DOCUMENTATION OF PILOT ACTION 1:

APPLICATION OF DELINEATION AND SEED TRANSFER MODELS IN CLIMATE CHANGE FOR FOREST COMPANIES

D.T3.4.1

Conservation and sustainable utilization of forest tree diversity in Climate change (SUSTREE Project n° CE614)

The objective of the project is to improve integrated environmental management capacities for the protection and sustainable use of natural heritage and resources

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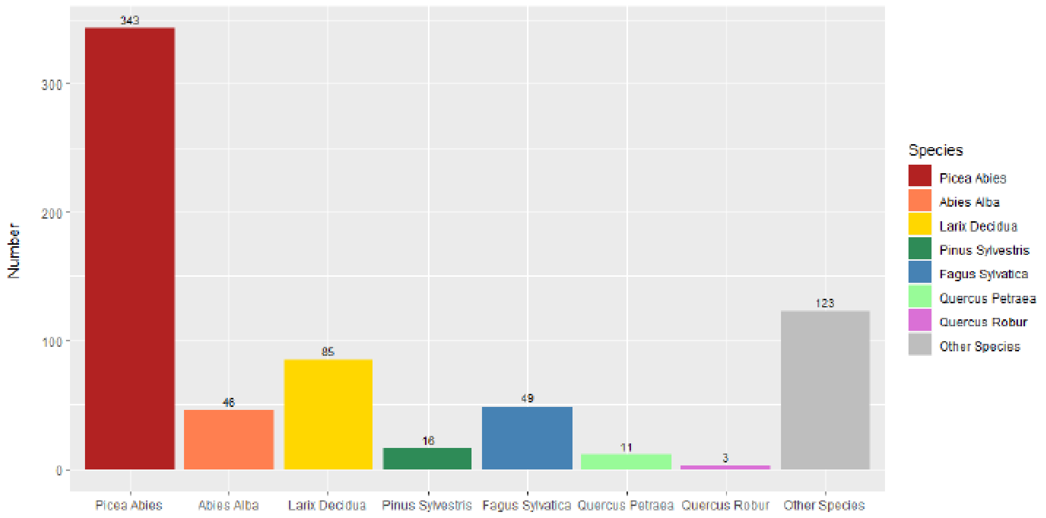
1. Goals of Pilot Action 1

The goal of Pilot Action 1 concerns the application of the models developed within the SUSTREE project (species distribution models and the delineation models) on forest stands managed by the Austrian Federal Forests (ÖBf). ÖBf is a large forest enterprise owned by the Republic of Austria and is also a project partner (PP7) within the SUSTREE project. They cultivate about 850,000 hectares of natural land for the Republic of Austria, of which about 510,000 hectares are forest - about one-tenth of the total state surface.

The assessment includes identification of seed stands, an estimate of regeneration requirements for test sites, model application and documentation. The goal is to test the models for its applicability and to assess the current stocking and target stocking across all management units and for 8 designated test sites.

2. Identification of Seed Stands

The first step of Pilot Action 1 includes the identification of all existing seed stands on ÖBf sites in order to assess which species the seed can be harvested from the company's seed stands. Results show that there are 669 seed stands in total which are located across 1697 forest stands. More than 50% of the seed stands are for Norway spruce (*Picea Abies*). The distribution across the 7 species is as follows:



Graphic 1: Number of ÖBf seed stands per species

3. ESTIMATE OF REGENERATION REQUIREMENTS

The second step includes the estimation of regeneration requirements for ÖBf forest sites. For this step, the assessment considers the change in species distribution between the current stocking and the future target stocking. Target values are available for each of the 156.772 ÖBf forest stands in our sample. They serve as a strategic goal for the tree species composition at each site. For each stand, multiple stocking options are available based on site characteristics such as climate conditions, soil characteristics, exposition, altitude, and hydrological regime. The targets were revised recently based on the need for climate change adaptation and an increasing orientation towards potential natural forest communities (Mayer & Zukrigl; Willner & Grabherr; Köck). Although in practice the local ranger is responsible for the final decision about which species to be planted, we calculated an average composition based on the available options per forest stand.

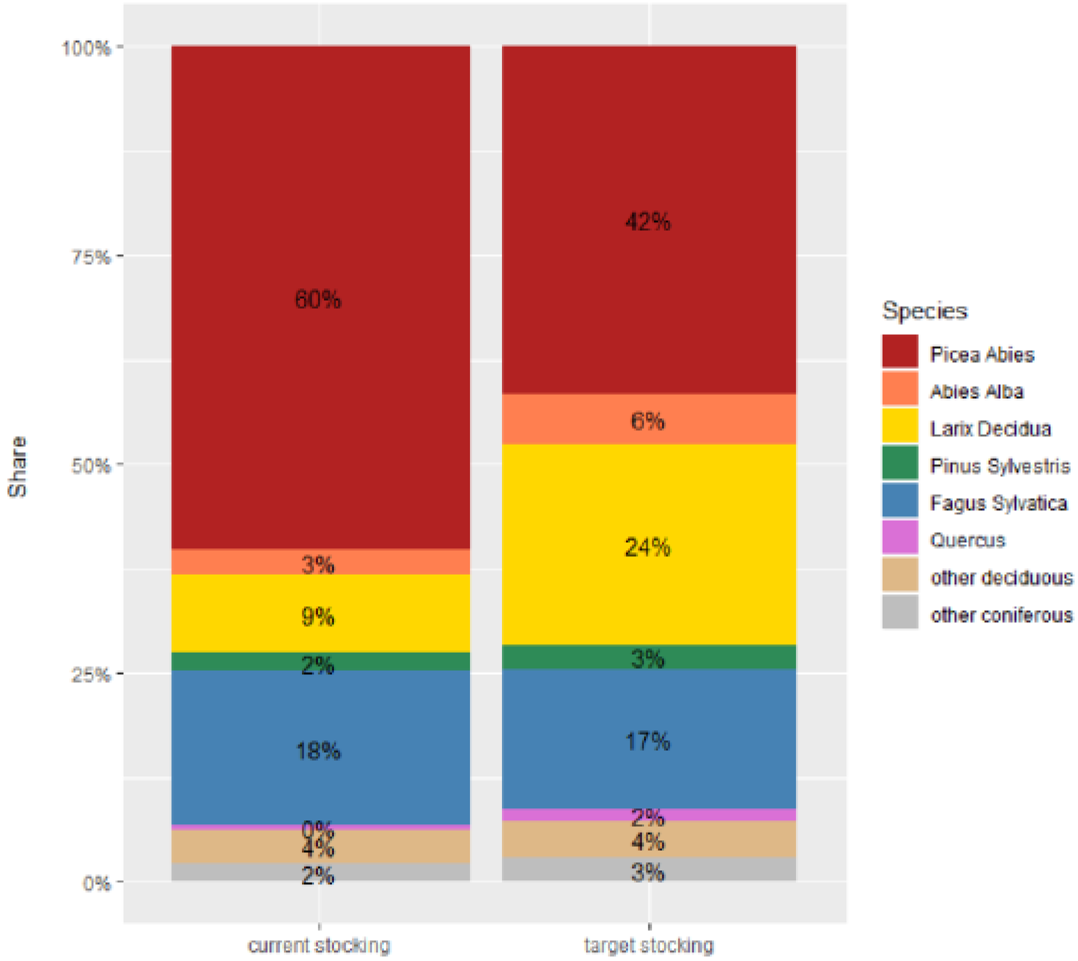
On aggregate, Norway spruce (*Picea Abies*) is currently the dominant species. However, in the target stocking it will be partly substituted by larch (*Larix Decidua*) and silver fir (*Abies Alba*).

