

Supplementary Information S1 for

Model based Comparison of Forest Carbon Uptake by Forest Growth and CO₂ Release due To Forest Operations for Case Studies in Europe and South Africa

by

Peter Biber, Eric Agestam, Kamil Bielak, Miren del Río, Ben du Toit, Stefano Grigolato, Marta Pardos, Hans Pretzsch, Ricardo Ruiz-Peinado, Julia Schmucker, Enno Uhl

Supplementary Table S1. Definitions of the nine silvicultural concepts applied in the study as required for simulations with *care4cmodel* (Biber et al., 2024). Each concept breaks the life of a forest stand down into several subsequent phases. For each phase, the information given in the table's column has to be provided with two exceptions: The volume increment during each phase results from the other given values and has, therefore not to be provided by the user, and the initial area shares were required for the "reality" scenarios only, as they are the estimated area shares of the different phases in the region the concept is applied. For users who want to make their own simulations with these concepts, we provide them as ready-to-go RData files that can be directly used with *care4cmodel* (Supplementary Information S2). The name of the corresponding file can be taken from the headline of each concept below.

The contents of the non-self-explaining columns are defined as follows: duration, the (average) duration of each phase in years; n subphases: the number of subphases used internally for calculation see Biber et al. (2024) for details; volume standing, average standing wood volume of a stand in each phase; volume removal, average annual removal volume; volume mortality, average annual mortality volume; n standing, average number of standing trees in each phase; n remove, average number of removal trees; dbh standing, mean diameter at breast height of the standing trees, dbh removal, mean dbh of the removal trees; harvest interval, typical time span between two subsequent harvest operations in each phase; survival cumulative, probability that a stand survives from its establishment until the end of the phase of interest; volume increment, the average annual volume increment of a stand in the phase of interest; initial area shares, see above.

Sweden - Scots pine		Concept file: c4cc_sw_p_sylvestris_t26_3th_7ph.Rdata							Forest road density: 20.0 m/ha					
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	initial_stand_I	8	3	0,0	0,0	0,00	2500	0	0,0	0,0	0	1,000	2,4	0,061
2	initial_stand_II	17	4	19,0	0,0	0,00	2500	0	4,4	0,0	0	0,997	3,2	0,149
3	young_growth	15	3	74,0	2,7	0,36	1634	81	11,5	9,4	15	0,992	8,7	0,163
4	polewood	10	3	159,0	6,8	0,81	920	45	17,2	16,6	10	0,985	9,8	0,163
5	pre_mature_stand	35	7	181,0	2,0	0,84	487	6	25,6	23,0	35	0,948	5,4	0,369
6	mature_stand	10	2	270,0	0,0	1,14	390	0	31,8	0,0	0	0,932	4,8	0,087
7	final_felling	1	1	307,0	309,4	0,00	386	386	33,4	33,4	1	0,930	2,4	0,009

Table continues on next page

Supplementary Table S1 continued

Poland - Scots pine		Concept file: c4cc_pl_p_sylvestris_boreal.Rdata						Forest road density: 14.1 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	young_growth	10	3	0,0	0,0	0,00	9150	0	0,0	0,0	0	1,000	4,0	0,060
2	thicket_stage	12	3	39,6	0,0	0,02	5450	3700	6,6	0,0	0	0,999	11,0	0,030
3	immature_timber	18	4	171,0	5,0	0,53	1326	17	15,2	9,2	6	0,991	11,1	0,060
4	premature_timber	20	4	272,2	3,5	0,54	970	9	22,6	16,8	8	0,989	7,9	0,270
5	mature_timber_I	37	8	348,8	3,0	0,35	510	2	29,3	23,8	10	0,984	5,1	0,480
6	mature_timber_II	20	4	414,4	0,0	1,01	349	0	33,9	28,6	0	0,883	3,3	0,060
7	final_harvest_phase	10	3	459,5	47,7	1,48	336	34	36,4	36,9	10	0,706	3,3	0,040
Germany - Scots pine		Concept file: c4cc_ger_p_sylvestris.Rdata						Forest road density: 20.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	initial_stand	15	3	0,0	0,0	0,00	7000	0	0,0	0,0	0	0,999	3,9	0,011
2	young_growth	14	3	58,5	0,0	0,14	6237	0	5,8	0,0	0	0,996	10,7	0,010
3	immature_timber	29	6	206,0	1,6	1,72	4168	18	10,3	12,9	5	0,979	9,1	0,053
4	mature_timber	49	10	373,5	4,4	1,60	970	8	22,9	25,8	10	0,910	7,5	0,451
5	final_harvest_phase_I	19	4	446,3	8,8	0,58	510	8	30,2	41,9	5	0,868	5,8	0,234
6	final_harvest_phase_II	29	6	378,2	16,5	0,47	356	12	32,7	41,5	5	0,791	3,9	0,241

Table continues on next page

Supplementary Table S1 continued

Spain - Scots pine		Concept file: c4cc_esp_p_sylvestris.Rdata						Forest road density: 20.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	initial_stand/young growth	20	4	0,0	0,0	0,00	8717	0	0,0	0,0	0	0,998	9,6	0,001
2	immature_timber	20	4	192,1	5,5	1,92	4785	120	10,3	8,9	10	0,992	18,0	0,029
3	mature_timber I	20	4	403,6	7,3	2,02	1607	25	21,4	16,7	10	0,977	16,3	0,214
4	mature_timber II	20	4	543,4	6,2	0,54	809	12	31,2	24,7	10	0,955	10,7	0,237
5	mature_timber III	20	4	623,5	17,0	0,62	549	5	38,0	31,0	20	0,923	8,2	0,188
6	final_harvest_phase_II	21	5	435,0	23,1	0,44	320	21	42,6	36,1	7	0,890	2,8	0,333

