Supplementary Material

Table S1: Net primary production (NPP) sites from Luyssaert et al. (2007).

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
1	Aheden	64.20	19.50	Forest
2	Aubure (F)	48.20	7.18	Forest
3	Aubure (P)	48.20	7.18	Forest
4	Belgium	51.20	5.00	Forest
5	Bornhoved Alder	54.10	10.20	Forest
6	Bornhoved Beech	54.10	10.20	Forest
7	Brasschaat Oak	51.30	4.52	Forest
8	Brasschaat Pine	51.30	4.52	Forest
9	Collelongo	41.80	13.60	Forest
10	Dooary	53.00	-7.30	Forest
11	Finland 1	60.50	23.90	Forest
12	Finland 2	60.50	23.90	Forest
13	Flakaliden C	64.10	19.50	Forest
14	Flakaliden I + F	64.10	19.50	Forest
15	France	48.40	2.70	Forest
16	Gribskov	56.00	12.30	Forest
17	Hainich	51.10	10.40	Forest
18	Hesse	48.70	7.07	Forest
19	Hestehaven	56.30	10.50	Forest
20	Hungary	47.90	20.50	Forest
21	Ilomantsi 1	62.80	31.00	Forest
22	Ilomantsi 2	62.80	31.00	Forest
23	Ilomantsi 3	62.80	31.00	Forest
24	Ilomantsi 4	62.80	31.00	Forest
25	Ispina Krakow	50.10	20.40	Forest
26	Jädraas C	60.80	16.50	Forest
27	Jädraas I + F	60.80	16.50	Forest
28	Jezeri	50.50	13.50	Forest
29	Kannenbruch Alder/Ash	53.80	10.60	Forest
30	Kannenbruch Beech	53.80	10.60	Forest
31	Kannenbruch Oak	53.80	10.60	Forest
32	Karelia_1	62.00	34.00	Forest
33	Karelia_10	62.00	34.00	Forest
34	Karelia_11	62.00	34.00	Forest
35	Karelia_12	62.00	34.00	Forest
36	Karelia_13	62.00	34.00	Forest
37	Karelia_14	62.00	34.00	Forest
38	Karelia_15	62.00	34.00	Forest
39	Karelia_16	62.00	34.00	Forest
40	Karelia_17	62.00	34.00	Forest
41	Karelia_2	62.00	34.00	Forest
42	Karelia_3	62.00	34.00	Forest
43	Karelia_4	62.00	34.00	Forest
44	Karelia_5	62.00	34.00	Forest
45	Karelia_6	62.00	34.00	Forest

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Table S1 – continued from previous page

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
46	Karelia_7	62.00	34.00	Forest
47	Karelia_8	62.00	34.00	Forest
48	Karelia_9	62.00	34.00	Forest
49	Klosterhede	56.50	8.40	Forest
50	Kongalund B	56.00	13.20	Forest
51	Kongalund S	56.00	13.20	Forest
52	Kuusamo	66.40	29.30	Forest
53	Langarod	55.80	13.90	Forest
54	Lei-135+15	51.30	10.40	Forest
55	Lei-30	51.30	10.40	Forest
56	Lei-62	51.30	10.40	Forest
57	Lei-T-111	51.30	10.40	Forest
58	Linnebjer	55.70	13.30	Forest
59	Loobos	52.20	5.74	Forest
60	Meathop	54.20	-2.90	Forest
61	Monte di Mezzo	41.80	14.90	Forest
62	Nacetin	50.60	13.30	Forest
63	Oved	55.70	13.60	Forest
64	Popface alba	42.40	11.80	Forest
65	Popface euamericana	42.40	11.80	Forest
66	Popface nigra	42.40	11.80	Forest
67	Schacht	50.10	11.80	Forest
68	Skogaby	56.50	13.20	Forest
69	Solling	51.80	9.58	Forest
70	Soroe	55.50	11.60	Forest
71	Tharandt	51.00	13.60	Forest
72	Tharandt 24	50.90	13.50	Forest
73	Tharandt 42	50.90	13.50	Forest
74	Tharandt 5	50.90	13.50	Forest
75	Tharandt 97	50.90	13.50	Forest
76	Virelles	50.10	4.35	Forest
77	Waldstein	50.20	11.90	Forest
78	Wet-T-57	50.50	11.50	Forest
79	Wytham Woods	51.50	-1.30	Forest

Table S2: Gross primary production (GPP) sites from Luyssaert et al. (2007).

