Supplementary material

1. LandClim model description

The LandClim model is sensitive to input files, and thus, an accurate description of forest stands characteristics is needed to avoid negative consequences [1]. Therefore, the information for the initial description of stand structure, species composition and diameter distribution was done using the management unit, volume, age and yield class are provided by forest management plans [2].

The model was applied without changing plant traits parameters (shade tolerance, temperature requirements, the maximum relative annual biomass growth) and phenomenological growth models [3].

Forest succession processes within each cell are simulated yearly, while landscape-level processes are simulated on a decadal time step.

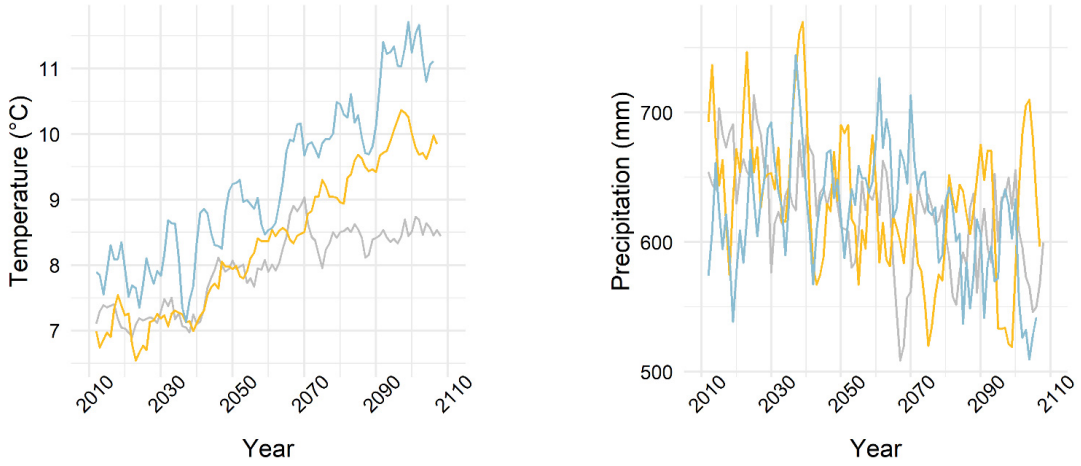
The LandClim control file requires different input files:

- a digital elevation model (DEM) resulted from GIS shapefiles from which for every centre of each cell was extracted elevation, aspect and slope;
- cell id for every cell of 25x25 m grid;
- the stand characteristics (age, species composition, basal area, yield class) were extracted from GIS Layer (attribute table) for the stand initial state file;
- climate data: monthly temperatures and precipitations having a lapse rate with increasing altitude for every climate scenario;
- soil available water capacity (AWC) was simulated for each cell as a function of elevation, aspect, and slope regarding the soil type (existing in a GIS layer). In Râșca FD, two main soil types are encountered: eutric cambisol (49%) with a soildepth of 110cm and district cambisol (41%) with 95 cm soil depth;
- forest area map of no forest, state forests, disputed lands, pasture lands, barren lands;
- management map with harvesting regime for each cell;
- stands map: to each cell was attributed the stand number of which is part of it [4];
- The LandClim produces various output as stem density and biomass, diameter at breast height (DBH), height, and age for each cohort in each grid cell. These variables were used further to calculate total standing biomass, mean age, total number of stems. The rooting system was determined using number of stems per specie and the rooting type of that species. The diameter at breast height and height were grouped in classes to determine stand structure through tree size diversity, which is post-hoc index.

The number of stems per species was also used to determine tree species diversity through the Shannon index.

This study did not use aggregate outputs, which offer information about species composition and biomass evolution during the simulation period. Instead, we identified the cells included in the soil protection category, and these cells were subset using 'sqldf' package.

Further, to determine PVI indicators (total biomass, age, total stems, rooting system, tree species diversity and tree size diversity) in each cell, the subset output was transposed using function reshape from package 'stats'.



*grey line – mild climate (CCSM3); orange line – moderate climate (ECHAM5); blue line – extreme climate (HADCM3)

Figure S1. Rolling average of mean temperature (°C) and precipitation sum (mm)

RCP and A1B scenarios were analysed by determining the mean temperature and sum of precipitation for reference years 2050 and 2070. The results showed that climate scenarios used in our simulations did not differ from RCP greenhouse gas scenarios and did not have extreme values.

