

Table S1. The description of field measurements from natural vegetation in different sites.

Number	PFT	location		Year	References
		Longitude	Latitude		
1	Forest: Spruce	11°25'E	48°46'N	1993-1995	Butterbach-Bahl et al., 1998
2	Forest: Spruce	09°34'E	51°46'N	2007-2008	Eickenscheidt and Brumme, 2012
3	Forest: Liana canopy	55°31'W	3°59'S	1998-2000	Davidson et al., 2004
4	Forest: Douglas-fir	124°30'W	44°00'N	2007-2008	Erickson and Perakis, 2014
5	Grassland	09°42'E	51°46'N	2008-2009	Hoefl et al., 2012
6	Forest	156°14'W	20°48'N	2000-2001	Holtgrieve et al., 2006
7	Forest: Spruce & Oak	19°57'–58'E	47°53'N	2002-2003	Horváth et al., 2006
8	Forest: Beech	16°15'E	48°14'N	2002-2004	Kitzler et al., 2006
9	Grassland	104°42'W	40°50'N	1997-2000	Mosier et al., 2002
10	Tropical rain forest	145°30'E	17°30'S	1997-1999	Breuer et al., 2000
11	Tropical rain forest	63°00'W	10°00'S	–	Stehfest and Bouwman, 2006
12	Savanna	28°30'E	24°30'S	1994	Scholes et al., 1997
13	Tropical forest	47°30'W	3°00'S	1987	Luizão et al., 1989
14	Tropical forest	115°30'E	2°00'S	1998-1999	Hadi et al., 2000
15	Tropical forest	84°00'W	10°26'N	1990-1991	Keller and Reiners, 1994
16	Subtropical forest	66°00'W	18°00'N	1995-1996	Erickson et al. 2001
17	Temperate forest	116°30'E	39°30'N	1997-1998	Sun and Xu, 2001
18	Temperate forest	89°00'W	43°00'N	1979-1981	Goodroad and Keeney, 1984
19	Grassland	116°04'E	43°26'N	1995	Chen et al., 2000
20	Temperate forest	126°55'E	41°23'N	1994-1995	

Table S2. All results of the global-, continental-, and biome-level N₂O emission from 100 sets of DLEM simulations in 1860. The unit is Tg N yr⁻¹.