3.1 REGENERATION REQUIREMENT PER SPECIES

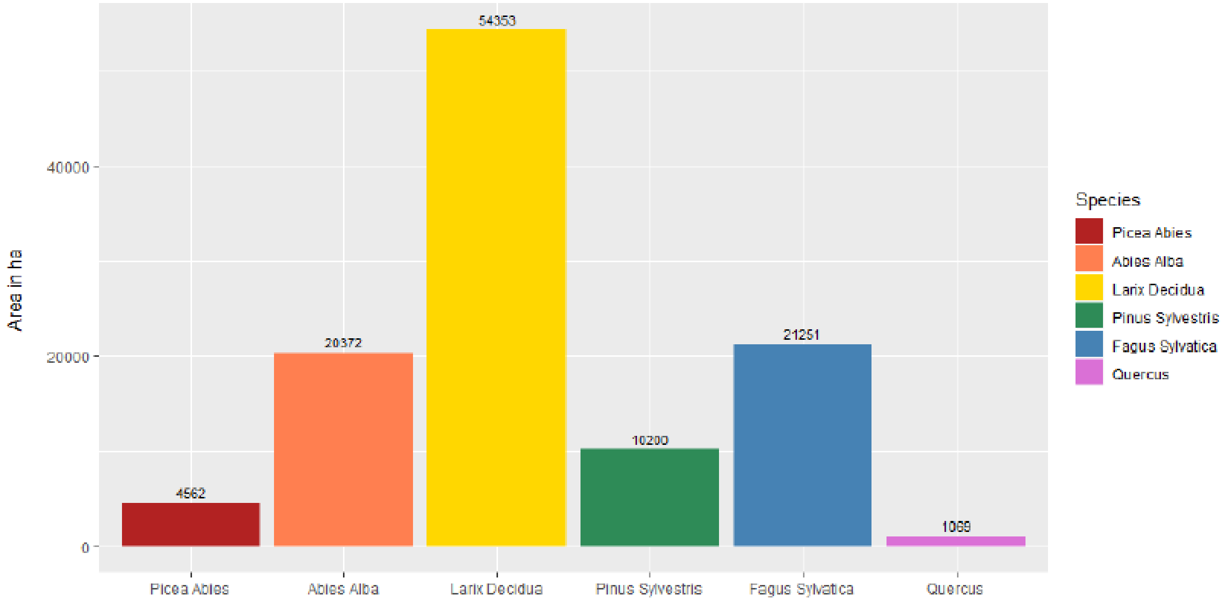
Following the changes of species distribution, we can assess the regeneration requirements to achieve the stocking target. In areas where a species is included in future stocking targets but not occurring at present, natural regeneration is not possible and adequate seed material is needed. Therefore, the regeneration requirement per species is calculated based on the total area where there is a need to newly introduce it. Total regeneration requirements per species (in hectar) are shown on the next page.

Additionally, regeneration requirements are evaluated for 8 test sites. The 8 test sites were identified at ÖBf as regions with a high degree of vulnerability due to climate change and the need for extensive adaptation measures. Test sites cover locations with high amounts of calamities in recent years (f.e. bark beetle infestation at site 7 – Waldviertel) or locations with considerable changes in species composition due to climate change (f.e. Site 1 – Kobernaußerwald; Site 5 – Oberwart). Location 8 (Mitterweißenbach Forest District) is added as a representative site for many ÖBf locations with more than 50% of protective forests, with mixed forest stands with Norway spruce (*Picea Abies*) as main tree species and on Limestone.

A list of all 8 test sites including results of the model application are provided in the annex section at the end of the document.



Graphic 2: Species distribution at ÖBf sites



Graphic 3: Additional regeneration requirements per species

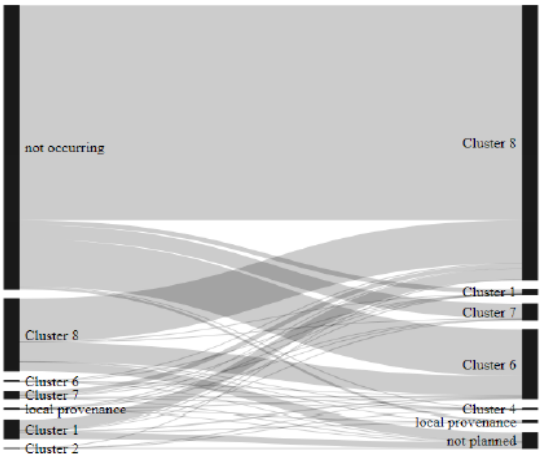
3.2 Regeneration Requirement per species per seed cluster

Regeneration requirements per species are assessed on behalf of the differences between current stocking and target stocking and calculated based on the respective spatial requirement for the introduction of the species. During the next step, the assessment concerns the provenances of this regeneration requirement.

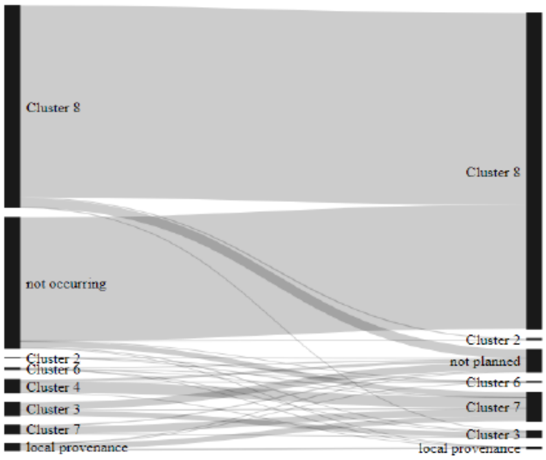
Based on the optimal seed clusters from D.T1.4.2, we calculated the optimal seed provenances under current und future climate conditions (baseline scenario vs. 2060-2080 under RCP 4.5) for each ÖBf forest location. Optimal provenance means that seeds from this region have optimal growth conditions and are more productive compared to other provenances. The Sankey diagrams show how the optimal cluster composition changes between current stocking/current climate on the left side and future climate/target stocking on the right side.

3.3 OPTIMAL PROVENANCES PER SPECIES

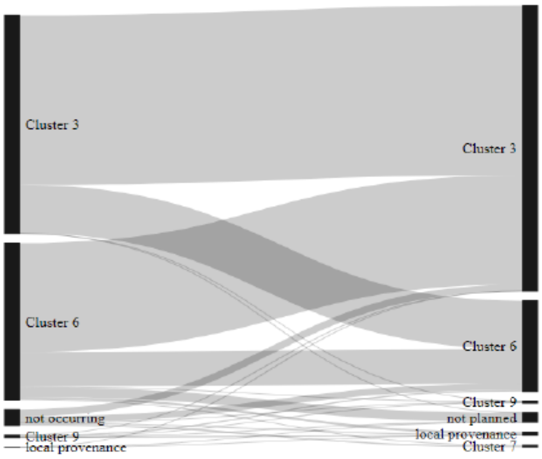
Abies Alba



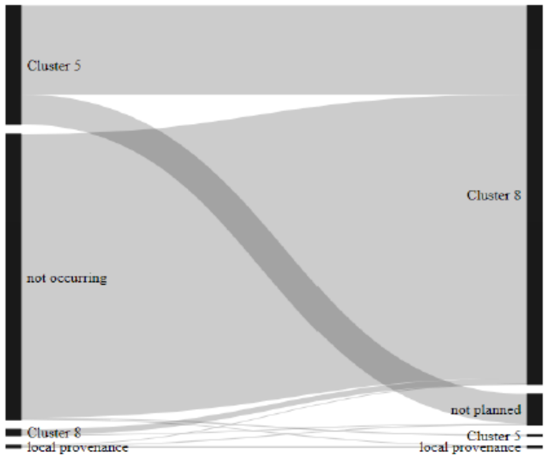
Fagus Sylvatica



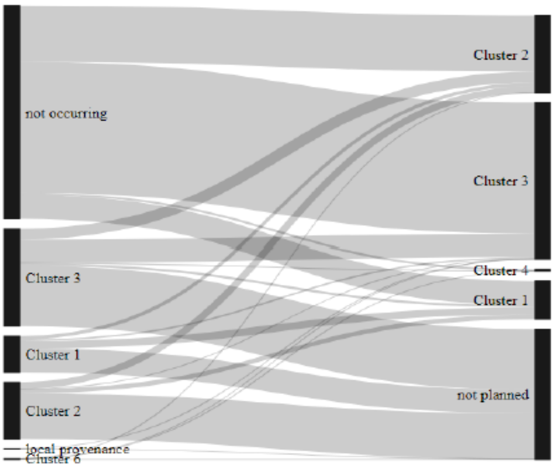
Picea Abies



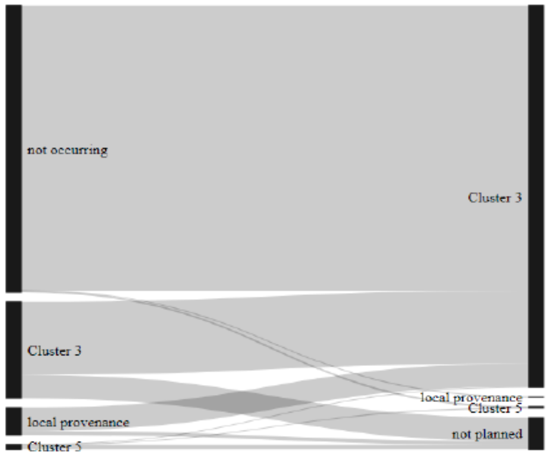
Quercus Petraea



Pinus Sylvestris



Quercus Robur



4. Model Application for 8 test sites

4.1 Risk Index

The application of the models created within the SUSTREE project included the application of the species distribution models (developed under D.T1.2.4) and seed delineation models for seed transfer (developed under D.T1.4.2) on the ÖBf forest stands. The main goal was to utilise these models for the evaluation of current stocking and future stocking targets at ÖBf sites. For this purpose, a risk index was created based on the SDMs to assess the potential risk under current and future climatic conditions, as well as for current stocking and future stocking targets.