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
1	Aberfeldy/Griffins	56.60	-3.78	Forest
2	Bayreuth/Weiden Brunnen	50.15	11.87	Forest
3	Bilos	44.49	-0.96	Forest
4	Bilos Clear	44.48	0.87	Forest
5	Bily Kriz Forest	49.50	18.54	Forest
6	Bornhoved Alder	54.10	10.23	Forest
7	Bornhoved Beech	54.10	10.23	Forest
8	Brasschaat	51.31	4.52	Forest
9	Castelporziano	41.71	12.38	Forest
10	Collelongo	41.85	13.59	Forest
11	Dooary	52.95	-7.25	Forest
12	El Saler	39.35	-0.32	Forest
13	Espirra	38.64	-8.60	Forest
14	Flakaliden C	64.12	19.45	Forest
15	Fyedorovskoye	56.45	32.92	Forest
16	Hainich	51.08	10.45	Forest
17	Hampshire	51.12	-0.86	Forest
18	Hardwood	55.10	-2.05	Forest
19	Hardwood Clear	55.10	-2.05	Forest
20	Hardwood_21	55.10	-2.05	Forest
21	Hardwood_7	55.10	-2.05	Forest
22	Hesse	48.67	7.07	Forest
23	Hyytiala	61.85	24.30	Forest
24	Hyytiala 12	61.85	24.30	Forest
25	Hyytiala 75	61.85	24.30	Forest
26	Hyytiala Clear	61.85	24.30	Forest
27	Ilomantsi Mekrijärvi	62.78	30.97	Forest
28	Kannenbruch Alder/Ash	53.78	10.60	Forest
29	Kannenbruch Beech	53.78	10.60	Forest
30	Kannenbruch Oak	53.78	10.60	Forest
31	La Majadas del Tietar	39.94	-5.77	Forest
32	La Mandria	45.58	7.15	Forest
33	Lavarone	45.96	11.28	Forest
34	Le Bray	44.72	-0.77	Forest
35	Loobos	52.17	5.74	Forest
36	Mehrstedt	51.28	10.66	Forest
37	Mitra	38.54	-8.00	Forest
38	Nonantola	44.69	11.09	Forest
39	Norunda	60.09	17.48	Forest
40	Parco Ticino	45.20	9.06	Forest
41	Popface alba	42.36	11.80	Forest
42	Popface euamericana	42.36	11.80	Forest
43	Popface nigra	42.36	11.80	Forest
44	Puechabon	43.72	3.58	Forest
45	Renon	46.59	11.43	Forest
46	Roccarespampami 1	42.41	11.93	Forest
47	San Rossore	43.73	10.28	Forest

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Table S2 – continued from previous page

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
48	Skyttorp1	60.13	17.92	Forest
49	Skyttorp2	60.13	17.84	Forest
50	Sodankylä	67.36	26.64	Forest
51	Solling	51.82	9.58	Forest
52	Soroe	55.49	11.65	Forest
53	Tharandt	50.96	13.57	Forest
54	Vielsalm	50.31	6.00	Forest
55	Wet-T-57	50.45	11.46	Forest
56	Wytham Woods	51.46	-1.32	Forest

Table S3: Gross primary production (GPP) sites from FLUXNET and ICOS.

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type	Source
1	Sodankyla	67.36	26.64	Forest	FLUXNET
2	Degero	64.18	19.56	Grassland	ICOS
3	Hyytiala	61.85	24.29	Forest	FLUXNET
4	Jokioinen	60.90	23.51	Cropland	FLUXNET
5	Lettosuo	60.64	23.96	Forest	FLUXNET
6	Norunda	60.09	17.48	Forest	ICOS
7	Foulum	56.48	9.59	Cropland	FLUXNET
8	Fyodorovskoye	56.46	32.92	Forest	FLUXNET
9	Hyltemossa	56.10	13.42	Forest	ICOS
10	Voulundgaard	56.04	9.16	Cropland	ICOS
11	Enghave	55.69	12.19	Grassland	FLUXNET
12	Soroe	55.49	11.64	Forest	FLUXNET, ICOS
13	Horstermeer	52.24	5.07	Grassland	FLUXNET
14	Loobos	52.17	5.74	Forest	FLUXNET
15	Hohes Holz	52.09	11.22	Forest	ICOS
16	Leinefelde	51.33	10.37	Forest	FLUXNET
17	Brasschaat	51.31	4.52	Forest	FLUXNET, ICOS
18	Gebesee	51.10	10.91	Cropland	FLUXNET, ICOS
19	Hainich	51.08	10.45	Forest	FLUXNET
20	Tharandt	50.96	13.57	Forest	FLUXNET, ICOS
21	Grillenburg	50.95	13.51	Grassland	FLUXNET
22	Klingenberg	50.89	13.52	Cropland	FLUXNET
23	Selhausen Juelich	50.87	6.45	Cropland	FLUXNET, ICOS
24	Selhausen	50.87	6.45	Cropland	FLUXNET
25	Oberb„renburg	50.79	13.72	Forest	FLUXNET
26	Rollesbroich	50.62	6.30	Grassland	FLUXNET
27	Lonzee	50.55	4.75	Cropland	FLUXNET, ICOS
28	Vielsalm	50.30	6.00	Forest	FLUXNET, ICOS
29	Bily Kriz forest	49.50	18.54	Forest	FLUXNET, ICOS
30	Bily Kriz grassland	49.49	18.54	Grassland	FLUXNET
31	Lackenberg	49.10	13.30	Forest	FLUXNET
32	Grignon	48.84	1.95	Cropland	FLUXNET, ICOS
33	Lanzhot	48.68	16.95	Forest	ICOS
34	Fontainebleau-Barbeau	48.48	2.78	Forest	FLUXNET, ICOS
35	Laegern	47.48	8.36	Forest	FLUXNET
36	Oensingen crop	47.29	7.73	Cropland	FLUXNET
37	Oensingen grassland	47.29	7.73	Grassland	FLUXNET
38	Chamau	47.21	8.41	Grassland	FLUXNET
39	Frebel	47.12	8.54	Grassland	FLUXNET
40	Davos	46.82	9.86	Forest	FLUXNET
41	Renon	46.59	11.43	Forest	FLUXNET, ICOS
42	Monte Bondone	46.01	11.05	Grassland	FLUXNET
43	Lavarone	45.96	11.28	Forest	FLUXNET
44	Lavarone2	45.95	11.29	Forest	FLUXNET
45	Torgnon	45.84	7.58	Grassland	FLUXNET
46	Ispra ABC-IS	45.81	8.63	Forest	FLUXNET
47	Parco Ticino forest	45.20	9.06	Forest	FLUXNET