No.	Total	Europe	North America	South America	Southern Asia	Northern Asia	Oceania	Africa	Boreal Forest	Tropical Forest	Temperate Forest	Shrubland	Grassland	Cropland	Tundra
1	6.986	0.339	0.774	2.323	1.315	0.175	0.348	1.645	0.695	4.467	0.695	0.925	0.225	0.479	0.010
2	6.546	0.292	0.684	2.244	1.225	0.166	0.325	1.545	0.594	4.281	0.594	0.845	0.199	0.428	0.013
3	5.121	0.243	0.554	1.724	0.959	0.124	0.254	1.213	0.504	3.309	0.504	0.672	0.159	0.341	0.005
4	6.699	0.350	0.772	2.167	1.248	0.179	0.339	1.578	0.734	4.180	0.734	0.926	0.219	0.443	0.012
5	5.386	0.257	0.585	1.807	1.004	0.137	0.268	1.275	0.536	3.466	0.536	0.715	0.165	0.347	0.009
6	6.178	0.317	0.701	2.016	1.152	0.163	0.312	1.458	0.661	3.882	0.661	0.846	0.199	0.408	0.011
7	6.029	0.268	0.627	2.073	1.129	0.150	0.298	1.424	0.545	3.953	0.545	0.775	0.182	0.396	0.010
8	6.966	0.303	0.720	2.405	1.306	0.176	0.346	1.643	0.612	4.583	0.612	0.892	0.211	0.455	0.014
9	6.033	0.289	0.659	2.019	1.132	0.150	0.300	1.426	0.595	3.878	0.595	0.796	0.190	0.406	0.008
10	5.666	0.259	0.602	1.932	1.067	0.134	0.278	1.338	0.530	3.703	0.530	0.728	0.175	0.381	0.005
11	5.796	0.267	0.616	1.970	1.088	0.142	0.287	1.369	0.545	3.770	0.545	0.751	0.179	0.389	0.008
12	4.945	0.218	0.508	1.713	0.929	0.117	0.244	1.167	0.442	3.258	0.442	0.628	0.149	0.333	0.006
13	7.677	0.376	0.855	2.536	1.437	0.205	0.386	1.806	0.773	4.873	0.773	1.033	0.246	0.511	0.017
14	5.347	0.236	0.551	1.851	1.003	0.129	0.264	1.263	0.478	3.523	0.478	0.681	0.161	0.355	0.007
15	6.257	0.321	0.709	2.041	1.167	0.168	0.317	1.474	0.667	3.924	0.667	0.859	0.201	0.416	0.013
16	7.443	0.335	0.787	2.540	1.414	0.181	0.371	1.742	0.666	4.847	0.666	0.955	0.237	0.528	0.011
17	6.384	0.287	0.670	2.184	1.188	0.167	0.318	1.509	0.590	4.164	0.590	0.833	0.192	0.404	0.014
18	6.019	0.303	0.675	1.979	1.123	0.158	0.303	1.421	0.629	3.803	0.629	0.818	0.192	0.400	0.011
19	5.520	0.251	0.587	1.886	1.042	0.127	0.269	1.304	0.514	3.615	0.514	0.706	0.171	0.376	0.003
20	6.455	0.291	0.673	2.205	1.206	0.170	0.324	1.523	0.589	4.197	0.589	0.842	0.196	0.422	0.016
21	6.145	0.253	0.580	2.090	1.170	0.128	0.278	1.583	0.480	4.105	0.480	0.805	0.185	0.443	0.015
22	6.886	0.343	0.770	2.266	1.287	0.183	0.347	1.623	0.708	4.354	0.708	0.933	0.221	0.459	0.014
23	6.927	0.300	0.714	2.395	1.313	0.166	0.344	1.627	0.596	4.563	0.596	0.876	0.214	0.480	0.010
24	7.927	0.381	0.866	2.635	1.482	0.221	0.403	1.862	0.774	5.038	0.774	1.067	0.251	0.524	0.024
25	8.045	0.388	0.885	2.669	1.501	0.224	0.407	1.892	0.795	5.117	0.795	1.085	0.253	0.521	0.023
26	4.766	0.219	0.507	1.627	0.898	0.108	0.233	1.129	0.451	3.120	0.451	0.610	0.147	0.323	0.002
27	5.459	0.253	0.578	1.856	1.025	0.134	0.271	1.288	0.514	3.547	0.514	0.708	0.168	0.369	0.007
28	5.181	0.252	0.567	1.730	0.964	0.134	0.260	1.226	0.526	3.314	0.526	0.696	0.160	0.334	0.008