Following the standard definition risk, the risk (R) of a species (Sp) at a location is based on its probability of occurrence (from the species distribution model) and its share within the tree species composition:

$$R_{Sp_1} = R_{PoO} * R_{Sh}$$

Accordingly, the overall risk at a particular forest site (FS) is dependent on the aggregate risk of all species occurring:

$$R_{FS} = R_{Sp_1} + R_{Sp_2} + \dots + R_{Sp_n}$$

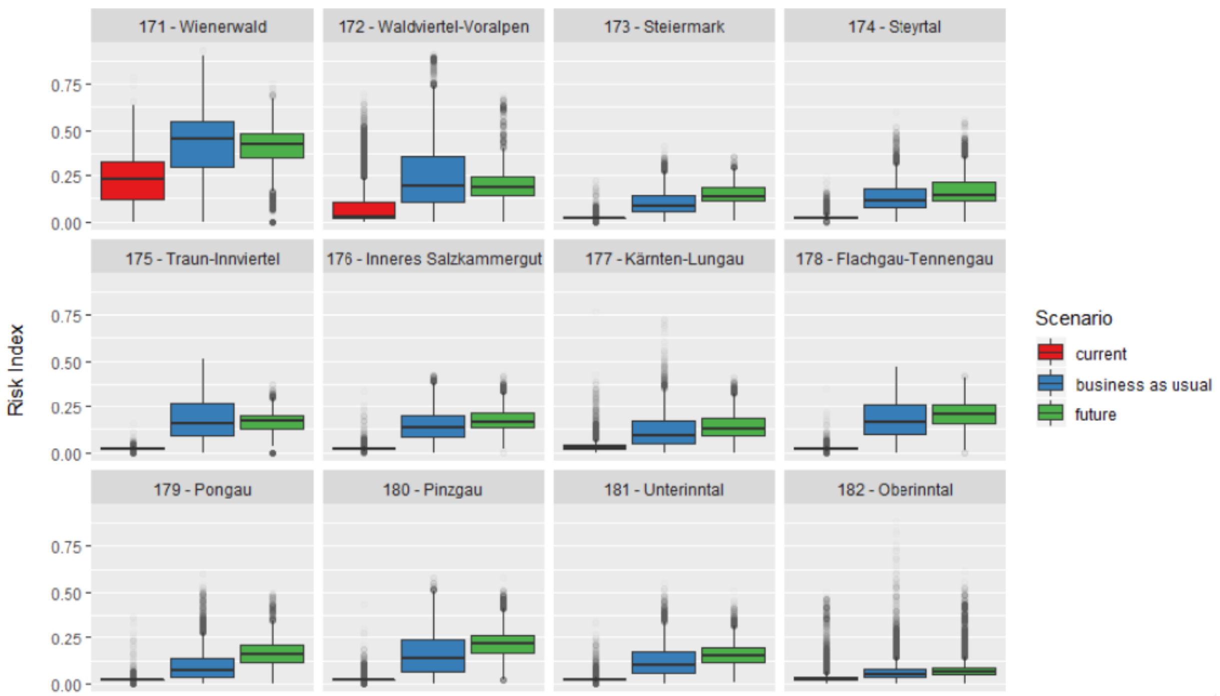
The risk index was calculated for 156.772 forest sites, which covers 97% of the total amount. For each site, the index shows the climatic adaptivity of the respective species. If the climate is very unsuitable for species under a certain scenario, the risk index is close to 1 for this location. If the climate conditions are optimal and the climate risk is low, values will be close to 0.

For the risk assessment the following three scenarios with combinations of climatic scenarios (current period and 2060-2080 under RCP 4.5) and stocking options (current stocking and stocking target) were identified:

	Current climate (1960-1990)	Future climate (2060-2080, RCP 4.5)
Current stocking	"current"	"business as usual"
Future stocking target		"future"

Table 1: Combination of climatic scenarios and stocking options

The assessment for the three scenarios was performed for the 12 management units, which provides an overview across all ÖBF forest areas. However, as these regions are internally diverse, a more precise assessment is possible with the smaller sample of the 8 test sites. Detailed results are provided in the annex section at the end of the document.

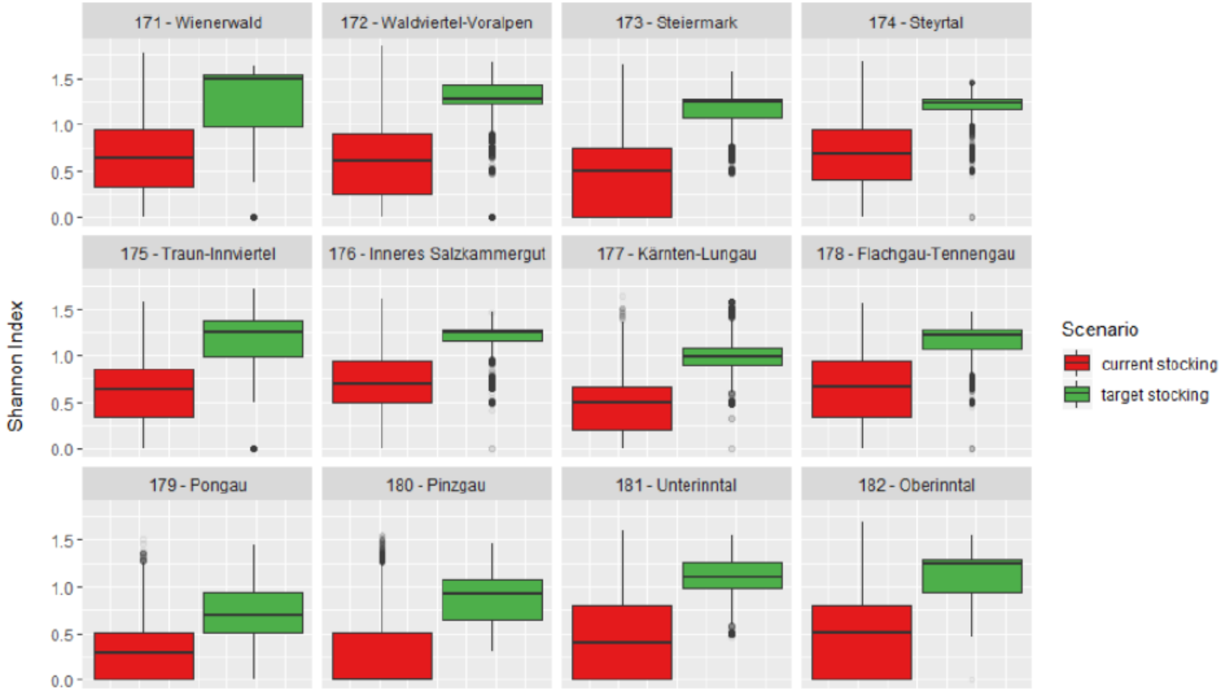


Graphic 4: Risk Index for Management Units

4.2 Biodiversity Index

The second indicator in this assessment is the Shannon Index. It is a measurement for biological diversity at a specific forest site. A higher value means that more species are present and that they are more evenly distributed. Consequently, a higher level of biodiversity lowers the risk for calamities such as pests, windfall, etc. which affect species differently. The

Shannon Index therefore serves as a non-climate related indicator of risk and resilience against calamities. The graph for all management units shows that biodiversity is increasing across all units with the implementation of the target stocking.