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Table S3 – continued from previous page

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type	Source
48	Le Bray	44.72	-0.77	Forest	FLUXNET
49	Bilos	44.49	-0.96	Forest	ICOS
50	Puechabon	43.74	3.60	Forest	FLUXNET, ICOS
51	San Rossore 2	43.73	10.29	Forest	FLUXNET
52	San Rossore	43.73	10.28	Forest	FLUXNET
53	Lamasquere	43.50	1.24	Cropland	ICOS
54	Roccarespampani 1	42.41	11.93	Forest	FLUXNET
55	Roccarespampani 2	42.39	11.92	Forest	FLUXNET
56	Castel d'Asso2	42.38	12.03	Cropland	FLUXNET
57	Castel d'Asso1	42.38	12.03	Forest	FLUXNET
58	Castel d'Asso3	42.38	12.02	Forest	FLUXNET
59	Collelongo	41.85	13.59	Forest	FLUXNET
60	Castelporziano	41.71	12.38	Forest	FLUXNET
61	Castelporziano2	41.70	12.36	Forest	FLUXNET, ICOS
62	Borgo Cioffi	40.52	14.96	Cropland	FLUXNET

Table S4: Gross primary production (GPP) sites from Campioli et al. (2015).

ID	Site	Latitude (° N)	Longitude (° E)	Ecosystem type
1	Aurade	43.55	1.11	Cropland
2	Lamasquere	43.50	1.24	Cropland
3	Grignon	48.84	1.95	Cropland
4	Lonzee_winter_wheat	50.55	4.74	Cropland
5	Lonzee_sugar_beet	50.55	4.74	Cropland
6	Lonzee_potato	50.55	4.74	Cropland
7	Avignon	43.92	4.88	Cropland
8	Lutjewad	53.40	6.36	Cropland
9	Oensingen	47.29	7.73	Cropland
10	Gebesee	51.10	10.91	Cropland
11	Risbyholm	55.53	12.10	Cropland
12	Beano1	46.00	13.02	Cropland
13	Klingenberg	50.89	13.52	Cropland
14	Dooary	52.95	-7.25	Forest
15	Wytham_Woods	51.46	-1.32	Forest
16	Puechabon	43.74	3.60	Forest
17	Lochristi	51.11	3.85	Forest
18	Hesse	48.67	7.07	Forest
19	Bornhoved_Alder	54.10	10.23	Forest
20	Bornhoved_Beech	54.10	10.23	Forest
21	Hainich	51.08	10.45	Forest
22	Kannenbruch_AlderAsh	53.78	10.60	Forest
23	Kannenbruch_Beech	53.78	10.60	Forest
24	Kannenbruch_Oak	53.78	10.60	Forest
25	Caldaro	46.35	11.27	Forest
26	Soroe	55.49	11.64	Forest
27	Popface_alba	42.36	11.80	Forest
28	Popface_euamericana	42.36	11.80	Forest
29	Popface_nigra	42.36	11.80	Forest
30	Tharandt	50.96	13.57	Forest
31	Collelongo	41.85	13.59	Forest
32	Flakaliden_C	64.11	19.46	Forest
33	Beano2	46.00	13.02	Grassland
34	Grillenburg	50.95	13.51	Grassland
35	Kursk	51.67	36.50	Grassland

Table S5: List of studies included in the meta-analysis for different land-use change (LUC) transitions: cropland-to-grassland (C-to-G), grassland-to-cropland (G-to-C), cropland-to-forest (C-to-F), grassland-to-forest (G-to-F), and forest-to-cropland (F-to-C). Three designs include P—paired plots, C—chronosequences, or M—mono-site samplings; N is the number of samples.

ID	Country	Design	N	Depth (cm)	LUC transitions	Reference
1	Italy	P	5	30	G-to-F, C-to-F	Alberti et al. (2011)
2	Italy	C	10	30	G-to-F	Alberti et al. (2008)
3	Crete	C	2	15	C-to-G	Apostolakis et al. (2017)
4	France	P	14	50	F-to-C	Arrouays and Pelissier (1994)
5	England	C	12	40	G-to-F, C-to-F	Ashwood et al. (2019)
6	Italy	C	8	30	C-to-F	Badalamenti et al. (2019)
7	Denmark	C	30	25	C-to-G, C-to-F	Bárcena et al. (2014)
8	Ireland	C	5	30	G-to-F	Black et al. (2009)
9	Germany	C	7	20	C-to-G	Breuer et al. (2006)
10	Turkey	P	1	20	G-to-C	Celik (2005)
11	Germany	P	12	20	C-to-G	Chen et al. (2009)
12	Italy	C	20	30	G-to-F, C-to-G, C-to-F	Tommaso et al. (2018)
13	Russia	C	4	20	C-to-G	lopes de Gerenyu et al. (2008)
14	Italy	M	2	30	G-to-C, C-to-F	Del Galdo et al. (2003)
15	Germany	P	2	50	C-to-G	Don et al. (2009)
16	Turkey	P	1	70	F-to-G	Gol and Dengiz (2008)
17	Russia	M	1	60	F-to-G	Heikkinen et al. (2014)
18	Germany	M	3	60	G-to-C, F-to-G	John et al. (2005)
19	France	M	6	25	F-to-C	Jolivet et al. (1997)
20	France	M	13	20	F-to-C	Jolivet et al. (2003)
21	Germany	M	3	30	C-to-G	Hofmann-Schielle et al. (1999)
22	Sweden	C	9	20	G-to-C, C-to-G	Kätterer et al. (2008)
23	Russia	M	3	20	C-to-G	Larionova et al. (2003)
24	Germany	P	4	30	G-to-C, C-to-G	Leifeld and Kögel-Knabner (2005)
25	Italy	P	3	40	G-to-C	Papini et al. (2011)
26	Ireland	P	2	30	G-to-F	Peichl et al. (2012)
27	Austria, Denmark, Germany, Ireland, Italy, Lithuania, Netherlands, Scotland, Sweden, Switzerland	P	24	80	C-to-G, G-to-C, G-to-F, C-to-F	Poeplau and Don (2013)
28	England	P	7	69	C-to-F, C-to-G	Poulton et al. (2003)
29	Spain	M	12	30	C-to-F	Romanyà et al. (2000)