Spain - Maritime pine		Concept file: c4cc_esp_p_pinaster.Rdata						Forest road density: 26.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	initial_stand (young growth)	15	3	0,0	0,0	0,00	2000	0	0,0	0,0	0,0	0,998	13,0	0,006
2	immature_timber	15	3	195,0	7,9	0,79	1225	62	18,6	16,4	7,5	0,994	22,3	0,266
3	mature_timber	30	6	399,0	8,9	1,21	488	22	34,8	31,9	15,0	0,970	13,9	0,520
4	final_harvest_phase_	10	2	512,0	57,1	1,30	250	23	49,7	39,8	5,0	0,950	7,2	0,208

Table continues on next page

Supplementary Table S1 continued

South Africa - Maritime pine, site index 13				Concept file: c4cc_zaf_p_pinaster_si_13.RData				Forest road density: 20.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	Temp. unplanted	1	1	0,0	0,0	0,00	0	0	0,0	0,0	0	1,000	0,0	0,057
2	Establishment	4	4	0,0	0,0	0,00	1110	0	1,7	0,0	0	0,900	2,4	0,012
3	young_growth	4	4	9,5	1,8	0,02	1074	105	9,3	11,2	4	0,850	7,1	0,014
4	immature_timber	5	5	30,6	2,8	0,06	646	49	15,1	19,6	5	0,800	6,5	0,028
5	mature_timber	5	5	48,6	3,8	0,10	398	29	20,4	22,0	5	0,750	10,5	0,052
6	final_crop	12	12	81,4	9,8	0,15	247	20	29,2	33,7	12	0,700	3,2	0,837

South Africa - Maritime pine, site index 17				Concept file: c4cc_zaf_p_pinaster_si_17.RData				Forest road density: 20.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	Temp. unplanted	1	1	0,0	0,0	0,00	0	0	0,0	0,0	0	1,000	0,0	0,057
2	Establishment	4	4	0,0	0,0	0,00	1110	0	2,3	0,0	0	0,900	5,7	0,012
3	young_growth	4	4	22,8	3,8	0,05	1074	105	11,3	13,6	4	0,850	12,8	0,014
4	immature_timber	5	5	58,4	5,2	0,12	646	49	18,2	20,4	5	0,800	11,5	0,028
5	mature_timber	5	5	89,4	6,8	0,18	398	29	24,6	26,5	5	0,750	18,7	0,052
6	final_harvest_phase	12	12	148,0	17,6	0,27	247	20	34,9	40,2	12	0,700	5,5	0,837

Table continues on next page

Supplementary Table S1 continued

South Africa - Monterey pine, site index 25				Concept file: c4cc_zaf_p_radiata_si_25.Rdata				Forest road density: 20.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	Temp. unplanted	1	1	0,0	0,0	0,00	0	0	0,0	0,0	0	1,000	0,0	0,039
2	Establishment	4	4	0,0	0,0	0,00	1028	0	2,2	0,0	0	0,900	2,1	0,074
3	young_growth	4	4	8,3	1,5	0,02	995	123	10,3	11,2	4	0,850	11,4	0,112
4	immature_timber	5	5	47,9	4,5	0,08	497	39	17,3	17,8	5	0,800	22,8	0,198
5	mature_timber	6	5	139,2	0,0	0,19	298	0	24,9	0,0	0	0,750	25,9	0,353
6	final_crop	6	6	293,3	58,7	0,39	294	49	30,2	32,0	6	0,700	10,2	0,224

South Africa - Monterey pine, site index 30				Concept file: c4cc_zaf_p_radiata_si_30.Rdata				Forest road density: 20.0 m/ha						
phase number	phase_name	duration (years)	n sub-phases	volume standing (m ³ /ha)	volume removal (m ³ /ha/yr)	volume mortality (m ³ /ha/yr)	n standing (trees/ha)	n remove (trees/ha/yr)	dbh standing (cm)	dbh removal (cm)	harvest interval (years)	survival cumulative	volume increment (m ³ /ha/yr)	initial area shares
1	Temp. unplanted	1	1	0,0	0,0	0,00	0	0	0,0	0,0	0	1,000	0,0	0,039
2	Establishment	5	5	0,0	0,0	0,00	1028	0	2,5	0,0	0	0,900	3,6	0,074
3	young_growth	4	4	18,1	3,2	0,04	995	132	11,5	12,5	4	0,850	21,7	0,112
4	immature_timber	5	5	91,8	9,1	0,15	497	49	19,3	19,8	5	0,800	38,8	0,198
5	mature_timber	6	6	239,4	0,0	0,32	298	0	27,7	0,0	0	0,750	39,0	0,353
6	final_crop	6	6	471,4	94,2	0,63	294	49	33,7	35,6	6	0,700	16,3	0,224

End of table

Reference

Biber, P., Grigolato, S., Schmucker, J., Pretzsch, H., Uhl, E., 2024. A generic simulation model for relating forest CO₂ intake and CO₂ emissions by forest operations – The R-package *care4cmodel*. Comput. Electron. Agric. 222, 109091. <https://doi.org/10.1016/j.compag.2024.109091>