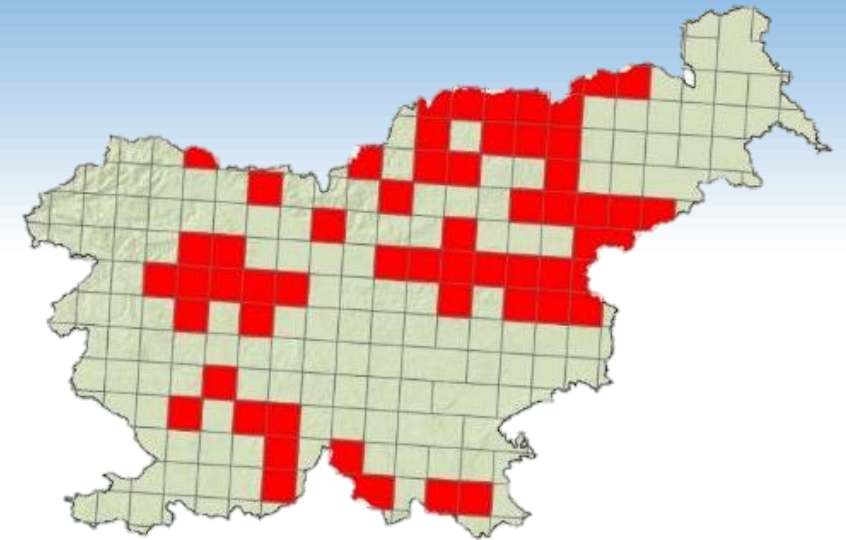
PODATKI O VRSTAH / ZDRUŽBAH

Prisotnost/odsotnost vrste – terenski podatki:

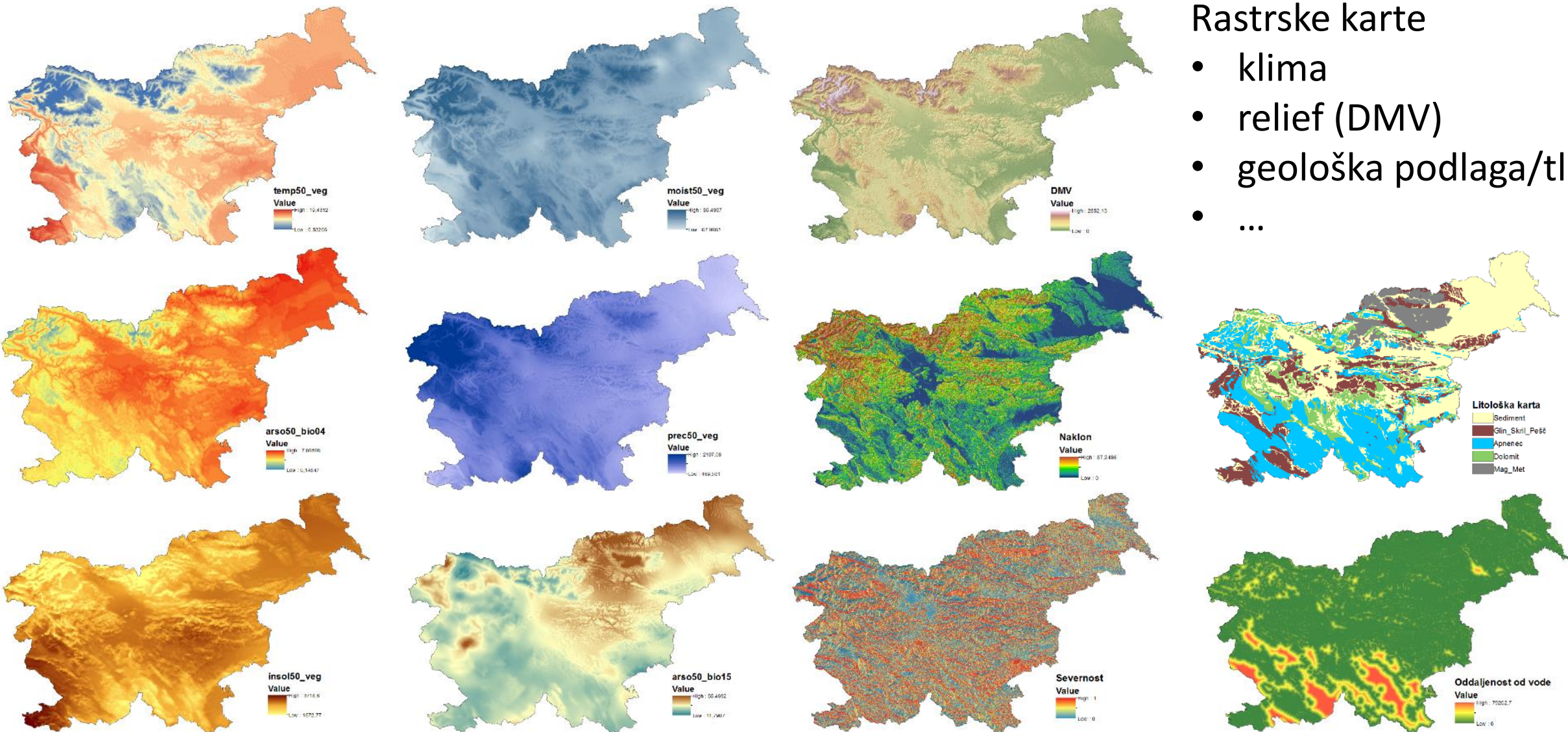
- geokodirane muzejske/herbarijske zbirke
- delne karte razširjenosti vrste
- velike podatkovne baze
- dodatna vzorčenja slabo pokritih območij

Problemi:

- slaba resolucija podatkov
- lokacije odsotnosti vrste?
- različna gostota podatkov po območjih
- **potreba po sistematično zbranih podatkih!**



PODATKI O OKOLJU



Rastrske karte

- klima
- relief (DMV)
- geološka podlaga/tla
- ...

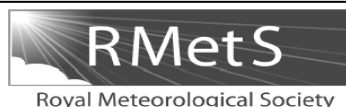
WorldClim Version2

WorldClim version 2 has average monthly climate data for minimum, mean, and maximum temperature and for precipitation for 1970-2000.

You can download the variables for different spatial resolutions, from 30 seconds (~1 km²) to 10 minutes (~340 km²). Each download is a "zip" file containing 12 GeoTiff (.tif) files, one for each month of the year (January is 1; December is 12).

variable	10 minutes	5 minutes	2.5 minutes	30 seconds
minimum temperature (°C)	tmin 10m	tmin 5m	tmin 2.5m	tmin 30s
maximum temperature (°C)	tmax 10m	tmax 5m	tmax 2.5m	tmax 30s
average temperature (°C)	tavg 10m	tavg 5m	tavg 2.5m	tavg 30s
precipitation (mm)	prec 10m	prec 5m	prec 2.5m	prec 30s
solar radiation (kJ m ⁻² day ⁻¹)	srad 10m	srad 5m	srad 2.5m	srad 30s
wind speed (m s ⁻¹)	wind 10m	wind 5m	wind 2.5m	wind 30s
water vapor pressure (kPa)	vapr 10m	vapr 5m	vapr 2.5m	vapr 30s

INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. (2017)
 Published online in Wiley Online Library
 (wileyonlinelibrary.com) DOI: 10.1002/joc.5086



WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas

Stephen E. Fick^{a*} and Robert J. Hijmans^b

^a Department of Plant Sciences, University of California, Davis, CA, USA

^b Department of Environmental Science and Policy, University of California, Davis, CA, USA

“Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965-1978.”

CMIP5 30-seconds

Downscaled IPCC5 (CMIP5) data at 30 seconds resolution

This page has the data at 30-seconds (of a longitude/latitude degree) spatial resolution (this is about 900 m at the equator). [Other spatial resolutions](#) are available.

The data available here are climate projections from GCMs that were [downscaled and calibrated \(bias corrected\)](#) using [WorldClim 1.4](#) as baseline 'current' climate. The file format is GeoTIFF.

Greenhouse gas scenarios: four [representative concentration pathways \(RCPs\)](#)

Time periods: **2050** (average for 2041-2060) and **2070** (average for 2061-2080)

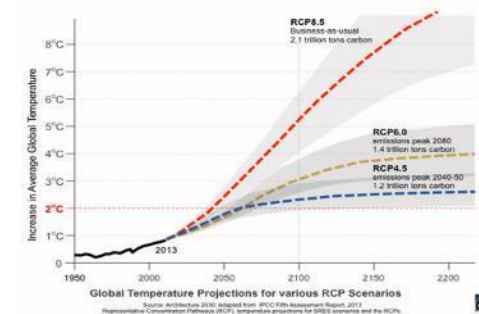
Variables:

tn - monthly average minimum temperature (degrees C * 10)

tx - monthly average maximum temperature (degrees C * 10)

pr - monthly total precipitation (mm)

bc - 'bioclimatic' variables



2050

GCM	code	rcp26	rcp45	rcp60	rcp85
ACCESS1-0 (#)	AC		tn, tx, pr, bi		tn, tx, pr, bi
BCC-CSM1-1	BC	tn, tx, pr, bi	tn, tx, pr, bi	tn, tx, pr, bi	tn, tx, pr, bi
CCSM4	CC	tn, tx, pr, bi	tn, tx, pr, bi	tn, tx, pr, bi	tn, tx, pr, bi
CESM1-CAM5-1-FV2	CE		tn, tx, pr, bi		
CNRM-CM5 (#)	CN	tn, tx, pr, bi	tn, tx, pr, bi		tn, tx, pr, bi
GFDL-CM3	GF	tn, tx, pr, bi	tn, tx, pr, bi		tn, tx, pr, bi

METODE

Statistične regresijske metode

- logistični regresijski model (GLM)
- posplošeni aditivni model (GAM)

Metode strojnega učenja

- klasifikacijska in regresijska drevesa (Classification And Regression Trees - CART)
- naključni gozd regresijskih dreves (Random forest - RF)
- metoda podpornih vektorjev (Support vector machine - SVM)
- nevronske mreže (Artificial neural network - ANN)
- metoda maksimalne entropije – le podatki o prisotnosti vrste (Maxent) ...

