

OUTPUT 3.3 TRANSNATIONAL SEED TRANSFER ZONES

Resilient riparian forests as ecological corridors in the Mura-Drava-Danube Biosphere Reserve
(DTP2-044-2.3 – REFOCuS)

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1. BACKGROUND

On the national level, riparian forests of the Mura-Drava-Danube biosphere reserve constitute only a small part of the countries forest ecosystem and this underrepresentation creates a serious shortcoming of suitable planting material well adapted to riparian forests. The utilization of forest seeds and seedlings is mainly regulated on the national level and restricted to nationally defined ecoregions (i.e. seed/provenance zones/regions) without considering the transnational importance of riparian forests. Thus, nationally sourced planting material is often maladapted and unsuitable for riparian forest reforestation resulting in lower forest stability, higher pest infection rates and lower resilience. In addition, climate change is expected to result in changing conditions within all forests, including riparian ones. Climate change will disrupt the link between climate and the local adaptation of forest tree populations creating physiological stress that leads to the so-called "adaptation lag". Therefore, forest managers are confronted with the challenge of finding adapted planting materials for reforestation to overcome this lag. As such, there has been considerable interest in developing models to aid our understanding of the limits of species distribution and their adaptive capacities in order to develop adaptive management strategies for the future.

The activity to develop transnational seed transfer models within the Interreg REFOCuS project capitalized on the results of the Interreg Central Europe project SUSTREE, where transnational seed zones were developed for 6 major tree species of mainly mountainous forests. REFOCuS adopted the SUSTREE strategy for 7 important tree species of the riparian forests:

- *Fraxinus excelsior*
- *Fraxinus angustifolia*
- *Populus nigra*
- *Quercus robur*
- *Alnus glutinosa*
- *Ulmus laevis*
- *Ulmus minor*

The transnational distribution modelling and seed zone delineation will support forest and conservation managers in selecting the most appropriate plant material for reforestation. With ongoing climate change, these zones will also dynamically change their spatial extent. Such a tool allows forest and conservation managers to already today select forest reproductive material that is suitable for future climate conditions.

2. METHODOLOGY TO CONSTRUCT THE MAPS

2.1 OCCURRENCE PROBABILITY MODELS

The following maps show the predicted potential distribution of 10 important tree species of south eastern European riparian forests under current conditions and under two future climatic scenarios (RCP 4.5 and RCP 8.5). The models predict the probability of occurrence of a certain tree species depending on the climate of a given location. If the climate of a given location is very unsuitable for a certain species, the probability of occurrence is very low, and the value is close to zero for this particular location. It is assumed that the species distribution on a large scale is driven by climate and the relationship between current occurrence of a tree species and climate remains stable during climate change.

2.2 CLIMATE CHANGE SCENARIOS

The Representative Concentration Pathway (RCP) is a trajectory for a greenhouse gas concentration. Two RCP scenarios were applied:

- RCP 4.5 was selected to reflect moderate climate change effects as it assumes that emissions peak around 2040 and then decline causing a rise in global temperature of 2.4 °C by year 2100.
- RCP 8.5 considers severe climate change effects in which the global temperature increases up to 4.9°C if no adaptive measures are applied.

2.3 DELINEATION OF TRANSNATIONAL SEED TRANSFER ZONES

Depending on the species, the modelling identified different variables as the important ones for modelling a species occurrence (such as seasonal maximum temperature, seasonal mean precipitation, degree-days below a certain temperature, annual heat:moisture index, etc.). Geographic ranges with similar climate have been grouped together into a cluster by these variables and given a unique colour code attribute. Therefore, the clusters are specifically adapted to the most important variables for each of the 10 species. The number of clusters depends on the variation of the selected variables.

For developing the seed transfer zones, areas with species occurrence probability of above 0.5 (0.2 for *Ulmus laevis*) was used. This area proved to be close to the natural distribution range of the selected species. With ongoing climate change, these modelled seed transfer zones with similar climatic conditions will dynamically change their spatial extent. The maps presented in this output will allow forest and conservation managers to already today select forest reproductive material that is suitable for future climate conditions.

3. GUIDELINE FOR INTERPRETATION AND EXAMPLES

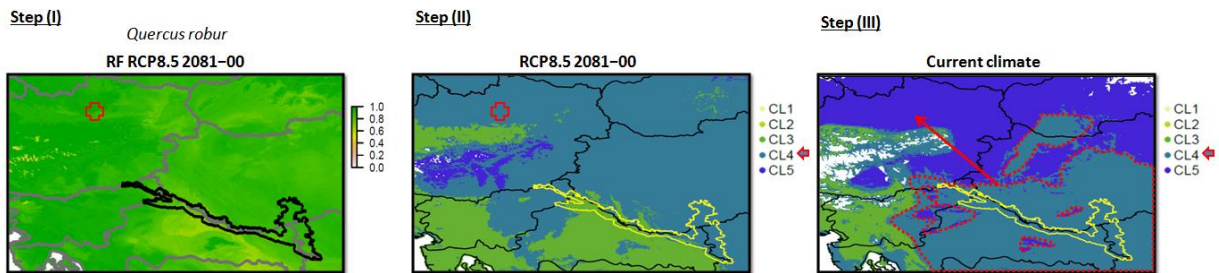
To plan reforestations, the provided set of maps should always be used in combination. First, the future suitability of the climatic conditions at the site should be checked (step I). Only if acceptable, a provenance suitable for future conditions should be selected. To identify this provenance, the seed transfer zone that is likely to appear in future at the site of interest needs to be identified (step II). Afterwards, the map of the transfer zone under current climate shows the area where to source the Forest Reproductive Material (FRM) (step III). We present maps both for an extreme (RCP 8.5) and a moderate climate change scenario (RCP 4.5).

The presented maps are an up-to-date-tool to support practitioners. Nevertheless, there are some limitations to be considered when using the maps:

- The models include only relevant climatic parameters. Other biotic and abiotic factors need to be considered (e.g. ground water supply, soil, storms, pests and diseases ...).
- The ability of tree species to adapt to changing climate conditions is not known. If they are not able to adapt, an “adaptation lag” will occur. Transfer of FRM can help to overcome it.
- Uncertainties of climate change scenarios
- Interpolated and downscaled climate data may not fit to local conditions of the site of interest or the provenance to be transferred.

Example (A) - Transnational seed transfer to fit future climate conditions

The forest management of an enterprise located in western Lower Austria (red cross in the map) faced climate change driven fallout of their main tree species. After checking the suitability of *Quercus robur* in future climate conditions with both RCP 4.5 and 8.5 for the location of the enterprise (both 0.8-1.0 occurrence probability), the management decides to plant this species (Step I). The chosen provenance shall be adapted to relevant climatic conditions that are likely to appear in future. Therefore, the seed transfer zone “CL4” is found to be present around the year of **2100** (Step II). Finally, forest reproductive material of an origin showing the same climatic conditions, thus of the **current** zone “CL4”, is selected to be transferred (Step III).

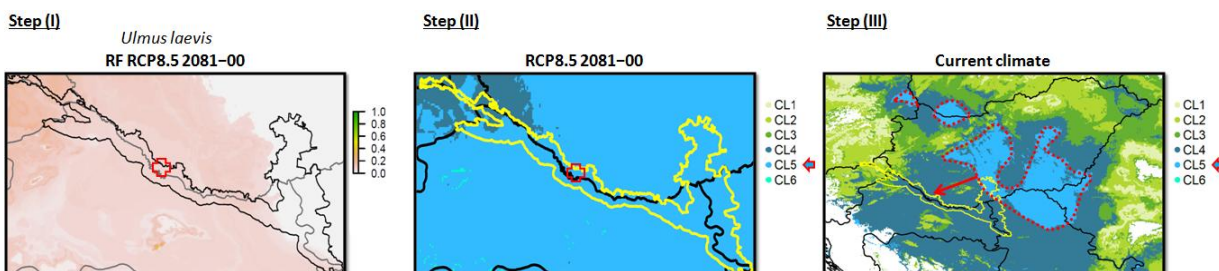


Example (B) – Identification of potential adaptation lags

A forest enterprise aims to restore and preserve the current potential vegetation at the Croatian-Hungarian border (red cross on the map). *Ulmus laevis* is the species of interest. The current climatic conditions are excellent (occurrence probability of 0.8-1.0, not displayed below), but the climate conditions with both RCP 4.5 and 8.5 predict the situation to become less suitable. The predicted occurrence probability under RCP 8.5 is below 0.2 (Step I). Nevertheless, the managers decide to plant *Ulmus laevis* counting both on

- the natural ability of the tree species to adapt to future conditions and
- selecting an origin of climatic conditions that are likely to appear in future.

Therefore, the seed transfer zone “CL5” is found to be present at the site around the year of **2100** (Step II). Finally, forest reproductive material of an origin showing the same climatic conditions today, thus of the **current** zone “CL5”, is selected to be transferred (Step III).

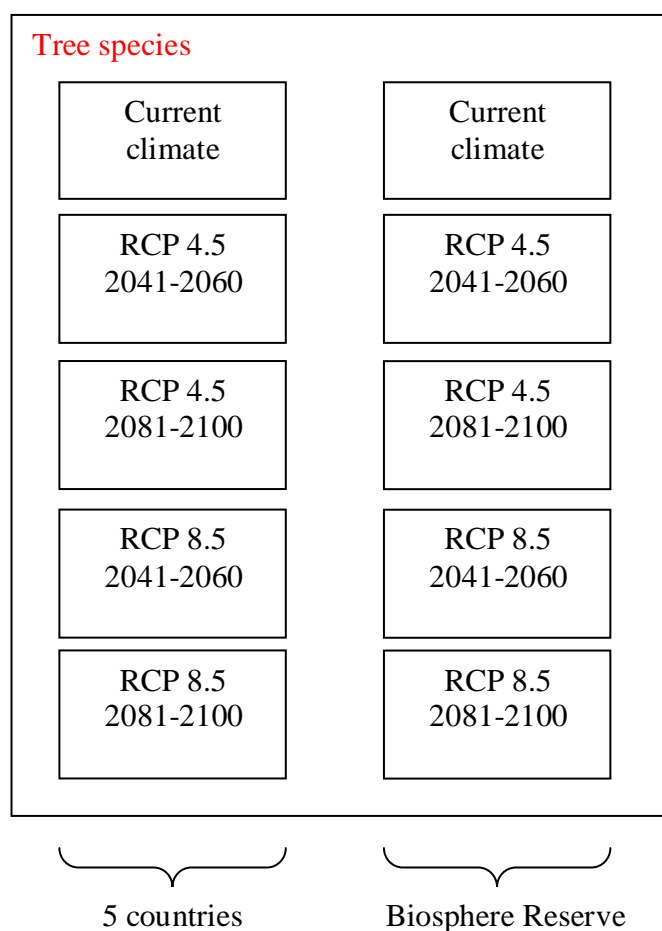


Remark: The maps of seed transfer zones for all other species are limited to the area of an occurrence probability above 0.5. For *Ulmus laevis* this threshold is 0.2 to fit the current natural distribution. For this species we additionally provide a set of maps without threshold in order to show which zone will be present in the future, even if the occurrence probability is predicted to be below 0.2.

4. SPECIES OCCURRENCE PROBABILITY UNDER CLIMATE CHANGE

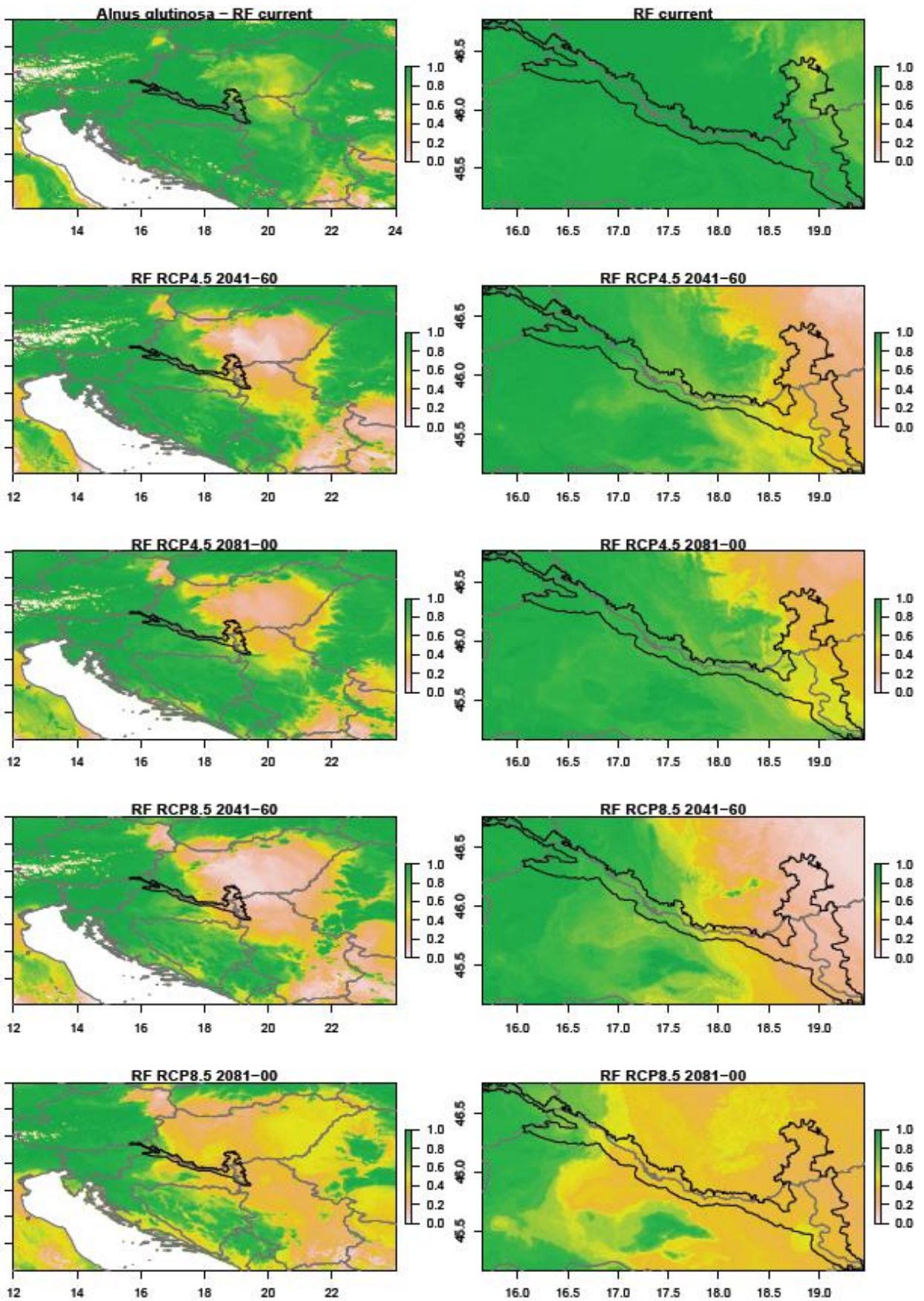
EXPLANATION

A selection of 10 maps (combined on one single page in two columns and five rows) shows the development of the occurrence probability with progress in time during both selected climate change scenarios. The left side is based on the spatial extent of the five project countries (Austria, Slovenia, Hungary, Croatia, and Serbia), the right side is cropped to the extent of the Mura-Drava-Danube Biosphere Reserve. The map on the top is modelled with the current climate, followed by two maps for RCP 4.5 in the middle and by two maps for RCP 8.5 on the bottom. The first map under each of the two RCP scenarios is for years 2041 to 2060 and the second for 2081 to 2100. The legend to the right of each map refers to the occurrence probability of the given species under given conditions.

