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Supplement of

Increasing soil carbon stocks in eight permanent forest plots in China

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1 **Supporting information**

2

3 **Supplementary Materials and Methods**

4 **Study sites and field measurements**

5 The sites of this study were selected in boreal, temperate, subtropical and tropical forests
6 spanning approximately 26° latitude in the eastern China (Fig. 1, Table 1). The detailed
7 information about each site is described below.

8 **Boreal forest:** The boreal site was established in Tahe, Great Xing'anling, northeastern China
9 (52°38'42"N, 123°46'08"E), in May 1998 (Wang et al., 2001). The topography is gently
10 undulating with an average slope of 10°. The elevation is 466 m. The mean annual
11 temperature (MAT) and precipitation (MAP) are -4.3 °C and 477 mm, respectively. The
12 frost-free period is shorter than 100 days, and the snow pack lasts for approximately 5 months
13 in this region. The *Larix* forest was a 100-year-old mature forest at the time of the first
14 sampling, dominated by *Larix gmelinii* accompanied by *Betula platyphylla*, *Pinus sylvestris*,
15 *Picea koraiensis*, and *Populus davidiana*. The understory is dominated by *Ledum palustre*.
16 The parent material is granite bedrock, and the soil is a dark brown forest soil. The soil in the
17 plots has depths of 30–40 cm, with a pH between 5.0 and 6.0.

18 **Temperate forests:** The temperate site on Mt. Dongling stands near the Xiaolongmen
19 forestland (39°57'04"N–39°57'35"N, 115°25'25"E–115°25'45"E), Beijing, China. The
20 temperate forests in this region are protected and have not experienced serious anthropogenic
21 disturbance (Fang et al., 2007). The MAT and MAP were 4.8 °C and 612 mm, respectively
22 (Fig. 1, Table 1). We selected three plots from the top to the foot of a mountain as the
23 temperate plots of deciduous broadleaf birch (*Betula platyphylla*) and oak (*Quercus*
24 *wutaishanica*) forests and a pine (*Pinus tabulaeformis*) plantation in 1992. The soil in this
25 region has a depth of 90–110 cm and a pH that ranges between 6.0 and 7.0.

26 The birch plot is located on a northwest-facing slope near the peak of the mountain, with
27 an elevation of 1,350 m. The forest is dominated by *B. platyphylla* accompanied by *B. utilis*
28 and *Populus alba*. The woody plants in the understory include *Sorbus pohuashanensis*,
29 *Lonicera japonica*, *Prunus armeniaca*, *Corylus mandshurica*, *Acer mono*, *Abelia biflora*,
30 *Leptodermis oblonga*, *Spiraea sargentiana*, and *Macrocarpium officinalis*. The oak plot is
31 located on a southwest-facing slope on the middle of the mountain, with an elevation of 1,150
32 m. The forest is a secondary forest recovered from human disturbance, dominated by *Q.*
33 *wutaishanica* accompanied by *B. utili*. The understory woody plants include *S. sargentiana*, *A.*
34 *mono*, *Lespedeza bicolor*, *L. japonica*, *C. mandshurica*, and *Deutzia scabra*. Both the birch
35 and the oak forests are secondary deciduous broadleaf forests (55 years at the time of the first
36 sampling). The pine forest is on a southeast-facing slope at the foot of the mountain, with an
37 altitude of 1,050 m. The pine forest was a 30-year-old plantation at the time of the first
38 sampling, dominated by only one tree species, *P. tabuliformis*, with very few plants in the
39 understory and a thick litter floor.

40 **Subtropical forests:** The subtropical site is located in the Dinghushan Biosphere Reserve
41 (23°09'21"N–23°11'30"N, 112°30'39"E–112°33'41"E) in Guangdong Province, China. The
42 region has a typical southern subtropical monsoon climate (warm and humid). The MAP is
43 1,678 mm, 80% of which falls in the wet season (April to September), and the MAT is
44 22.3 °C. The altitude in the reserve ranges from 10 m to 1,000 m. The bedrock is sandstone
45 and shale, with a pH that ranges between 4.0 and 4.9.