Kombinacije modelov

- povprečenja ansambla najverjetnejših modelov



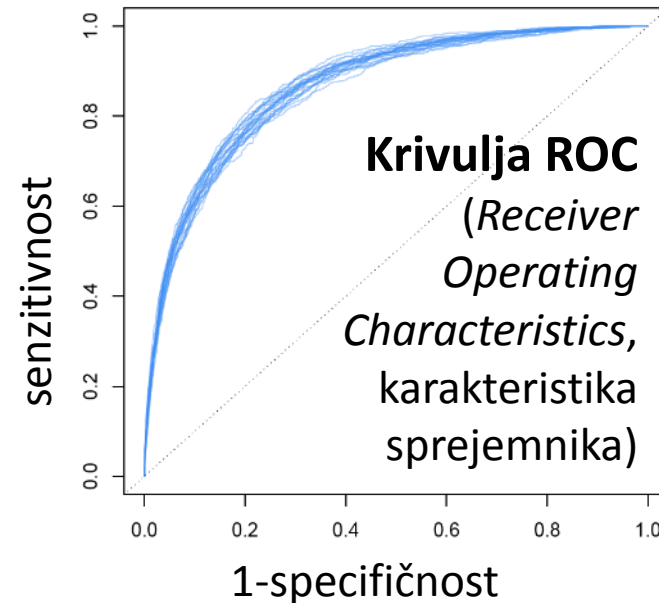
pretirana prilagojenost modela!



VREDNOTENJE MODELOV

- Trening podatki – **testni podatki**: navzkrižno preverjanje (*Cross-validation*)
- **AUC** (*area under the ROC curve*) – površina pod krivuljo ROC

		dejanski razred	
		+	-
napovedani razred	+	TP	FP
	-	FN	TN



AUC

- > 0.8 dobre napovedi
- 0.6 – 0.8 povprečne napovedi
- > 0.6 slabe napovedi
- 0.5 naključno

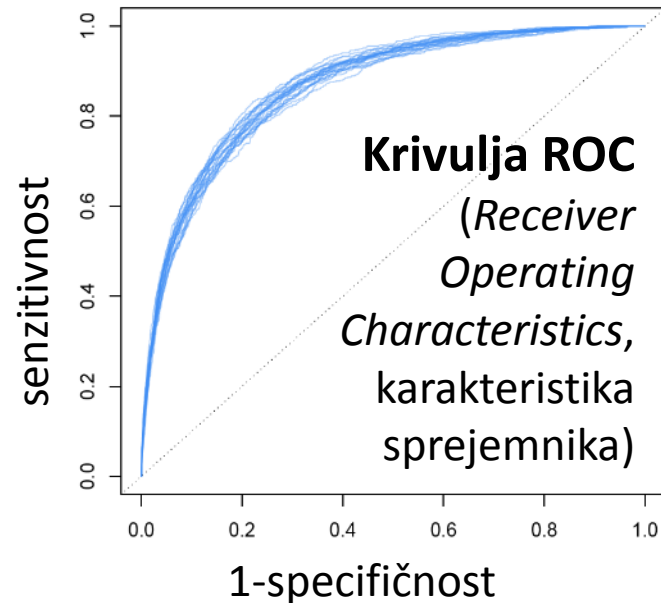
Senzitivnost $TP/(FN+TP)$ (delež pravilno uvrščenih pozitivnih primerov)

Specifičnost $TN/(FP+TN)$ (delež pravilno uvrščenih negativnih primerov)

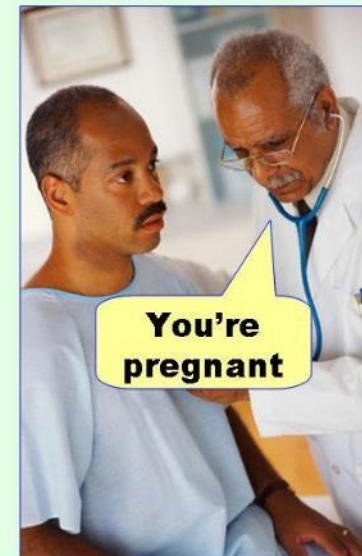
VREDNOTENJE MODELOV

- Trening podatki – testni podatki: navzkrižno preverjanje (*Cross-validation*)
- AUC (*area under the ROC curve*) – površina pod krivuljo ROC

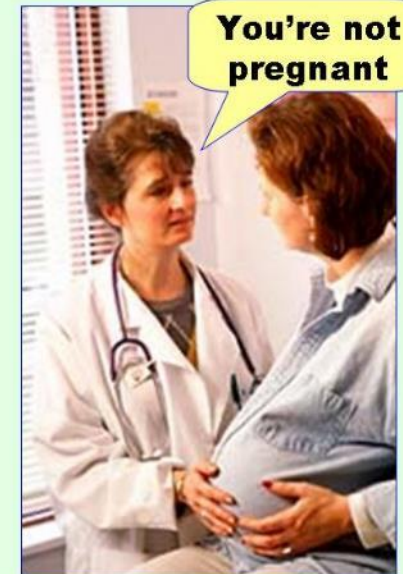
		dejanski razred	
		+	-
napovedani razred	+	TP	FP
	-	FN	TN



Type I error
(false positive)

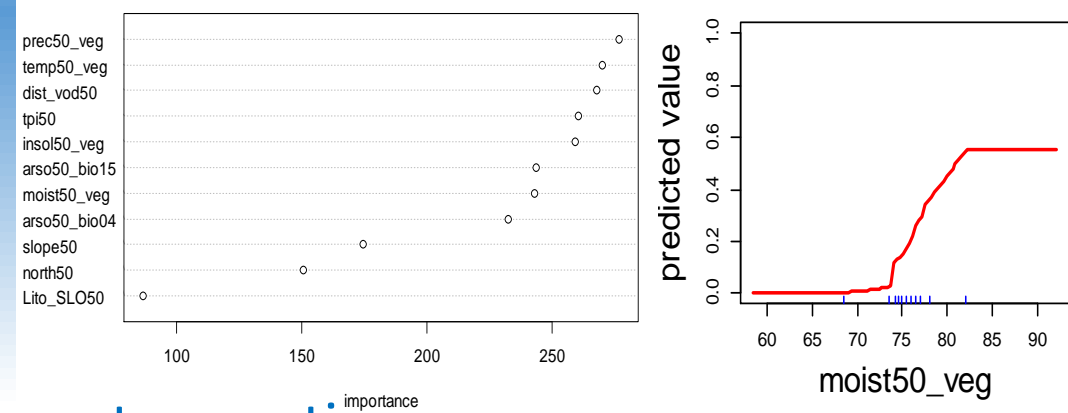


Type II error
(false negative)



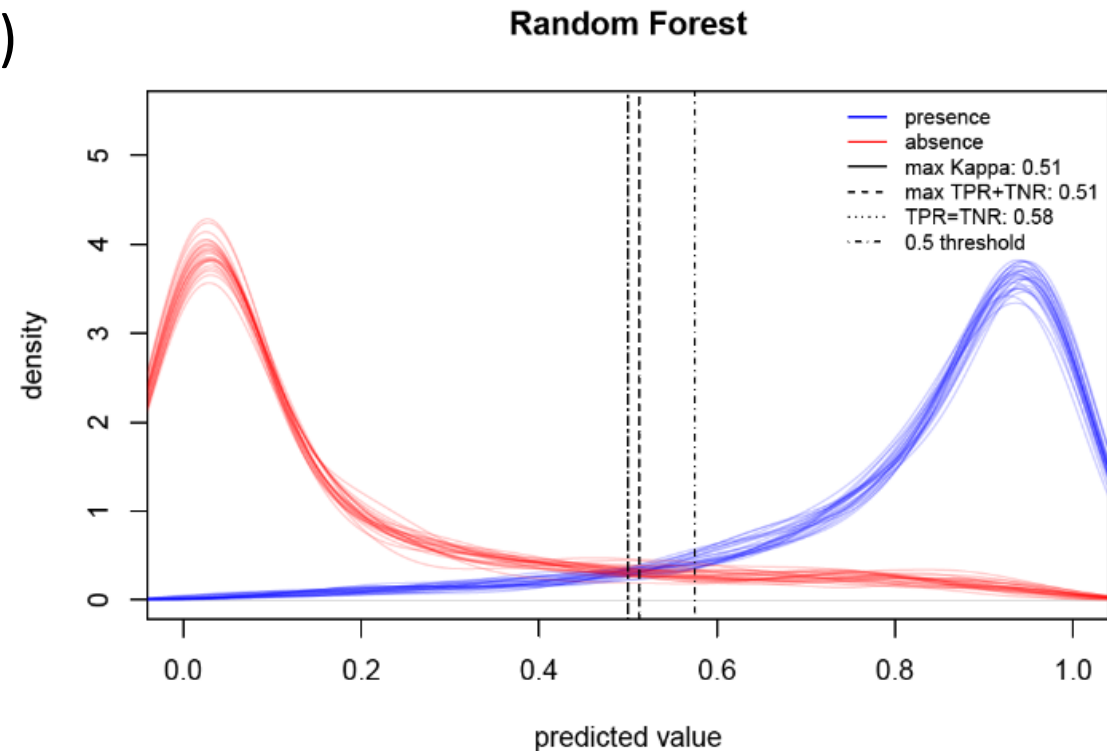
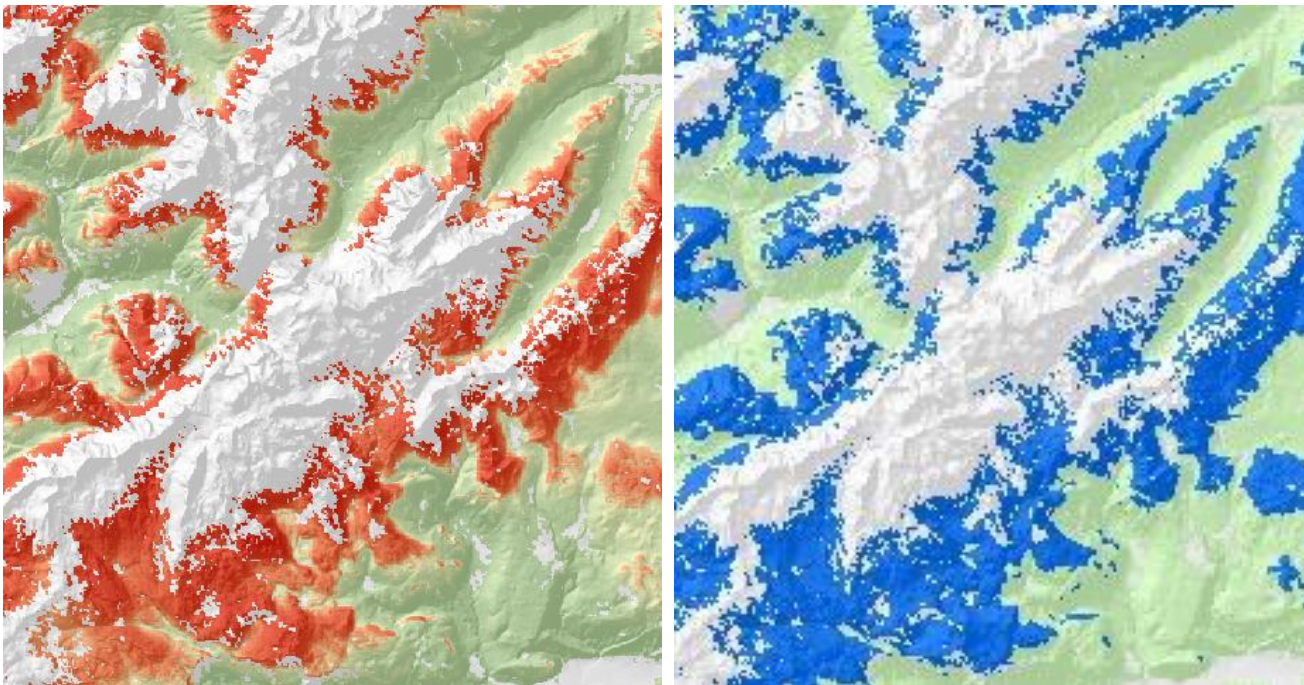
Senzitivnost $TP/(FN+TP)$ (delež pravilno uvrščenih pozitivnih primerov)
Specifičnost $TN/(FP+TN)$ (delež pravilno uvrščenih negativnih primerov)