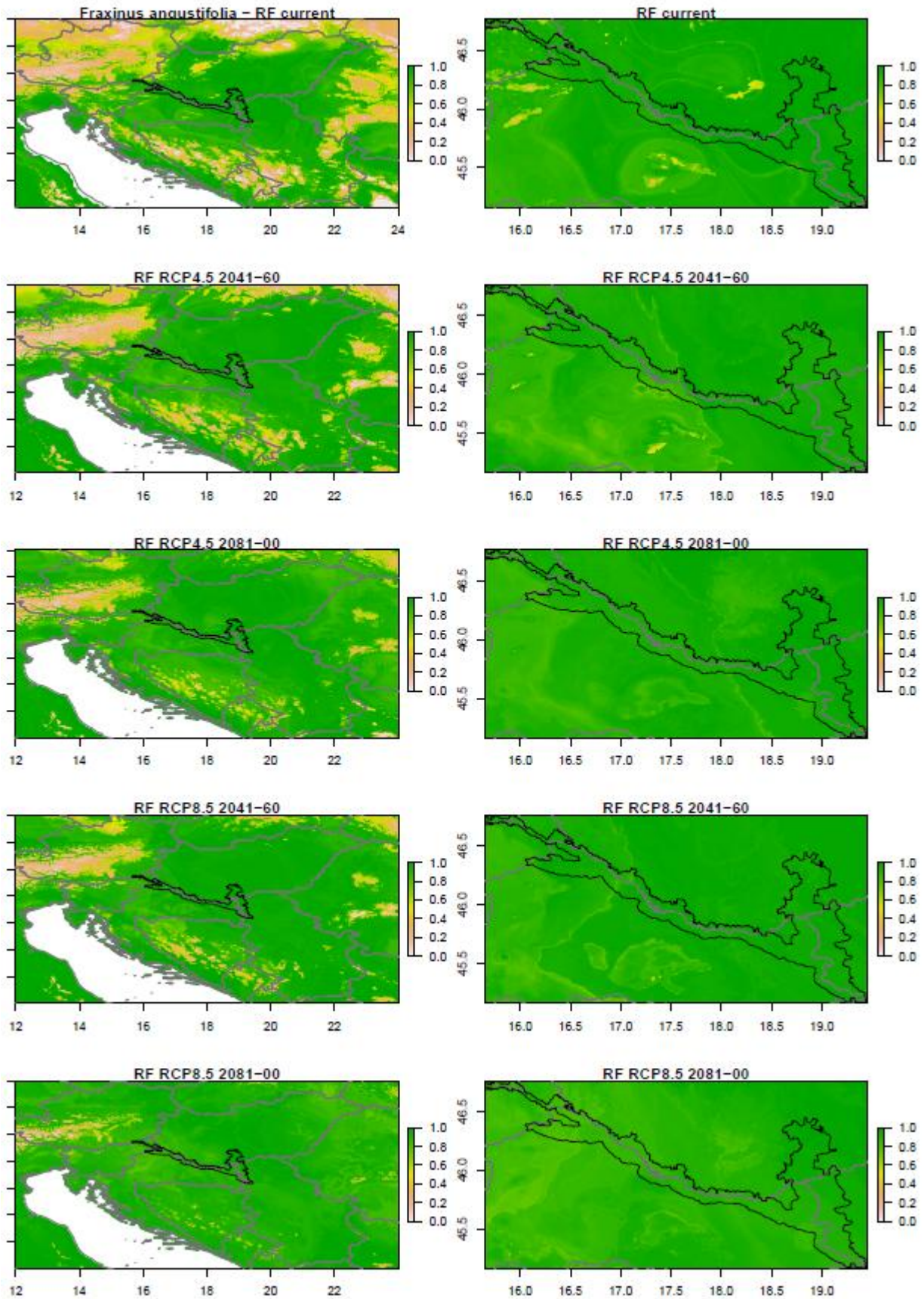


White and red colours display a low probability of occurrence, followed by yellow for medium, and green for a high probability of occurrence. The boundaries of the Mura-Drava-Danube Biosphere Reserve are displayed in black colour on the maps, national borders are in grey.

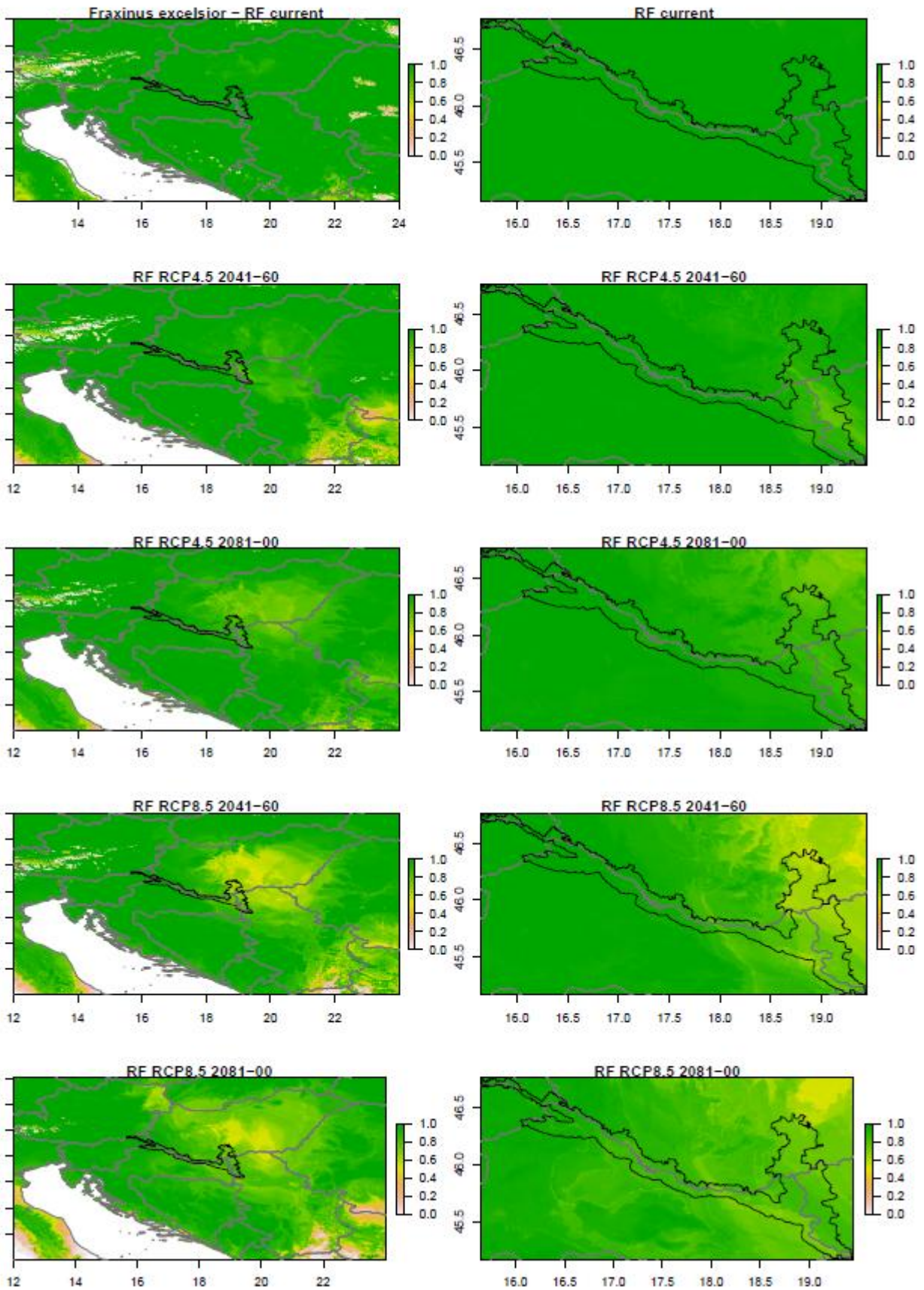
4.1 TARGET SPECIES 1: ALNUS GLUTINOSA



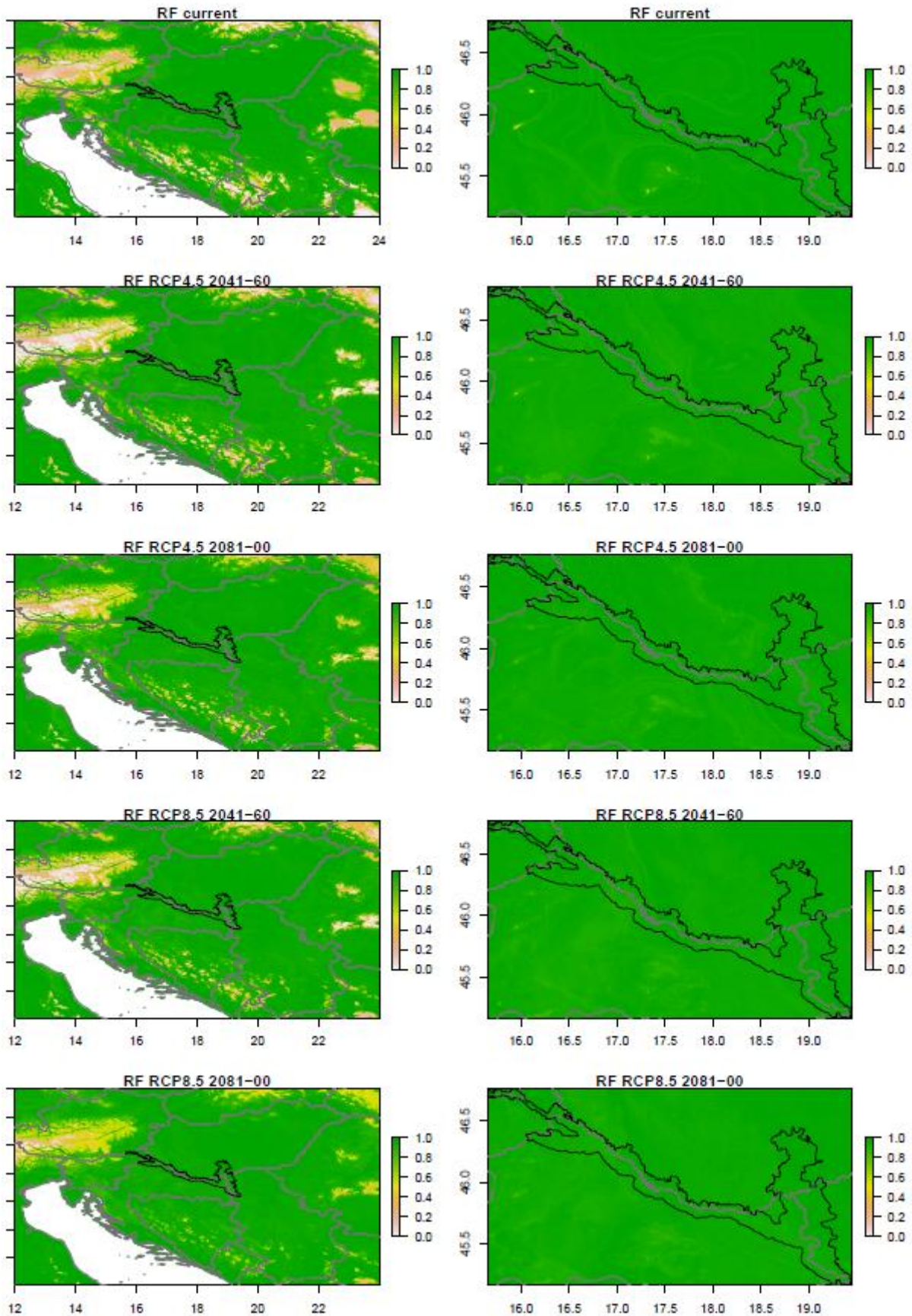
4.2 TARGET SPECIES 2: FRAXINUS ANGUSTIFOLIA



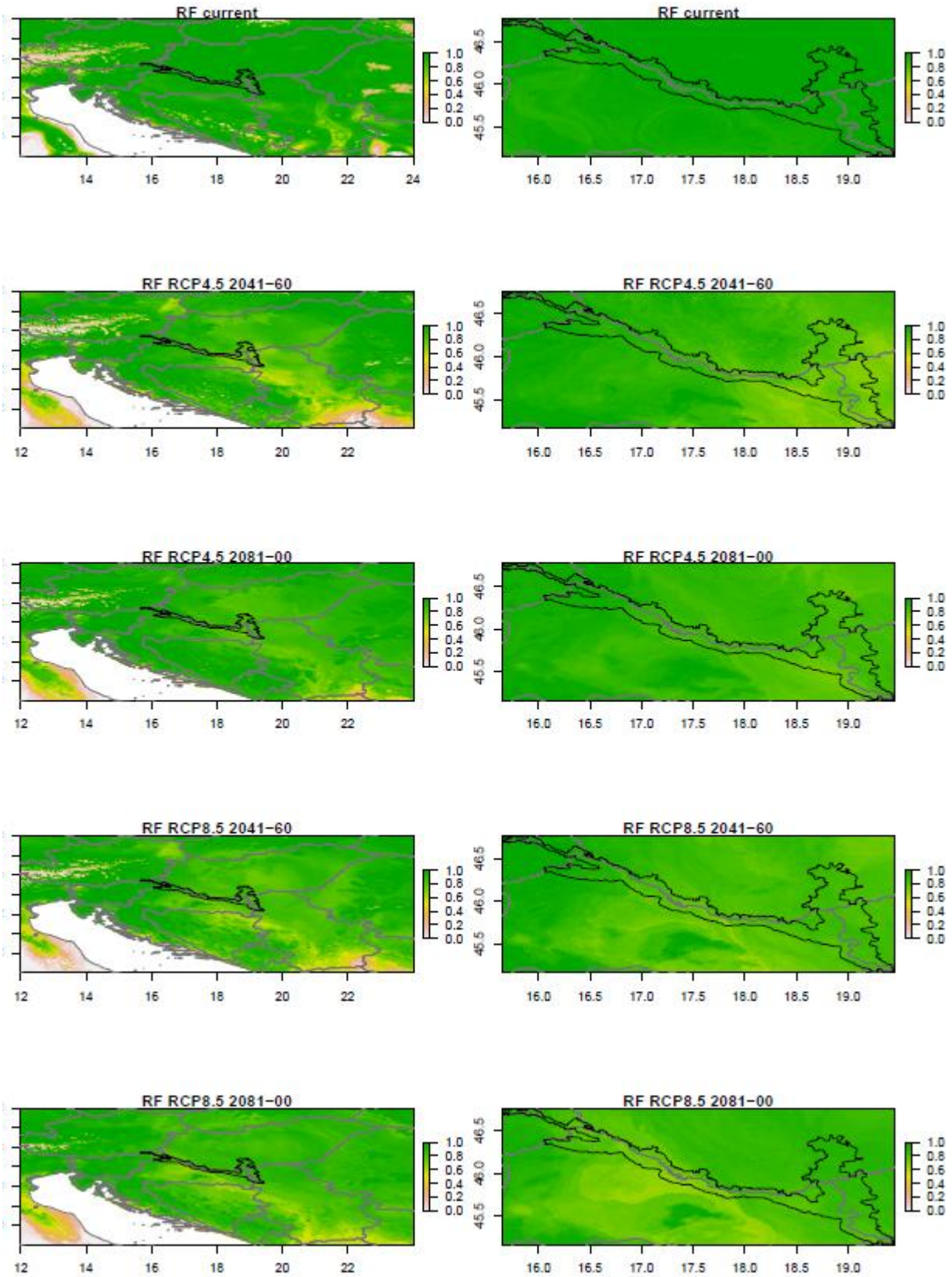
4.3 TARGET SPECIES 3: FRAXINUS EXCELSIOR