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Table S5 – continued from previous page

ID	Country	Design	N	Depth (cm)	LUC transitions	Reference
30	Germany	C	7	29	G-to-C	Springob et al. (2001)
31	Italy, Germany	C	26	50	G-to-C	Thuille and Schulze (2006)
32	Sweden, Denmark, Netherlands	C	60	25	C-to-F	Vesterdal et al. (2007)
33	Ireland	P	42	30	G-to-F	Wellock et al. (2011)
34	England	C	4	10	F-to-F	Zerva et al. (2005)

Table S6: The observed carbon response function (CRF) and the leave-one-out coefficient of determination (R^2) measure for each land-use change (LUC) scenario in meta-analyses. (R^2 values range from 0 to 1, where values closer to 1 indicate better predictive performance of the model.)

LUC	ID	Model	R^2
Cropland-to-grassland	C-to-G	0.85 × age + 11.75	0.57
Grassland-to-cropland	G-to-C	-13.92 × $e^{age/133.80}$	0.62
Grassland-to-forest (mineral soil or without forest floor)	G-to-F_{woFF}	-0.10 × age + 3.54	0.89
Grassland to forest (with forest floor)	G-to-F_{wFF}	0.03 × age + 2.24	0.58
Cropland-to-forest (mineral soil)	C-to-F_{woFF}	0.74 × age - 5.78	0.99
Cropland-to-forest (with forest floor)	C-to-F_{wFF}	1.09 × age + 3.54	0.52
Forest-to-cropland (mineral soil)	F-to-C_{woFF}	-1.10 × age - 16.03	0.98

Table S7: The leave-one-out coefficient of determination (R^2) and root mean square error (RMSE in $kg\ m^{-2}$) between the random forest regression and model bias for each land-use change (LUC) scenario. Results with negative R^2, indicating poor regression, are not shown. Two distinct forest types, namely temperate broadleaf summergreen (TeBS) and temperate needleleaf evergreen (TeNE), are considered for the forest sites.

Forest type	LUC	ID	R^2	RMSE
	Cropland-to-grassland	C-to-G	0.13	1.25
	Grassland-to-cropland	G-to-C	0.44	1.08
TeBS	Grassland to forest (mineral soil or without forest floor)	G-to-F_{woFF}	0.19	3.59
	Grassland-to-forest (with forest floor)	G-to-F_{wFF}	-	-
	Cropland-to-forest (mineral soil)	C-to-F_{woFF}	0.26	1.92
	Cropland-to-forest (with forest floor)	C-to-F_{wFF}	-	-
	Forest-to-cropland (mineral soil)	F-to-C_{woFF}	0.11	3.03
TeNE	Grassland to forest (mineral soil or without forest floor)	G-to-F_{woFF}	0.18	3.58
	Grassland-to-forest (with forest floor)	G-to-F_{wFF}	-	-
	Cropland-to-forest (mineral soil)	C-to-F_{woFF}	0.19	2.03
	Cropland-to-forest (with forest floor)	C-to-F_{wFF}	-	-
	Forest-to-cropland (mineral soil)	F-to-C_{woFF}	0.18	3.14

References

Alberti, G., Peressotti, A., Piussi, P., and Zerbi, G.: Forest ecosystem carbon accumulation during a secondary succession in the Eastern Prealps of Italy, Forestry: An International Journal of Forest Research, 81, 1–11, https://doi.org/10.1093/forestry/cpm026, 2008.

Alberti, G., Leronni, V., Piazzi, M., Petrella, F., Mairota, P., Peressotti, A., Piussi, P., Valentini, R., Gristina, L., La Mantia, T., Novara, A., and Rühl, J.: Impact of woody encroachment on soil organic carbon and nitrogen in abandoned agricultural lands along a rainfall gradient in Italy, Regional Environmental Change, 11, 917–924, https://doi.org/10.1007/s10113-011-0229-6, 2011.

Apostolakis, A., Panakoulia, S., Nikolaidis, N. P., and Paranychianakis, N. V.: Shifts in soil structure and soil organic matter in a chronosequence of set-aside fields, Soil and Tillage Research, 174, 113–119, https://doi.org/https://doi.org/10.1016/j.still.2017.07.004, 2017.

Arrouays, D. and Pelissier, P.: Changes in carbon storage in temperate humic loamy soils after forest clearing and continuous corn cropping in France, Plant and Soil, 160, 215–223, https://doi.org/10.1007/BF00010147, 1994.