No.	Total	Europe	North America	South America	Southern Asia	Northern Asia	Oceania	Africa	Boreal Forest	Tropical Forest	Temperate Forest	Shrubland	Grassland	Cropland	Tundra
29	6.774	0.314	0.724	2.290	1.267	0.176	0.339	1.597	0.642	4.373	0.642	0.891	0.210	0.447	0.015
30	6.805	0.325	0.741	2.275	1.268	0.184	0.341	1.605	0.671	4.357	0.671	0.911	0.211	0.436	0.016
31	6.258	0.260	0.603	2.121	1.204	0.125	0.282	1.598	0.494	4.168	0.494	0.822	0.191	0.465	0.012
32	7.660	0.370	0.839	2.543	1.438	0.205	0.388	1.802	0.749	4.877	0.749	1.024	0.245	0.517	0.019
33	6.276	0.319	0.711	2.054	1.167	0.167	0.316	1.481	0.670	3.955	0.670	0.860	0.199	0.404	0.012
34	6.591	0.294	0.691	2.261	1.242	0.160	0.326	1.551	0.595	4.315	0.595	0.845	0.204	0.447	0.010
35	5.087	0.224	0.525	1.763	0.963	0.115	0.249	1.198	0.451	3.360	0.451	0.639	0.156	0.354	0.003
36	8.133	0.381	0.878	2.728	1.521	0.222	0.411	1.911	0.772	5.213	0.772	1.081	0.255	0.536	0.024
37	6.066	0.293	0.665	2.026	1.144	0.147	0.301	1.431	0.597	3.895	0.597	0.796	0.194	0.421	0.007
38	4.979	0.243	0.545	1.660	0.930	0.125	0.249	1.178	0.505	3.185	0.505	0.664	0.155	0.331	0.007
39	5.230	0.249	0.569	1.760	0.980	0.124	0.257	1.240	0.519	3.386	0.519	0.685	0.163	0.345	0.004
40	6.075	0.275	0.641	2.076	1.135	0.153	0.301	1.435	0.566	3.964	0.566	0.788	0.185	0.394	0.010
41	6.822	0.266	0.681	2.228	1.223	0.264	0.519	1.577	0.550	4.225	0.550	1.074	0.233	0.440	0.050
42	5.872	0.242	0.582	2.075	1.113	0.135	0.288	1.380	0.477	3.931	0.477	0.724	0.176	0.407	0.006
43	6.743	0.298	0.702	2.317	1.261	0.172	0.335	1.592	0.607	4.416	0.607	0.870	0.204	0.438	0.014
44	7.161	0.380	0.832	2.300	1.338	0.195	0.365	1.682	0.788	4.435	0.788	0.996	0.237	0.483	0.016
45	5.090	0.224	0.525	1.764	0.954	0.121	0.250	1.203	0.457	3.358	0.457	0.647	0.153	0.337	0.006
46	5.912	0.253	0.596	2.061	1.108	0.147	0.294	1.395	0.506	3.908	0.506	0.749	0.176	0.393	0.011
47	6.370	0.332	0.731	2.066	1.191	0.165	0.321	1.502	0.692	3.987	0.692	0.873	0.209	0.428	0.010
48	5.153	0.214	0.513	1.821	0.967	0.120	0.252	1.216	0.432	3.452	0.432	0.640	0.151	0.339	0.006
49	6.057	0.290	0.665	2.030	1.138	0.146	0.298	1.431	0.600	3.906	0.600	0.795	0.192	0.407	0.006
50	4.905	0.217	0.507	1.699	0.922	0.114	0.241	1.158	0.441	3.236	0.441	0.621	0.148	0.331	0.004
51	4.862	0.227	0.521	1.650	0.912	0.115	0.239	1.153	0.470	3.165	0.470	0.631	0.149	0.322	0.004
52	7.706	0.355	0.825	2.603	1.441	0.206	0.387	1.814	0.724	4.972	0.724	1.016	0.239	0.504	0.020
53	6.758	0.306	0.708	2.304	1.266	0.176	0.339	1.593	0.617	4.390	0.617	0.881	0.207	0.448	0.016
54	5.321	0.248	0.565	1.806	0.993	0.136	0.266	1.255	0.508	3.443	0.508	0.699	0.162	0.349	0.009
55	5.758	0.281	0.635	1.914	1.076	0.146	0.288	1.362	0.584	3.678	0.584	0.769	0.181	0.382	0.008
56	5.814	0.247	0.586	2.033	1.078	0.150	0.288	1.375	0.503	3.850	0.503	0.742	0.169	0.362	0.014