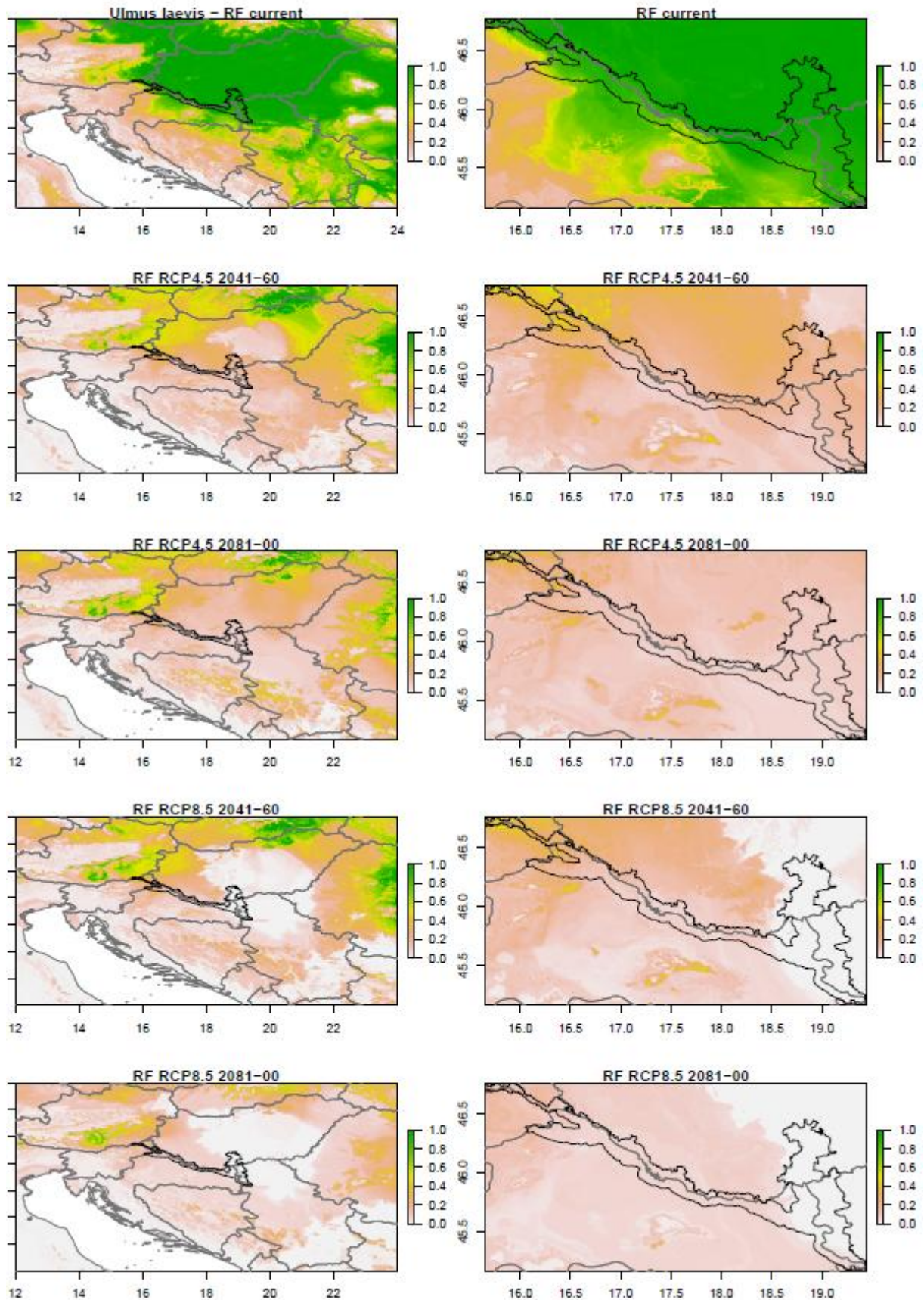
4.4 TARGET SPECIES 4: POPULUS NIGRA



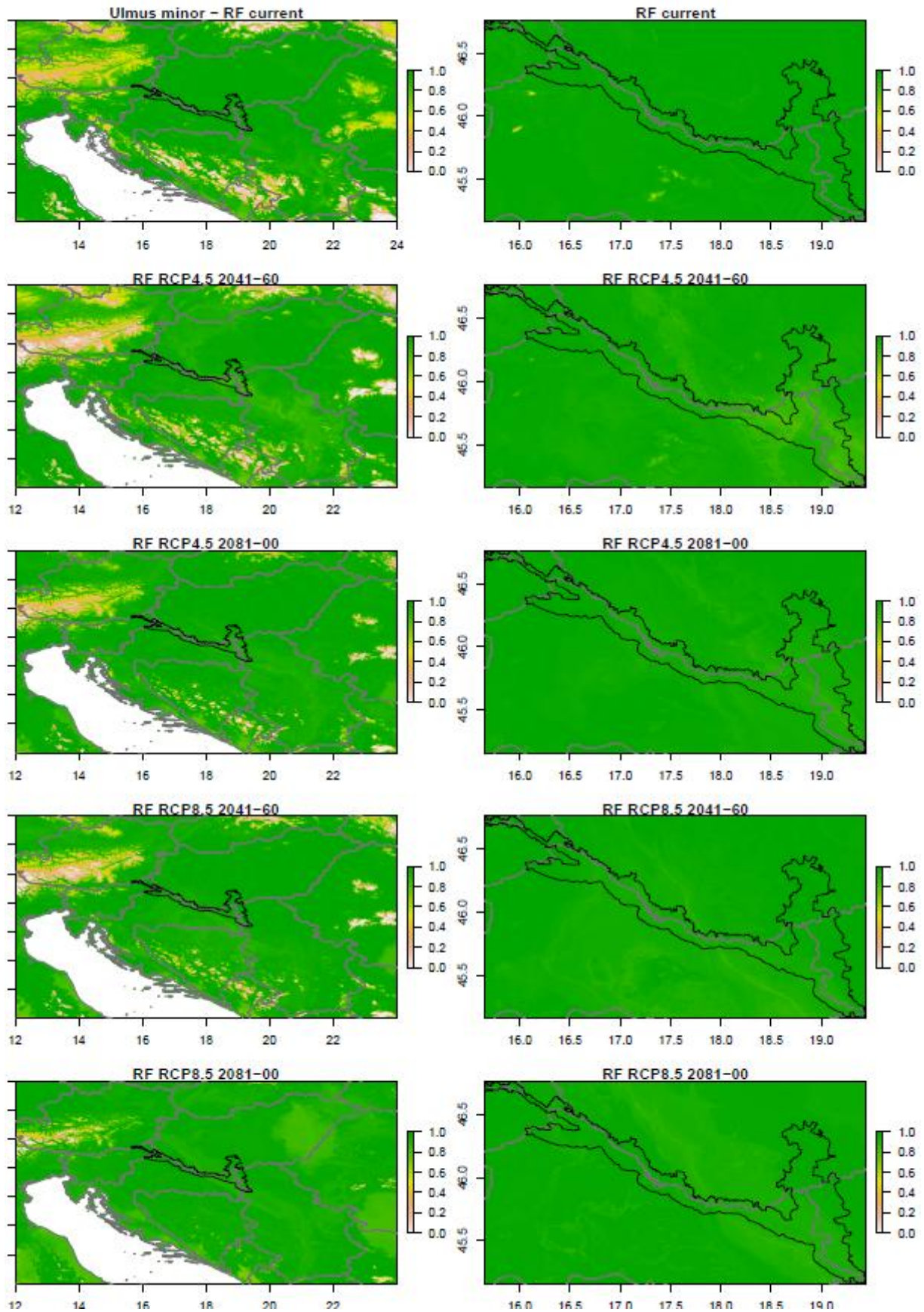
4.5 TARGET SPECIES 5: QUERCUS ROBUR



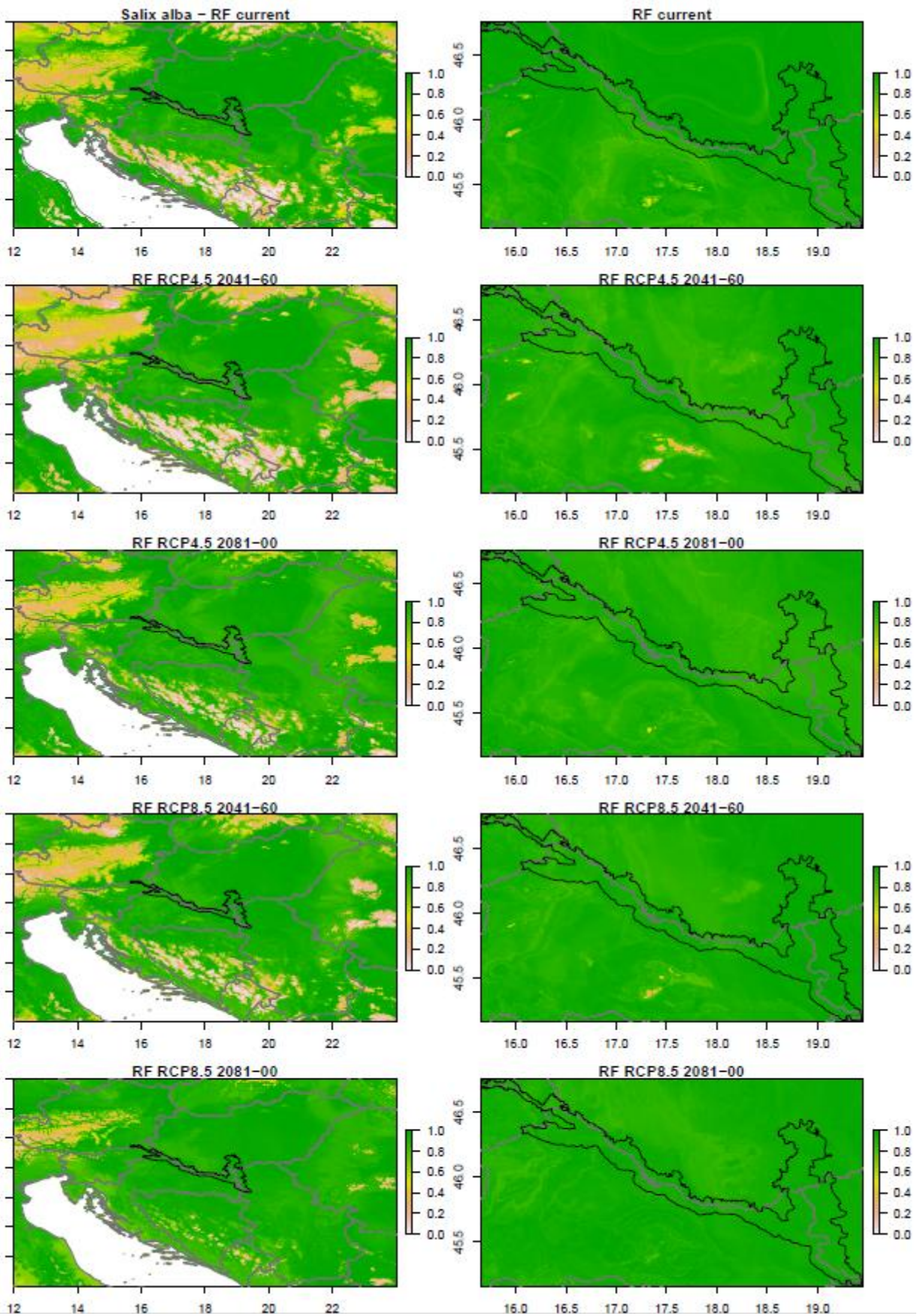
4.6 TARGET SPECIES 6: ULMUS LAEVIS



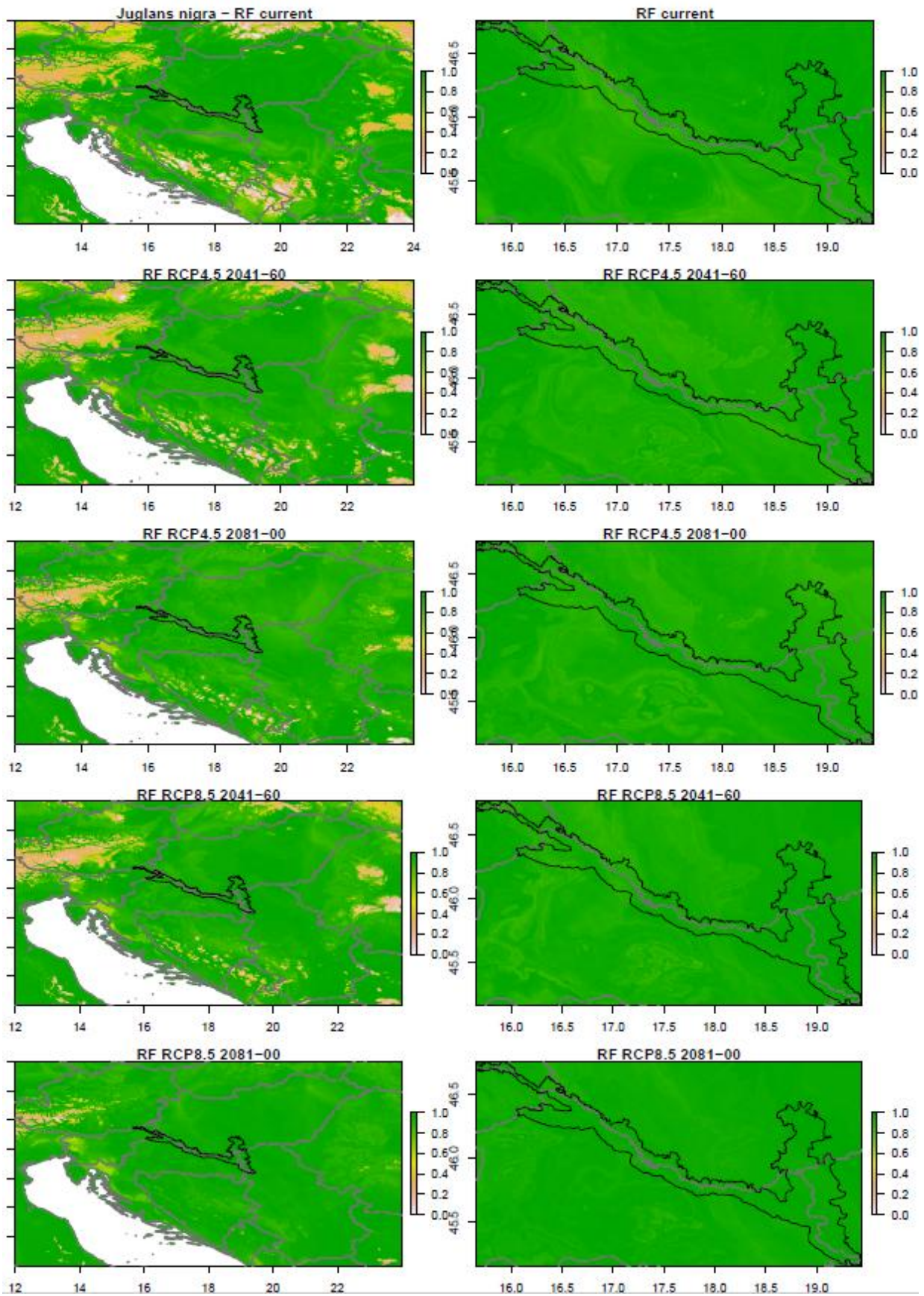
4.7 TARGET SPECIES 7: ULMUS MINOR



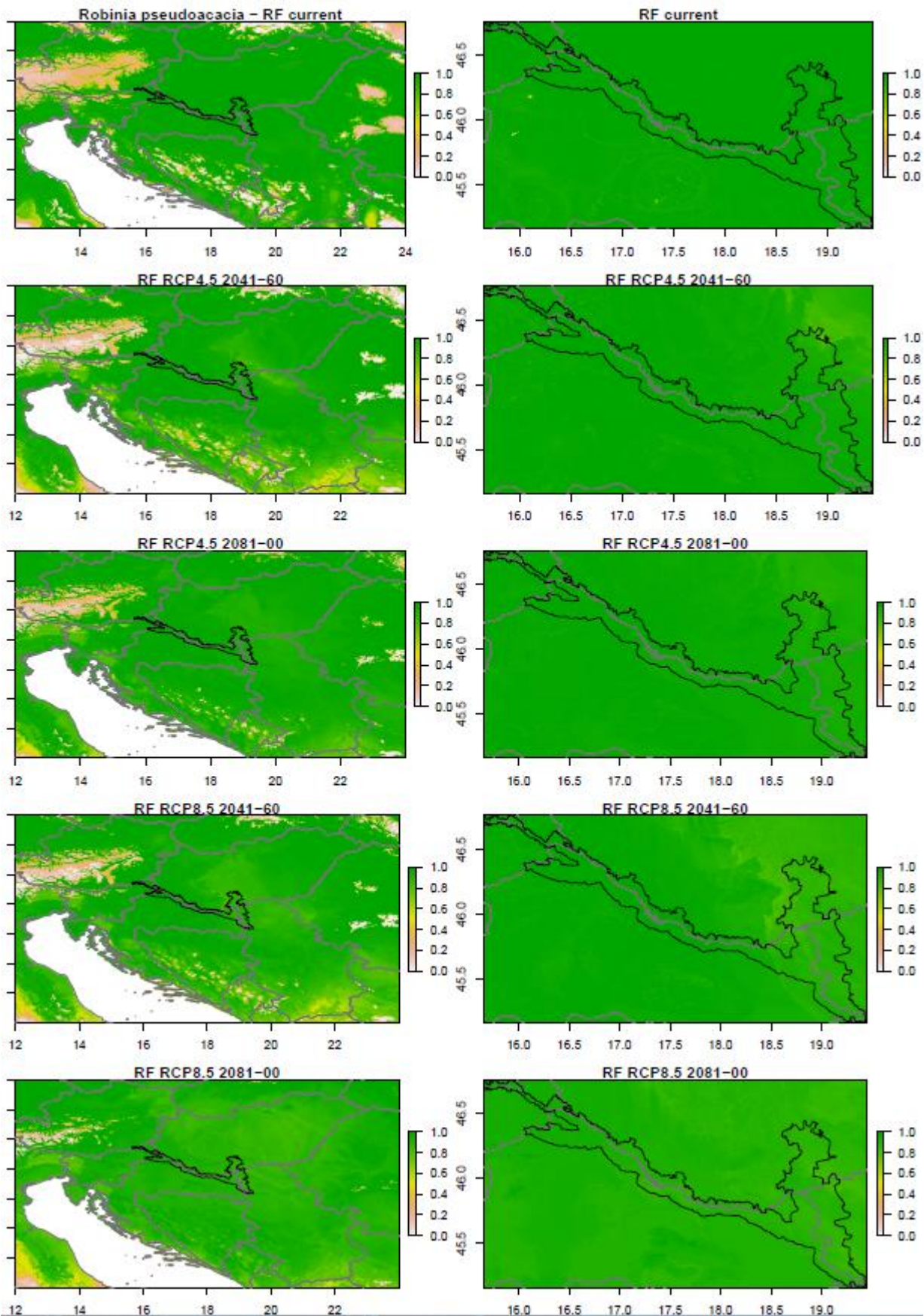
4.8 ADDITIONAL SPECIES 1: SALIX ALBA



4.9 ADDITIONAL SPECIES 2: JUGLANS NIGRA



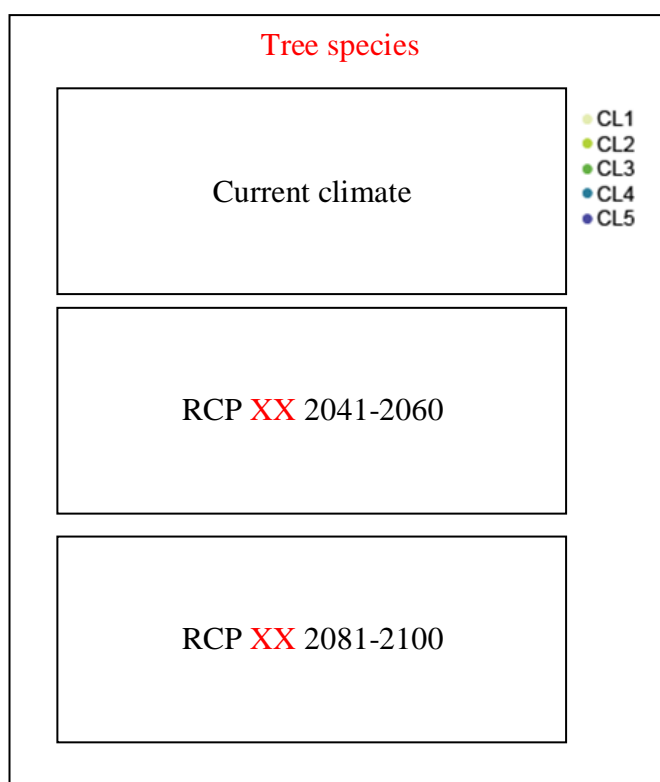
4.10 ADDITIONAL SPECIES 3: ROBINIA PSEUDOACACIA



5. SEED TRANSFER ZONES AND THEIR PREDICTED SPATIAL CHANGE OVER TIME

EXPLANATION

A selection of 6 maps (combined on two pages per species) shows the development of the seed transfer zones during both selected climate change scenarios. The first page is for RCP 4.5, the second page for RCP 8.5 for