46 A 50 × 50 m² plot, representative of the monsoon evergreen broadleaf forests in the
47 region, was established in 1979 at an elevation of 275 m on a south-facing slope. The
48 evergreen broadleaf forest has not been disturbed for more than 400 years (Zhou et al., 2006).
49 The plants in the evergreen plot are typical and natives of tropics and subtropics, including
50 *Castanopsis chinensis*, *Canarium pimela*, *Schima superba*, and *Engelhardtia roxburghiana*,

51 among others. The sub-canopy layer is mainly composed of *Cryptocarya concinna* and
52 *Machilus chinensis*. Another two 30 × 40 m² plots had also been established in 1979. The pine
53 (*Pinus massoniana*) plantation and the mature mixed pine and broadleaf forests are the other
54 two most common forest communities that represent the early- and mid-successional stages of
55 monsoon evergreen broadleaf forest, respectively, in this region. The age of the pine
56 plantation was approximately 40 years at the time of the first sampling.

57 **Tropical forest:** The tropical site was established in the Jianfengling National Natural
58 Reserve (18°23'N–18°50'N, 108°36'E–109°05'E) on southwestern Hainan Island, China, in
59 1992 (Zhou et al., 2013). The region has a typical tropical mountain rain forest with an
60 elevation of 800–1,000 m. The MAT and MAP were 19.8 °C and 2,449 mm, respectively. The
61 primary forest in this region has not been disturbed for more than 300 years and is dominated
62 by species in families Lauraceae and Fagaceae, e.g., *Mallotus hookerianus*, *Gironniera*
63 *subaequali*, *Cryptocarya chinensis*, *Cyclobalanopsis patelliformis* and *Nephel-ium topengii*.
64 The soils are lateritic yellow soil, with a pH that ranges between 4.3 and 4.7.

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81 **Table S1.** Allometric equations of above-ground biomass by species and sites used in this
 82 study. The equations are expressed as $B=a (D^2 H)^b$, where B , D , and H are the biomass (kg),
 83 DBH (cm) and height (m) of each stem, respectively.

Site	Species	Component	a	b	R^2
Boreal	<i>Larix gmelinii</i>	Bole	0.01258	0.99331	0.99
		Branch	0.00136	1.02797	0.99
		Leaf and Fruit	0.01009	0.64543	0.98
	<i>Betula platyphylla</i>	Bole	0.02853	0.89271	0.99
		Branch	0.00278	1.02568	0.99
		Leaf and Fruit	0.01545	0.61265	0.98
Temperate	<i>Pinus tabulaeformis</i>	Stem	0.0475	0.8539	0.98
		Branch	0.0017	1.1515	0.94
		Leaf	0.0134	0.8099	0.92
		Fruit	0.0013	0.9055	0.27
	<i>Betula platyphylla & B. dahurica</i>	Stem	0.0319	0.9356	0.99
		Branch	0.00063	1.2781	0.91
		Leaf and Fruit	0.00016	1.1688	0.88
	<i>Quercus wutaishanica</i>	Stem	0.0369	0.9165	0.99
		Branch	0.00051	1.3377	0.9
		Leaf and Fruit	0.00021	1.171	0.95
	<i>Populus davidiana</i>	Stem	0.2286	0.6933	0.98
		Branch	0.0247	0.7378	0.96
		Leaf and Fruit	0.0108	0.8181	0.98
	<i>Acer mono</i>	Stem	0.03136	0.9775	0.99
		Branch	0.00588	1.103	0.98
		Leaf and Fruit	0.01141	0.8803	0.98
	<i>Ulmus macrocarpa</i>	Stem	0.05229	0.891	0.99
		Branch	0.01233	0.9359	0.91
		Leaf and Fruit	0.01736	0.7738	0.85
	<i>Fraxinus rhynchophylla</i>	Stem	0.06013	0.8906	0.99
		Branch	0.00556	1.169	0.98
		Leaf and Fruit	0.00829	0.9919	0.98
	<i>Juglans mandshurica</i>	Stem	0.02511	0.9271	0.99
		Branch	0.00957	0.974	0.86
Leaf and Fruit		0.08725	0.2634	0.81	
<i>Tilia mongolica</i>	Stem	0.0811	0.7994	0.99	
	Branch	0.05703	0.463	0.88	
	Leaf and Fruit	0.001259	0.7802	0.98	
Sub-tropical	All species	Stem	0.0608	2.5585	0.97
		Branch	0.0254	2.587	0.97
		Leaf and Fruit	0.0385	2.0739	0.97
Tropical	All species	Stem	0.022816	0.992674	0.98
		Branch	0.005915	0.999046	0.98
		Leaf and Fruit	0.005997	0.804661	0.98

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86 **Table S2.** Mean soil organic carbon (SOC) content, bulk density, and SOC stock at the 0–10
 87 and 10–20 cm depths in the 1990s and the 2010s at the four forest biomes.