NAPOVEDI MODELOV



Rastrska karta potencialne razširjenosti / habitatne ustreznosti

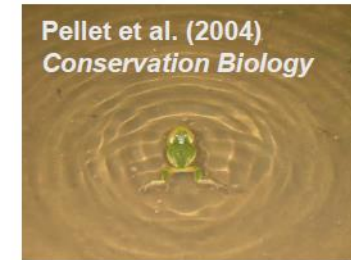
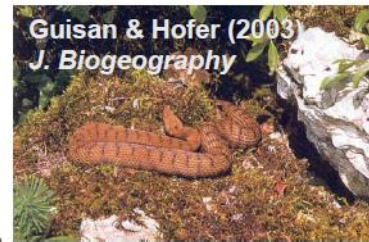
- interpolacija znotraj območja / ekstrapolacija na nova območja ali časovna obdobja
- verjetnost prisotnosti vrste (0–1)
- klasifikacija rezultatov: binarna napoved (0/1)



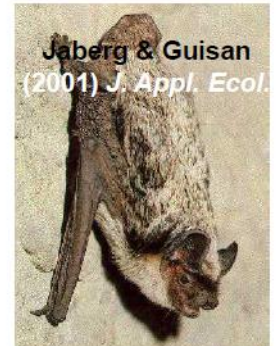
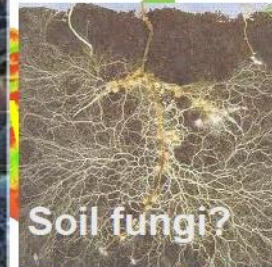
UPORABA MODELOV RAZŠIRJENOSTI VRST OZ. HABITATNE USTREZNOSTI