each species. The map on the top is modelled with the current climate, followed by a map for the period 2041-2060 in the middle and one for 2081-2100 on the bottom.

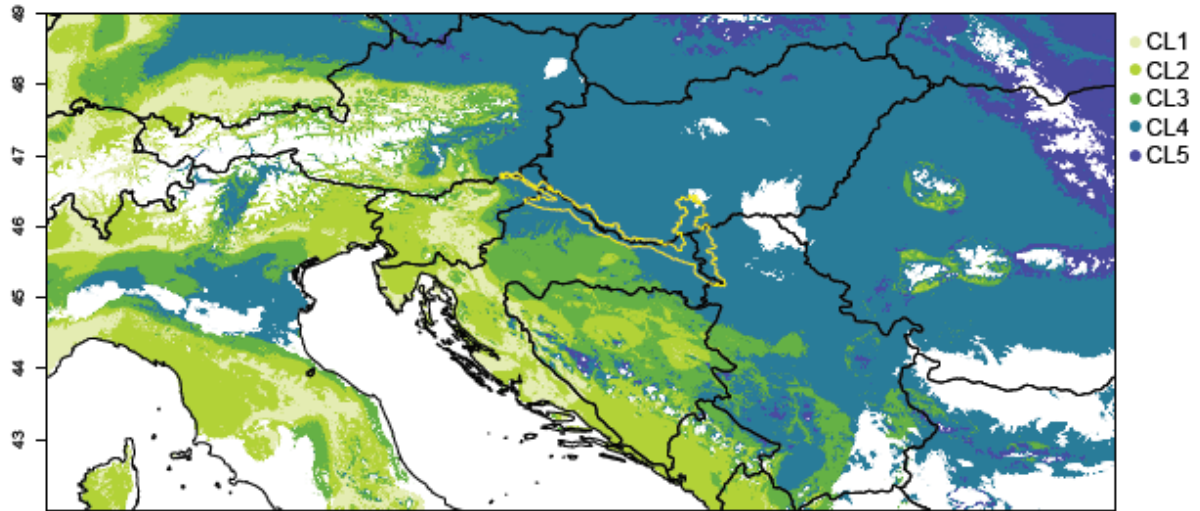


All coloured areas have a species specific occurrence probability of above 0.5 (0.2 for *Ulmus laevis*). Therefore, areas displayed in white have a probability below 0.5. The different colours show spatial zones (clusters) with similar climate conditions. The clusters are labelled with CL1, CL2, CL3, etc. Therefore, areas in CL1 are climatically more similar to themselves than to areas in any other CL. The colour codes for the clusters (CL) are depicted to the right of each combination map.

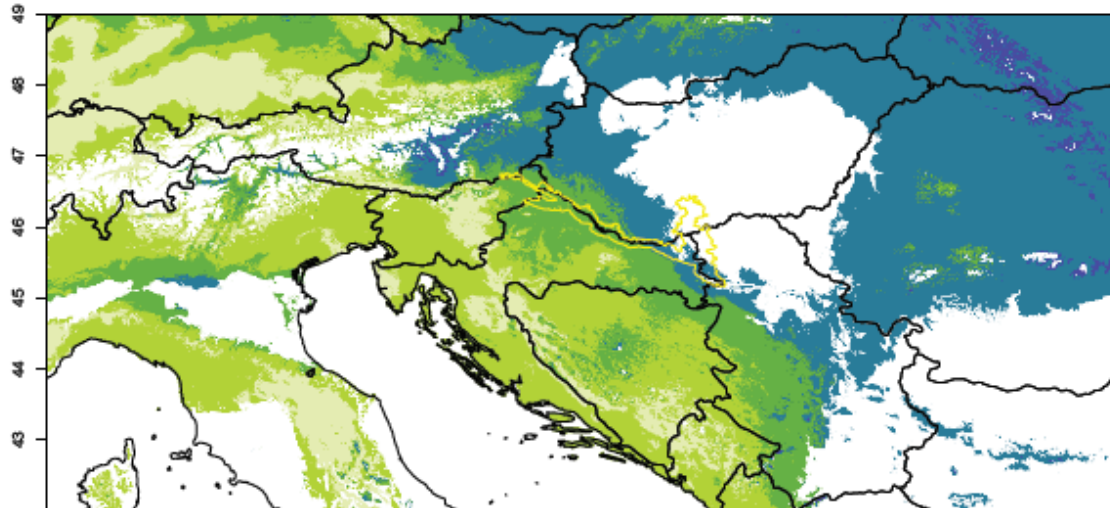
The boundaries of the Mura-Drava-Danube Biosphere Reserve are displayed in yellow.