Biome	Forest type	0-10 cm			10-20 cm		
		1990s	2010s	Change rate	1990s	2010s	Change rate
SOC content*							
Boreal	Larch	7.9±1.4	8.1±1.2	+0.02±0.00	1.8±0.4	1.9±0.8	+0.01±0.00
Temperate	Birch	8.8±4.5	8.7±1.7	-0.00±0.00	3.3±1.3	3.7±0.3	+0.02±0.01
	Oak	4.3±0.1	4.8±0.6	+0.03±0.00	3.2±0.0	3.3±0.9	+0.01±0.00
	Pine	3.1±0.4	4.3±1.5	+0.06±0.02	2.8±0.1	3.2±0.7	+0.02±0.00
	Mean	5.4±3.0	6.0±2.4	+0.03±0.03	3.1±0.3	3.4±0.3	+0.02±0.01
Subtropical	Evergreen	2.5±0.4	3.6±0.4	+0.05±0.01	1.3±0.2	1.7±0.3	+0.02±0.00
	Mixed	1.8±0.5	2.5±0.4	+0.03±0.01	1.0±0.1	1.1±0.3	+0.01±0.00
	Pine	1.1±0.3	1.7±0.2	+0.03±0.01	0.7±0.2	0.7±0.2	+0.00±0.00
	Mean	1.8±0.7	2.6±1.0	+0.04±0.01	1.0±0.3	1.1±0.5	+0.01±0.01
Tropical	Evergreen	2.5±0.5	3.2±1.0	+0.03±0.01	1.4±0.2	1.4±0.3	+0.00±0.00
Mean		4.0±2.8	4.6±2.6	+0.03±0.02	1.9±1.1	2.1±1.2	+0.01±0.01
Bulk density*							
Boreal	Larch	0.3±0.1	0.3±0.1	+2.6±0.5	1.4±0.3	1.3±0.2	-5.2±1.1
Temperate	Birch	0.5±0.4	0.6±0.1	+4.6±2.3	0.9±0.1	0.9±0.1	-3.0±0.3
	Oak	0.9±0.0	0.8±0.1	-3.6±0.3	1.0±0.1	1.0±0.1	-0.1±0.0
	Pine	1.1±0.1	0.9±0.2	-5.5±0.6	1.1±0.0	1.1±0.1	+0.1±0.0
	Mean	0.8±0.3	0.8±0.2	-1.5±5.3	1.0±0.1	1.0±0.1	-1.0±1.7
Subtropical	Evergreen	0.9±0.1	0.8±0.0	-3.0±0.2	1.0±0.1	0.9±0.0	-3.4±0.2
	Mixed	1.1±0.1	0.9±0.0	-11.3±0.5	1.1±0.1	1.1±0.0	-2.4±0.1
	Pine	1.3±0.1	1.1±0.0	-8.5±0.3	1.3±0.1	1.1±0.0	-8.9±0.3
	Mean	1.1±0.2	0.9±0.1	-7.7±4.2	1.1±0.2	1.0±0.1	-4.9±3.5
Tropical	Evergreen	1.1±0.0	1.2±0.2	+1.9±0.2	1.1±0.1	1.2±0.1	+2.9±0.2
Mean		0.9±0.3	0.8±0.3	-3.1±5.6	1.1±0.2	1.1±0.2	-2.5±3.6
SOC stock*							
Boreal	Larch	22.1±0.9	26.1±4.9	+247.1±30.3	25.5±1.1	25.6±1.4	+4.0±0.8
Temperate	Birch	44.2±1.0	51.8±2.2	+379.4±12.6	30.4±8.8	32.1±0.8	+82.7±13.2
	Oak	38.6±2.3	40.1±10.9	+72.7±12.3	30.7±2.6	31.7±7.5	+47.9±8.3
	Pine	32.5±2.5	40.7±9.7	+413.2±68.4	30.1±2.6	34.4±9.5	+217.6±40.5
	Mean	38.4±5.9	44.2±6.6	+288.4±187.5	30.4±0.3	32.7±1.5	+116.1±89.5
Subtropical	Evergreen	22.6±4.0	30.1±3.8	+375.0±55.9	13.1±2.0	15.5±3.1	+123.3±21.6
	Mixed	20.1±5.9	21.9±3.7	+85.8±18.8	10.7±1.5	11.3±2.8	+31.5±6.3
	Pine	14.1±3.9	17.9±2.6	+189.6±38.0	8.5±1.9	7.5±2.0	-51.4±12.2
	Mean	18.9±4.3	23.3±6.2	+217.2±146.6	10.8±2.3	11.5±4.0	+34.5±87.4
Tropical	Evergreen	28.5±6.9	36.5±6.7	+401.8±84.1	15.2±3.9	15.9±3.6	+39.2±9.2
Mean		27.8±10.1	33.1±11.2	+270.6±141.5	20.5±9.6	21.8±10.5	+61.9±81.2