No.	Total	Europe	North America	South America	Southern Asia	Northern Asia	Oceania	Africa	Boreal Forest	Tropical Forest	Temperate Forest	Shrubland	Grassland	Cropland	Tundra
57	7.764	0.400	0.887	2.516	1.452	0.215	0.396	1.822	0.823	4.840	0.823	1.070	0.254	0.523	0.020
58	5.386	0.230	0.545	1.884	1.019	0.124	0.265	1.268	0.459	3.581	0.459	0.672	0.162	0.370	0.005
59	5.222	0.232	0.543	1.801	0.970	0.131	0.259	1.236	0.482	3.427	0.482	0.676	0.154	0.328	0.009
60	6.341	0.290	0.667	2.159	1.182	0.168	0.318	1.495	0.589	4.110	0.589	0.832	0.192	0.411	0.016
61	7.150	0.326	0.761	2.430	1.354	0.175	0.356	1.678	0.653	4.645	0.653	0.922	0.227	0.500	0.011
62	5.007	0.229	0.531	1.709	0.947	0.113	0.245	1.183	0.469	3.275	0.469	0.639	0.156	0.348	0.002
63	5.877	0.259	0.610	2.030	1.112	0.138	0.289	1.383	0.521	3.869	0.521	0.744	0.181	0.406	0.006
64	5.175	0.231	0.539	1.786	0.976	0.119	0.254	1.220	0.468	3.409	0.468	0.655	0.158	0.353	0.004
65	6.739	0.324	0.740	2.244	1.255	0.179	0.338	1.591	0.674	4.307	0.674	0.905	0.210	0.433	0.014
66	5.383	0.253	0.577	1.819	1.006	0.134	0.268	1.273	0.521	3.483	0.521	0.706	0.165	0.353	0.008
67	6.911	0.344	0.772	2.276	1.296	0.181	0.347	1.628	0.705	4.376	0.705	0.930	0.223	0.469	0.013
68	5.503	0.219	0.536	1.967	1.031	0.128	0.268	1.299	0.440	3.719	0.440	0.675	0.158	0.357	0.007
69	6.429	0.297	0.684	2.181	1.201	0.166	0.321	1.516	0.606	4.164	0.606	0.843	0.197	0.420	0.013
70	7.045	0.333	0.766	2.361	1.326	0.179	0.351	1.660	0.678	4.531	0.678	0.927	0.223	0.479	0.012
71	6.688	0.309	0.720	2.263	1.268	0.159	0.330	1.573	0.626	4.338	0.626	0.864	0.214	0.470	0.007
72	5.739	0.280	0.633	1.911	1.077	0.141	0.285	1.357	0.579	3.675	0.579	0.760	0.183	0.390	0.006
73	4.956	0.232	0.529	1.679	0.925	0.123	0.247	1.172	0.480	3.207	0.480	0.651	0.152	0.326	0.007
74	5.216	0.252	0.566	1.746	0.974	0.134	0.261	1.233	0.519	3.342	0.519	0.695	0.161	0.345	0.009
75	5.450	0.258	0.592	1.838	1.031	0.125	0.267	1.287	0.529	3.534	0.529	0.704	0.173	0.379	0.002
76	5.734	0.238	0.570	2.021	1.069	0.141	0.282	1.357	0.481	3.828	0.481	0.720	0.167	0.367	0.010
77	5.783	0.273	0.621	1.948	1.086	0.144	0.289	1.366	0.557	3.731	0.557	0.759	0.180	0.391	0.009
78	5.469	0.223	0.541	1.938	1.027	0.127	0.267	1.291	0.450	3.673	0.450	0.676	0.160	0.360	0.007
79	7.412	0.352	0.802	2.480	1.387	0.200	0.374	1.744	0.714	4.743	0.714	0.987	0.233	0.491	0.020
80	5.884	0.281	0.641	1.972	1.107	0.144	0.292	1.390	0.576	3.789	0.576	0.772	0.186	0.402	0.007
81	5.102	0.218	0.519	1.786	0.961	0.116	0.249	1.203	0.442	3.398	0.442	0.637	0.152	0.342	0.003
82	6.319	0.291	0.673	2.144	1.189	0.156	0.314	1.491	0.592	4.101	0.592	0.821	0.197	0.429	0.009
83	5.903	0.276	0.637	1.995	1.120	0.136	0.290	1.391	0.560	3.829	0.560	0.760	0.189	0.418	0.004
84	5.845	0.250	0.599	2.037	1.102	0.136	0.285	1.378	0.508	3.880	0.508	0.734	0.176	0.391	0.006