Možnost uporabe modelov
za vse organizme

Guisan, 2014



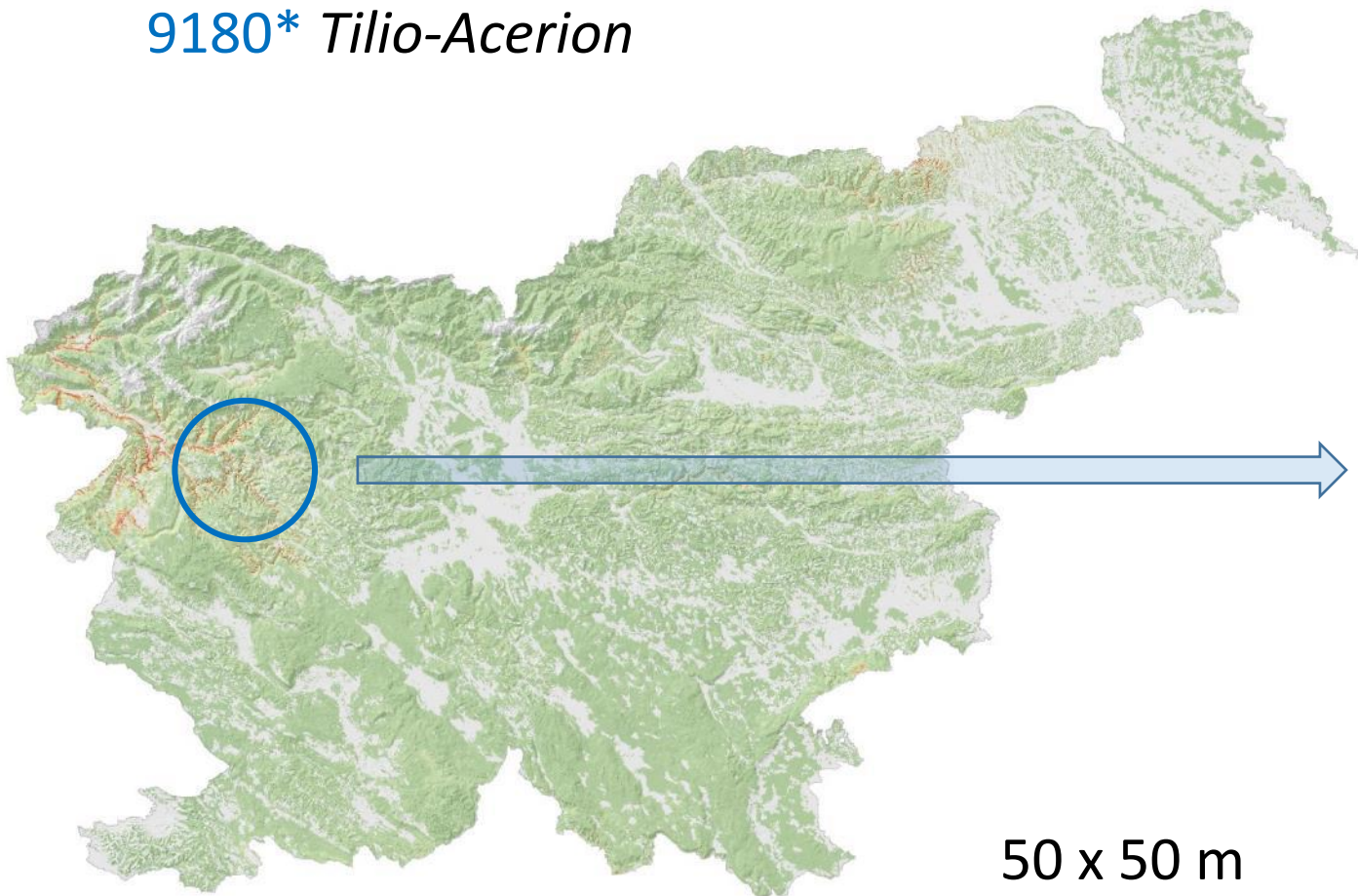
Lütolf et al. (2006) *J. Appl. Ecol.*



PRIMERI



9180* *Tilio-Acerion*



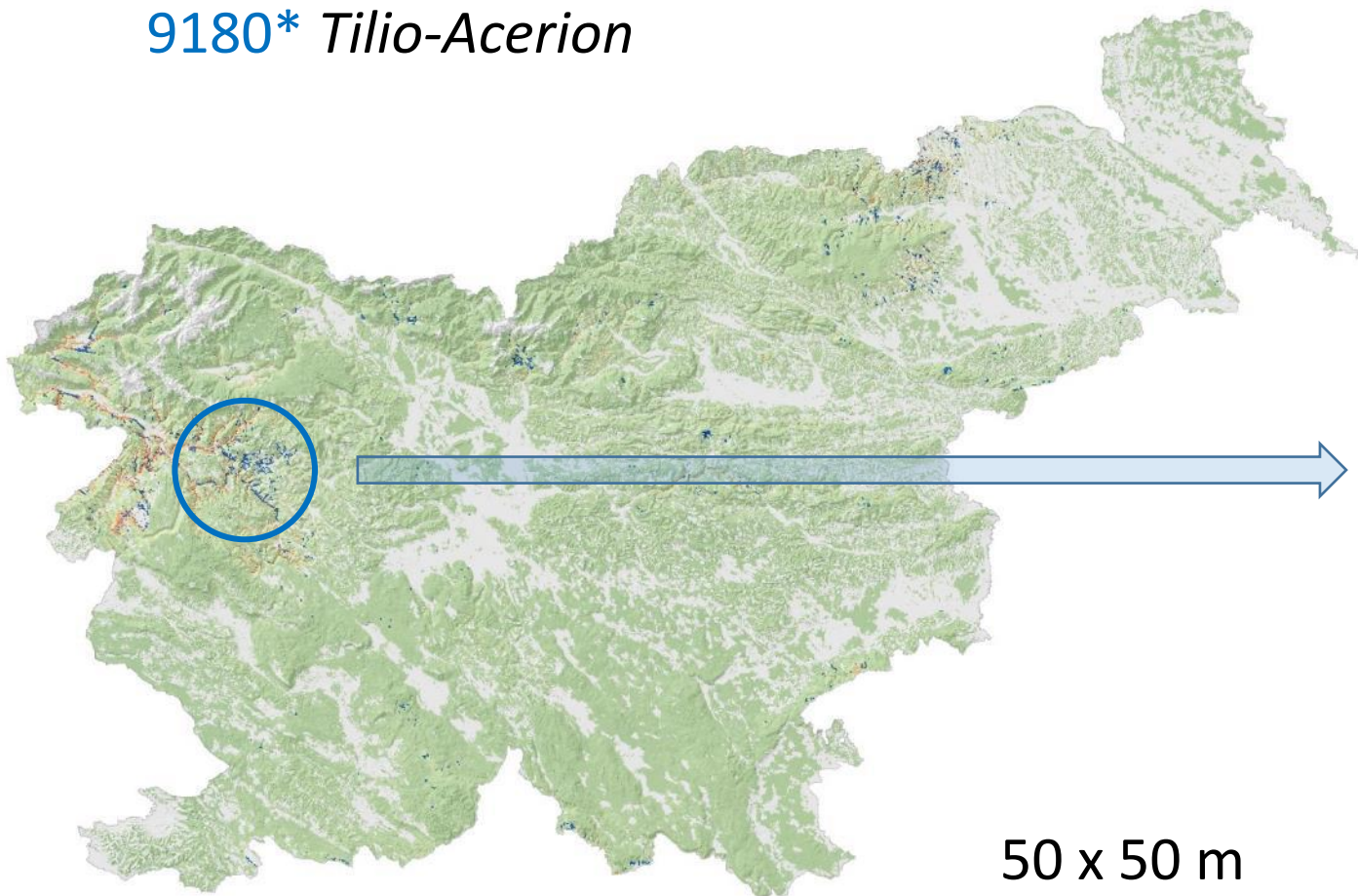
50 x 50 m



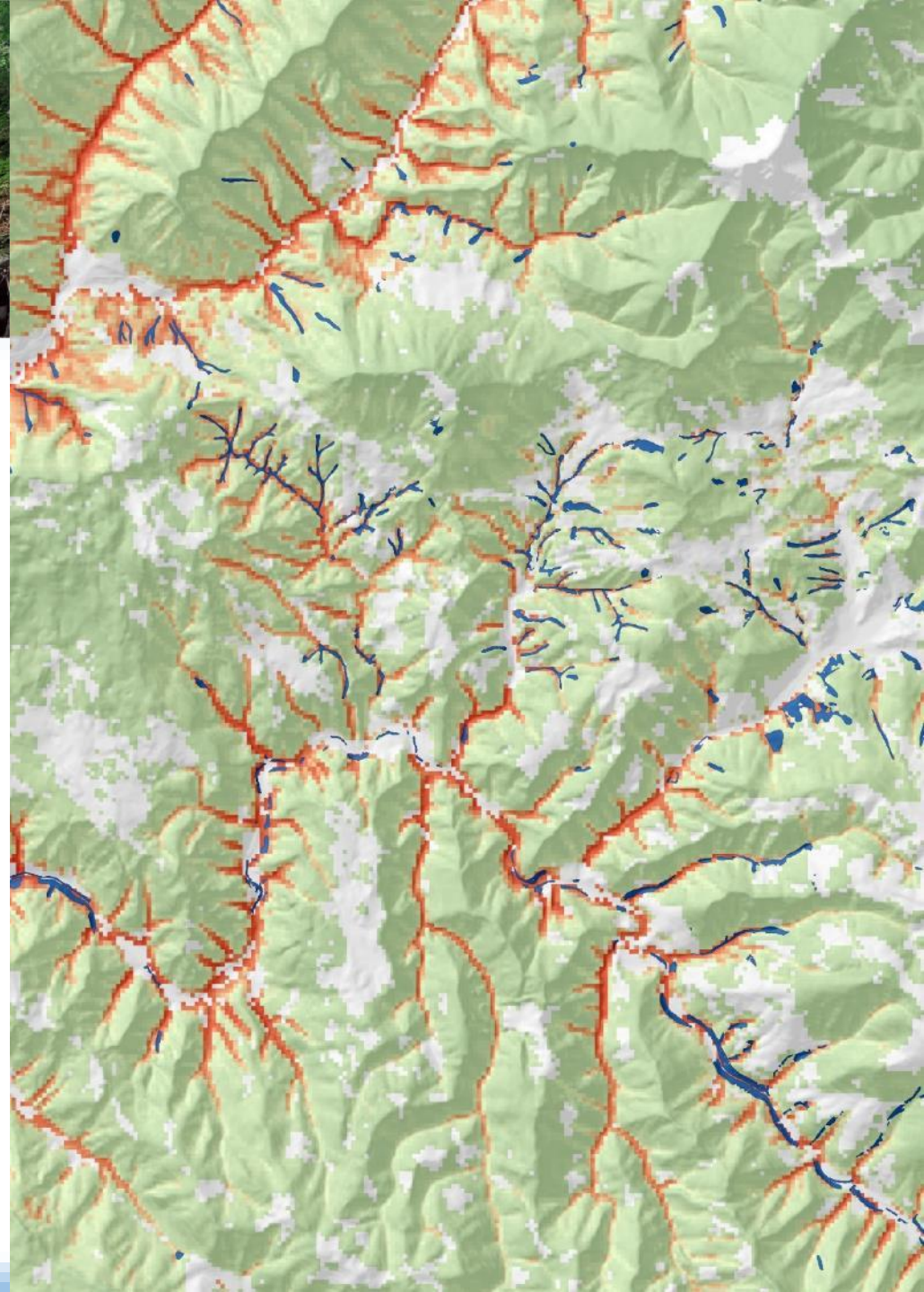
PRIMERI



9180* *Tilio-Acerion*



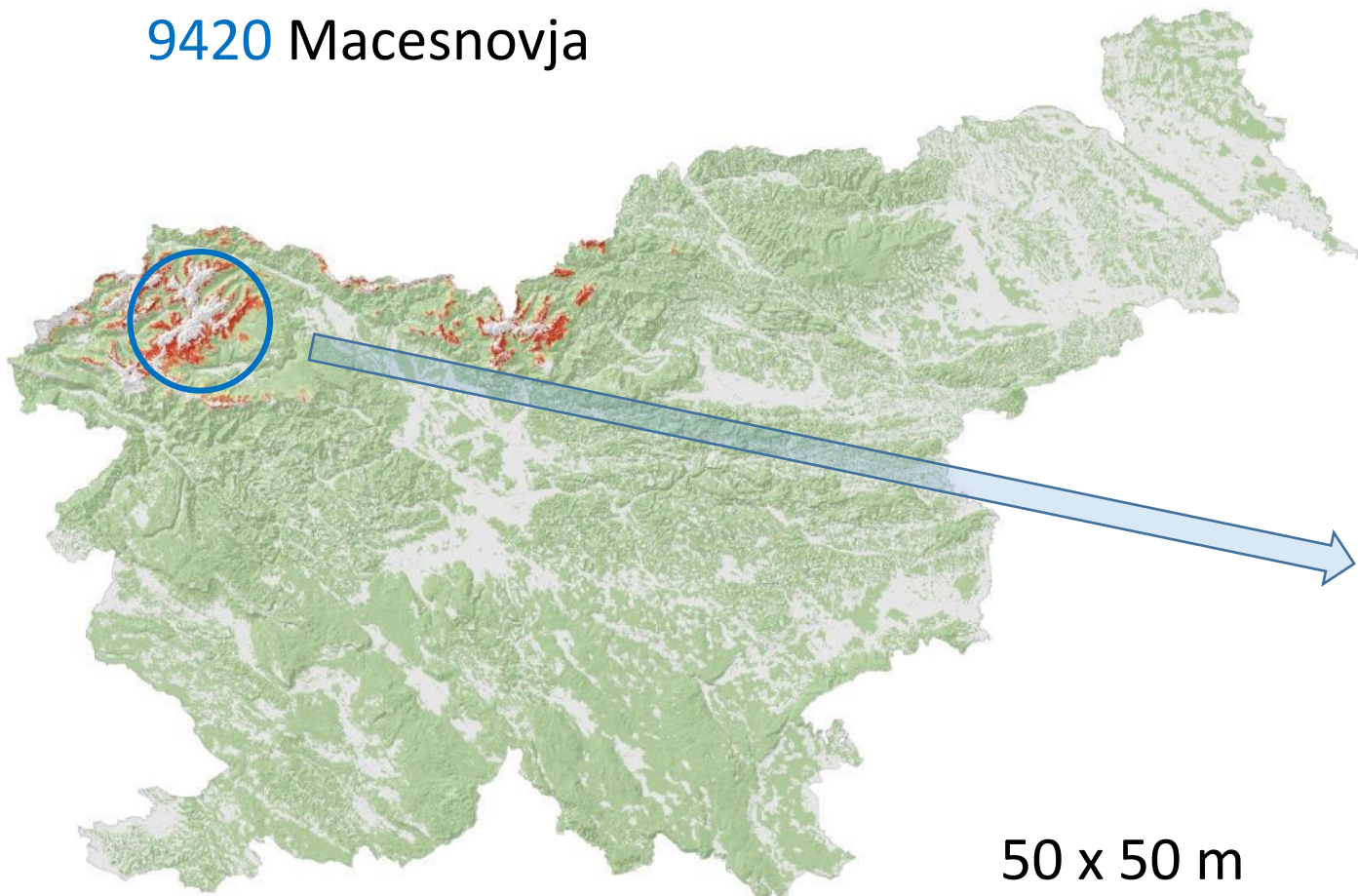
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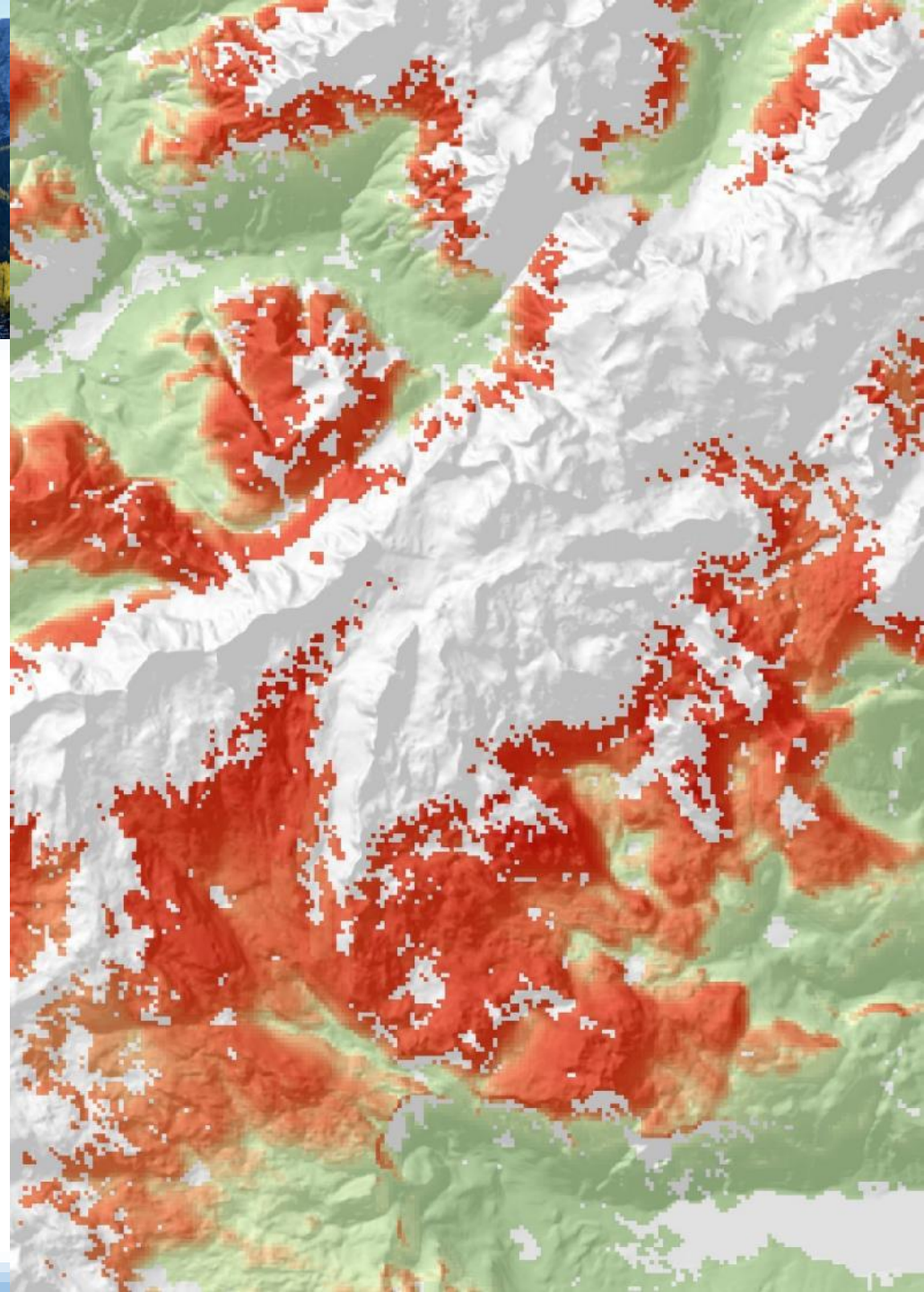
PRIMERI



