

13 Terrestrial Biodiversity

13.1 Experiments

Table 34: provides an overview of all experiments to be run in the terrestrial-biodiversity sector in ISIMIP2a.

Table 34: Experiment summary for terrestrial-biodiversity models.

	Climate Data	Scenario	Human influences, land use (LU)	Other settings (sens-scenario)	# runs
Historical runs	EWEMBI	hist	nat	no CO2	1

13.2 Sector-specific input

Table 35: Biodiversity-specific input data used for building our models.

Dataset	Description	More info	Dates	Scale	Variables included
EWEMBI	Bioclimatic variables	30-year monthly means of minimum temperature (tasmin), maximum temperature (tasmax) and total precipitation (pr) were calculated and used to derive 19 bioclimatic variables; see (Hijmans, Cameron, Parra, Jones, & Jarvis, 2005)	30-yr averages of 1980 - 2009 (1995)	global, 0.5° (EWEMBI)	Bio4 (temperature seasonality), Bio5 (max temperature of warmest month), Bio12 (annual precipitation) and Bio15 (precipitation seasonality), Bio18 (precipitation of warmest quarter) and Bio19 (precipitation of coldest quarter)

13.3 Output data

Table 36: Output variables to be reported by terrestrial-biodiversity sector models.

Variable (long name)	Variable name	Units (NetCDF format)	Frequency	Comment
Essential outputs				
Species probability of occurrence				
Amphibian species probability of occurrence	amphibianprob	Probability of occurrence per cell ¹	30-year period centered around 1995 (1980 - 2009)	Results from individual SDMs assuming no dispersal. ²
Terrestrial bird species probability of occurrence	birdprob			
Terrestrial mammal species probability of occurrence	mammalprob			
Summed probability of occurrence				
Amphibian summed probability of occurrence	amphibiansumprob	Summed probability of occurrence per cell ¹	30-year period centered around 1995 (1980 - 2009)	Aggregated results from individual SDMs assuming no dispersal. ²
Terrestrial bird summed probability of occurrence	birdsumprob			
Terrestrial mammal summed probability of occurrence	mammalsumprob			
Endemic summed probability of occurrence				
Summed probability of endemic amphibian species ³	endamphibiansumprob	Summed probability of occurrence per cell ¹	30-year period centered around 1995 (1980 - 2009)	Aggregated results from individual SDMs assuming no dispersal. ²
Summed probability of endemic terrestrial bird species ³	endbirdsumprob			
Summed probability of endemic terrestrial mammal species ³	endmammalsumprob			
Threatened summed probability of occurrence				
Summed probability of threatened amphibian species ⁴	thramphibiansumprob	Summed probability of occurrence per cell ¹	30-year period centered around	Aggregated results from individual SDMs assuming

Summed probability of threatened terrestrial bird species ⁴	thrbirdsumprob		1995 (1980 - 2009)	no dispersal. ²
Summed probability of threatened terrestrial mammal species ⁴	thrmammalsumprob			
Species richness				
Amphibian species richness	amphibiansr	Estimated number of species (species richness) per cell	30-year period centered around 1995 (1980 - 2009)	Results from macroecological richness models
Terrestrial bird species richness	birdsr			
Terrestrial mammal species richness	mammalsr			

¹ For the Maximum Entropy (MaxEnt) model algorithm the output is not probability, but habitat suitability/relative occurrence probability. Values also range between 0 and 1.

² No dispersal assumes that species can only be present where they are actually present according to the IUCN and BirdLife range maps.

³ Endemic (range-restricted) species are the smallest ranging 15% of all species.

⁴ Threatened species are all species that are either (i) critically endangered, (ii) endangered or (iii) vulnerable according to their IUCN red list status.