5.1 SEED TRANSFER ZONES FOR TARGET SPECIES 1: ALNUS GLUTINOSA

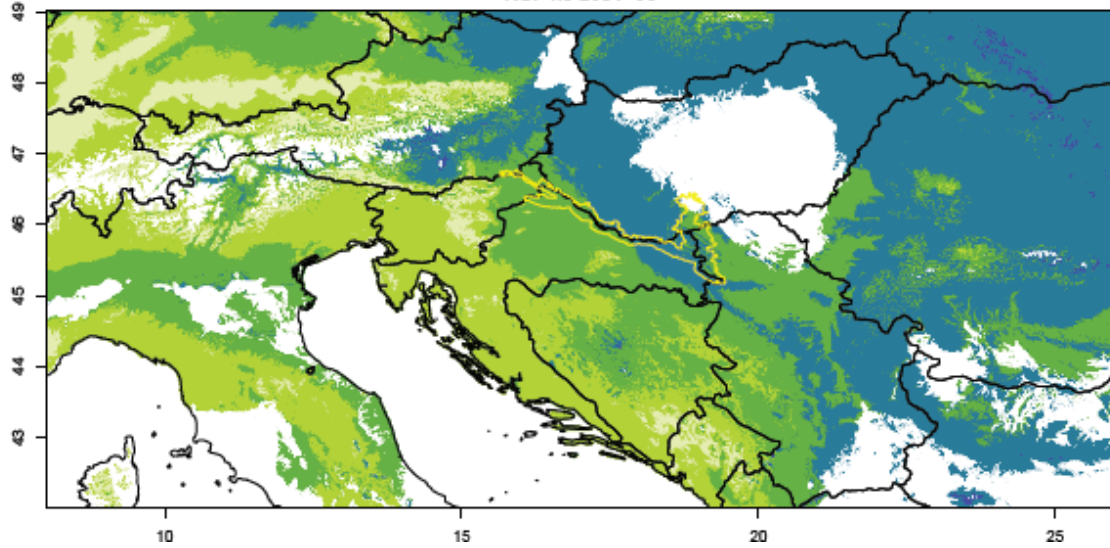
Alnus glutinosa
Current climate



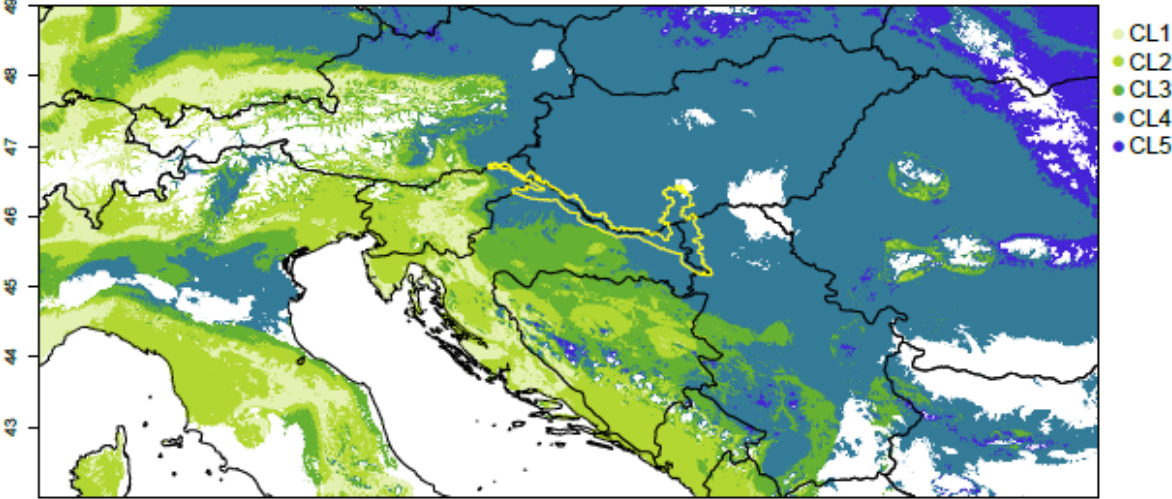
RCP4.5 2041-60



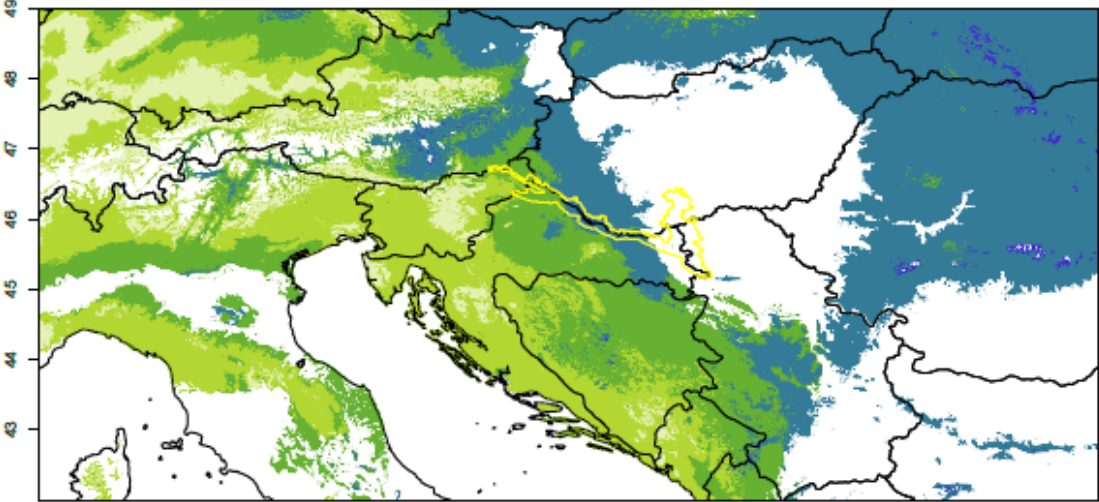
RCP4.5 2081-00



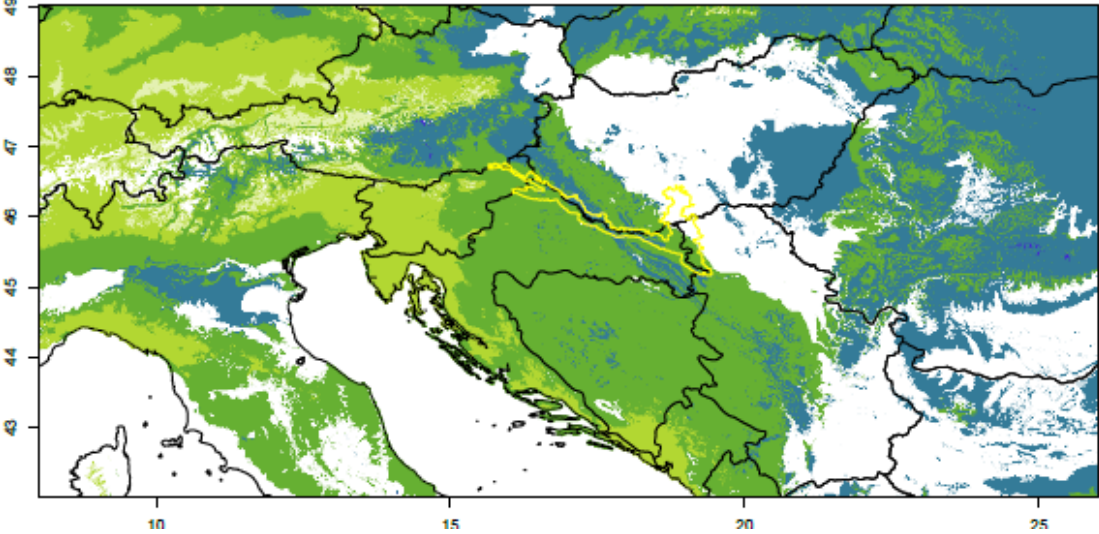
Alnus glutinosa
Current climate



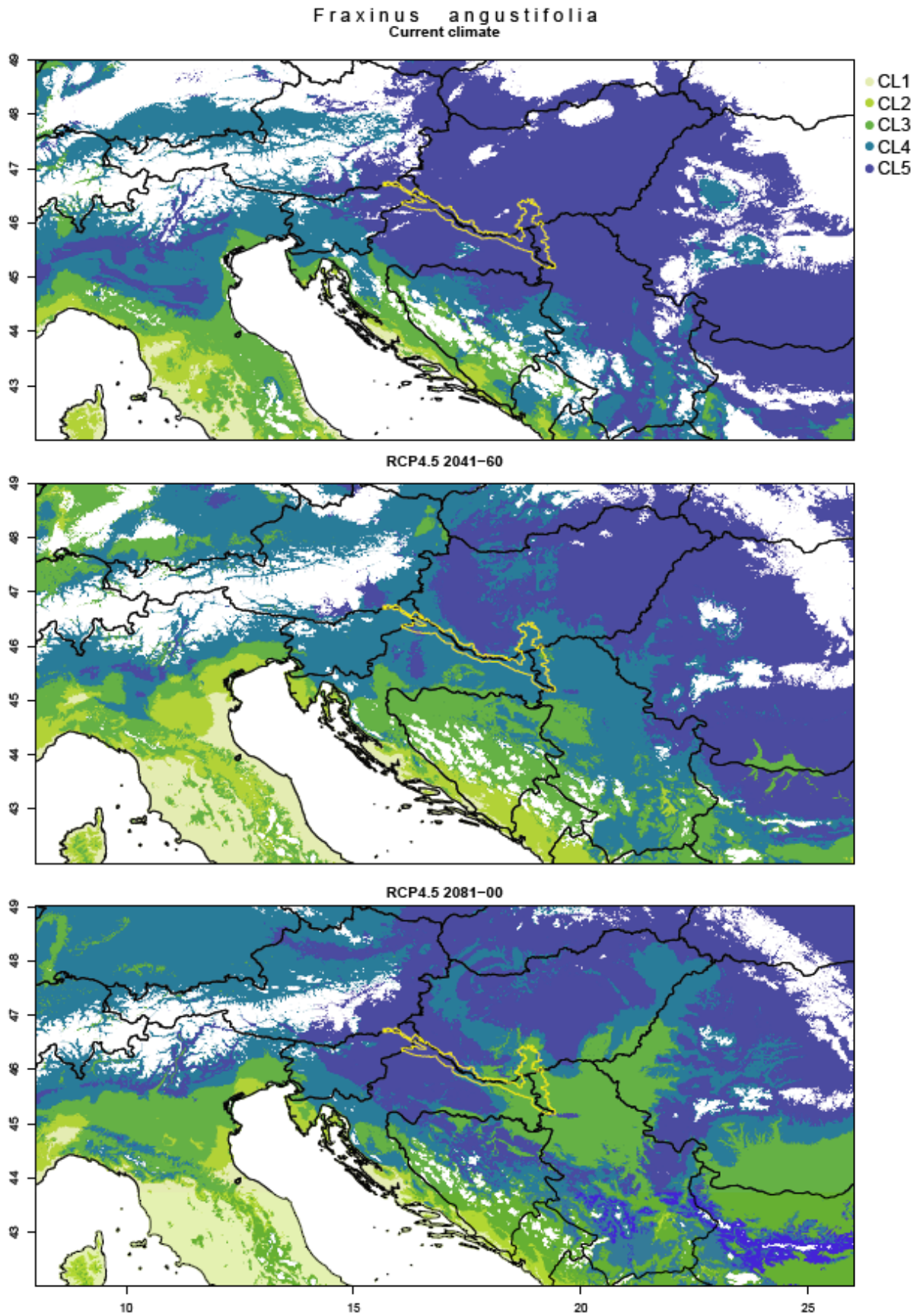
RCP8.5 2041-60



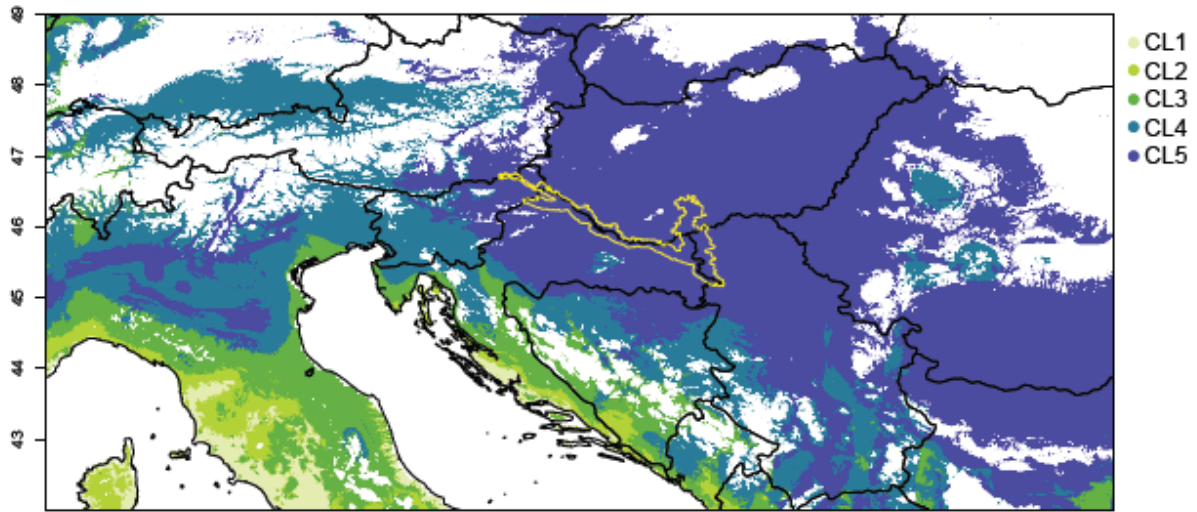
RCP8.5 2081-00



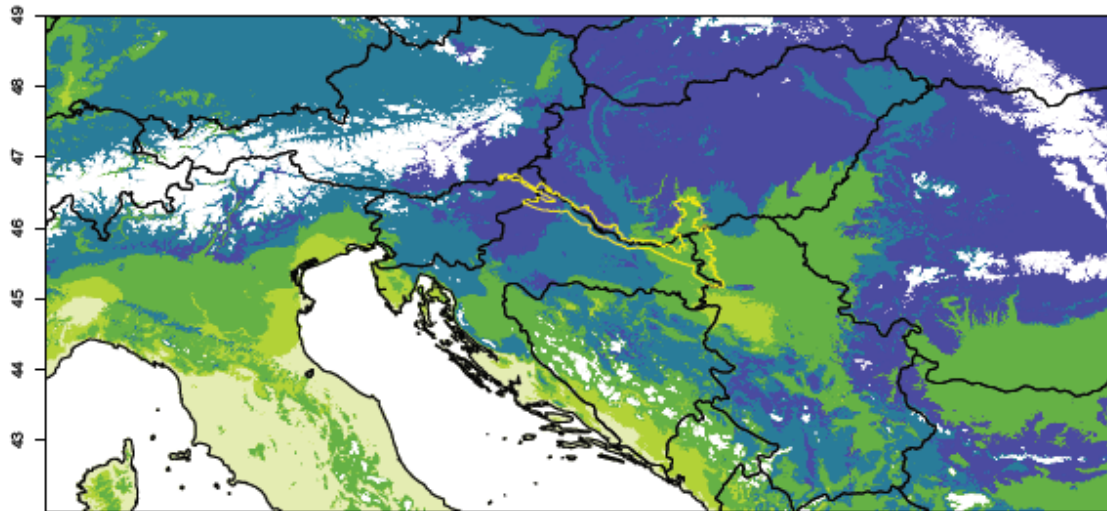
5.2 SEED TRANSFER ZONES FOR TARGET SPECIES 2: FRAXINUS ANGUSTIFOLIA



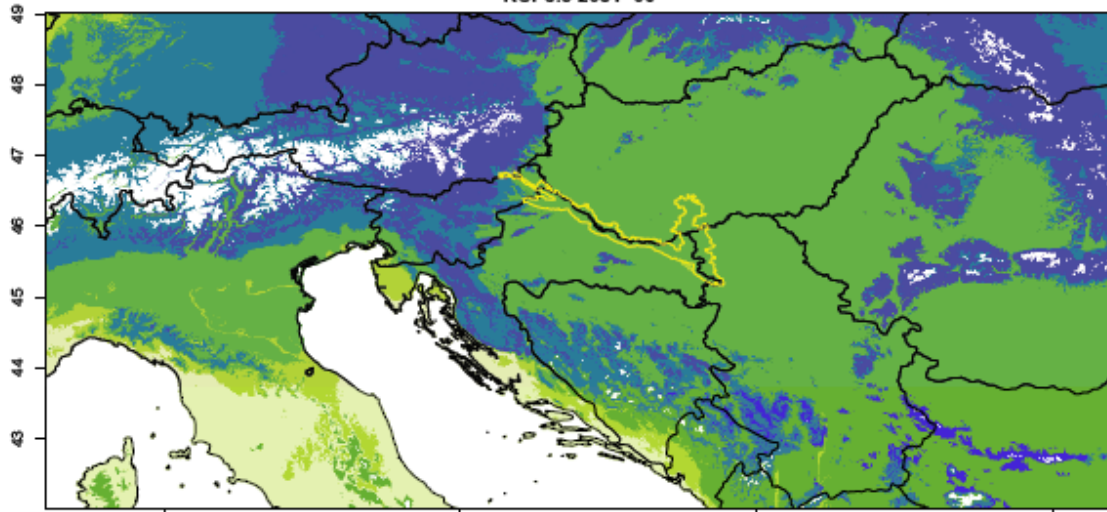
Fraxinus angustifolia
Current climate



RCP8.5 2041-60



RCP8.5 2081-00



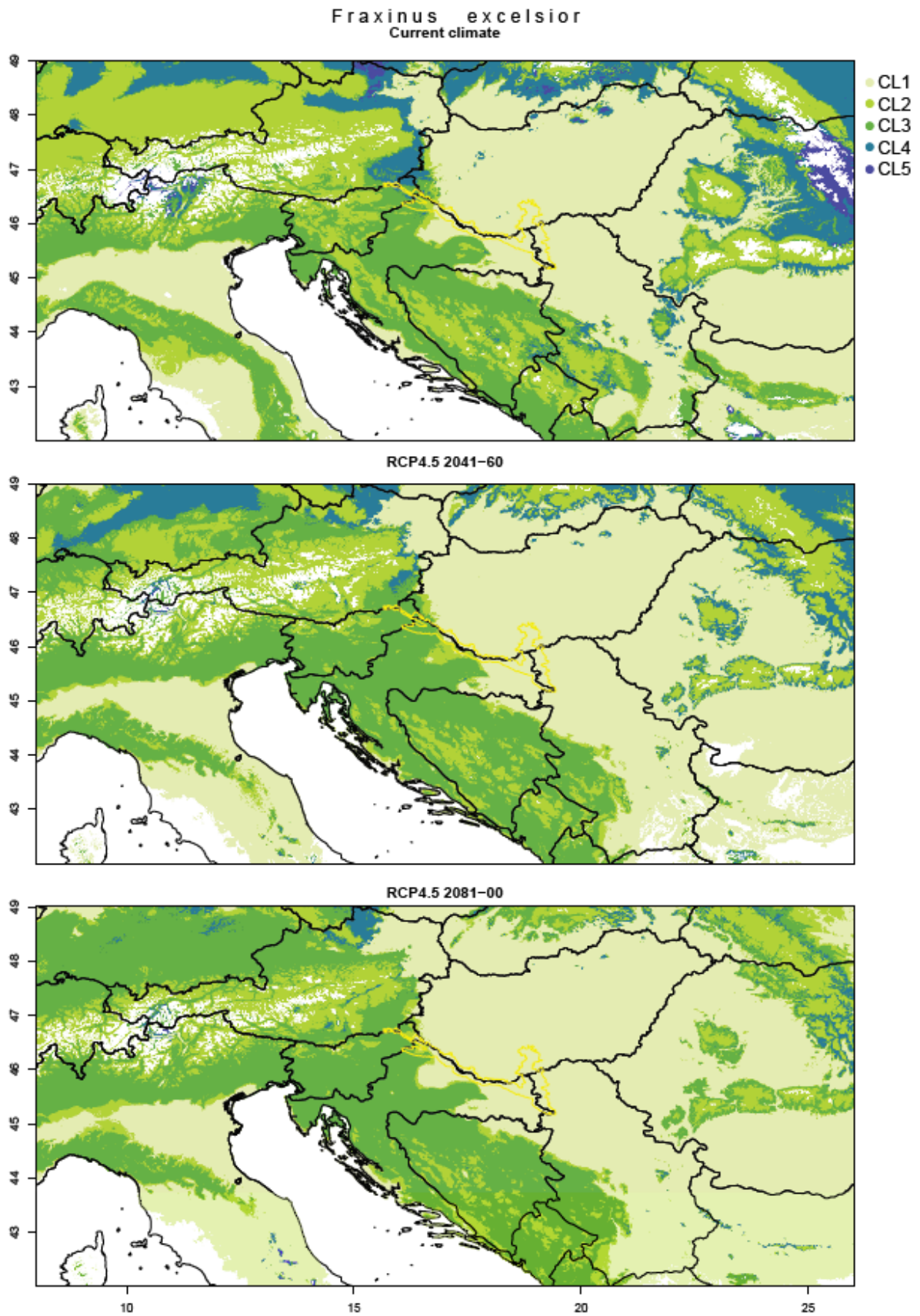
10

15

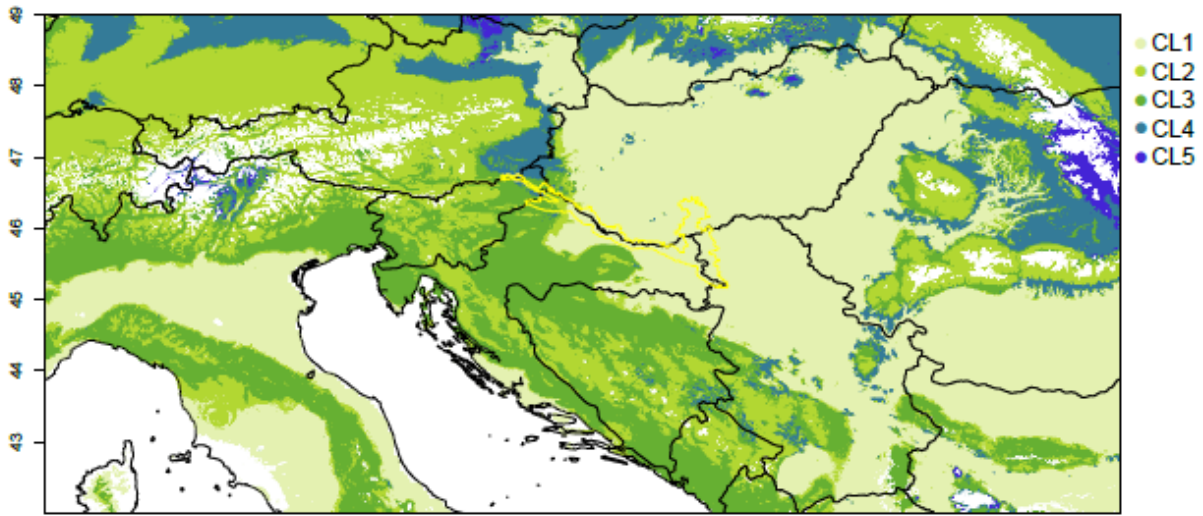
20

25

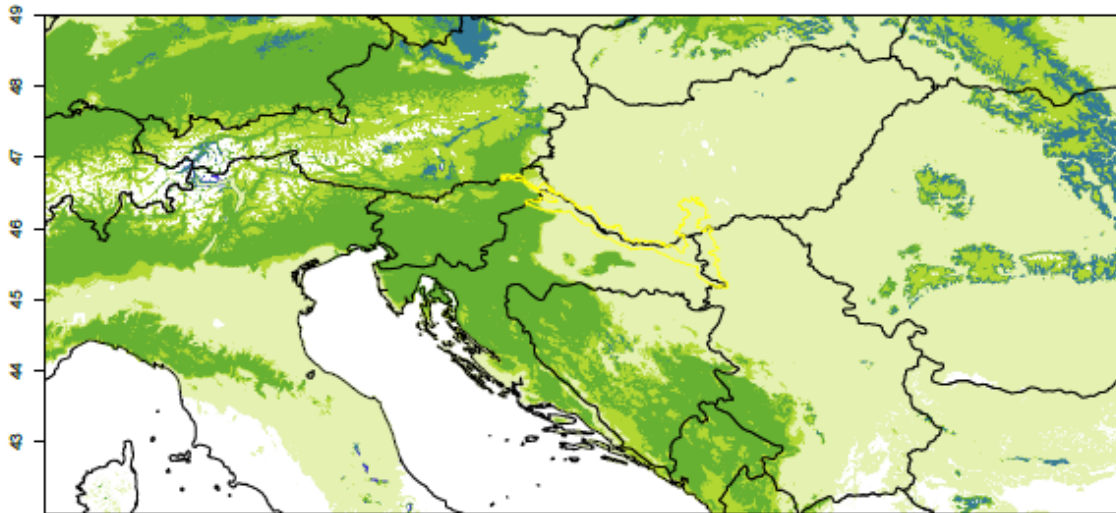