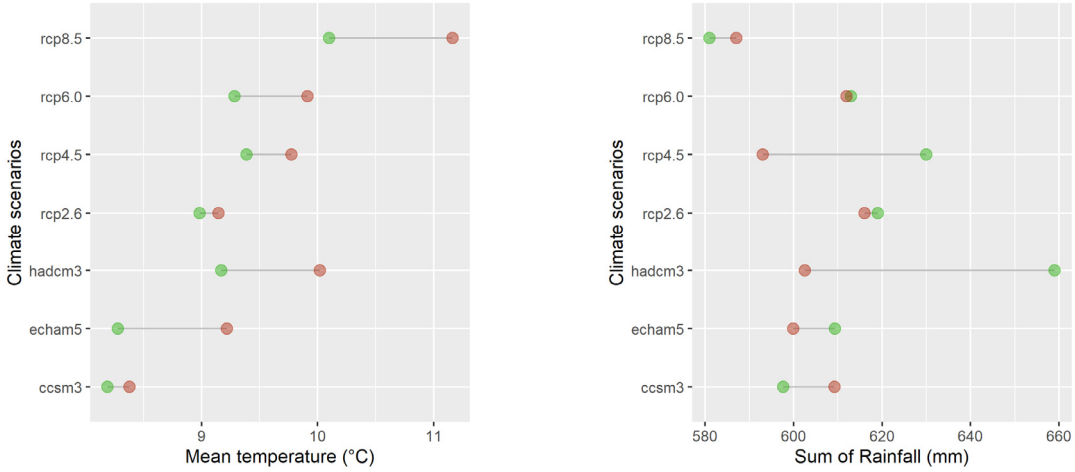


Figure S2. Comparing A1B scenarios (CCSM3, ECHAM5 and HADCM3) with RCP scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5)

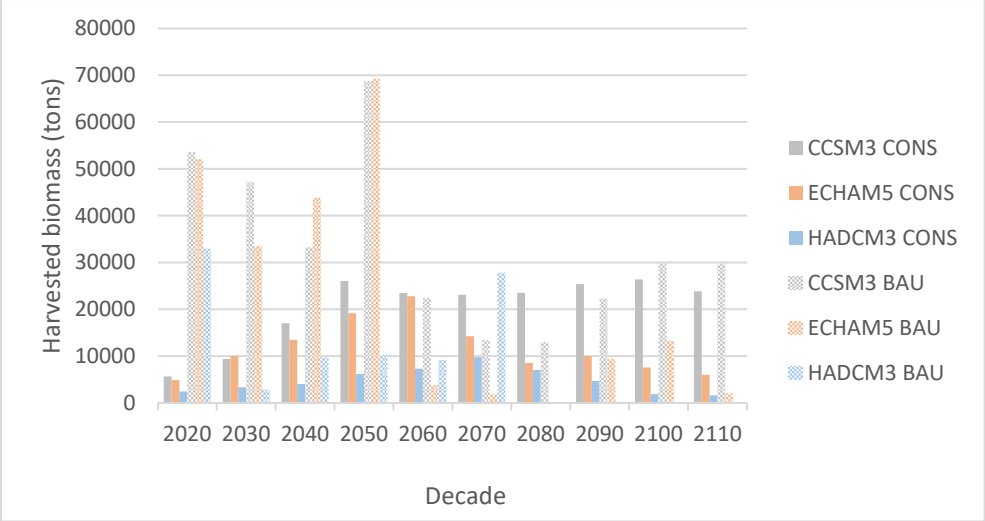


Figure S3. Harvested biomass from forest stands included in the soil protection category (grey column– mild climate (CCSM3); orange column – moderate climate (ECHAM5); blue column – extreme climate (HADCM3); full column – low-intensity management (CONS); gridded column – high-intensity management (BAU)

Table S1 Root type for forest species simulated in Râșca FD.