No.	Total	Europe	North America	South America	Southern Asia	Northern Asia	Oceania	Africa	Boreal Forest	Tropical Forest	Temperate Forest	Shrubland	Grassland	Cropland	Tundra
85	6.217	0.300	0.683	2.075	1.162	0.158	0.309	1.469	0.622	3.986	0.662	0.827	0.195	0.408	0.010
86	6.938	0.312	0.729	2.371	1.307	0.173	0.346	1.633	0.627	4.525	0.627	0.894	0.215	0.471	0.013
87	5.874	0.276	0.631	1.981	1.093	0.154	0.294	1.387	0.572	3.785	0.572	0.779	0.180	0.377	0.012
88	5.571	0.276	0.619	1.847	1.043	0.138	0.277	1.318	0.573	3.556	0.573	0.743	0.177	0.372	0.006
89	5.908	0.260	0.608	2.040	1.099	0.153	0.294	1.396	0.531	3.875	0.531	0.764	0.175	0.375	0.013
90	6.759	0.304	0.708	2.307	1.259	0.181	0.339	1.595	0.619	4.394	0.619	0.885	0.204	0.433	0.018
91	6.084	0.306	0.685	2.002	1.141	0.151	0.303	1.438	0.637	3.862	0.637	0.816	0.197	0.411	0.007
92	5.669	0.279	0.626	1.880	1.058	0.148	0.285	1.339	0.579	3.608	0.579	0.763	0.178	0.372	0.011
93	6.102	0.278	0.644	2.080	1.139	0.157	0.304	1.440	0.570	3.967	0.570	0.797	0.185	0.396	0.012
94	6.085	0.281	0.646	2.065	1.136	0.157	0.304	1.436	0.576	3.939	0.576	0.800	0.186	0.397	0.012
95	8.086	0.378	0.872	2.716	1.519	0.214	0.408	1.899	0.760	5.194	0.760	1.067	0.256	0.547	0.021
96	7.247	0.342	0.784	2.429	1.354	0.195	0.365	1.707	0.700	4.648	0.700	0.964	0.226	0.474	0.018
97	7.495	0.344	0.797	2.537	1.406	0.197	0.377	1.764	0.695	4.845	0.695	0.982	0.234	0.500	0.018
98	7.284	0.365	0.822	2.389	1.358	0.196	0.367	1.716	0.760	4.597	0.760	0.992	0.233	0.476	0.016
99	6.607	0.341	0.756	2.148	1.232	0.175	0.333	1.557	0.714	4.141	0.714	0.908	0.214	0.436	0.012
100	7.233	0.334	0.775	2.446	1.351	0.190	0.361	1.705	0.683	4.678	0.683	0.951	0.223	0.469	0.016

Table S3 The estimated mean N₂O emissions and emission rates per unit area at continental- and biome-scale with the uncertainty ranges. 1 kg N ha⁻¹ yr⁻¹ = 0.1 g N m⁻² yr⁻¹

Continental-scale	Europe	North America	South America	Southern Asia	Northern Asia	Oceania	Africa
N ₂ O emissions (Tg N yr ⁻¹)	0.29 (0.21~0.40)	0.66 (0.51~0.89)	2.09 (1.63~2.73)	1.16 (0.90~1.52)	0.16 (0.11~0.26)	0.31 (0.23~0.52)	1.46 (1.13~1.91)
N ₂ O emission rate (kg N ha ⁻¹)	0.31 (0.23~0.43)	0.31 (0.24~0.42)	1.23 (0.96~1.61)	0.52 (0.40~0.68)	0.13 (0.09~0.22)	0.41 (0.31~0.69)	0.73 (0.56~0.95)
Biome-scale	Boreal Forest	Tropical Forest	Temperate Forest	Shrubland	Grassland	Cropland	Tundra
N ₂ O emissions (Tg N yr ⁻¹)	0.17 (0.10~0.25)	4.01 (3.12~5.21)	0.59 (0.43~0.82)	0.82 (0.61~1.08)	0.20 (0.15~0.25)	0.41 (0.32~0.55)	0.01 (0.002~0.05)
N ₂ O emission rate (kg N ha ⁻¹)	0.17 (0.11~0.26)	1.60 (1.25~2.09)	0.37 (0.27~0.51)	0.34 (0.26~0.45)	0.2 (0.15~0.26)	0.46 (0.36~0.61)	–