5.3 SEED TRANSFER ZONES FOR TARGET SPECIES 3: FRAXINUS EXCELSIOR



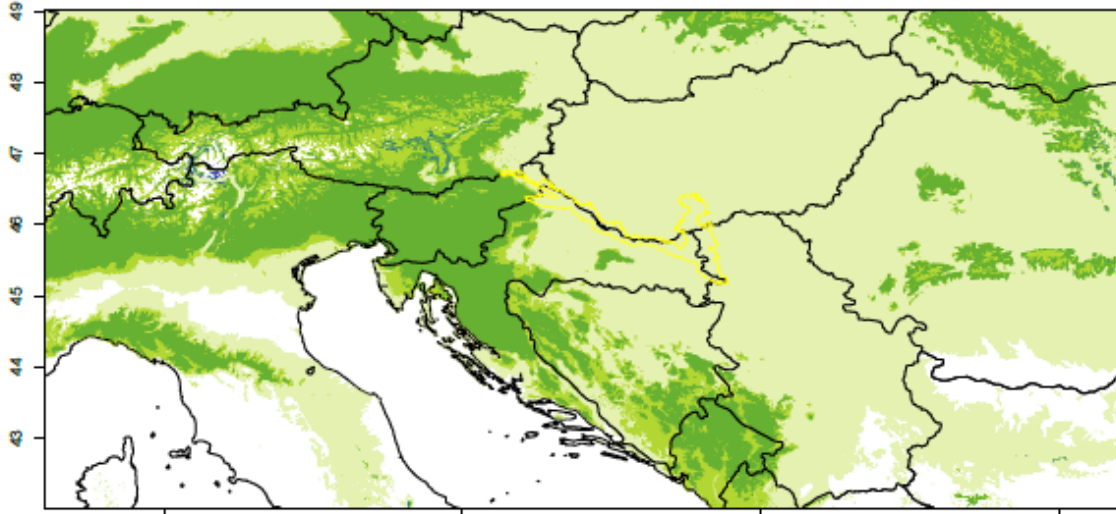
Fraxinus excelsior
Current climate



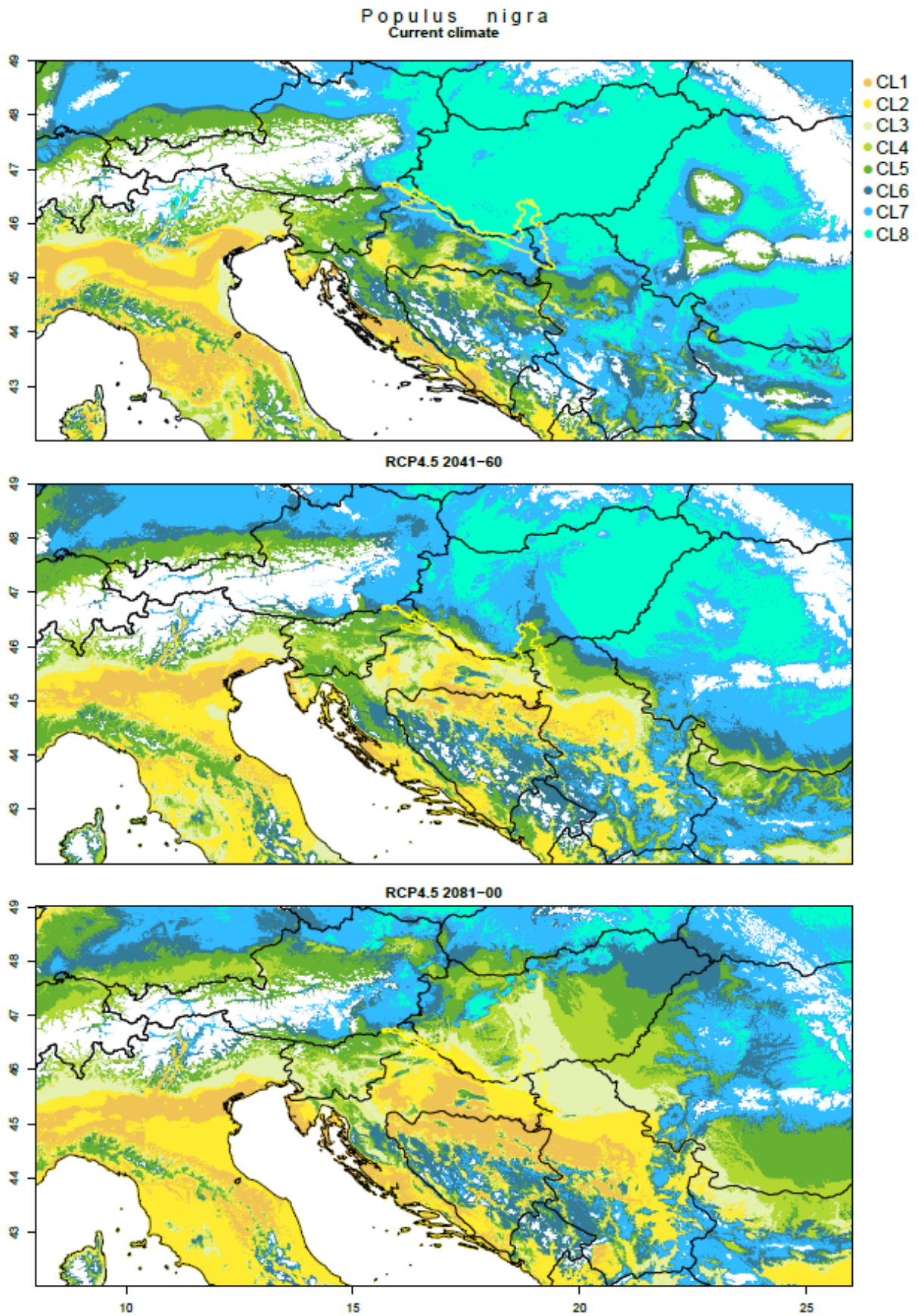
RCP8.5 2041-60



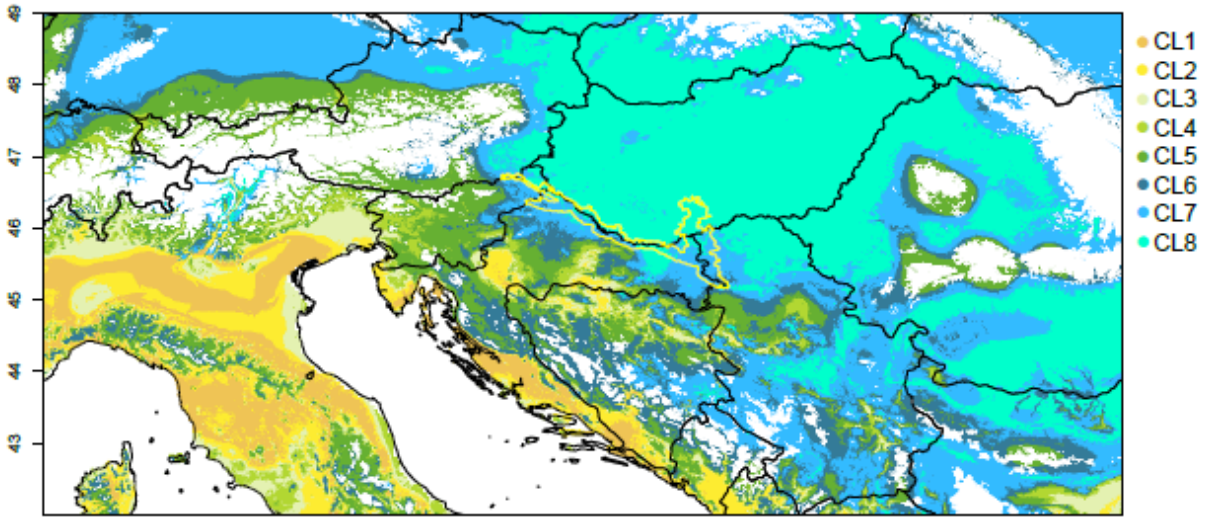
RCP8.5 2081-00



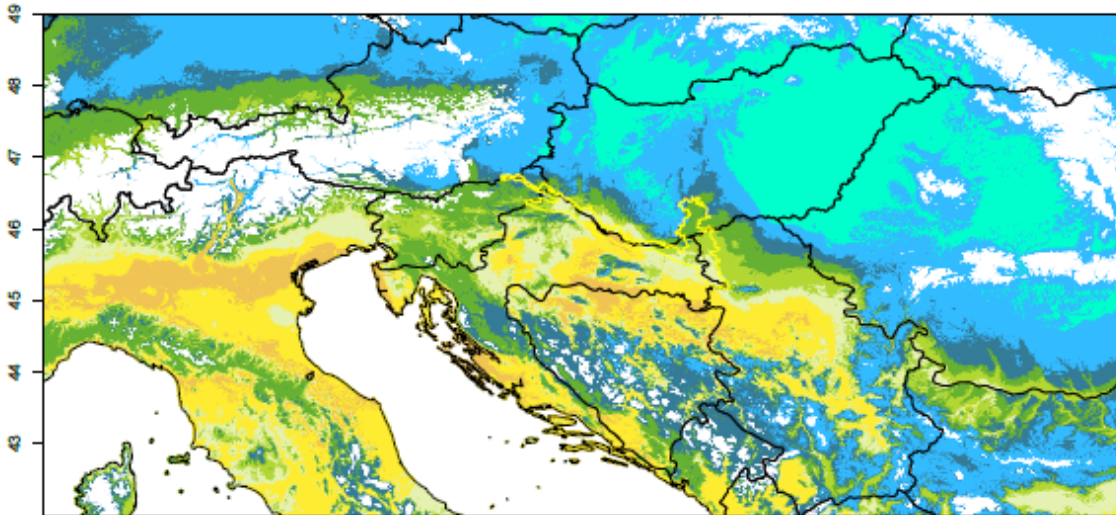
5.4 SEED TRANSFER ZONES FOR TARGET SPECIES 4: POPULUS NIGRA



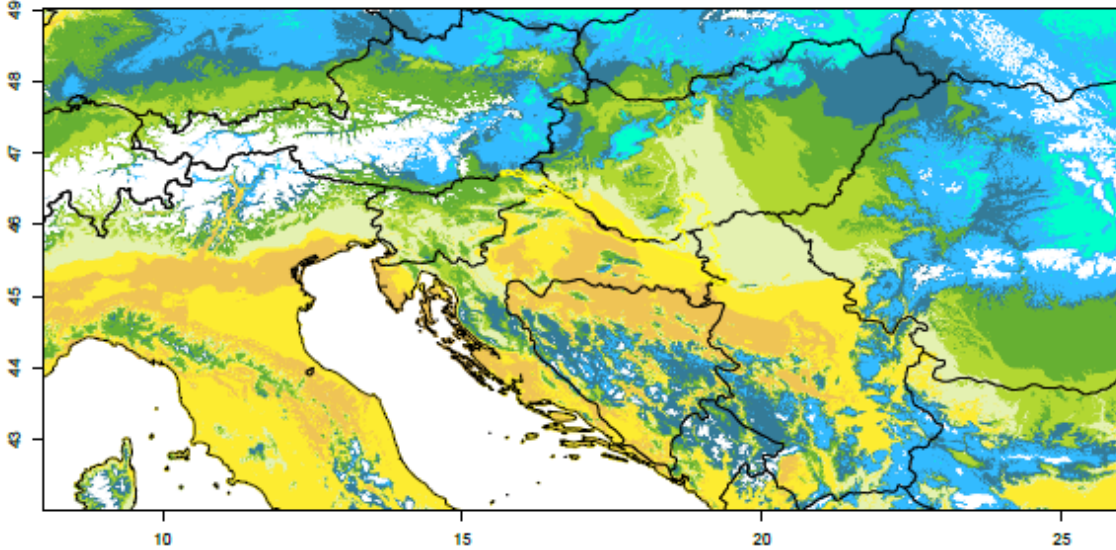
Populus nigra
Current climate



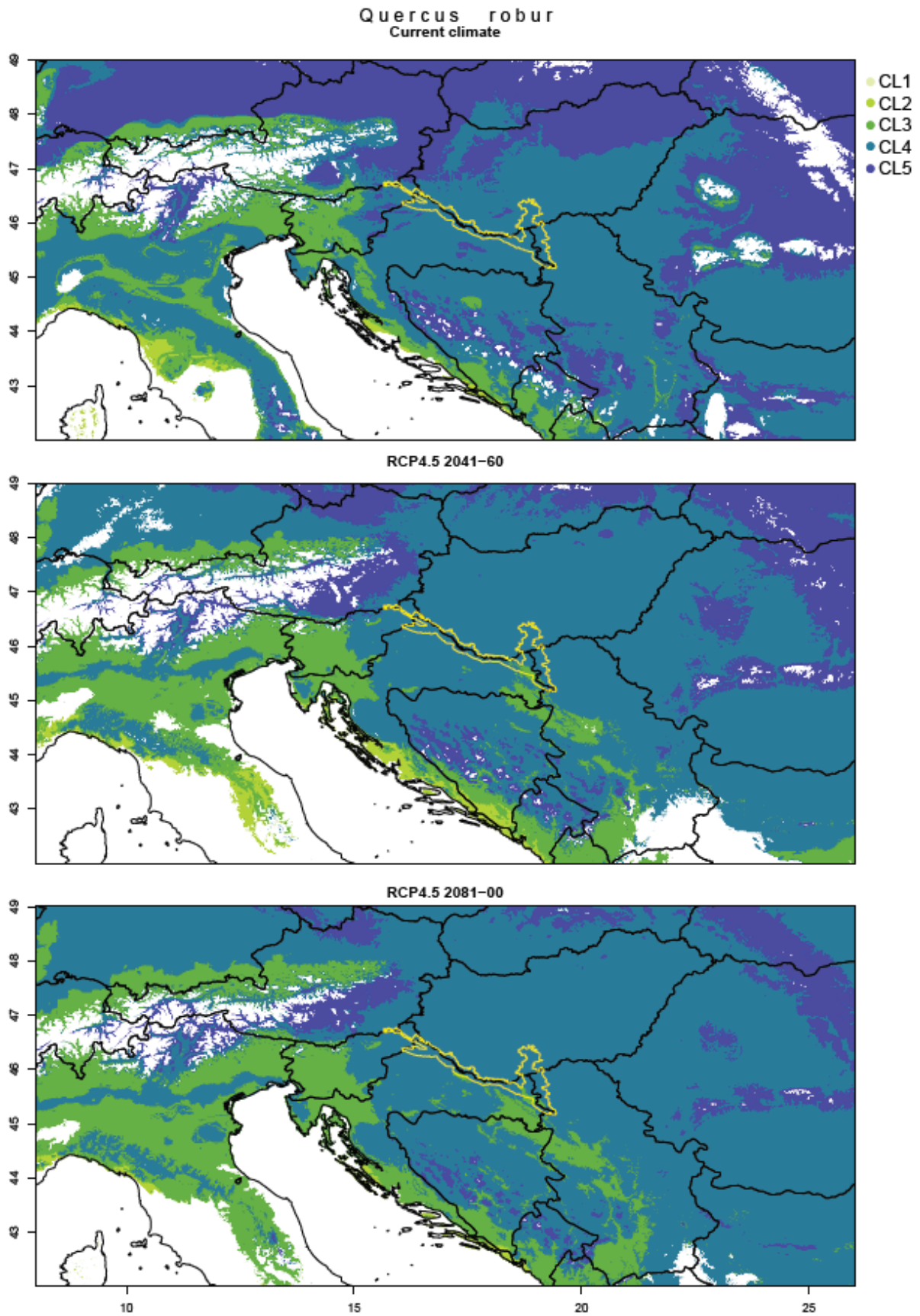
RCP4.5 2041-60



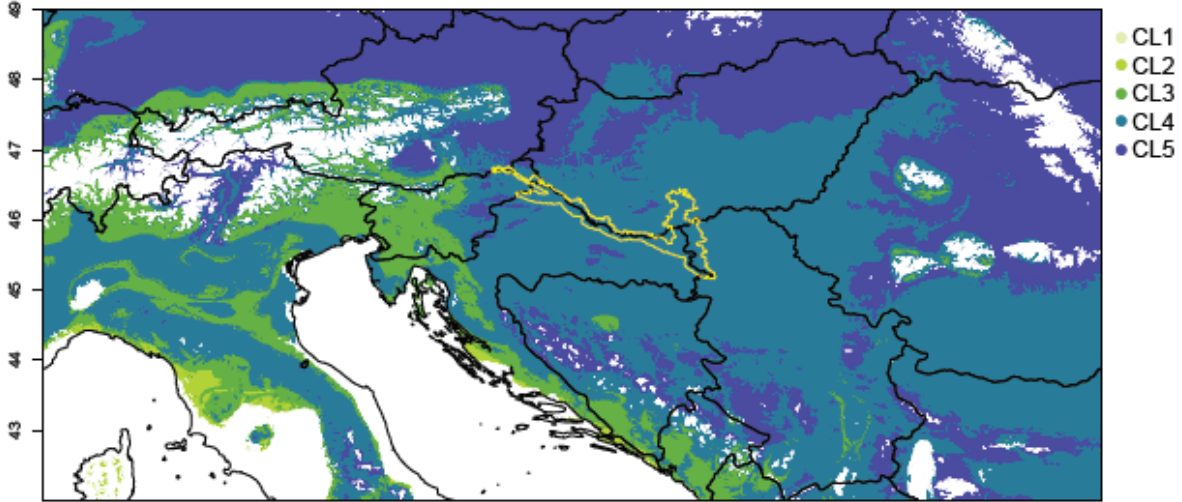
RCP4.5 2081-00



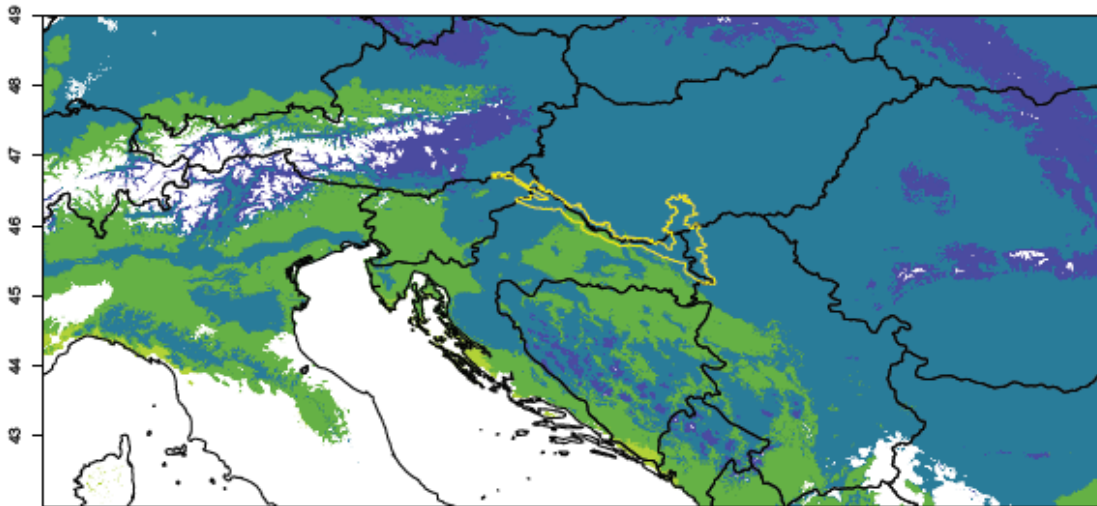
5.5 SEED TRANSFER ZONES FOR TARGET SPECIES 5: QUERCUS ROBUR



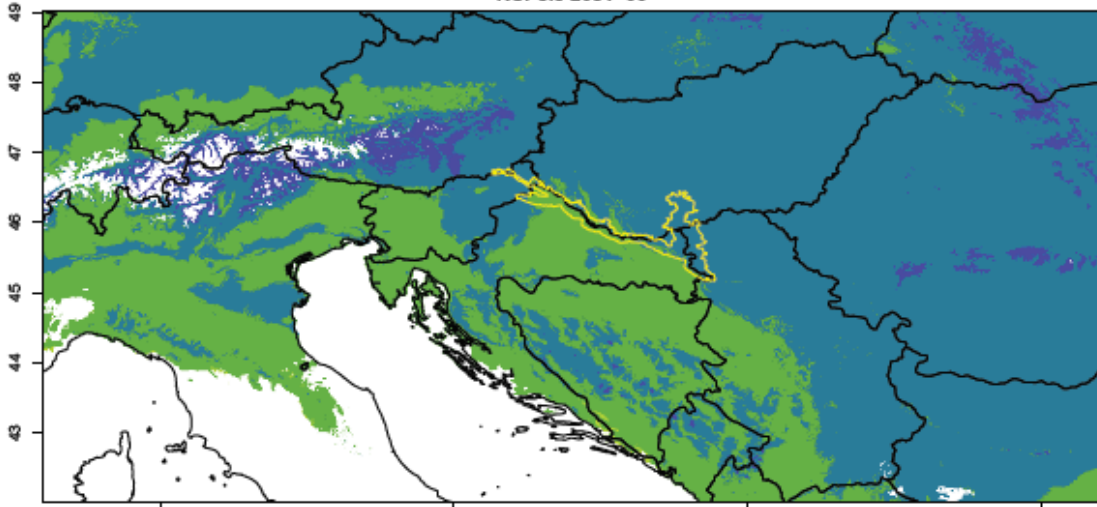
Quercus robur
Current climate



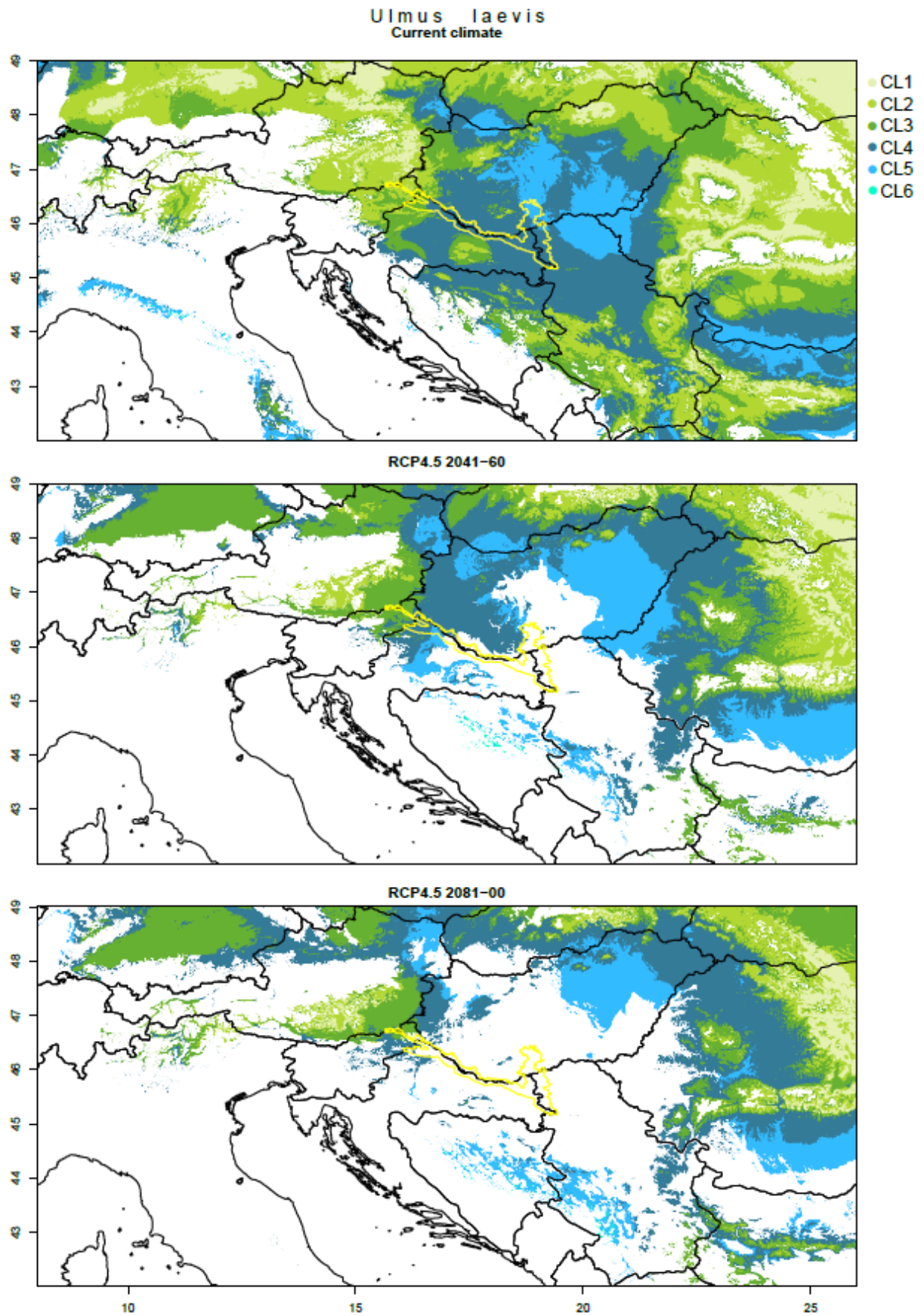
RCP8.5 2041-60



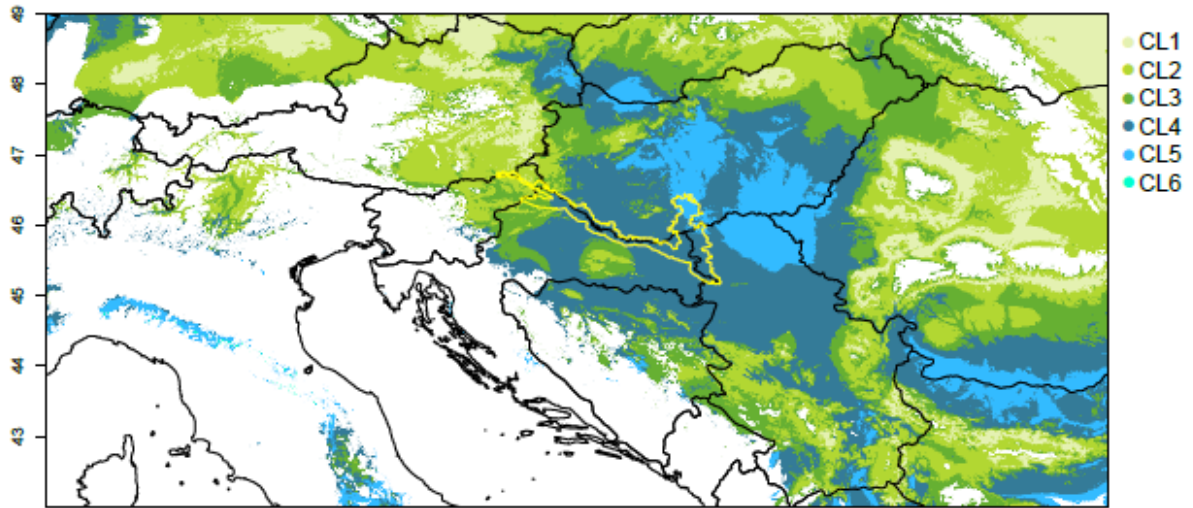