Graphic 5: Biodiversity Index for Management Units

4.3 List of 8 Test Sites with Filters

The following table provides a list with all test sites and the respective filters for sub-setting the forest areas:

Nr.	Test Site	Management Unit	Forest District	Geology	Growth Area	Coordinates
1	Kobernaußerwald	175	9, 10, 11			x > 12.9
2	Pongau and Pinzgau on Silicate	179, 180		Silicate		
3	Northern Traun-Innviertel on Flysch	175	5, 7, 8			
4	North-Eastern Wienerwald	171	1, 2, 3			
5	Oberwart Forest District	171	13			
6	Styria on Limestone	173		Limestone		
7	Waldviertel	172			9.2	
8	Mitterweißenbach Forest District	176	1			

Table 2: Test sites and their respective filters

4.4 RESULTS FOR 8 TEST SITES

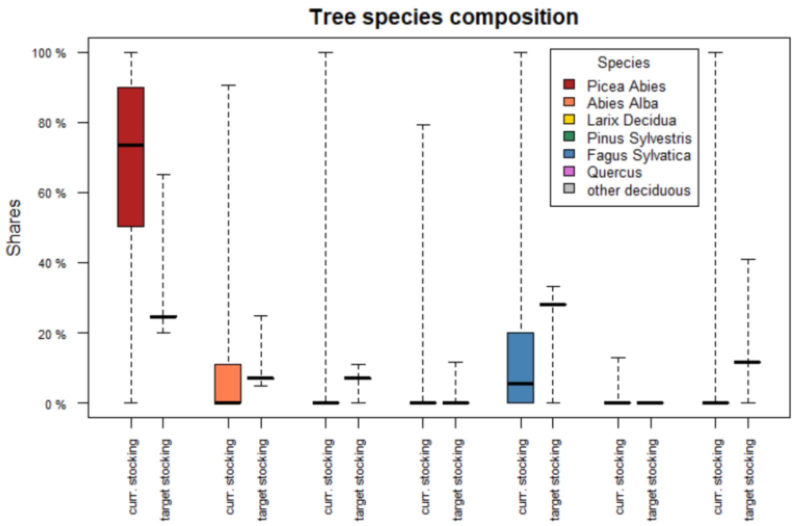
Results for 8 test sites show four graphs for each test site:

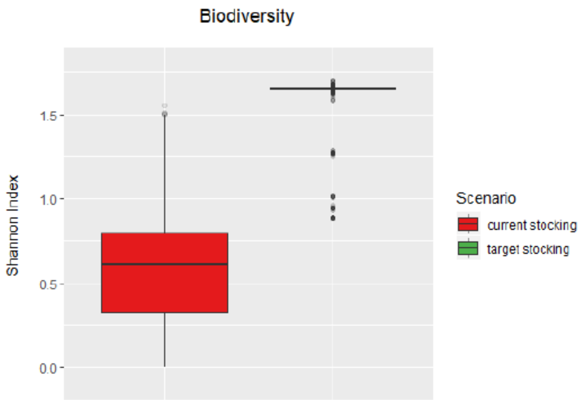
- Change between current stocking and target stocking per species (box plot)
- Risk index (box plot)
- Shannon index for biodiversity (box plot)
- Additional regeneration requirement for each species (bar plot)

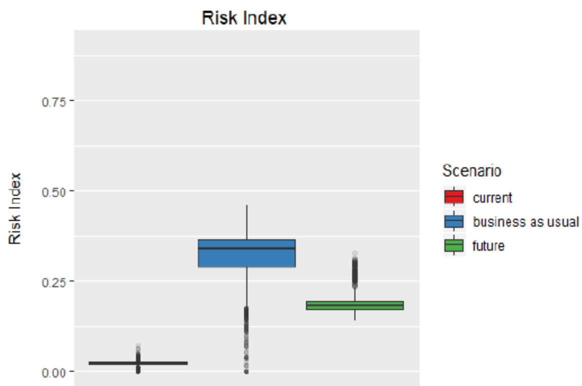
Results for biodiversity index show similar results as for the management units. For all locations an increase in biological diversity can be observed.

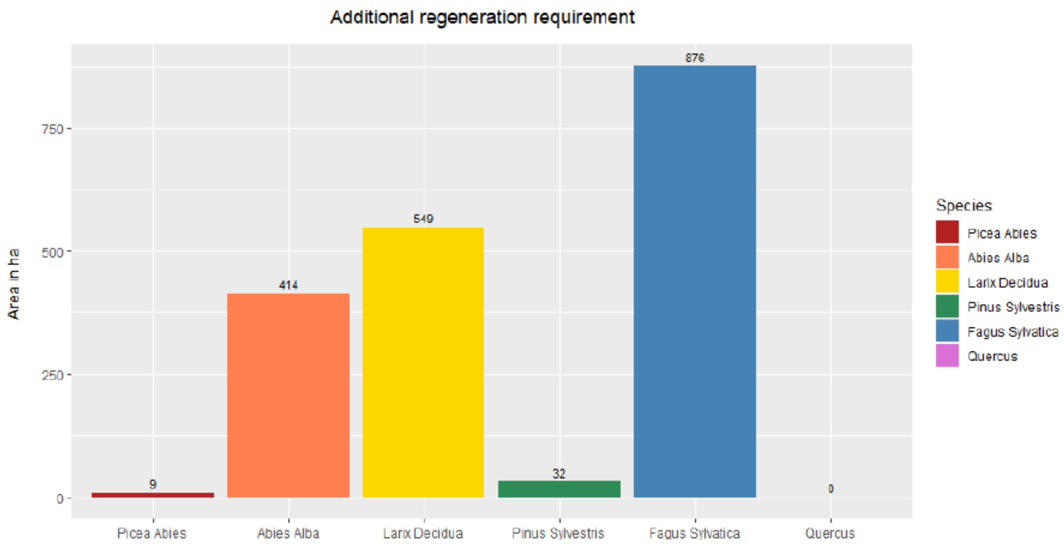
The risk assessment shows the results for current, business as usual and future scenario. Currently, the risk level is low for most sites (exception sites 1, 3, 7). Where Norway spruce (*Picea Abies*) is substituted with larch (*Larix Decidua*), climate-related risk is generally increasing (site 2 and 6, to some extent also site 8) due to better model results under climate change for the former. Conversely, where it is substituted with beech (*Fagus Sylvatica*) at lower altitudes, risk will lower (site 1). Results with high for “other deciduous” should be treated with caution, as these values are not considered due to lack of data.