Table S8: Correlation (COR) and root mean square error (RMSE in $kg\ m^{-2}$) between observed and simulated soil organic carbons ($SOC_{LUCAS\ topsoil}$ and $SOC_{derived\ ORC}$) at different grid scales (from 0.5° × 0.5° to 3° × 3° cells), for three groups of vegetation (forest, grass, and crop).

Grid scale	Forest			Grass			Crop		
	COR	RMSE ($kg\ m^{-2}$)	rRMSE (%)	COR	RMSE ($kg\ m^{-2}$)	rRMSE (%)	COR	RMSE ($kg\ m^{-2}$)	rRMSE (%)
0.5° × 0.5°	0.17	2.82	59.15	0.53	1.57	39.38	0.42	1.18	35.98
1° × 1°	0.26	2.57	52.87	0.56	1.43	35.41	0.47	1.04	30.78
2° × 2°	0.39	2.48	48.21	0.52	1.31	31.77	0.54	0.91	26.6
3° × 3°	0.45	2.36	45.59	0.68	1.14	27.43	0.59	0.88	25.39

Ashwood, F., Watts, K., Park, K., Fuentes-Montemayor, E., Benham, S., and Vanguelova, E. I.: Woodland restoration on agricultural land: long-term impacts on soil quality, Restoration Ecology, 27, 1381–1392, https://doi.org/https://doi.org/10.1111/rec.13003, 2019.

Badalamenti, E., Battipaglia, G., Gristina, L., Novara, A., Rühl, J., Sala, G., Sapienza, L., Valentini, R., and La Mantia, T.: Carbon stock increases up to old growth forest along a secondary succession in Mediterranean island ecosystems, PLOS ONE, 14, 1–13, https://doi.org/10.1371/journal.pone.0220194, 2019.

Black, K., Byrne, K. A., Mencuccini, M., Tobin, B., Nieuwenhuis, M., Reidy, B., Bolger, T., Saiz, G., Green, C., Farrell, E. T., and Osborne, B.: Carbon stock and stock changes across a Sitka spruce chronosequence on surface-water gley soils, Forestry: An International Journal of Forest Research, 82, 255–272, https://doi.org/10.1093/forestry/cpp005, 2009.

Breuer, L., Huisman, J., Keller, T., and Frede, H.-G.: Impact of a conversion from cropland to grassland on C and N storage and related soil properties: Analysis of a 60-year chronosequence, Geoderma, 133, 6–18, https://doi.org/https://doi.org/10.1016/j.geoderma.2006.03.033, advances in landscape-scale soil research, 2006.

Bárcena, T. G., Gundersen, P., and Vesterdal, L.: Afforestation effects on SOC in former cropland: oak and spruce chronosequences resampled after 13 years, Global Change Biology, 20, 2938–2952, https://doi.org/https://doi.org/10.1111/gcb.12608, 2014.

Campioli, M., Vicca, S., Luyssaert, S., Bilcke, J., Ceschia, E., Chapin III, F. S., Ciais, P., Fernández-Martínez, M., Malhi, Y., Obersteiner, M., Olefeldt, D., Papale, D., Piao, S. L., Peñuelas, J., Sullivan, P. F., Wang, X., Zenone, T., and Janssens, I. A.: Biomass production efficiency controlled by management in temperate and boreal ecosystems, Nature Geoscience, 8, 843–846, https://doi.org/10.1038/ngeo2553, 2015.

Celik, I.: Land-use effects on organic matter and physical properties of soil in a southern Mediterranean highland of Turkey, Soil and Tillage Research, 83, 270–277, https://doi.org/https://doi.org/10.1016/j.still.2004.08.001, 2005.

Chen, H., Marhan, S., Billen, N., and Stahr, K.: Soil organic-carbon and total nitrogen stocks as affected by different land uses in Baden-Württemberg (southwest Germany), Journal of Plant Nutrition and Soil Science, 172, 32–42, https://doi.org/https://doi.org/10.1002/jpln.200700116, 2009.

Del Galdo, I., Six, J., Peressotti, A., and Francesca Cotrufo, M.: Assessing the impact of land-use change on soil C sequestration in agricultural soils by means of organic matter fractionation and stable C isotopes, Global Change Biology, 9, 1204–1213, https://doi.org/https://doi.org/10.1046/j.1365-2486.2003.00657.x, 2003.

Don, A., Scholten, T., and Schulze, E.-D.: Conversion of cropland into grassland: Implications for soil organic-carbon stocks in two soils with different texture, Journal of Plant Nutrition and Soil Science, 172, 53–62, https://doi.org/https://doi.org/10.1002/jpln.200700158, 2009.

Gol, C. and Dengiz, O.: Effect of modifying land cover and long-term agricultural practices on the soil characteristics in native forest-land, J Environ Biol, 29, 677–682, 2008.

Heikkinen, J., Kurganova, I., Lopes de Gerenyu, V., Palosuo, T., and Regina, K.: Changes in soil carbon stock after cropland conversion to grassland in Russian temperate zone: measurements versus model simulation, Nutrient Cycling in Agroecosystems, 98, 97–106, https://doi.org/10.1007/s10705-014-9599-8, 2014.