15 References

- Arnell, N. (1999). A simple water balance model for the simulation of streamflow over a large geographic domain. *Journal of Hydrology*, 217(3-4), 314-335.
- Cescatti, A., & Piutti, E. (1998). Silvicultural alternatives, competition regime and sensitivity to climate in a European beech forest. *Forest Ecology and Management*, 102(2), 213-223.
- Choulga, M., Kourzeneva, E., Zakharova, E., & Doganovsky, A. (2014). Estimation of the mean depth of boreal lakes for use in numerical weather prediction and climate modelling. *Tellus A. Dyn. Meteorol. Oceanogr.*, 66(1), 21295.
- Davie, J. C., Falloon, P. D., Kahana, R., Dankers, R., Betts, R., Portmann, F. T., . . . Arnell, N. (2013). Comparing projections of future changes in runoff and water resources from hydrological and ecosystem models in ISI-MIP. *Earth System Dynamics Discussions*, 4(1), 279-315.
- De Lary, R. (October, 2015). *Massif des Landes de Gascogne. II – ETAT DES CONNAISSANCES TECHNIQUES*. Bordeaux: CRPF Aquitaine.
- Dlugokencky, E., & Tans, P. (2019). *Trends in atmospheric carbon dioxide*. Retrieved November 2, 2019, from National Oceanic & Atmospheric Administration, Earth System Research Laboratory (NOAA/ESRL): https://www.esrl.noaa.gov/gmd/ccgg/trends/gl_data.html
- Döll, P., & Schmied, H. M. (2012). How is the impact of climate change on river flow regimes related to the impact on mean annual runoff? A global-scale analysis. *Environmental Research Letters*, 7(1), 14037.
- Döll, P., Kaspar, F., & Lehner, B. (2003). A global hydrological model for deriving water availability indicators: Model tuning and validation. *Journal of Hydrology*, 270(1-2), 105-134.
- Duncker, P. S., Barreiro, S. M., Hengeveld, G. M., Lind, T., Mason, W. L., Ambrozy, S., & Spiecker, H. (2012). Classification of Forest Management Approaches: A New Conceptual Framework and Its Applicability to European Forestry. *Ecology and Society*, 17(4).
- Elliott, J., Müller, C., Deryng, D., Chryssanthacopoulos, J., Boote, K. J., Büchner, M., . . . Ruane, A. C. (2015). The Global Gridded Crop Model Intercomparison: Data and modeling protocols for Phase 1 (v1.0). *Geosci. Model Dev.*, 8, 261-277.

- Fekete, B. M., Vörösmarty, C. J., & Grabs, W. (2000). Global Composite Runoff Fields on Observed River Discharge and Simulated Water Balances. *GRDC Reports*, 22(115).
- Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., . . . Hill. (2011). Solutions for a cultivated planet. *Nature*, 478(7369), 337-342.
- Fürstenau, C., Badeck, F. W., Lasch, P., Lexer, M. J., Lindner, M., Mohr, P., & Suckow, F. (2007). Multiple-use forest management in consideration of climate change and the interests of stakeholder groups. *Eur J Forest Res*, 126, 225-239.
- González, J. R., & Palahí, M. (2005). Optimising the management of *Pinus sylvestris* L. stand under risk of fire in Catalonia (north-east of Spain). *Ann. For. Sci.* 62, 62, 493-501.
- Gosling, S. N., & Arnell, N. W. (2011). Simulating current global river runoff with a global hydrological model: Model revisions, validation, and sensitivity analysis. *Hydrological Processes*, 25(7), 1129–1145.
- Gosling, S. N., Warren, R., Arnell, N. W., Good, P., Caesar, J., Bernie, D., . . . Smith, S. M. (2011). A review of recent developments in climate change science. Part II: The global-scale impacts of climate change. *Progress in Physical Geography*, 35(4), 443–464.
- Gutsch, M., Lasch, P., Suckow, F., & Reyer, C. (2011). Management of mixed oak-pine forests under climate scenario uncertainty. *Forest Systems*, 20(3), 453-463.
- Haddeland, I. C. (2011). Multimodel estimate of the global terrestrial water balance: setup and first results. *Journal of Hydrometeorology*, 110531121709055.
- Haith, D. A., & Shoemaker., L. L. (1987). Generalized Watershed Loading Functions for stream flow nutrients. *Water Resour. Bull.*, 23, 471-478.
- Håkanson, L. (1995). Models to predict Secchi depth in small glacial lakes. *Aquatic Science*, 57(1), 31–53.
- Hanewinkela, M., & Pretzsch, H. (2000). Modelling the conversion from even-aged to uneven-aged stands of Norway spruce (*Picea abies* L. Karst.) with a distance-dependent growth simulator. *Forest Ecology and Management*, 134, 55-70.