9420 Macesnovja



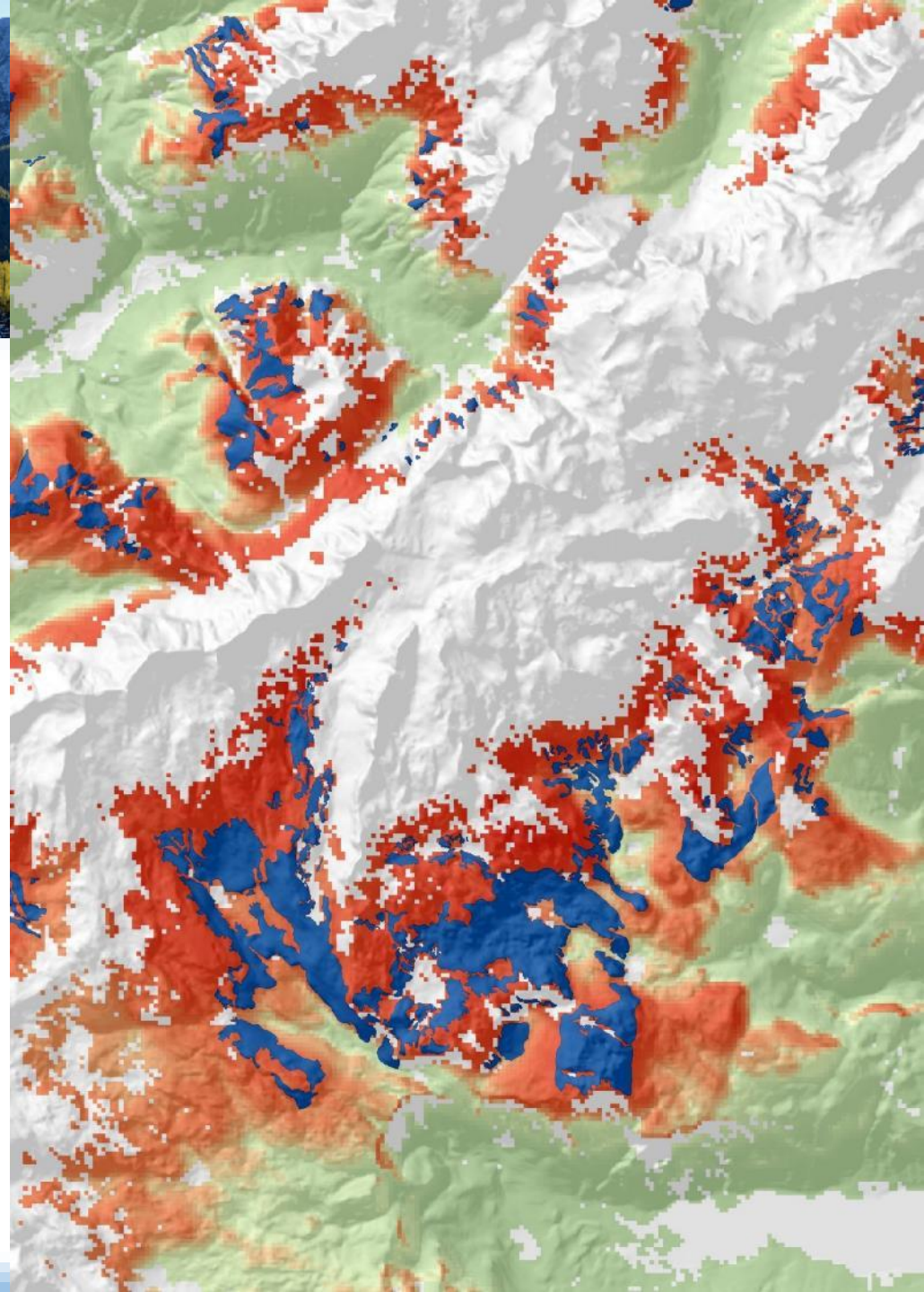
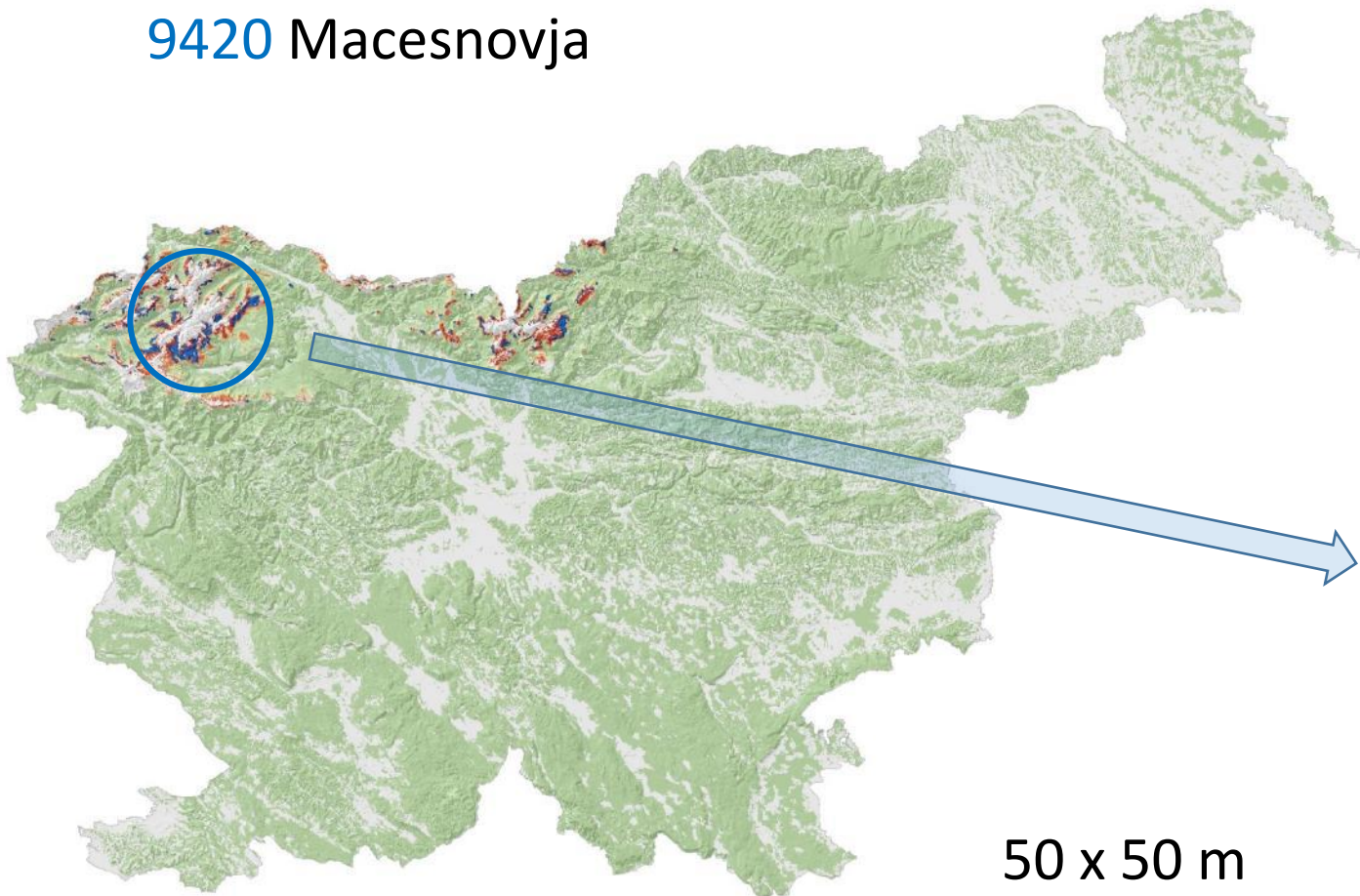
50 x 50 m



