Supplementary Information

Table A. Summary of soil methane (CH_4) and nitrous oxide (N_2O) emissions of pre and post land use change and absolute change (post − pre) in natural forest.

Land use type		Location (city, country)	CH_4 emission (kg CH_4 ha^{-1} y^{-1})			N_2O emission (kg N_2O–N ha^{-1} y^{-1})			Reference
Pre	Post		Pre	Post	Absolute change	Pre	Post	Absolute change	
Forest	Crop land	Xianning, Hubei Province, Central China				0.72	2.11	1.39	Lin et al. 2012
Forest	Crop land	Xianning, Hubei Province, Central China				0.72	1.37	0.65	Lin et al. 2012
Forest	Crop land	Xianning, Hubei Province, Central China				0.72	1.25	0.53	Lin et al. 2012
Forest	Crop land	Victoria, Australia	1.27	2.52	1.25	0.16	0.44	0.28	Galbally et al. 2010
Forest	Crop land	Mooloolah Valley, Queensland, Australia	-4.96	-0.08	4.88	0.52	5.21	4.70	Rowlings 2010
Forest	Crop land	Mean ± confidence interval (CI, 95%)			3.1 ± 3.6			1.5 ± 1.6	
Forest	Grass land	Western Australia	-1.84	-0.32	1.52	0.16	2.33	2.17	Li Vesley et al 2009
Forest	Grass land	Mooloolah Valley, Queensland, Australia	-4.96	-0.04	4.92	0.52	1.83	1.31	Rowlings 2010
Forest	Grass land	Western Australia	-1.84	-0.59	1.25	0.16	0.12	-0.05	Li Vesley et al. 2009
Forest	Grass land	Mean ± CI (95%)			2.6 ± 2.3			1.1± 1.3	
Forest	Secondary forest	Western Australia	-1.84	-0.80	1.04	0.16	0.15	-0.02	Li Vesley et al. 2009
Forest	Secondary Forest	Mean			1.04			-0.02	

Table B. Summary of soil methane (CH_4) and nitrous oxide (N_2O) emissions of pre and post land use change and absolute change (post – pre) in crop lands.

Land use type		Location (city, country)	CH_4 emission (kg CH_4 ha^{-1} y^{-1})			N_2O emission (kg N_2O–N ha^{-1} y^{-1})			Reference
pre	post		Pre	Post	Absolute change	Pre	Post	Absolute change	
Crop land	Grass land	Iowa, USA	-1.07	0.05	1.12	12.00	2.60	-9.40	Kim et al. 2009, 2010
Crop land	Grass land	Spain	-0.04	0.09	0.13	2.85	2.81	-0.04	Merino et al. 2004
Crop land	Grass land	Mean ± CI (95%)			0.6 ± 1.0			-4.7 ± 9.2	
Crop land	Secondary forest	Iowa, USA	-1.07	-0.61	0.45	12.00	3.15	-8.85	Kim et al. 2009, 2010
Crop land	Secondary forest	western Finland				5.50	11.60	6.10	Maljanen et al. 2012
Crop land	Secondary forest	Spain	-0.04	-5.09	-5.05	2.85	1.05	-1.80	Merino et al. 2004
Crop land	Secondary forest	Mean ± CI (95%)			-2.3 ± 5.4			-1.5 ± 8.5	
Crop land	Agroforest	Costa Rica	-4.40	-1.47	2.93	4.3	5.8	1.5	Hergoualc'h et al. 2012
Crop land	Agroforest	Mean			2.93			1.5	

Table C. Summary of soil methane (CH_4) and nitrous oxide (N_2O) emissions of pre and post land use change and absolute change (post – pre) in grass lands.

Land use type		Location (city, country)	CH_4 emission (kg CH_4 ha^{-1} y^{-1})			N_2O emission (kg N_2O–N ha^{-1} y^{-1})			Reference
pre	post		Pre	Post	Absolute change	Pre	Post	Absolute change	
Grass land	Secondary forest	Christchurch, New Zealand	-1.52	-0.65	0.87	0.03	0.09	0.06	Price et al. 2010
Grass land	Secondary forest	Christchurch, New Zealand	-1.52	-5.09	-3.57	0.03	0.16	0.13	Price et al. 2010
Grass land	Secondary forest	Central New South Wales, Australia	-9.37	-7.01	2.36	0.28	0.28	0.00	Allen et al. 2009
Grass land	Secondary forest	Central New South Wales, Australia	-16.39	-13.40	2.99	0.11	0.17	0.06	Allen et al. 2009
Grass land	Secondary forest	Central New South Wales, Australia	-10.43	-22.16	-11.73	0.28	0.06	-0.22	Allen et al. 2009
Grass land	Secondary forest	South−western Australia	-8.41	-5.35	3.07	0.22	0.33	0.11	Allen et al. 2009
Grass land	Secondary forest	South−western Australia	-4.56	-4.64	-0.08	0.17	0.33	0.17	Allen et al. 2009
Grass land	Secondary forest	South−western Australia	-4.12	-8.41	-4.29	0.84	0.06	-0.78	Allen et al. 2009
Grass land	Secondary forest	South−east Queensland, Australia	-2.11	-14.19	-12.08	0.22	0.11	-0.11	Allen et al 2009
Grass land	Secondary forest	South−east Queensland, Australia	-6.21	-15.07	-8.85	0.17	0.28	0.11	Allen et al. 2009
Grass land	Secondary forest	South−east Queensland, Australia	-7.09	-30.05	-22.96	0.22	0.17	-0.06	Allen et al. 2009
Grass land	Secondary forest	Mean ± CI (95%)			-4.9 ± 4.9			-0.05 ± 0.16	