- Hein, S., & Dhôte, J.-F. (2006). Effect of species composition, stand density and site index on the basal area increment of oak trees (*Quercus* sp.) in mixed stands with beech (*Fagus sylvatica* L.) in northern France. *Ann. For. Sci.*, *63*, 457-467.
- Hijmans, R., Cameron, S., Parra, J., Jones, P., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, *25*, 1965-1978.
- Hurttt, G., Chini, L., Sahajpal, R., Frohking, S., & et al, .. (In prep.). Harmonization of global land-use change and management for the period 850-2100. *Geoscientific Model Development*.
- Kerr, G. (1996). The effect of heavy or 'free growth' thinning on oak (*Quercus petraea* and *Q. robur*). *Forestry: An International Journal of Forest Research*, *69*(4), 303-317.
- Kim, H. (. (n.d.). *Global Soil Wetness Project Phase 3*. Retrieved from Global Soil Wetness Project Phase 3: <http://hydro.iis.u-tokyo.ac.jp/GSWP3/>
- Klein Goldewijk, D. i. (2016). *A historical land use data set for the Holocene; HYDE 3.2 (replaced)*. Utrecht University. DANS.
- Koster, R. D., Fekete, B. M., Huffman, G. J., & Stackhouse, P. W. (2006). Revisiting a hydrological analysis framework with International Satellite Land Surface Climatology Project Initiative 2 rainfall, net radiation, and runoff fields. *Journal of Geophysical Research*, *111*(D22), D22S05.
- Kourzeneva, E. (2010). External data for lake parameterization in Numerical Weather Prediction and climate modeling. *Boreal Environ. Res.*, *15*(2), 165-177.
- Lähde, E., Laiho, O., & Lin, J. C. (2010). Silvicultural alternatives in an uneven-sized forest dominated by *Picea abies*. *Journal of Forest Research*, *15*(1), 14-20.
- Lange, S. (2019a). WFDE5 over land merged with ERA5 over the ocean (W5E5). V. 1.0. doi:10.5880/pik.2019.023
- Lange, S. (2019b). Earth2Observe, WFDEI and ERA-Interim data Merged and Bias-corrected for ISIMIP (EWEMBI) v1.1. *GFZ Data Services*. doi:10.5880/pik.2019.004
- Lascha, P., Badecka, F.-W., Suckowa, F., Lindnera, M., & Mohr, P. (2005). Model-based analysis of management alternatives at stand and regional

level in Brandenburg. *Forest Ecology and Management*, 207, 59-74.

Lehner, B., & Döll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. *J. Hydrol.*, 296(1-4), 1-22.

Liu, J., You, L., Amini, M., Obersteiner, M., Herrero, M., Zehnder, A. J., & Yang, H. (2010). A high-resolution assessment on global nitrogen flows in cropland. *National Academy of Sciences*, 107(17), 8035-8040.

Loustau, D., Bosc, A., Colin, A., Ogée, J., Davi, H., Francois, C., . . . Delage, F. (2005). Modeling climate change effects on the potential production of French plains forests at the sub-regional level. *Tree physiology*, 25, 813-23.

Meinshausen, M., Raper, S. C., & Wigley, T. M. (2011). Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6 – Part 1: Model description and calibration. *Atmospheric Chemistry and Physics*, 11(4), 1417–1456.

Millero, F., & Poisson, A. (1981). International one-atmosphere equation of state of seawater. *Deep-Sea Research*, 28, 625-629.

Monfreda, C., Ramankutty, N., & Foley, J. (2008). Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000. *Global Biogeochemical Cycles*, 22(GB1022).

Mueller, N., Gerber, J., Johnston, M., Ray, D., Ramankutty, N., & Foley, J. (2012). Closing yield gaps through nutrient and water management. *Nature*, 490, 254-257.

Mund, M. (2004). *Carbon pools of European beech forests (Fagus sylvatica) under different silvicultural management*. Göttingen: Forschungszentrum Waldökosysteme.

Oleson, K. W., Niu, G.-Y., Yang, Z.-L., Lawrence, D. M., Thornton, P. E., Lawrence, P. J., . . . Qian, T. (2008). Improvements to the Community Land Model and their impact on the hydrological cycle. *Journal of Geophysical Research*, 113(G1), G01021.

Pape, R. (1999). Effects of Thinning Regime on the Wood Properties and Stem Quality of *Picea abies*. *Scandinavian Journal of Forest Research*, 14(1), 38-50.

Portmann, F., Siebert, S., & Döll, P. (2010). MIRCA2000 – global monthly irrigated and rainfed crop areas around the year 2000: a new

high-resolution data set for agricultural and hydrological modeling. *Global Biogeochemical Cycles*, 24(1).