PRIMERI



9420 Macesnovja



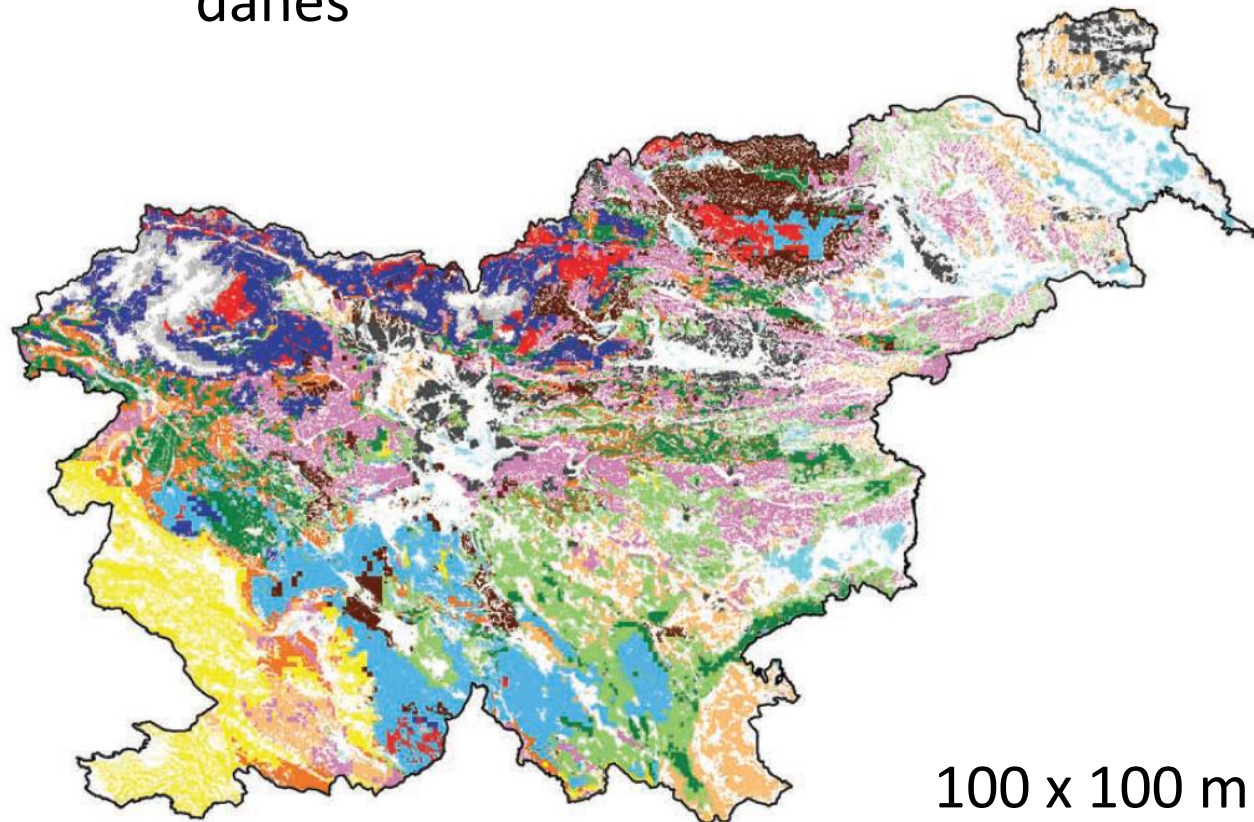
PRIMERI

PREDICTION OF FOREST VEGETATION SHIFT DUE TO DIFFERENT CLIMATE-CHANGE SCENARIOS IN SLOVENIA

PROGNOZA PROMJENA ŠUMSKEVEGETACIJE ZBOG RAZLIČITIH SCENARIJA KLIMASKIH PROMJENA U SLOVENIJI

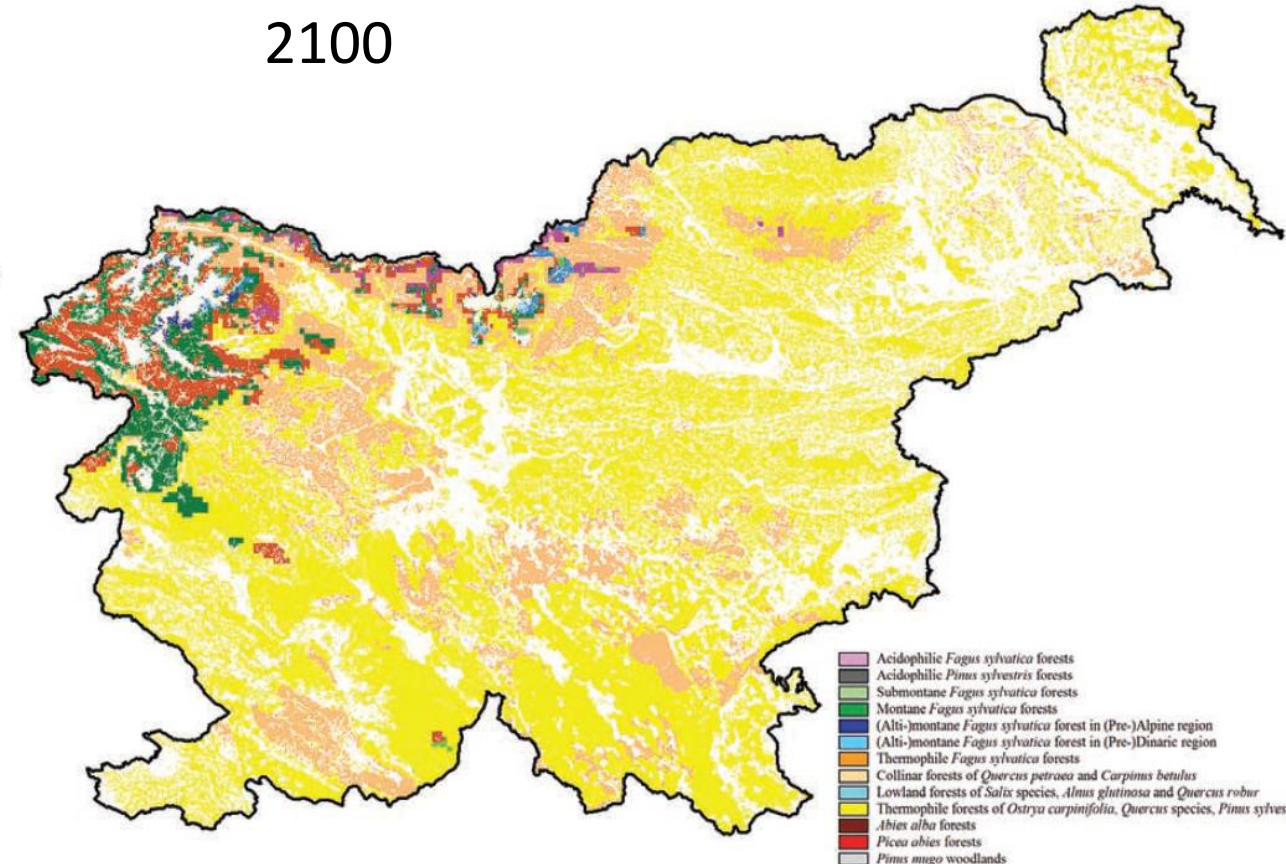
Lado KUTNAR¹, Andrej KOBLER²

danes



100 x 100 m

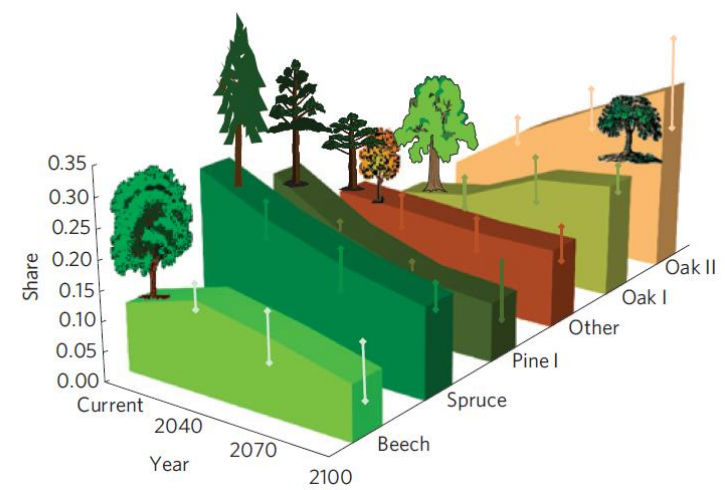
2100



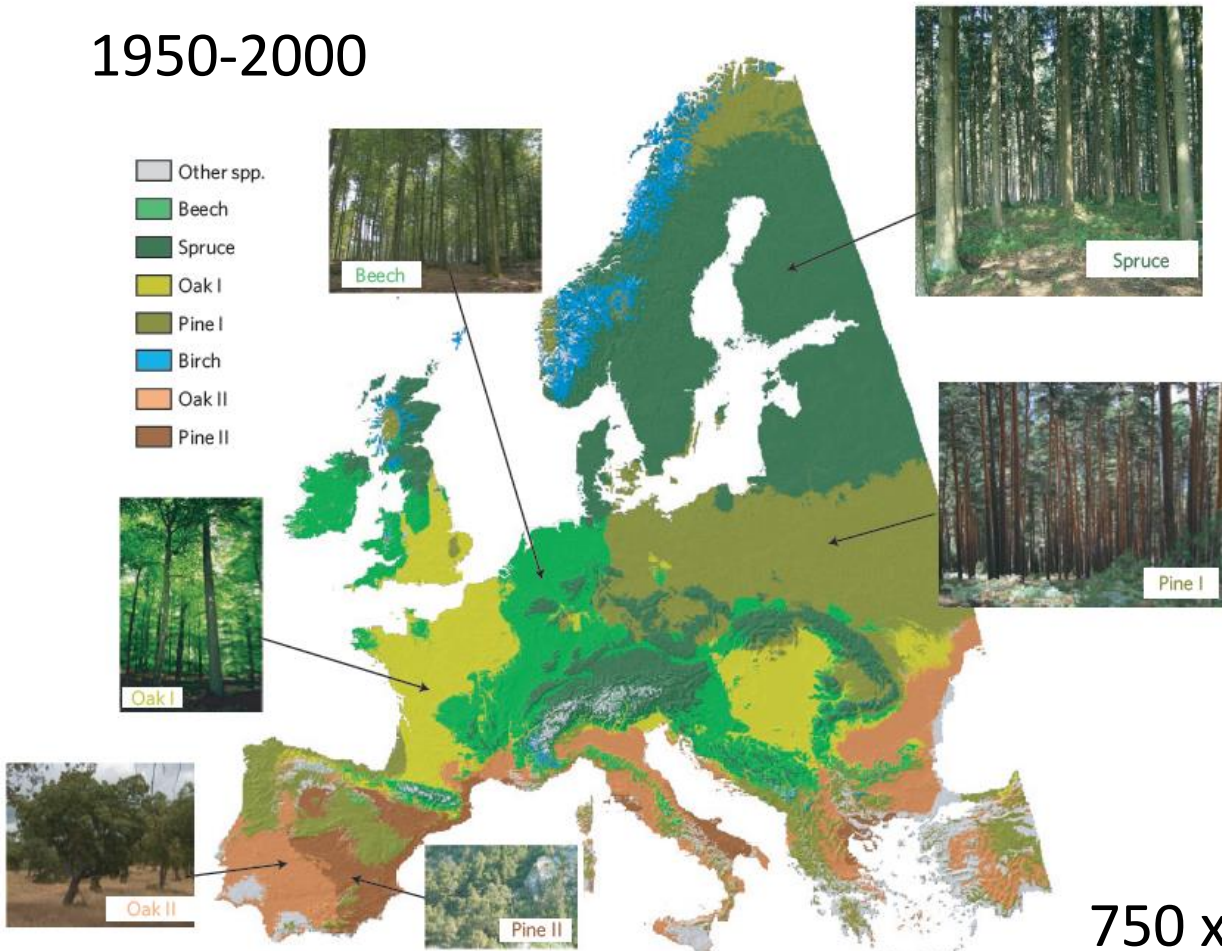
PRIMERI

Climate change may cause severe loss in the economic value of European forest land