Nr. crt	Forest species	Root type	Root code
1.	*Abies alba*	tap root	2
2.	*Larix decidua*	heart root	3
3.	*Picea abies*	flat	1
4.	*Pinus sylvestris*	heart root	3
5.	*Acer pseudoplatanus*	heart root	3
6.	*Fagus sylvatica*	heart root	3
7.	*Quercus petrea*	tap root	2
8.	*Quercus robur*	tap root	2
9.	*Sorbus aucuparia*	heart root	3
10.	*Populus tremula*	flat	1
11.	*Salix caprea*	heart root	3
12.	*Alnus glutinosa*	heart root	3
13.	*Betula pendula*	heart root	3
14.	*Carpinus betulus*	heart root	3
15.	*Fraxinus excelsior*	heart root	3
16.	*Ulmus glabra*	heart root	3
17.	*Populus nigra*	flat	1
18.	*Alnus incana*	flat	1
19.	*Salix alba*	flat	1

Table S2 Harvesting parameters for current (low intensity) and business as usual (high intensity) management types

LABEL	min Bdt (t)	density	tAT (0-1)	tCT (0-1)
BAU_eaMix_Pr1_Harv	1.12	0	0.3	1
BAU_eaMix_Pr1_Thin7	0.96	400	1	1
BAU_eaMix_Pr1_Thin6	0.8	500	1	1
BAU_eaMix_Pr1_Thin5	0.68	650	1	1
BAU_eaMix_Pr1_Thin4	0.52	800	1	1
BAU_eaMix_Pr1_Thin3	0.4	1000	1	1
BAU_eaMix_Pr1_Thin2	0.24	1400	1	1
BAU_eaMix_Pr1_Thin1	0.16	2300	1	1
BAU_eaMix_Pr2_Harv	0.72	0	0.3	1
BAU_eaMix_Pr2_Thin7	0.64	500	1	1
BAU_eaMix_Pr2_Thin6	0.56	550	1	1
BAU_eaMix_Pr2_Thin5	0.48	650	1	1
BAU_eaMix_Pr2_Thin4	0.4	750	1	1
BAU_eaMix_Pr2_Thin3	0.32	900	1	1
BAU_eaMix_Pr2_Thin2	0.24	1100	1	1
BAU_eaMix_Pr2_Thin1	0.08	3200	1	1
BAU_eaMix_Pr3_Harv	0.4	0	0.3	1
BAU_eaMix_Pr3_Thin7	0.32	800	1	1
BAU_eaMix_Pr3_Thin6	0.24	1000	1	1
BAU_eaMix_Pr3_Thin5	0.2	1300	1	1
BAU_eaMix_Pr3_Thin4	0.16	1800	1	1
BAU_eaMix_Pr3_Thin3	0.12	2300	1	1
BAU_eaMix_Pr3_Thin2	0.08	3200	1	1
BAU_eaMix_Pr3_Thin1	0.04	5000	1	1
CONS_Uneven_Pr1	1.2	-	1	0.10

tAT – target Area Thinning (proportion of the mgmt area to cut (0-1)), the value differs from 1 in BAU final harvesting where is 0.3; tCT - target Cohort Thinning (proportion of each harvested cohort to cut (0-1)), the overall proportion is 1 and it is different in CONS where is 0.10; min Bdt – minimum Biomass of dominant trees (for the 100 trees/ha); value as for one individual); density - The target density of stems per ha for the species.

References

1. Temperli, C.; Zell, J.; Bugmann, H.; Elkin, C. Sensitivity of Ecosystem Goods and Services Projections of a Forest Landscape Model to Initialization Data. *Landsc. Ecol.* **2013**, *28*, 1337–1352, doi:10.1007/s10980-013-9882-0.

2. Bouriaud, L.; Bouriaud, O.; Elkin, C.; Temperli, C.; Reyer, C.; Duduman, G.; Barnoaiea, I.; Nichiforel, L.; Zimmermann, N.; Bugmann, H. Age-Class Disequilibrium as an Opportunity for Adaptive Forest Management in the Carpathian Mountains, Romania. *Reg. Environ. Chang.* **2014**, doi:10.1007/s10113-014-0717-6.

3. Schumacher, S.; Bugmann, H. The Relative Importance of Climatic Effects, Wildfires and Management for Future Forest Landscape Dynamics in the Swiss Alps. *Glob. Chang. Biol.* **2006**, *12*, 1435–1450, doi:10.1111/j.1365-2486.2006.01188.x.

4. Duduman, G.; Bouriaud, O.; Barnoaiea, I.; Drăgoi, M.; Bouriaud, L. Metodology and Preliminary Results of LANDCLIM Application in Mountainous Mixed Forests with Coniferous and Beech from Northern Romania - Draft. **2013**, 1–9.