4.4.1 <u>Location 1:</u> *Kobernaußerwald*

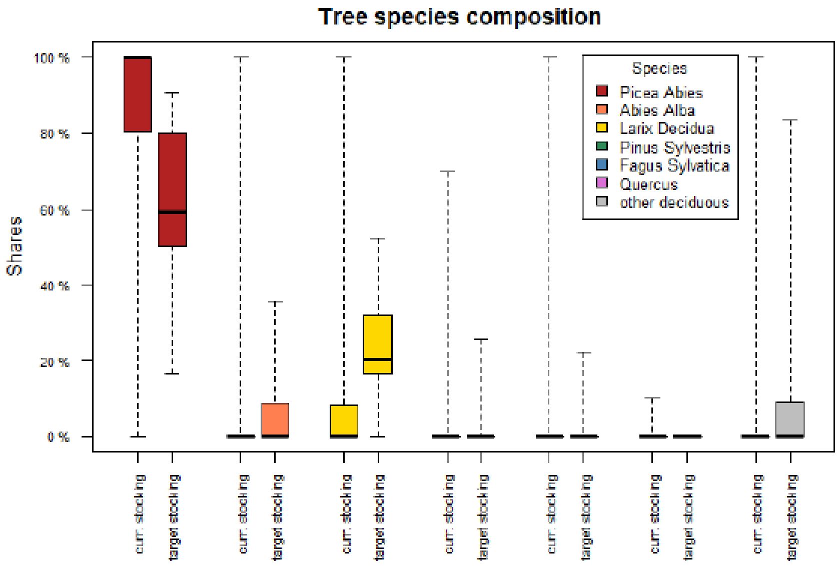


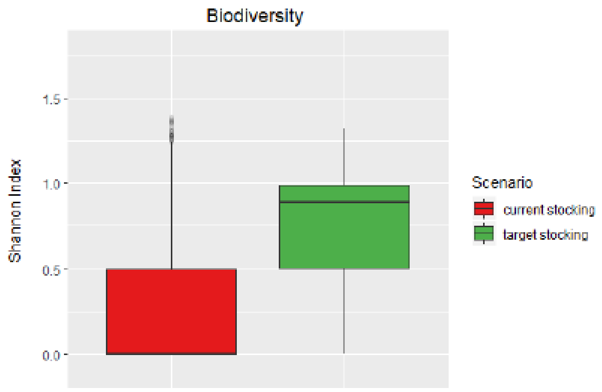


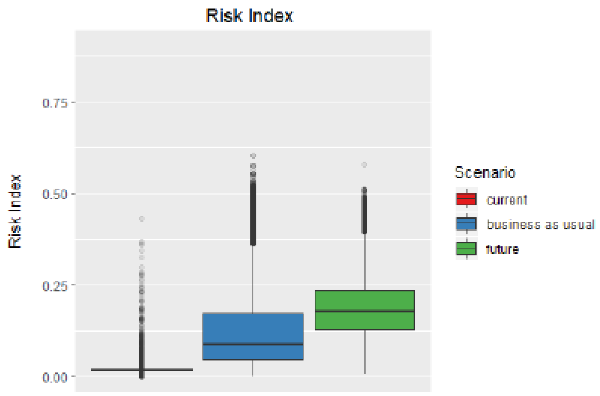


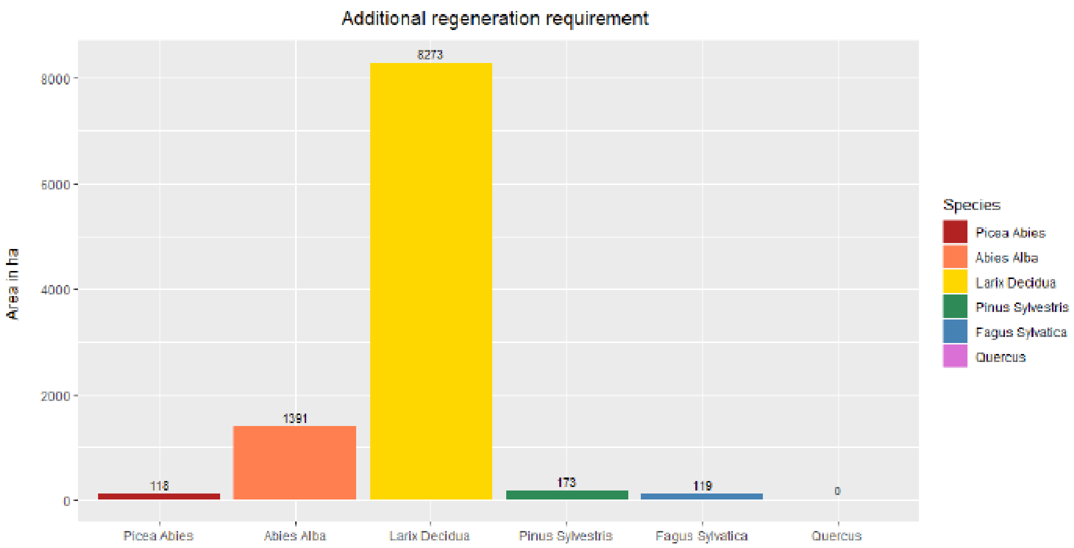


4.4.2 Location 2: Pongau and Pinzgau on Silicate

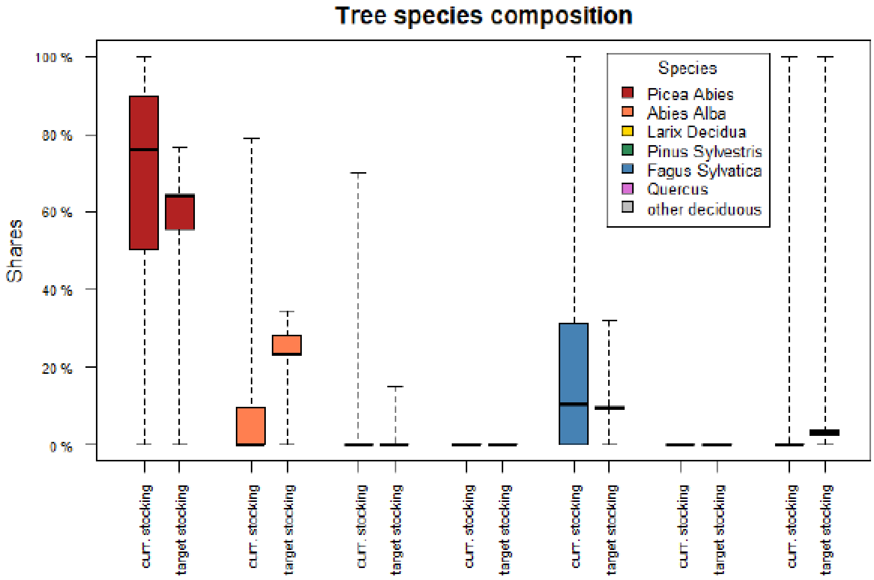


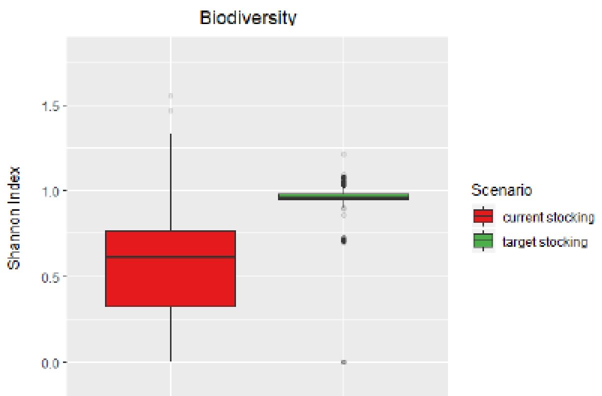


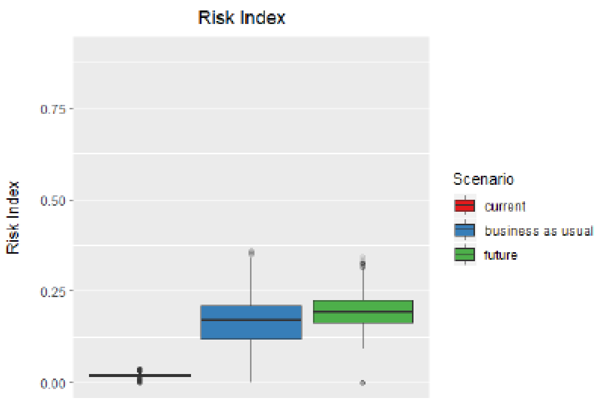


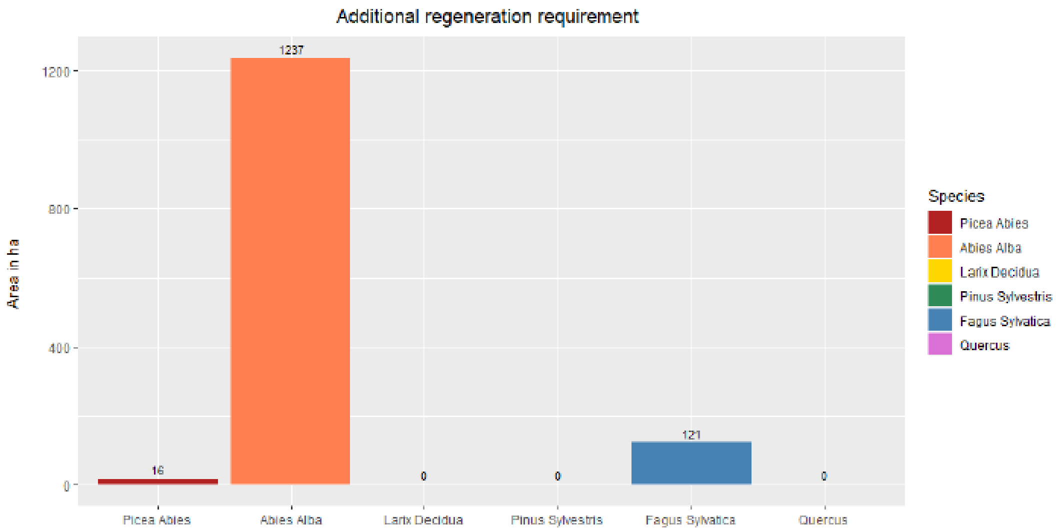


4.4.3 Location 3: Northern Traun-Innviertel on Flysch