88 *Shown are SOC contents (%) and their change rates (% yr⁻¹), soil bulk density (g cm⁻³) and
 89 their change rates (mg cm⁻³ yr⁻¹) and SOC stock (Mg C ha⁻¹) and their change rates (kg C ha⁻¹
 90 yr⁻¹) between the 1990s and the 2010s.

91 **Table S3.** Mean soil organic carbon (SOC) content, bulk density, SOC stock and their change rates during the past two decades at eight forest
 92 sites, which are categorized into four forest biomes.
 93

Biome	Forest type	SOC content (%)			Bulk density (g cm ⁻³)			SOC stock (Mg C ha ⁻¹)			
		1990s	2010s	Change rate (% yr ⁻¹)	1990s	2010s	Change rate (mg cm ⁻³ yr ⁻¹)	1990s	2010s	Change rate (kg C ha ⁻¹ yr ⁻¹)	Relative rate (% yr ⁻¹)
0–20 cm soil depth											
Boreal	Larch	2.8±0.6	3.2±0.9	+0.02±0.01	0.9±0.2	0.8±0.1	-1.3±0.3	47.6±2.0	51.6±16.3	251.1±46.4	+0.5±0.1
Temperate	Birch	5.3±2.4	5.8±0.9	+0.03±0.01	0.7±0.3	0.7±0.1	+0.8±0.2	74.6±9.8	83.8±3.0	462.1±37.2	+0.6±0.1
	Oak	3.7±0.0	4.0±0.7	+0.01±0.00	0.9±0.1	0.9±0.1	-1.9±0.1	69.4±4.8	71.8±18.5	120.6±19.9	+0.2±0.0
	Pine	3.0±0.3	3.7±1.1	+0.04±0.01	1.1±0.1	1.0±0.1	-2.7±0.2	62.5±5.1	75.1±19.2	630.8±111.2	+1.0±0.2
	Mean	4.2±1.0	4.6±0.9	+0.03±0.01	0.9±0.1	0.9±0.1	-1.3±1.8	68.8±6.1	76.9±6.2	404.5±259.9	+0.6±0.4
Subtropical	Evergreen	1.9±0.3	2.6±0.4	+0.04±0.01	1.0±0.1	0.9±0.0	-3.2±0.2	35.6±6.0	45.6±6.9	498.3±78.8	+1.4±0.2
	Mixed	1.4±0.3	1.7±0.3	+0.02±0.00	1.1±0.1	1.0±0.0	-6.9±0.3	30.8±7.3	33.3±6.4	117.3±25.2	+0.4±0.1
	Pine	0.9±0.2	1.2±0.2	+0.01±0.00	1.3±0.1	1.1±0.0	-8.7±0.3	22.7±5.8	25.4±4.5	138.2±29.7	+0.6±0.1
	Mean	1.4±0.3	1.8±0.3	+0.02±0.01	1.1±0.1	1.0±0.0	-6.3±2.8	29.7±6.5	34.8±10.1	251.3±214.2	+0.9±0.5
Tropical	Evergreen	2.0±0.4	2.3±0.7	+0.02±0.00	1.1±0.0	1.2±0.1	+2.4±0.2	43.6±10.8	52.5±10.3	441.0±96.6	+1.0±0.2
	Mean	2.9±0.6	3.2±0.7	+0.02±0.00	1.0±0.1	1.0±0.1	-2.7±3.7	48.4±18.8	54.9±20.6	332.4±200.2	+0.7±0.4
Whole soil depth											
Boreal	Larch	1.4±0.2	1.5±0.1	+0.00±0.00	1.2±0.2	1.2±0.2	+0.8±0.1	65.6±11.0	69.4±6.2	243.4±31.1	+0.4±0.1
Temperate	Birch	2.0±0.3	2.1±0.2	+0.01±0.00	1.1±0.1	1.0±0.2	-2.8±0.4	207.0±31.7	214.8±19.5	390.8±47.4	+0.2±0.0
	Oak	2.0±0.7	2.4±0.2	+0.02±0.00	1.2±0.1	1.0±0.1	-10.3±0.9	239.1±80.4	241.7±15.2	127.2±25.3	+0.1±0.0
	Pine	1.8±0.5	1.9±0.3	+0.00±0.00	1.3±0.1	1.3±0.1	-0.1±0.0	231.7±67.0	238.4±41.4	332.8±76.7	+0.1±0.0
	Mean	1.9±0.1	2.1±0.1	+0.01±0.01	1.2±0.1	1.1±0.2	-4.3±5.3	226.0±16.8	231.6±14.6	283.6±138.5	+0.1±0.1
Subtropical	Evergreen	1.1±0.1	1.4±0.1	+0.02±0.00	1.1±0.1	1.0±0.0	-3.6±0.2	68.4±5.7	86.6±4.5	907.5±60.1	+1.3±0.1
	Mixed	0.7±0.1	1.0±0.1	+0.01±0.00	1.2±0.1	1.1±0.04	-3.8±0.2	51.4±5.5	67.4±7.2	763.3±82.4	+1.5±0.2
	Pine	0.6±0.1	0.7±0.1	+0.01±0.00	1.3±0.1	1.1±0.0	-9.0±0.3	43.5±5.7	47.7±6.5	206.6±28.3	+0.5±0.1
	Mean	0.8±0.2	1.1±0.3	+0.02±0.01	1.2±0.1	1.1±0.1	-5.5±3.0	54.4±12.7	67.2±19.5	627.6±370.1	+1.1±0.5
Tropical	Evergreen	0.7±0.2	0.8±0.2	+0.00±0.00	1.3±0.0	1.3±0.1	+0.5±0.0	94.6±21.8	102.6±19.9	397.9±84.2	+0.4±0.1
	Mean	1.3±0.3	1.5±0.2	+0.01±0.01	1.2±0.1	1.1±0.1	-3.5±4.2	125.2±85.2	133.6±83.1	421.2±274.4	+0.6±0.5

94 **Table S4.** Measured carbon input rates and ratio of soil accumulation to the above-ground net primary production (ANPP) of the eight forest
 95 types.