Hofmann-Schielle, C., Jug, A., Makeschin, F., and Rehfuess, K.: Short-rotation plantations of balsam poplars, aspen and willows on former arable land in the Federal Republic of Germany. I. Site–growth relationships, Forest Ecology and Management, 121, 41–55, https://doi.org/https://doi.org/10.1016/S0378-1127(98)00555-6, 1999.

John, B., Yamashita, T., Ludwig, B., and Flessa, H.: Storage of organic carbon in aggregate and density fractions of silty soils under different types of land use, Geoderma, 128, 63–79, https://doi.org/https://doi.org/10.1016/j.geoderma.2004.12.013, mechanisms and regulation of organic matter stabilisation in soils, 2005.

Jolivet, C., Arrouays, D., Andreux, F., and Lévèque, J.: Soil organic carbon dynamics in cleared temperate forest spodosols converted to maize cropping, Plant and Soil, 191, 225–231, https://doi.org/10.1023/A:1004294822799, 1997.

Jolivet, C., Arrouays, D., Lévèque, J., Andreux, F., and Chenu, C.: Organic carbon dynamics in soil particle-size separates of sandy Spodosols when forest is cleared for maize cropping, European Journal of Soil Science, 54, 257–268, https://doi.org/https://doi.org/10.1046/j.1365-2389.2003.00541.x, 2003.

Kätterer, T., Andersson, L., Andrén, O., and Persson, J.: Long-term impact of chronosequential land use change on soil carbon stocks on a Swedish farm, Nutrient Cycling in Agroecosystems, 81, 145–155, https://doi.org/10.1007/s10705-007-9156-9, 2008.

Larionova, A. A., Rozanova, L. N., Yevdokimov, I. V., Yermolayev, A. M., Kurganova, I. N., and Blagodatsky, S. A.: Land-use change and management effects on carbon sequestration in soils of Russia's South Taiga zone, Tellus B, 55, 331–337, https://doi.org/https://doi.org/10.1034/j.1600-0889.2003.00042.x, 2003.

Leifeld, J. and Kögel-Knabner, I.: Soil organic matter fractions as early indicators for carbon stock changes under different land-use?, Geoderma, 124, 143–155, https://doi.org/https://doi.org/10.1016/j.geoderma.2004.04.009, 2005.

lopes de Gerenyu, V., Kurganova, I., and Kuzyakov, Y.: Carbon pool and sequestration in former arable Chernozems depending on restoration period, Ekologija, 54, 232–238, https://doi.org/10.2478/v10055-008-0034-9, 2008.

Luyssaert, S., Inglima, I., Jung, M., Richardson, A., Reichsteins, M., Papale, D., Piao, S., Schulzes, E., Wingate, L., Matteucci, G., Aragao, L., Aubinet, M., Beers, C., Bernhoffer, C., Black, K., Bonal, D., Bonnefond, J., Chambers, J., Ciais, P., Cook, B., Davis, K., Dolman, A., Gielen, B., Goulden, M., Grace, J., Granier, A., Grelle, A., Griffis, T., Gruenwald, T., Guidolotti, G., Hanson, P., Harding, R., Hollinger, D., Hutyra, L., Kolar, P., Kruijt, B., Kutsch, W., Lagergren, F., Laurila, T., Law, B., Le Maire, G., Lindroth, A.,

Loustau, D., Malhi, Y., Mateus, J., Migliavacca, M., Misson, L., Montagnani, L., Moncrieff, J., Moors, E., Munger, J., Nikinmaa, E., Ollinger, S., Pita, G., Rebmann, C., Roupsard, O., Saigusa, N., Sanz, M., Seufert, G., Sierra, C., Smith, M., Tang, J., Valentini, R., Vesala, T., and Janssens, I.: CO2 balance of boreal, temperate, and tropical forests derived from a global database, Global Change Biology, 13, 2509–2537, https://doi.org/https://doi.org/10.1111/j.1365-2486.2007.01439.x, 2007.

Papini, R., Valboa, G., Favilli, F., and L'Abate, G.: Influence of land use on organic carbon pool and chemical properties of Vertic Cambisols in central and southern Italy, Agriculture, Ecosystems and Environment, 140, 68–79, https://doi.org/https://doi.org/10.1016/j.agee.2010.11.013, 2011.

Peichl, M., Leava, N. A., and Kiely, G.: Above- and belowground ecosystem biomass, carbon and nitrogen allocation in recently afforested grassland and adjacent intensively managed grassland, Plant and Soil, 350, 281–296, https://doi.org/10.1007/s11104-011-0905-9, 2012.

Poeplau, C. and Don, A.: Sensitivity of soil organic carbon stocks and fractions to different land-use changes across Europe, Geoderma, 192, 189–201, https://doi.org/https://doi.org/10.1016/j.geoderma.2012.08.003, 2013.

Poulton, P. R., Pye, E., Hargreaves, P. R., and Jenkinson, D. S.: Accumulation of carbon and nitrogen by old arable land reverting to woodland, Global Change Biology, 9, 942–955, https://doi.org/https://doi.org/10.1046/j.1365-2486.2003.00633.x, 2003.

Romanyà, J., Cortina, J., Falloon, P., Coleman, K., and Smith, P.: Modelling changes in soil organic matter after planting fast-growing Pinus radiata on Mediterranean agricultural soils, European Journal of Soil Science, 51, 627–641, https://doi.org/https://doi.org/10.1111/j.1365-2389.2000.00343.x, 2000.