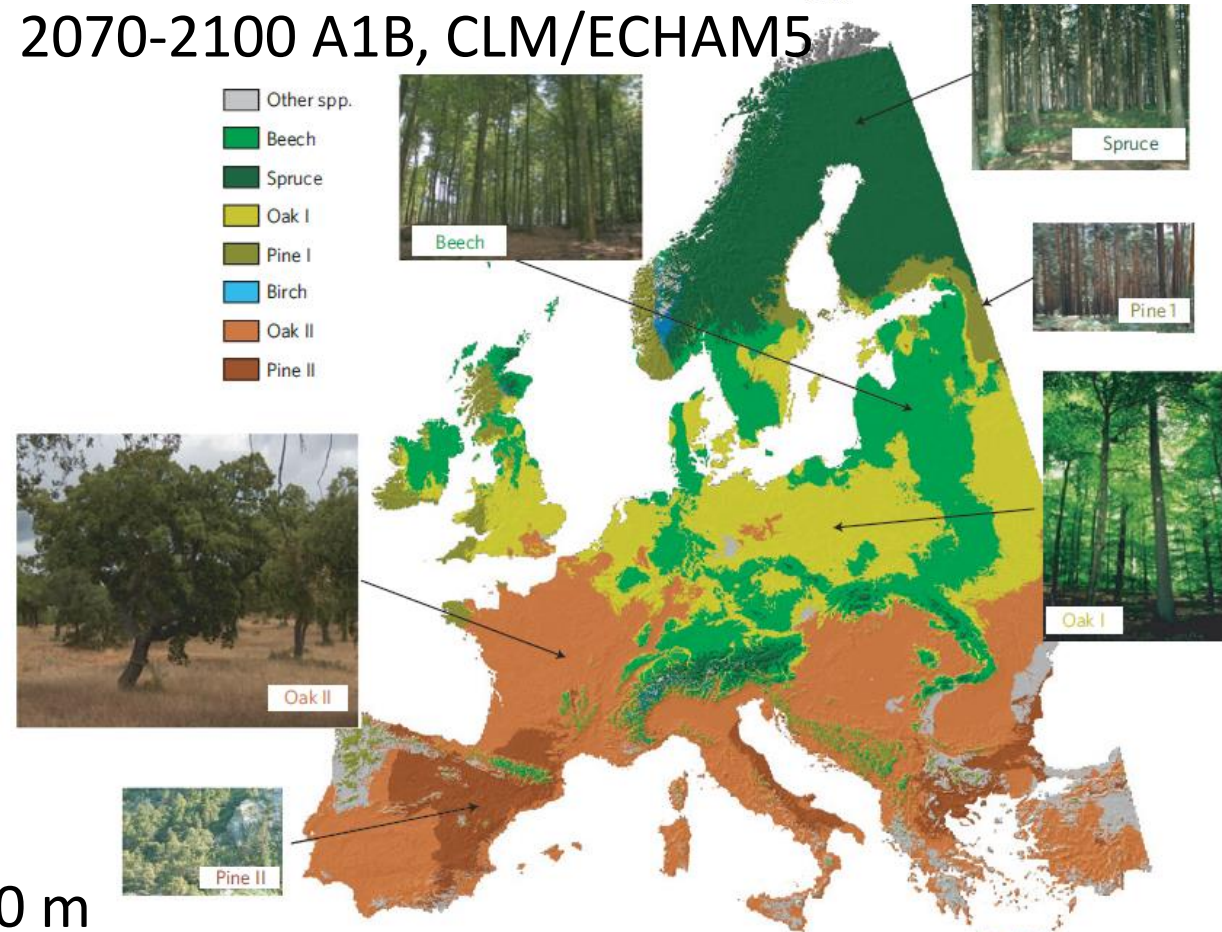
Marc Hanewinkel^{1,2*}, Dominik A. Cullmann³, Mart-Jan Schelhaas⁴, Gert-Jan Nabuurs⁵
and Niklaus E. Zimmermann⁶