Parameters	Boreal	Temperate			Subtropical		Tropical	
	Larch	Birch	Oak	Pine	Evergreen	Mixed	Pine	Evergreen
Carbon pool (Mg C ha⁻¹)								
AGB	91.1±25.0	99.3±9.0	69.6±4.4	100.0±17.4	140.0±5.5	120.9±16.3	60.1±3.4	213.6±41.4
Litter	4.4±0.0	5.1±1.1	2.5±0.4	4.1±0.8	1.4±0.4	2.2±0.3	2.8±0.5	1.8±0.2
Dead wood	1.3±0.5	5.6±0.8	3.3±0.1	4.5±0.6	13.2±0.2	8.7±5.7	0.1±0.1	5.7±0.8
Soil	69.4±6.2	214.8±19.5	241.7±15.2	238.4±41.4	86.6±7.2	67.4±6.5	47.7±4.5	102.6±19.9
Ecosystem total	166.2±31.7	324.9±30.3	317.1±20.2	346.9±60.2	241.2±13.3	199.2±28.8	110.7±8.5	323.7±62.3
Carbon flux (kg C ha⁻¹ yr⁻¹)								
AGB growth	899.4±411.0	2075.2±253.3	1209.0±240.61	2144.4±495.76	-1000.3±78.2	1911.0±207.58	1485.3±166.9	684.1±145.0
Litterfall	2424.2±283.1	1630.2±220.4	1869.8±249.7	2340.1±310.0	4160.2±449.0	4277.3±272.8	1718.8±430.0	3970.0±279.8