Table D. Summary of soil methane (CH_4) and nitrous oxide (N_2O) emissions of pre and post land use change and absolute change (post − pre) in secondary forest.

Land use type		Location (city, country)	CH_4 emission (kg CH_4 ha^{-1} y^{-1})			N_2O emission (kg N_2O–N ha^{-1} y^{-1})			Reference
pre	post		Pre	Post	Absolute change	Pre	Post	Absolute change	
Secondary forest	Crop land	Central Sulawesi, Indonesia	-2.92	-3.51	-0.59	2.19	0.79	-1.40	Veldkamp et al. 2008
Secondary forest	Crop land	Mean			-0.59			-1.40	

Table E. Summary of soil methane (CH_4) and nitrous oxide (N_2O) emissions of pre and post land use change and absolute change (post − pre) in natural lands.

Land use type		Location (city, country)	CH_4 emission (kg CH_4 ha^{-1} y^{-1})			N_2O emission (kg N_2O–N ha^{-1} y^{-1})			Reference
pre	post		Pre	Post	Absolute change	Pre	Post	Absolute change	
Wetland	Crop land	Dalat Peat Research Station, Sarawak, Malaysia	96.36	121.76	25.40				Inubushi et al.1998
Wetland	Crop land	Gambut in South Kalimantan, Indonesia	16.00	8.00	-8.00	-0.51	-1.10	-0.59	Inubushi et al. 2003
Wetland	Crop land	Gambut in South Kalimantan, Indonesia	16.00	25.33	9.33	-0.51	-0.37	0.14	Inubushi et al. 2003
Wetland	Crop land	Heilongjiang province, China	199.12	94.83	-104.29	4.07	2.09	-1.98	Jiang et al. 2009
Wetland	Crop land	Heilongjiang province, China	199.12	-1.37	-200.49	4.07	4.90	0.83	Jiang et al. 2009
Wetland	Crop land	Mean ± CI (95%)			-56 ± 84			-0.4 ± 1.2	
Savannah	Grass land	Douglas Daly region of Northern Australia	-2.07	-1.41	0.65	0.02	0.05	0.03	Grover et al. 2012
Savannah	Grass land	Douglas Daly region of Northern Australia	-2.07	3.36	5.43	0.02	0.07	0.05	Grover et al. 2012
Savannah	Grass land	Mean ± CI (95%)			3.0 ± 4.7			0.04 ± 0.02	

Table F. Greenhouse gas emissions in land use changes from forest to crop and grasslands in 1765 to 2005. Mean ± 95% confidence intervals.

	Forest to Cropland (A)		Forest to Grassland (B)		Total (A+B)
Regions	Converted area* (million ha)	Greenhouse gas emissions (Gt CO_2 eq)	Converted area* (million ha)	Greenhouse gas emissions (Gt CO_2 eq)	Greenhouse gas emissions (Gt CO_2 eq)
North America	137.0 ± 29.4	204 ± 84.5	30.5 ± 2.4	35.1 ± 18.8	239 ± 86.6
Latin America	102.3 ± 38.2	152 ± 63.1	181.7 ± 93.3	210 ± 111.9	362 ± 128.5
Europe	71.0 ± 32.1	106 ± 43.7	16.0 ± 4.7	18.4 ± 9.8	124 ± 44.8
North Africa & Middle East	7.7 ± 1.4	11.4 ± 4.7	1.0	1.15 ± 0.6	12.6 ± 4.7
Tropical Africa	48.3 ± 11.8	71.9 ± 29.8	52.5 ± 2.4	60.5 ± 32.3	132 ± 43.9
Former USSR	60.0 ± 40.2	89.3 ± 37.0	15.5 ± 5.7	18.0 ± 9.6	107.1 ± 38.2
China	56.7 ± 14.7	84.3 ± 34.9	19.5 ± 8.8	22.5 ± 12.0	106.8 ± 36.9
South & South-East Asia	178.7 ± 26.9	266 ± 110.2	7.0 ± 3.1	8.1 ± 4.3	273.9 ± 110.3
Pacific developed region	13.3 ± 2.5	19.8 ± 8.2	6.0	6.9 ± 3.7	26.8 ± 9.0
World	674.3 ± 16.3	1000 ± 415.5	280.3 ± 10.4	323 ± 172.7	1326 ± 449.0

* Data from Meiyappan and Jain (2012)

References for Supplementary information

Allen, D., Mendham, D., Cowie, A., Wang, W., Dalal, R., and Raison, R.: Nitrous oxide and methane emissions from soil are reduced following afforestation of pasture lands in three contrasting climatic zones, Soil Research, 47, 443-458, 2009.