RCP8.5 2081-00



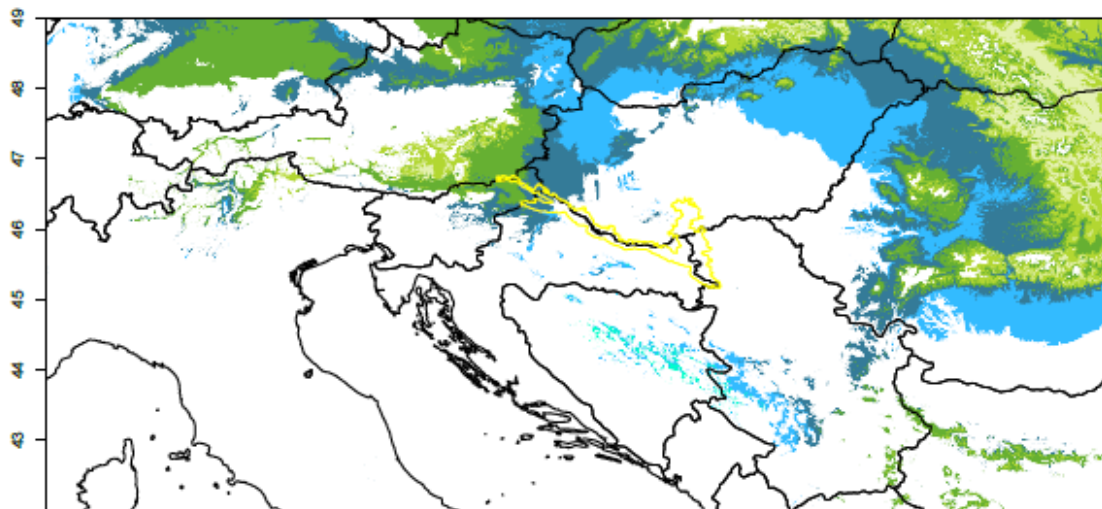
5.6 SEED TRANSFER ZONES FOR TARGET SPECIES 6: ULMUS LAEVIS



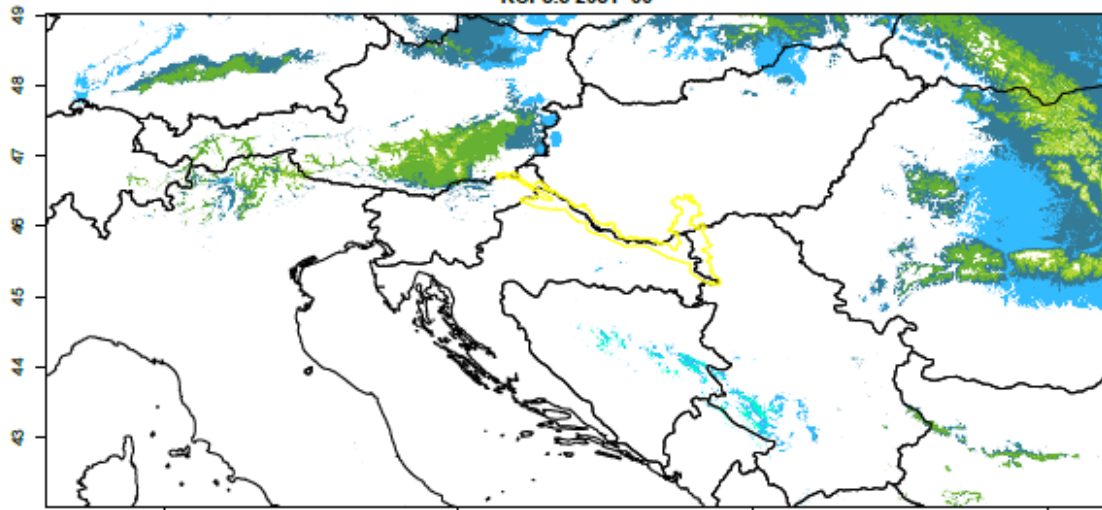
Ulmus laevis
Current climate



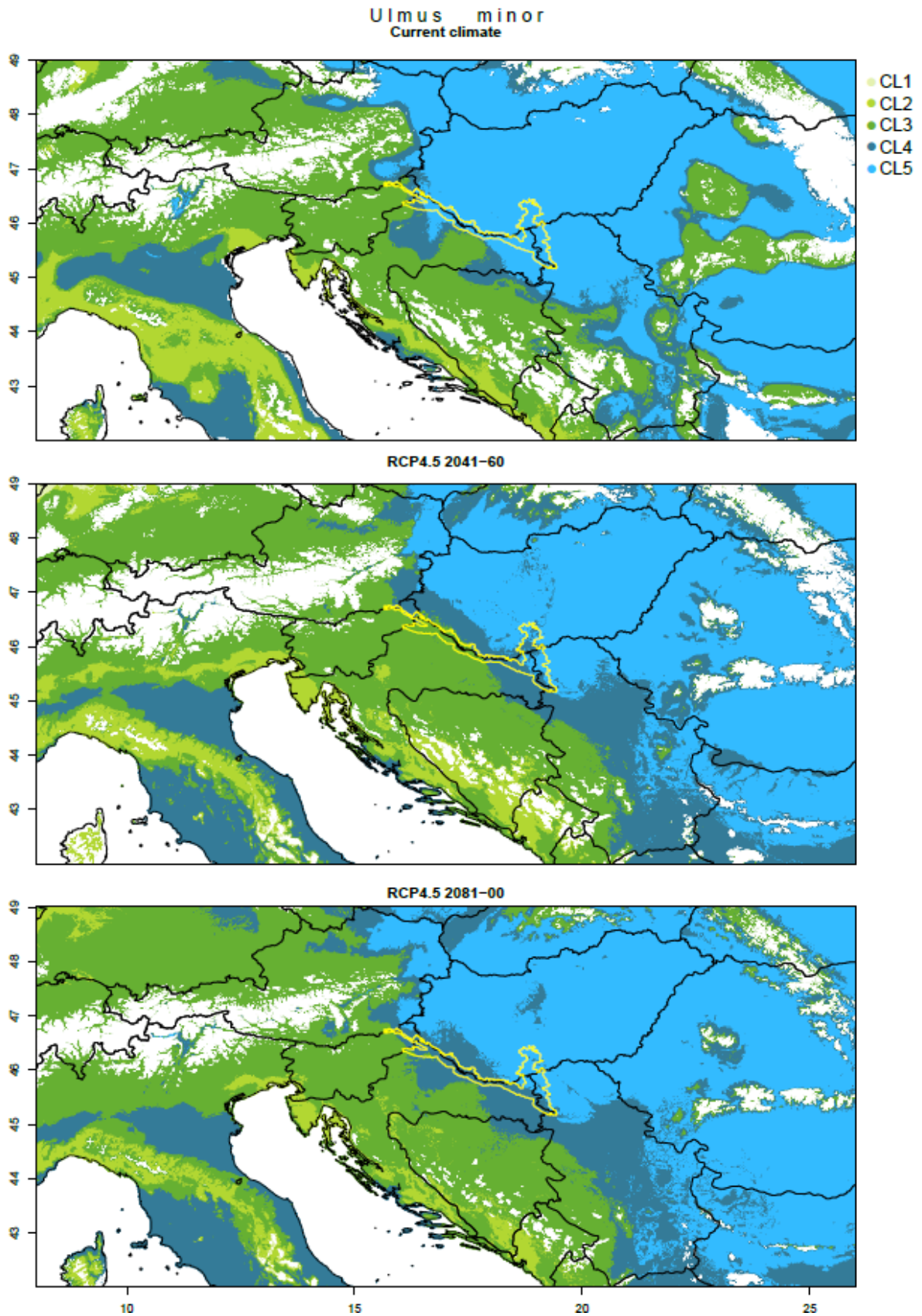
RCP8.5 2041-60



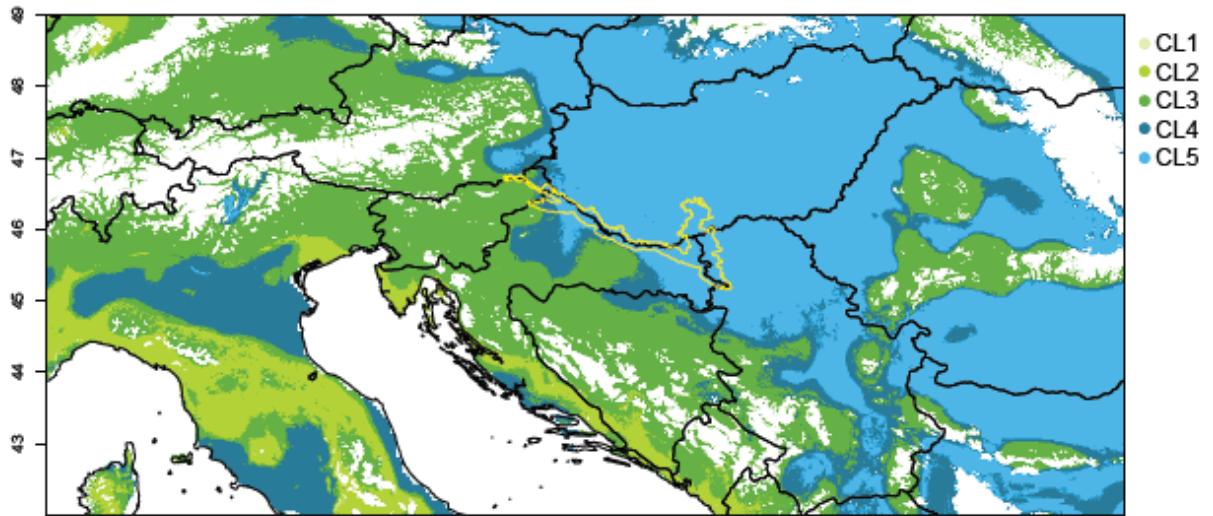
RCP8.5 2081-00



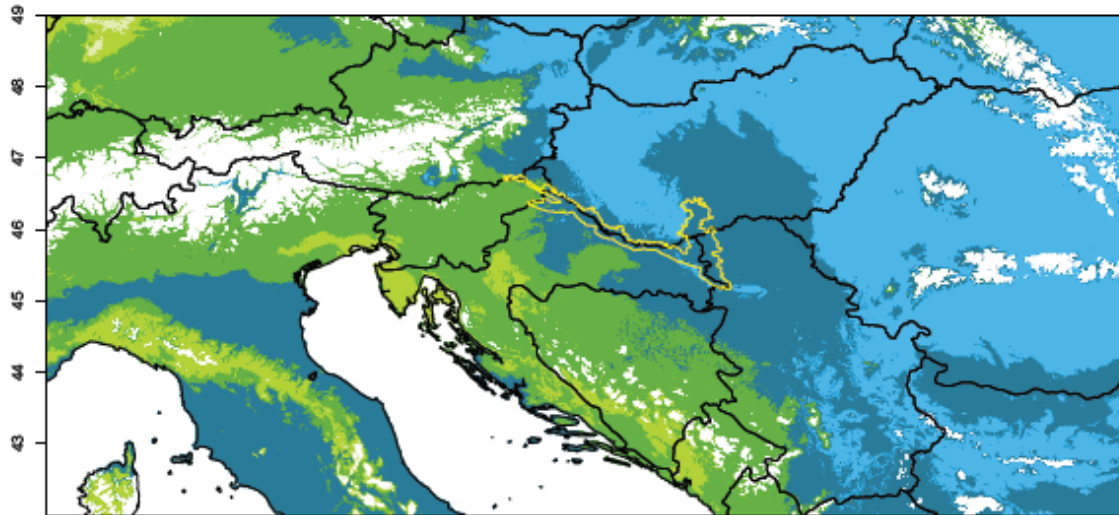
5.7 SEED TRANSFER ZONES FOR TARGET SPECIES 7: ULMUS MINOR



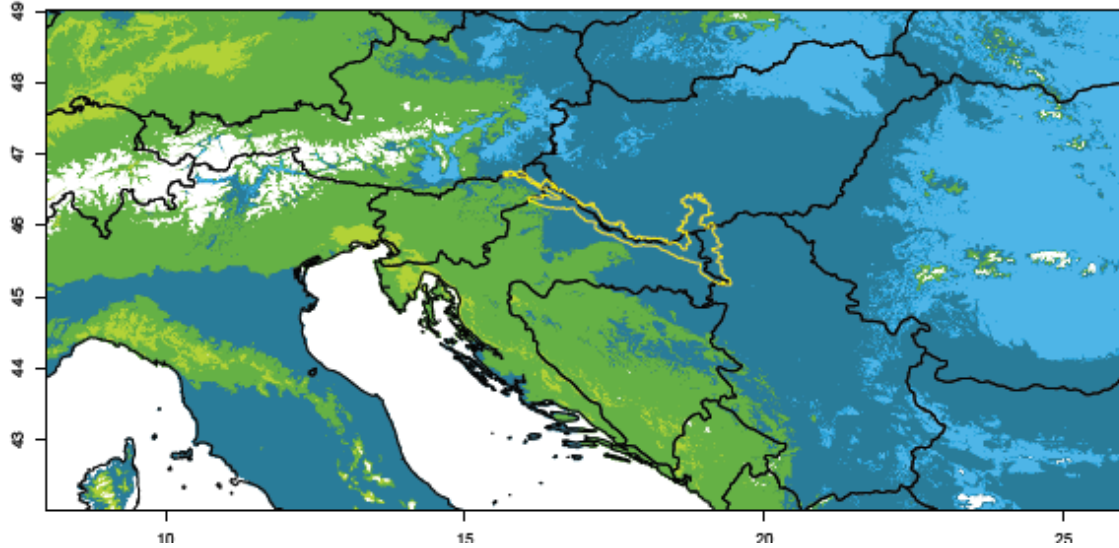
Ulmus minor
Current climate



RCP8.5 2041-60



RCP8.5 2081-00



6. DOWNLOAD LINKS FOR HIGH RESOLUTION MAPS

Target species 1: *Alnus glutinosa*

https://danubeforesthealth.eu/dat/Output3.3/Alnus_glutinosa/

Target species 2: *Fraxinus angustifolia*

https://danubeforesthealth.eu/dat/Output3.3/Fraxinus_angustifolia/

Target species 3: *Fraxinus excelsior*

https://danubeforesthealth.eu/dat/Output3.3/Fraxinus_excelsior/

Target species 4: *Populus nigra*

https://danubeforesthealth.eu/dat/Output3.3/Populus_nigra/

Target species 5: *Quercus robur*

https://danubeforesthealth.eu/dat/Output3.3/Quercus_robur/

Target species 6: *Ulmus laevis*

https://danubeforesthealth.eu/dat/Output3.3/Ulmus_laevis/

Target species 7: *Ulmus minor*

https://danubeforesthealth.eu/dat/Output3.3/Ulmus_minor/

Additional species 1: *Salix alba*

https://danubeforesthealth.eu/dat/Output3.3/Additional_species/Salix_alba_occurrence.pdf

Additional species 2: *Juglans nigra*

https://danubeforesthealth.eu/dat/Output3.3/Additional_species/Juglans_nigra_occurrence.pdf

Additional species 3: *Robinia pseudoacacia*

https://danubeforesthealth.eu/dat/Output3.3/Additional_species/Robinia_pseudoacacia_occurrence.pdf