Fallen log	13.0±3.7	192.2±26.0	66.2±7.4	60.0±12.8	2070.3±221.2	679.5±43.6	210.3±50.8	1034.3±71.6
Standing snag	3.5±1.8	337.9±46.8	343.8±46.1	148.5±18.5	346.8±42.3	76.9±3.2	236.3±56.9	803.4±62.4
ANPP	3340.1±698.8	4235.4±546.1	3488.8±544.2	4693.0±837.5	5577.0±789.8	6944.7±528.4	3650.6±704.7	6491.6±559.2
Soil accumulation	243.4±31.1	390.8±47.4	127.2±25.3	332.8±76.7	907.5±60.1	763.3±82.4	206.6±28.3	397.9±84.2
Ratio of soil accumulation to ANPP (%)	7.3±7.8	9.2±3.8	3.6±3.4	7.1±5.4	16.3±4.2	11.0±3.0	5.7±3.5	6.1±3.3

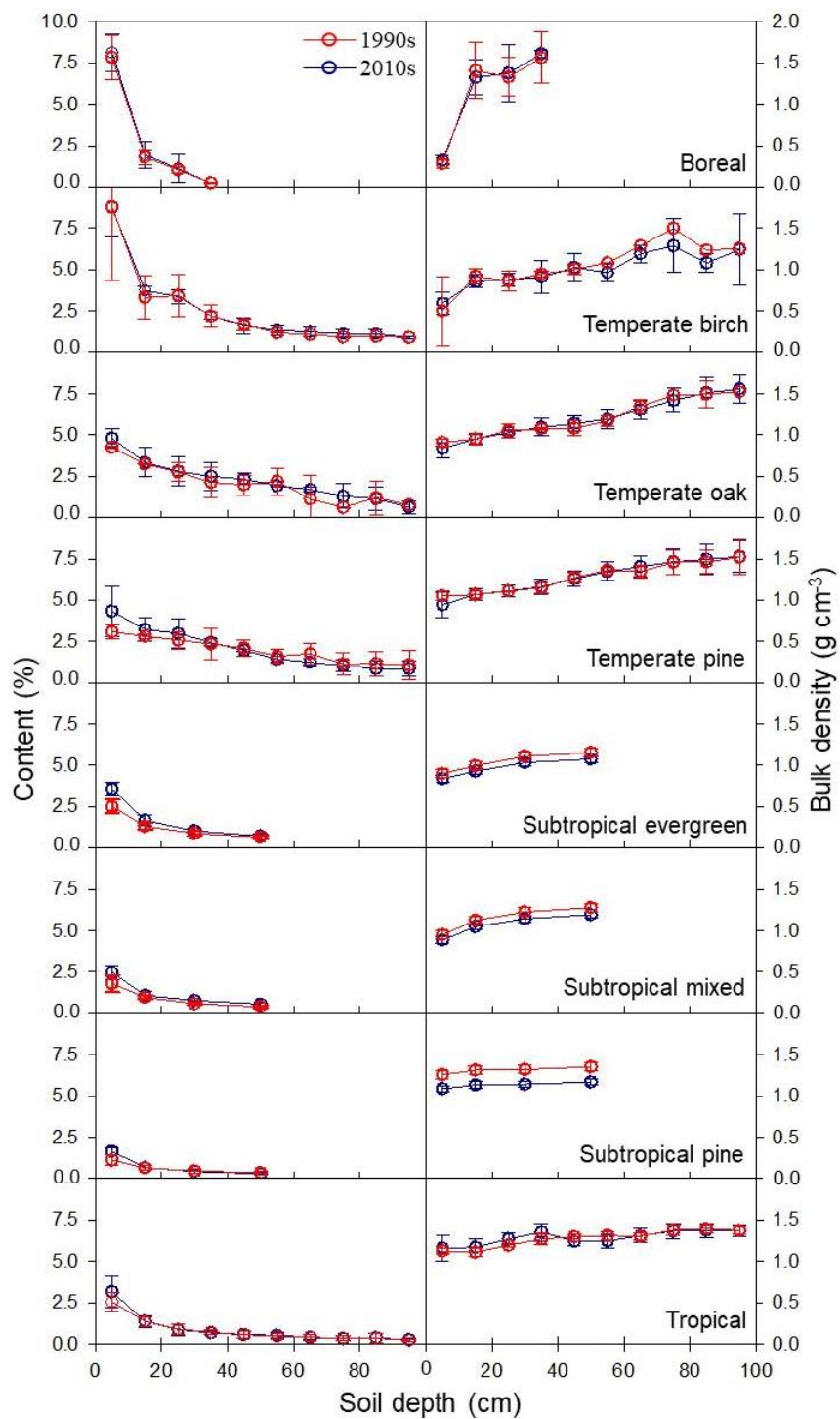
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97 **Table S5.** Summary for C pools and changes in each component of forests in China over the
 98 past two decades.