1950-2000

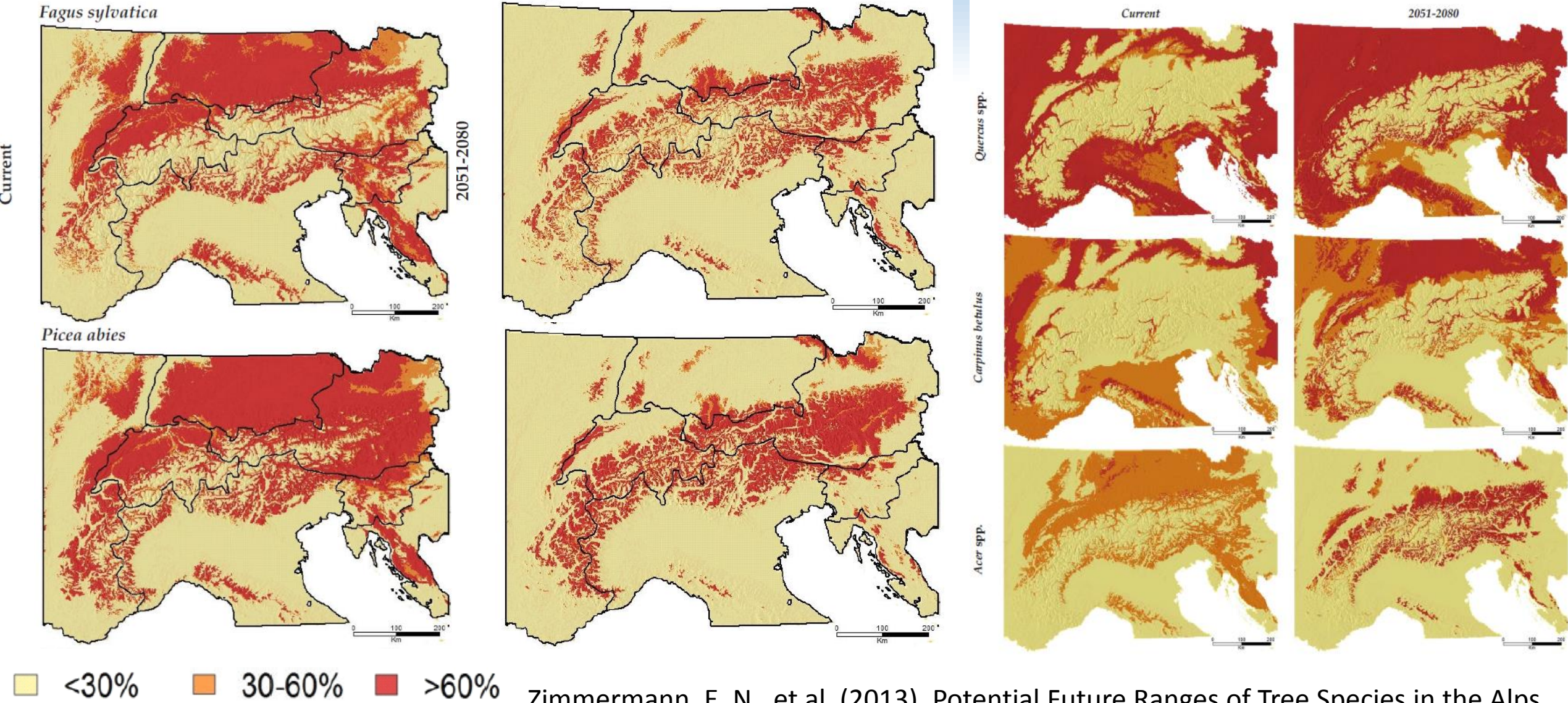


2070-2100 A1B, CLM/ECHAM5



750 x 750 m

PRIMERI

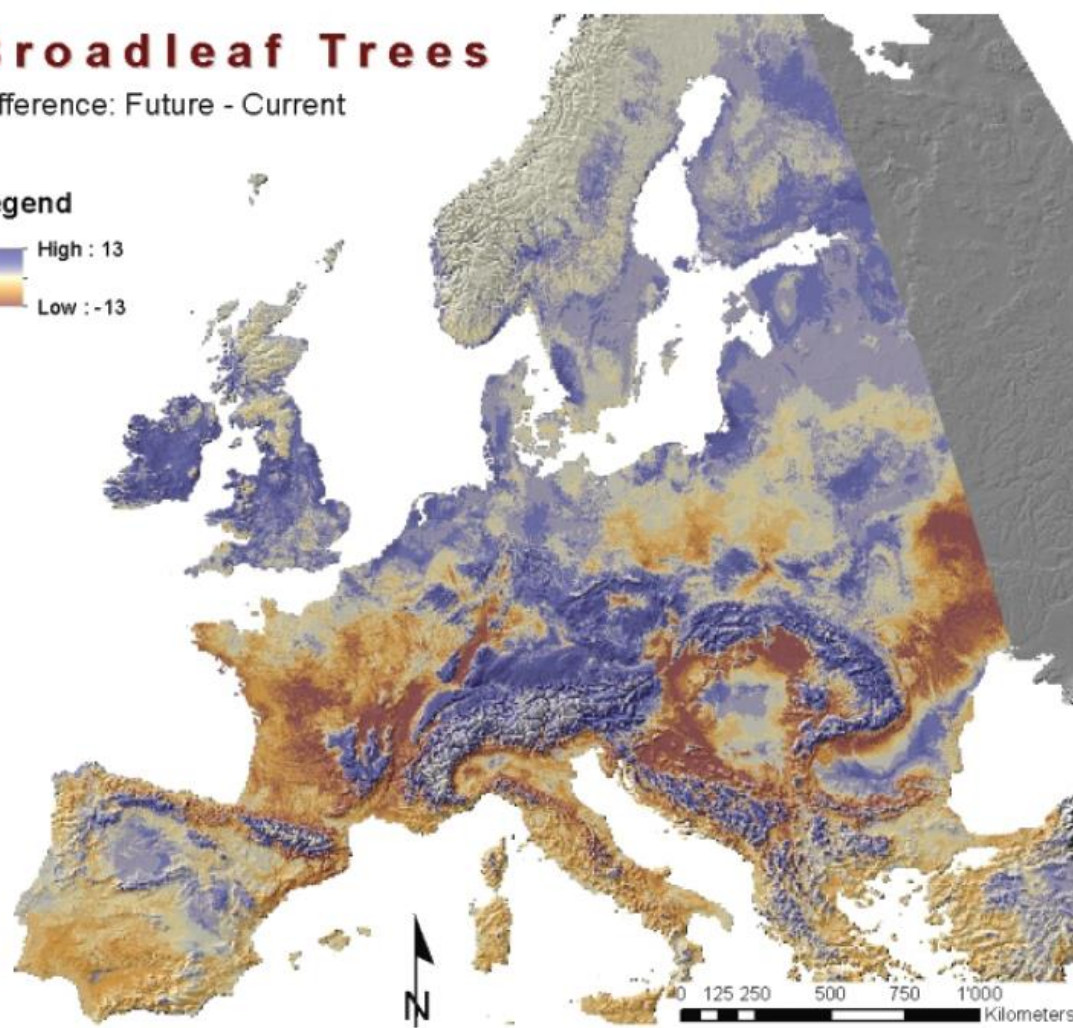


Zimmermann, E. N., et al. (2013). Potential Future Ranges of Tree Species in the Alps.

Broadleaf Trees

Difference: Future - Current

Legend



Needleleaf Trees

Difference: Future - Current

Legend

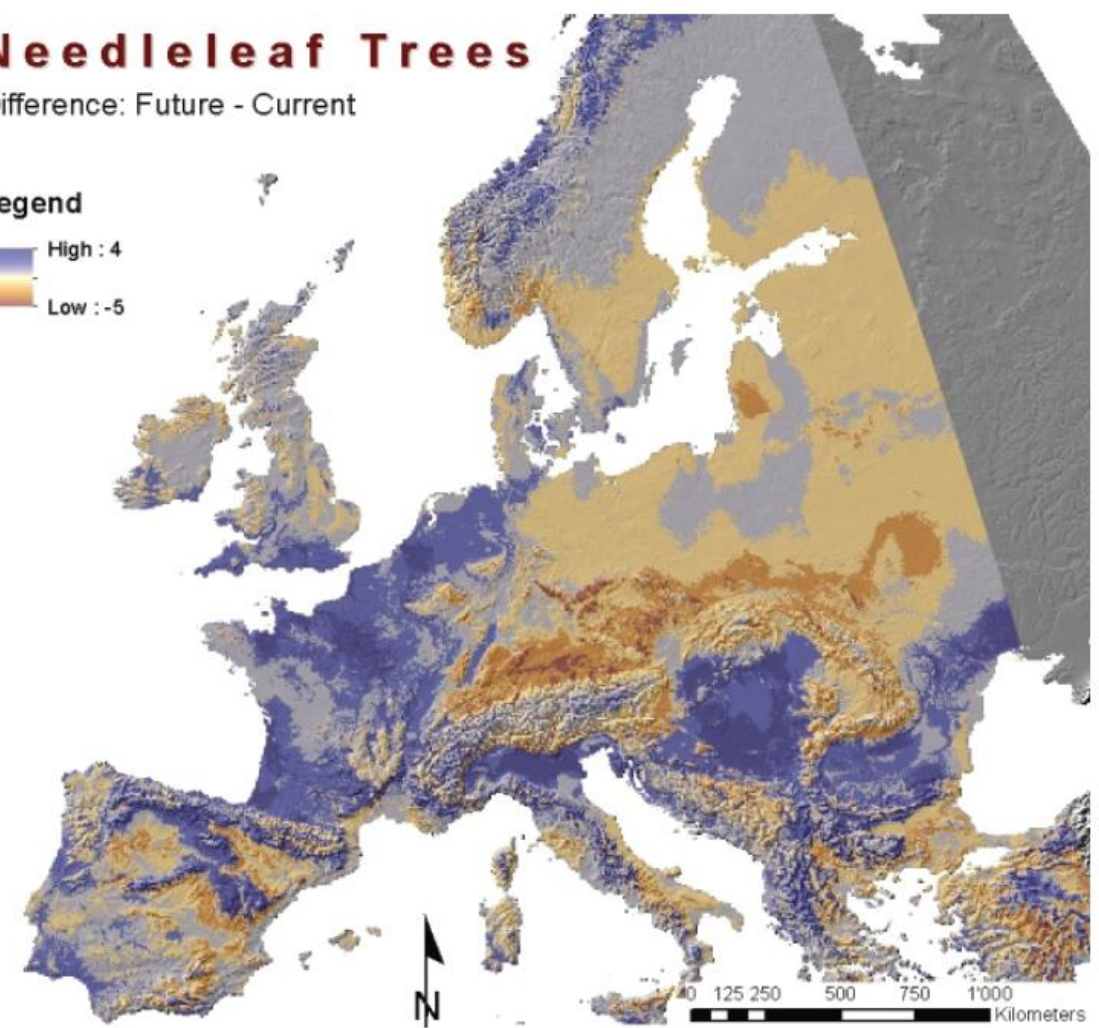
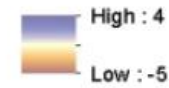
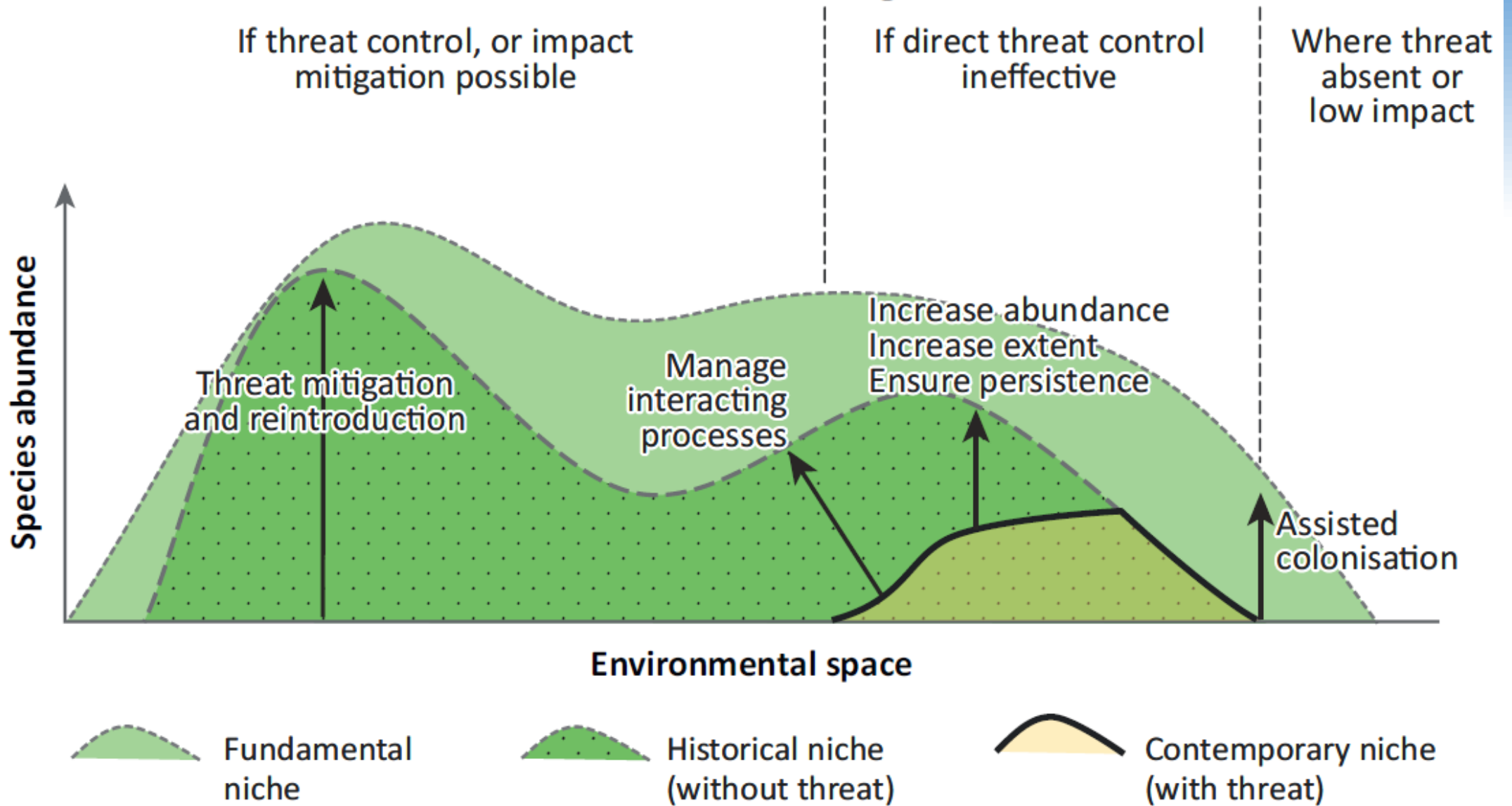


Figure 3. Changes in plant functional type composition from single species habitat suitability changes following climate change. The two panels indicate to what degree broadleaf (left panel) and needleleaf (right panel) tree species are expected to increase (blue) or decrease (red) in numbers. The results represent ensemble SDM simulations from six climate scenario (A1B) simulations and six statistical models.

Where to focus management



UPORABA MODELOV RAZŠIRJENOSTI VRST OZ. HABITATNE USTREZNOSTI

Ugotavljanje ekološke niše organizmov

- prekrivanje niš, kompeticija, diverzitet
- dvojnost: niša-habitat!

Ugotavljanje sedanje razširjenosti / habitatne ustreznosti vrst

- upravljanje z vrstami in habitati, oblikovanje prioritet
- ocena vrstne pestrosti, izbira zavarovanih območij

Napovedovanje razširjenosti vrst v prihodnosti / predvidena habitatna ustreznost

- klimatske spremembe...
- migracijske poti vrst ob spremenjenih podnebnih razmerah / spremembah rabe
- invazivne vrste, odkrivanje pomembnih spremenljivk invazivnosti



HVALA.