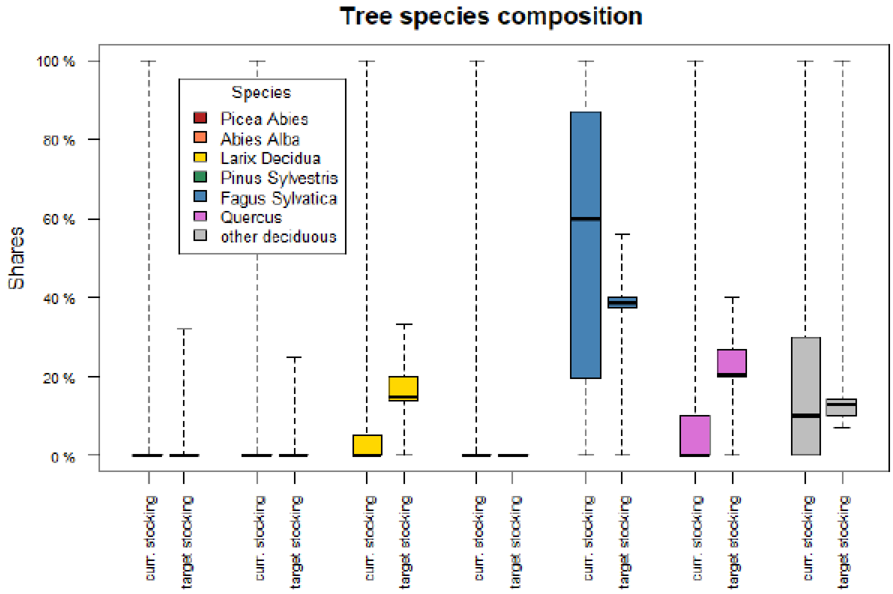


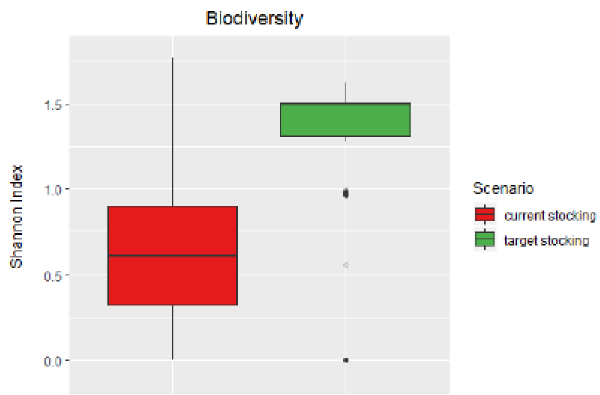


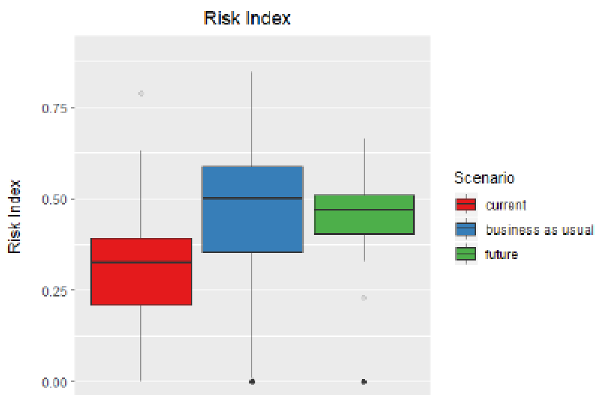


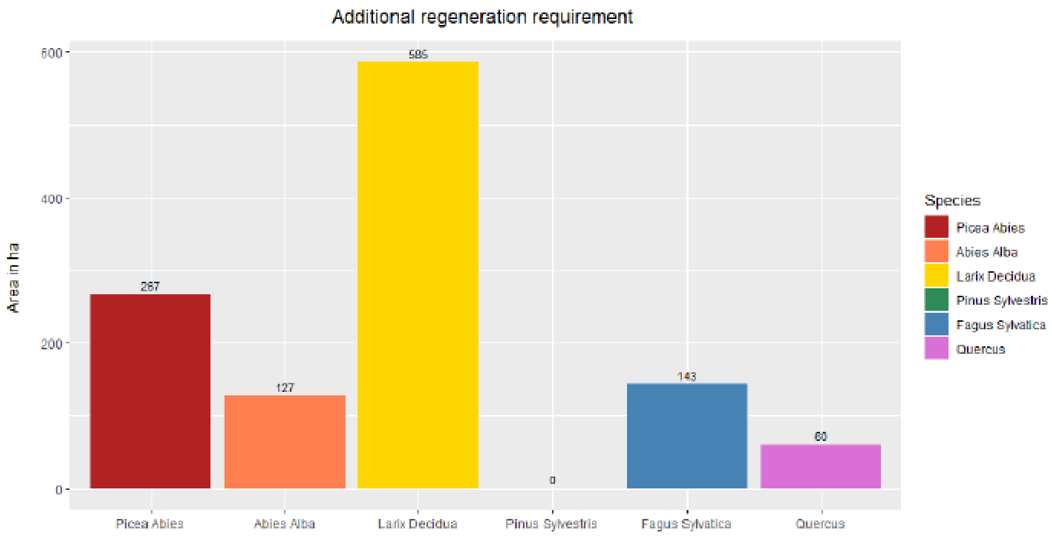


4.4.4 <u>Location 4:</u> North-Eastern Wienerwald

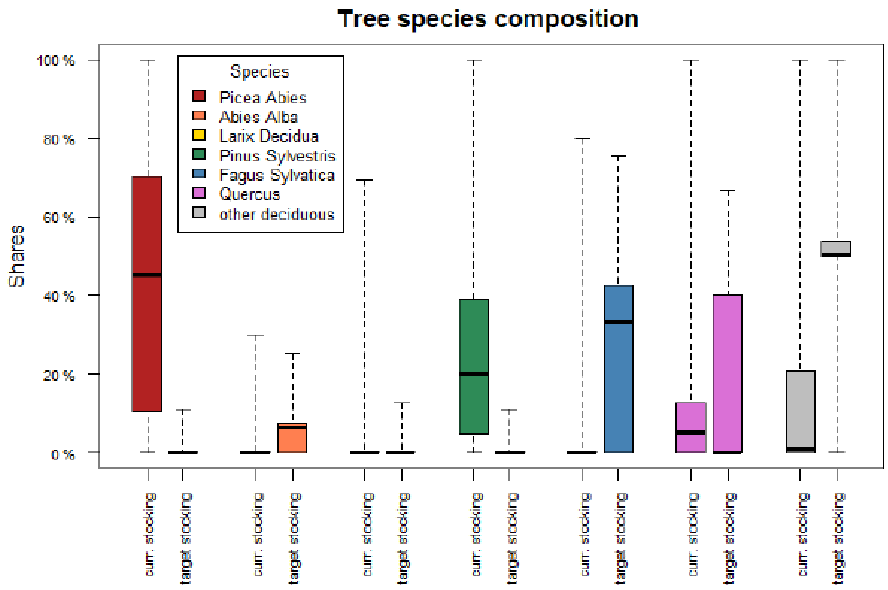


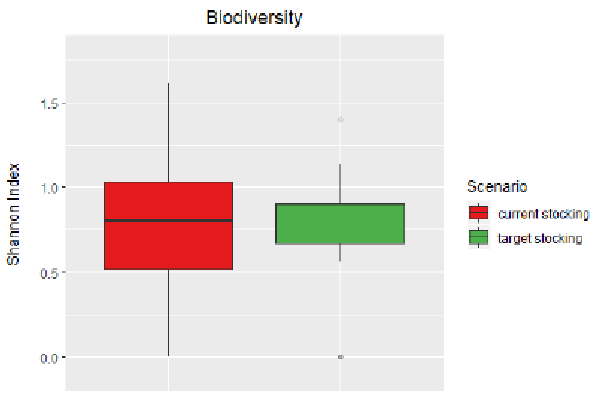


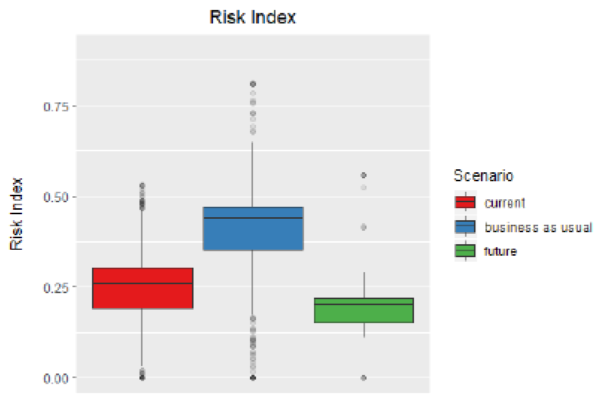




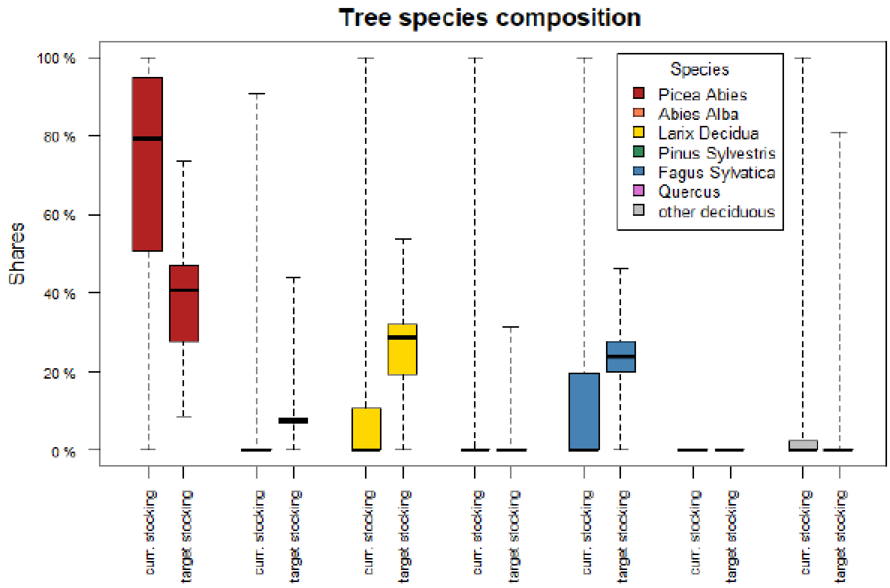
4.4.5 Location 5: Oberwart Forest District