Galbally, I., Meyer, C., Wang, Y., and Kirstine, W.: Soil-atmosphere exchange of CH_4, CO, N_2O and NO_x and the effects of land-use change in the semiarid Mallee system in Southeastern Australia, Global Change Biol., 16, 2407-2419, 2010.

Grover, S., Livesley, S., Hutley, L., Jamali, H., Fest, B., Beringer, J., Butterbach-Bahl, K., and Arndt, S.: Land use change and the impact on greenhouse gas exchange in north Australian savanna soils, Biogeosciences, 9, 423-437, 2012.

Hergoualc'h, K., Blanchart, E., Skiba, U., Hénault, C., and Harmand, J.-M.: Changes in carbon stock and greenhouse gas balance in a coffee (Coffea arabica) monoculture versus an agroforestry system with Inga densiflora, in Costa Rica, Agric. Ecosyst. Environ., 148, 102-110, 2012.

Inubushi, K., Furukawa, Y., Hadi, A., Purnomo, E., and Tsuruta, H.: Seasonal changes of CO_2, CH_4 and N_2O fluxes in relation to land-use change in tropical peatlands located in coastal area of South Kalimantan, Chemosphere, 52, 603-608, 2003.

Inubushi, K., Hadi, A., Okazaki, M., and Yonebayashi, K.: Effect of converting wetland forest to sago palm plantations on methane gas flux and organic carbon dynamics in tropical peat soil, Hydrological Processes, 12, 2073-2080, 1998.

Jiang, C., Wang, Y., Hao, Q., and Song, C.: Effect of land-use change on CH_4 and N_2O emissions from freshwater marsh in Northeast China, Atmospheric Environment, 43, 3305-3309, 2009.

Kim, D. -G., Isenhart, T. M., Parkin, T. B., Schultz, R. C., Loynachan, T. E., and Raich, J. W.: Nitrous oxide emissions from riparian forest buffers, warm-season and cool-season grass filters, and crop fields, Biogeosciences Discussion, 6, 607-650, 2009.

Kim, D.-G., Isenhart, T. M., Parkin, T. B., Schultz, R. C., and Loynachan, T. E.: Methane flux in cropland and adjacent riparian buffers with different vegetation covers, Journal of Environmental Quality, 39, 97-105, 2010.

Lin, S., Iqbal, J., Hu, R., Ruan, L., Wu, J., Zhao, J., and Wang, P.: Differences in nitrous oxide fluxes from red soil under different land uses in mid-subtropical China, Agric. Ecosyst. Environ., 146, 168-178, 2012.

Livesley, S., Kiese, R., Miehle, P., Weston, C., Butterbach-Bahl, K., and Arndt, S.: Soil-atmosphere exchange of greenhouse gases in a Eucalyptus marginata woodland, a clover-grass pasture, and Pinus radiata and Eucalyptus globulus plantations, Global Change Biol., 15, 425-440, 2009.

Maljanen, M., Shurpali, N., Hytönen, J., Mäkiranta, P., Aro, L., Potila, H., Laine, J., Li, C., and Martikainen, P. J.: Afforestation does not necessarily reduce nitrous oxide emissions from managed boreal peat soils, Biogeochemistry, 108, 199-218, 2012.

Meiyappan, P., and Jain, A. K.: Three distinct global estimates of historical land-cover change and land-use conversions for over 200 years, Frontiers of Earth Science, 6, 122–139, 2012.

Merino, A., Pérez-Batallón, P., and Macıás, F.: Responses of soil organic matter and greenhouse gas fluxes to soil management and land use changes in a humid temperate region of southern Europe, Soil Biol. Biochem., 36, 917-925, 2004.

Price, S., Whitehead, D., Sherlock, R., McSeveny, T., and Rogers, G.: Net exchange of greenhouse gases from soils in an unimproved pasture and regenerating indigenous Kunzea ericoides shrubland in New Zealand, Soil Research, 48, 385-394, 2010.

Rowlings, D.W.: Influence of historic land use change on the biosphere-atmosphere exchange of C and N trace gases in the humid, subtropical region of Queensland. Ph.D thesis, Queensland University of Technology, page 213, 2010.

Veldkamp, E., Purbopuspito, J., Corre, M. D., Brumme, R., and Murdiyarso, D.: Land use change effects on trace gas fluxes in the forest margins of Central Sulawesi, Indonesia, Journal of Geophysical Research, 113, G02003, 2008.