Springob, G., Brinkmann, S., Engel, N., Kirchmann, H., and Böttcher, J.: Organic C levels of Ap horizons in North German Pleistocene sands as influenced by climate, texture, and history of land-use, Journal of Plant Nutrition and Soil Science, 164, 681–690, https://doi.org/https://doi.org/10.1002/1522-2624(200112)164:6¡681::AID-JPLN681¿3.0.CO;2-V, 2001.

Thuille, A. and Schulze, E.-D.: Carbon dynamics in successional and afforested spruce stands in Thuringia and the Alps, Global Change Biology, 12, 325–342, https://doi.org/https://doi.org/10.1111/j.1365-2486.2005.01078.x, 2006.

Tommaso, C., Emanuele, B., Guido, P., Lucia, P., Vincenza, C. M., and Riccardo, V.: Soil organic carbon pool's contribution to climate change mitigation on marginal land of a Mediterranean montane area in Italy, Journal of Environmental Management, 218, 593–601, https://doi.org/https://doi.org/10.1016/j.jenvman.2018.04.093, 2018.

Vesterdal, L., Rosenqvist, L., Van Der Salm, C., Hansen, K., Groenenberg, B. J., and Johansson, M. B.: Carbon Sequestration in Soil and Biomass Following Afforestation: Experiences from Oak and Norway Spruce Chronosequences in Denmark, Sweden and the Netherlands, pp. 19–51, Springer Netherlands, https://doi.org/10.1007/1-4020-4568-9_2, 2007.

Wellock, M. L., LaPerle, C. M., and Kiely, G.: What is the impact of afforestation on the carbon stocks of Irish mineral soils?, Forest Ecology and Management, 262, 1589–1596, https://doi.org/https://doi.org/10.1016/j.foreco.2011.07.007, 2011.

Zerva, A., Ball, T., Smith, K. A., and Mencuccini, M.: Soil carbon dynamics in a Sitka spruce (Picea sitchensis (Bong.) Carr.) chronosequence on a peaty gley, Forest Ecology and Management, 205, 227–240, https://doi.org/https://doi.org/10.1016/j.foreco.2004.10.035, 2005.

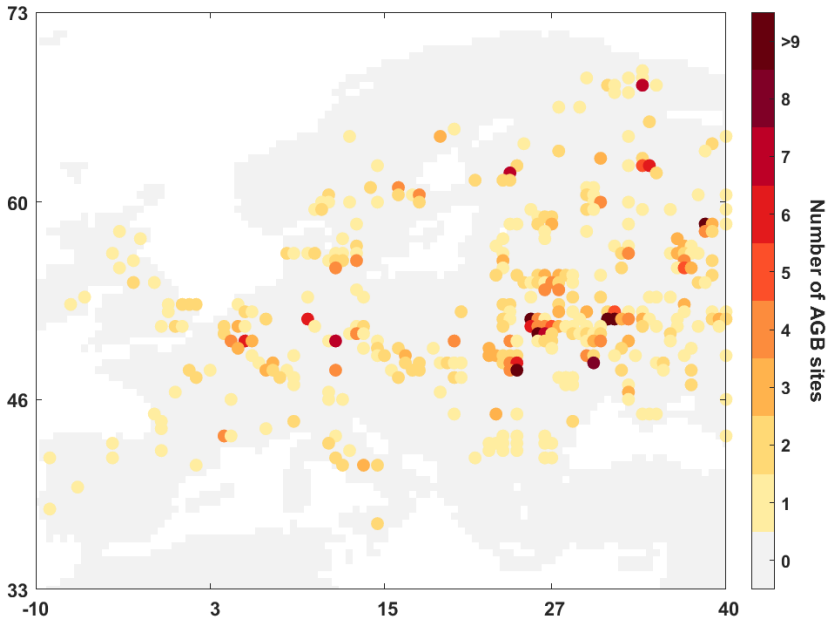

Figure S1: Map showing the observed above-ground biomass (AGB) sites included in the study.