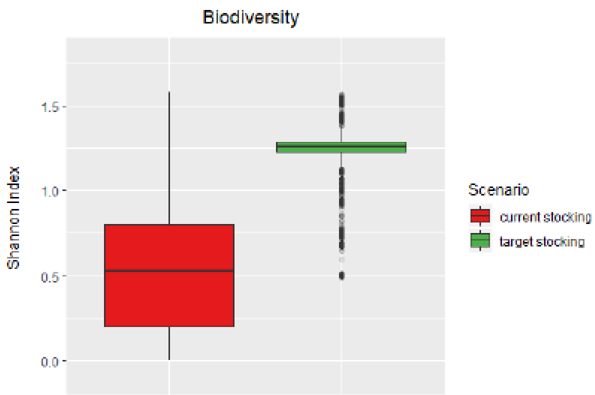


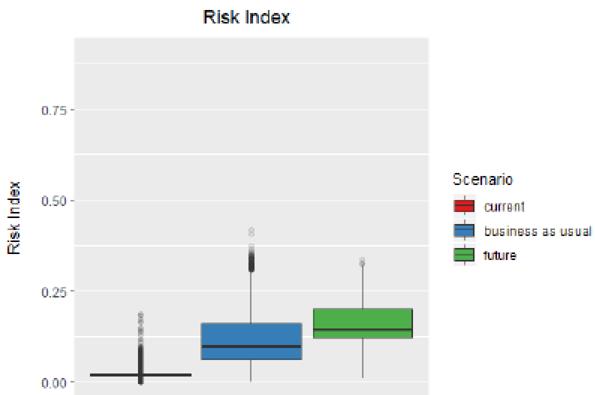


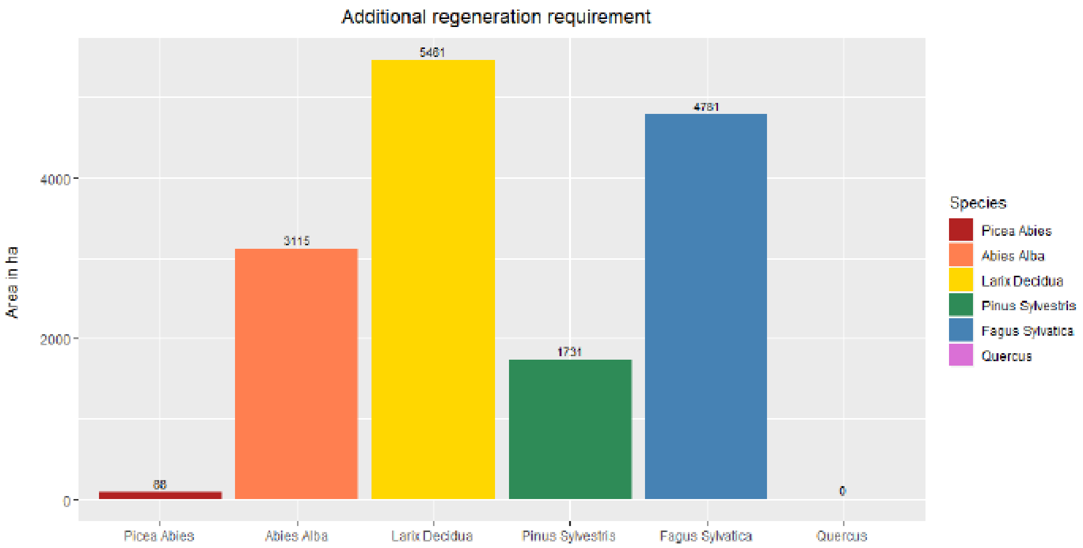


4.4.6 Location 6: Styria on Limestone

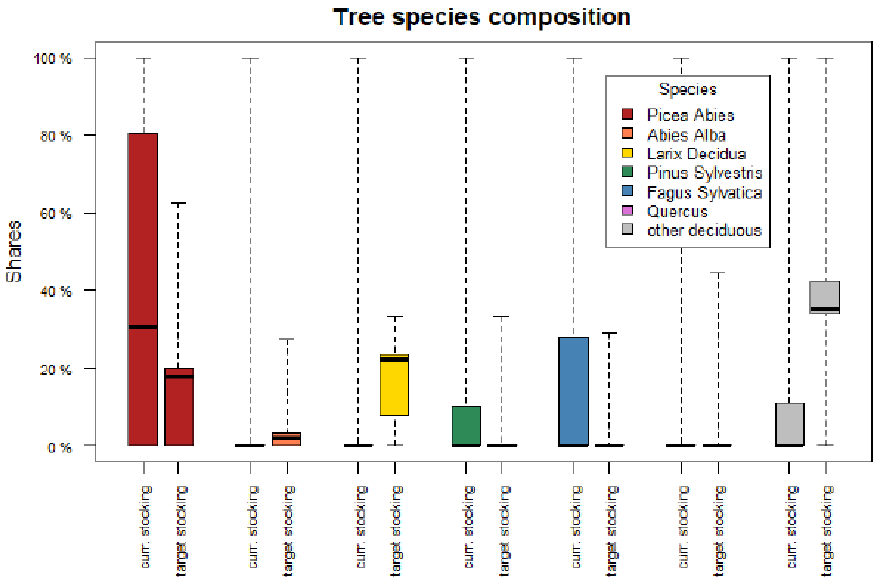


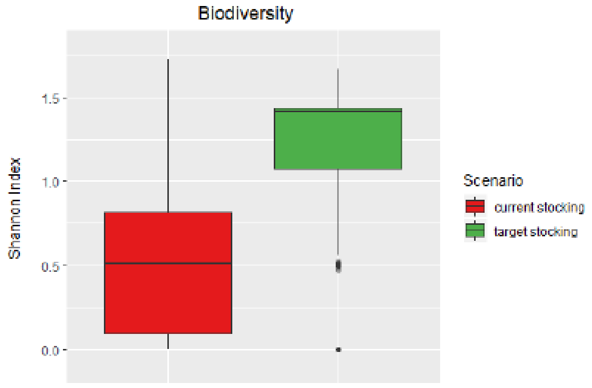


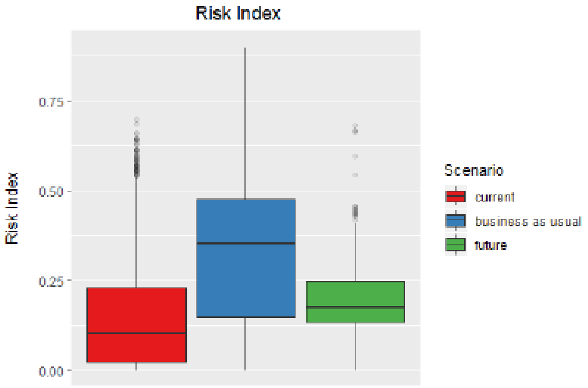


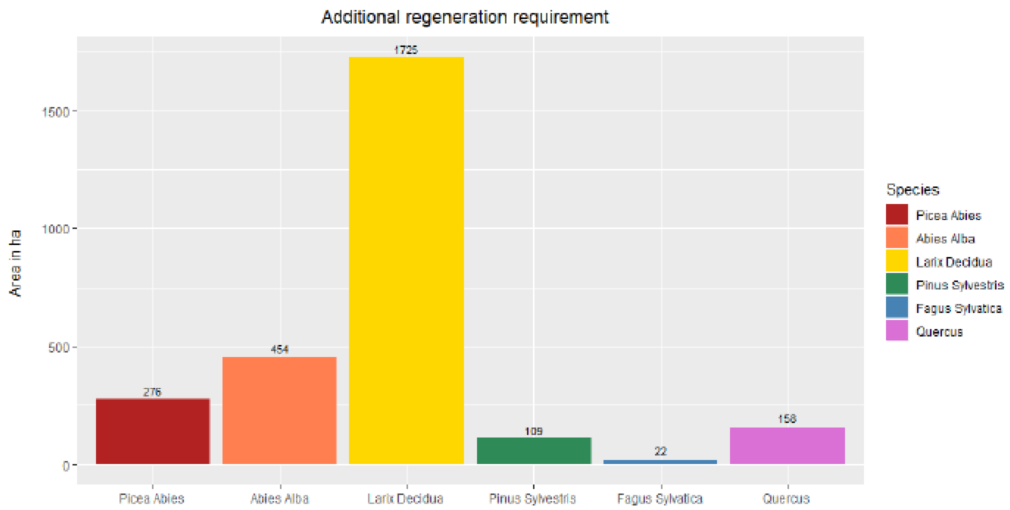


4.4.7 Location 7: Waldviertel

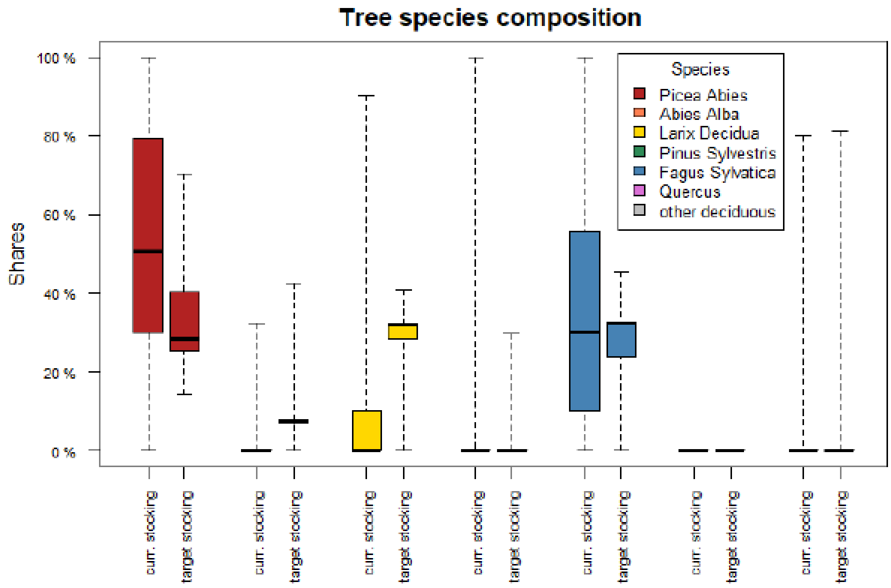


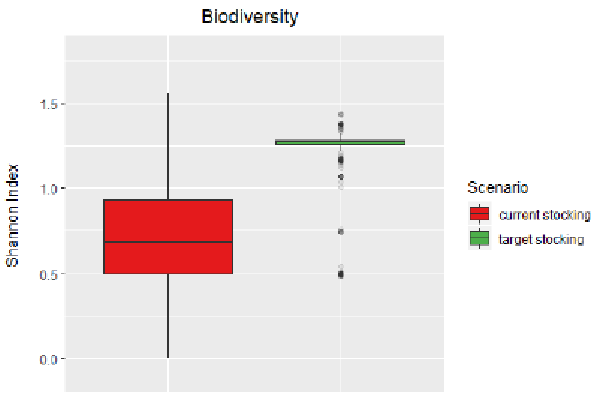


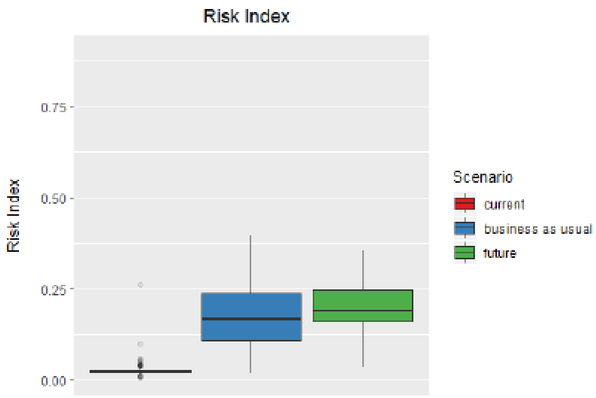


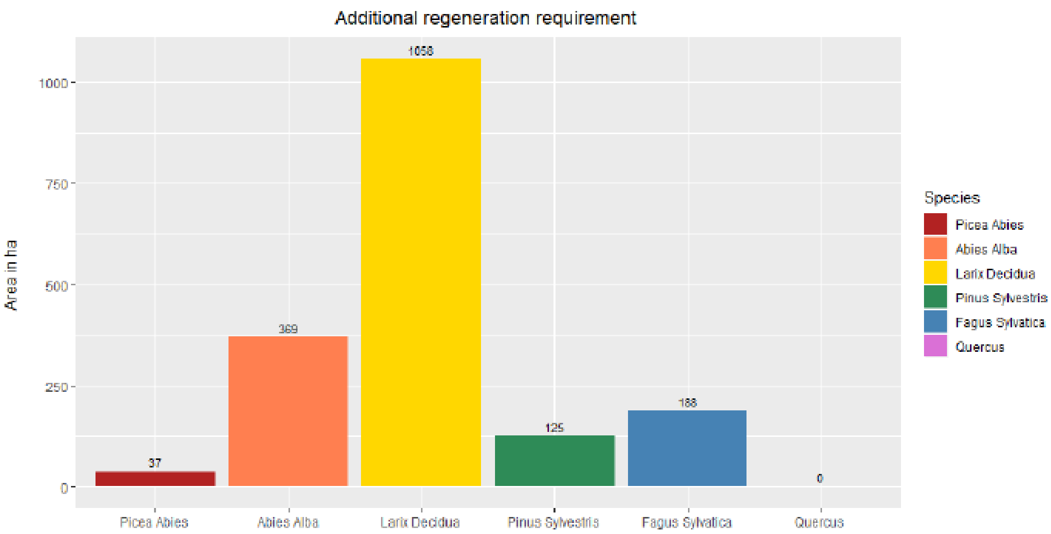


4.4.8 Location 8: Mitterweißenbach Forest District









5. CONCLUSIONS

The Austrian federal forests ÖBf proposes to respond to the effects of climate change by changing the current tree species composition by increasing the share of native broadleaved species such as the European beech and conifers such as the European larch and Silver fir The pilot action reveals that such a proposed change in species composition reduces vulnerability of the forests in almost all the Bioclimatic regions of Austria and within the most forest management units of the ÖBf. In addition, the increase in share of broadleaved species also promotes an increase in biodiversity, as estimated by Shannons Diversity index. In general for all the species, future adapted populations should originate from the warm and drier parts of their current distribution. Although the ÖBF has a reasonably good network of forest seed stands and seeds stored, the demands of adapted planting materials might not be met, if the suggested seed transfer is implemented as suggested. Therefore, new seed stands from adapted tree populations need to be identified and seed import from outside Austria need to be considered.