Component	Carbon pool (Pg C)	Carbon density (Mg ha ⁻¹)	National sink (Tg C yr ⁻¹)	Source
Biomass	6.9	41.3	70.9	Guo et al., 2013
Soil	20.0	106.1	57.1	Tang et al., 2018; This study
Litter	0.5	3.2	2.8	Zhu et al., 2017
Dead wood	0.4	2.8	3.9	Zhu et al., 2017
Ecosystem	27.4	153.4	134.7	

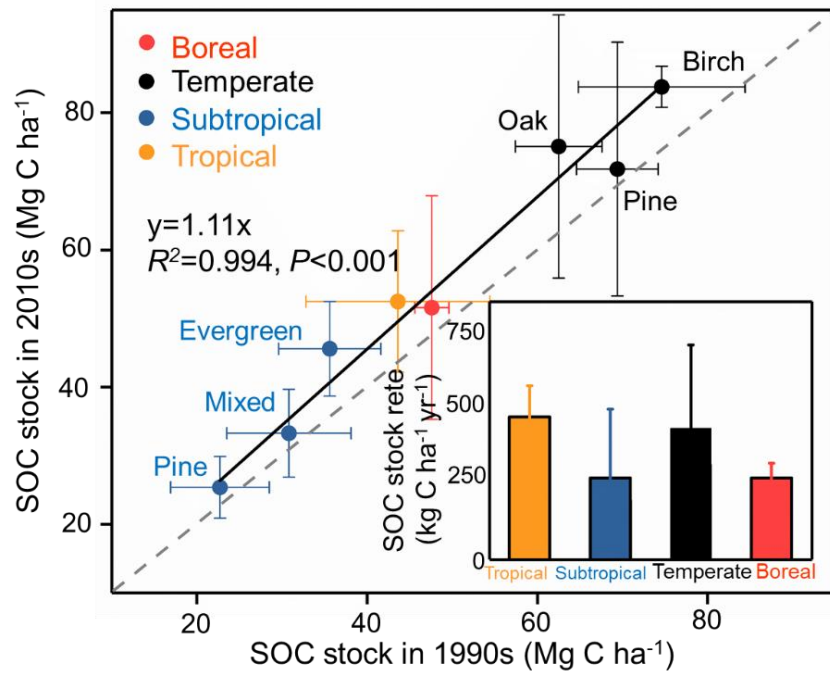
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100 **Figure S1.** Changes in soil organic carbon contents (left, %) and bulk densities (right, g cm^{-3})
 101 with soil depth for the eight forests in the 1990s and the 2010s in China. For the details on the
 102 sites, see Table 1.
 103



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 105

106 **Figure S2.** Comparison of soil organic carbon stocks of the surface soil depth (0-20 cm) in
 107 the eight forest plots of China between the 1990s and the 2010s. The inset graph shows the
 108 SOC change rates of the surface soil depth (0-20 cm) by forest biomes.
 109



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