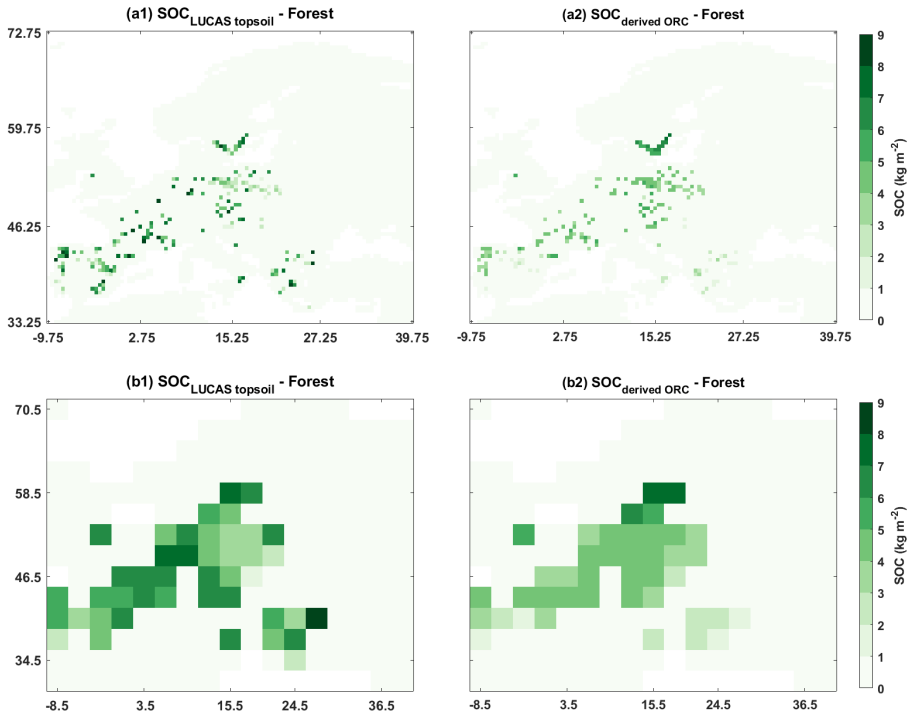

Figure S2: Maps showing the comparison between soil organic carbon of LUCAS topsoil and corresponding ORCHIDEE values ($SOC_{LUCAS\ topsoil}$ (a1,b1) and $SOC_{derived\ ORC}$ (a2,b2), in $kg\ m^{-2}$) at different grid scales ($0.5° \times 0.5°$ (a1, a2) and $3° \times 3°$ (b1,b2)) for forest sites.

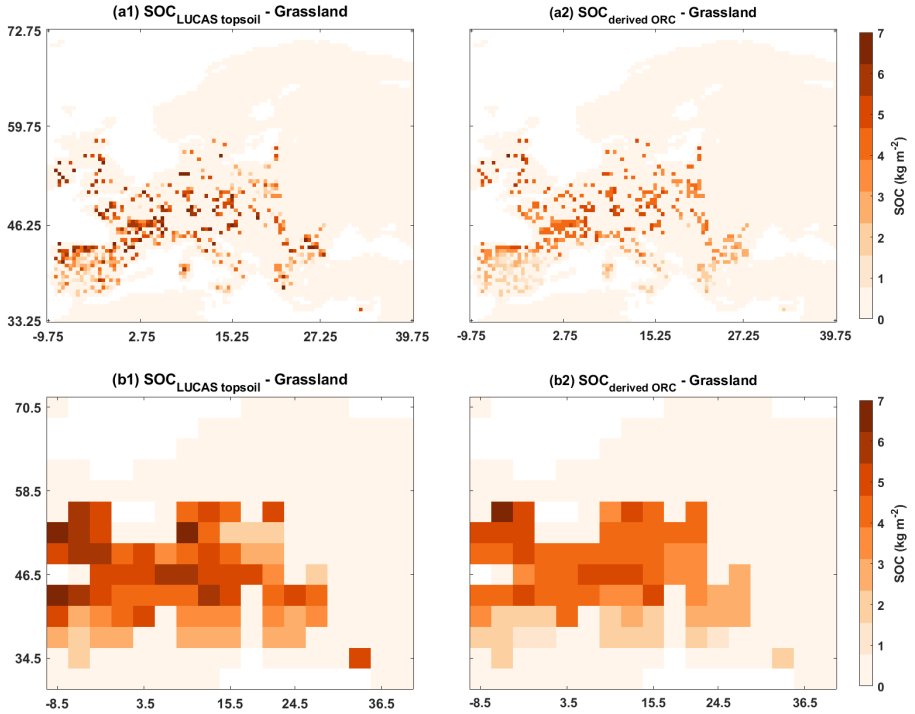

Figure S3: Same as Fig. S2, but for grassland sites.

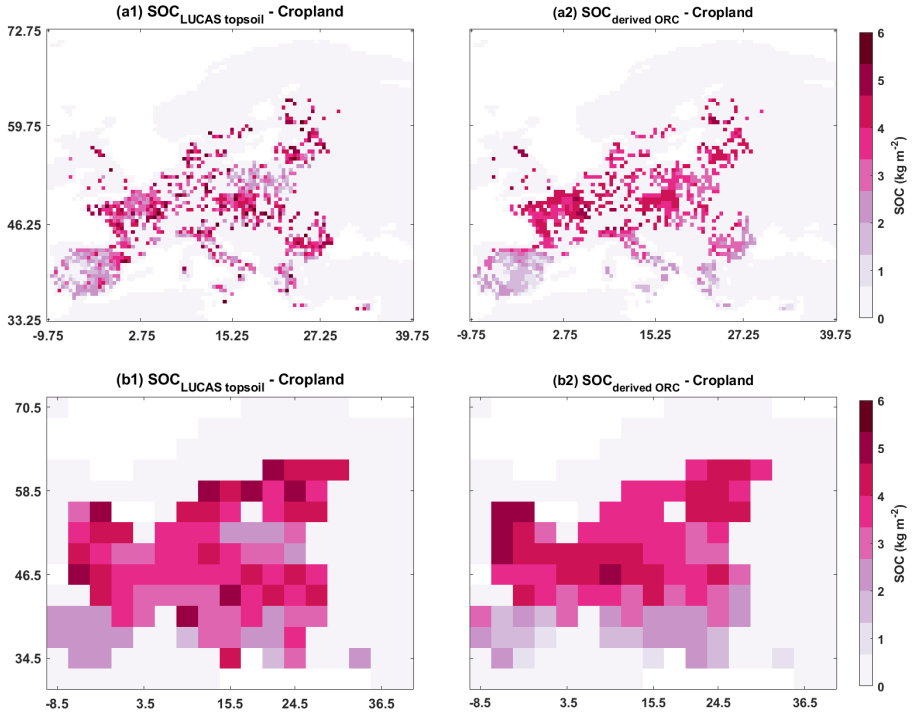

Figure S4: Same as Fig. S2, but for cropland sites.