- Potter, P., Ramankutty, N., Bennett, E. M., & Donner, S. D. (2011). Global fertilizer and manure, version 1: nitrogen fertilizer application. NASA Socioeconomic Data and Applications Center.
- Pukkala, T., Miina, J., Kurttila, M., & Kolström, T. (1998). A spatial yield model for optimizing the thinning regime of mixed stands of *Pinus sylvestris* and *Picea abies*. *Scandinavian Journal of Forest Research*, 13(1-4), 31-42.
- Sacks, W. J., Deryng, D., Foley, J. A., & Ramankutty, N. (2010). Crop planting dates: an analysis of global patterns. *Global Ecology and Biogeography*, 19(5), 607-620.
- Schneiderman, E. M., Pierson, D. C., Lounsbury, D. G., & Zion, M. S. (2002). Modeling the hydrochemistry of the Cannonsville watershed with Generalized Watershed Loading Functions (GWLF). *J. Am. Water Resour. Assoc.*, 38, 1323-1347.
- Schütz, J.-P., Götz, M., Schmid, W., & Mandallaz, D. (2006). Vulnerability of spruce (*Picea abies*) and beech (*Fagus sylvatica*) forest stands to storms and consequences for silviculture. *Eur J Forest Res*, 125, 291-302.
- Shatwell, T., Thiery, W., & Kirillin, G. (2019). Future projections of temperature and mixing regime of European temperate lakes. *Hydrology and Earth System Sciences*, 23(3), 1533-1551.
- Sheffield, J., Goteti, G., & Wood, E. F. (2006). Development of a 50-Year High-Resolution Global Dataset of Meteorological Forcings for Land Surface Modeling. *Journal of Climate*, 19(13), 3088-3111.
- Štefančík, I. (2012). Growth characteristics of oak (*Quercus petraea* [Mattusch.] Liebl.) stand under different thinning regimes. *Journal of Forest Science*, 58(2), 67-78.
- Sterba, H. (1987). Estimating Potential Density from Thinning Experiments and Inventory Data. *Forest Science*, 33(4), 1022-1034.
- Stock, C. A., Dunne, J. P., & John, J. G. (2014). Global-scale carbon and energy flows through the marine planktonic food web: An analysis with a coupled physical-biological model. *Progress in Oceanography*, 120, 1-28.

- Subin, Z. M., Riley, W. J., & Mironov, D. (2012). An improved lake model for climate simulations: Model structure, evaluation, and sensitivity analyses in CESM1. *J. Adv. Model. Earth Syst.*, 4(1), M02001.
- Thivolle-Cazat, A. (2013). *Disponibilité en bois en Aquitaine de 2012 à 2025*. Bordeaux: FCBA, IGN, INRA, CRPF Aquitaine.
- Tian, H., Yang, J., Lu, C., Xu, R., Canadell, J. G., Jackson, R., . . . Wini. (2018). The global N2O Model Intercomparison Project (NMIP): Objectives, Simulation Protocol and Expected Products. *B. Am. Meteorol. Soc.*
- Weedon, G. P., Balsamo, G., Bellouin, N., Gomes, S., Best, M. J., & Viterbo, P. (2014). The WFDEI meteorological forcing data set: WATCH Forcing Data methodology applied to ERA-Interim reanalysis data. *Water Resources Research*, 50, 7505–7514.
- Weedon, G. P., Gomes, S., Viterbo, P., Shuttleworth, W. J., Blyth, E., Österle, H., . . . Best, M. (2011). Creation of the WATCH Forcing Data and Its Use to Assess Global and Regional Reference Crop Evaporation over Land during the Twentieth Century. *Journal of Hydrometeorology*, 12(5), 823–848.
- Wu, B., Yu, B., Yue, W., Shu, S., Tan, W., Hu, C., . . . Liu, H. (2013). A Voxel-Based Method for Automated Identification and Morphological Parameters Estimation of Individual Street Trees from Mobile Laser Scanning Data. *Remote Sensing*, 5(2), 584–611.
- Yoshimura, K., & Kanamitsu, M. (2008). Dynamical Global Downscaling of Global Reanalysis. *Monthly Weather Review*, 136(8), 2983–2998.
- Yoshimura, K., & Kanamitsu, M. (2013). Incremental Correction for the Dynamical Downscaling of Ensemble Mean Atmospheric Fields. *Monthly Weather Review*, 141(9), 3087–3101.