

Imbalanced phosphorus and nitrogen deposition in China's forests

Enzai Du¹, Wim de Vries^{2, 3}, Wenxuan Han⁴, Xuejun Liu⁴, Zhengbing Yan⁵, Yuan Jiang¹

¹State Key Laboratory of Earth Surface Processes and Resource Ecology, and College of Resources Science & Technology,
5 Beijing Normal University, Xijiekouwai Street 19#, Beijing, 100875, China

²Environmental Systems Analysis Group, Wageningen University, PO Box 47, 6700 AA Wageningen, The Netherlands

³Alterra, Wageningen University and Research Center, PO Box 47, 6700 AA Wageningen, the Netherlands

⁴College of Resources and Environmental Sciences, China Agricultural University, Beijing, 100193, China

⁵Department of Ecology, and Key Laboratory for Earth Surface Processes of the Ministry of Education, Peking University,
10 Beijing, 100871, China

Correspondence to: Enzai Du (enzaidu@bnu.edu.cn) and Yuan Jiang (jiangy@bnu.edu.cn)

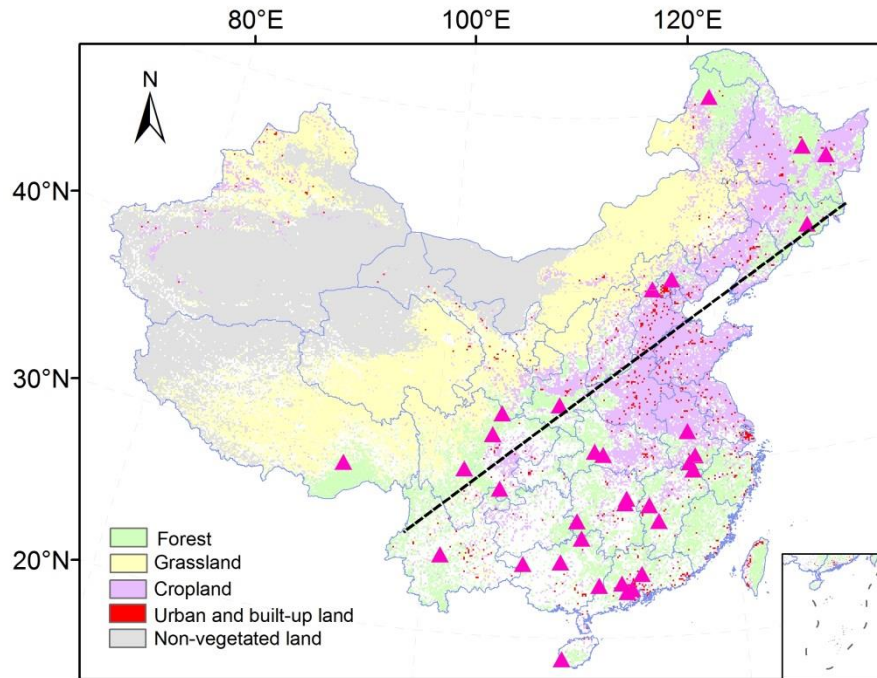


Figure S1. Locations of 33 forested sites with bulk precipitation and throughfall observations in this study. The 11 sites in the northwest of the dashed line have a distance less than 400 km to the nearest semiarid regions (grassland), while the 22 sites in the southeast of the dashed line were far from the semiarid regions.

Table S1 Information on the sites of the datasets.

Site ID	Lon (E)	Lat (N)	BP		TF		Precipitation (mm)	Year(s)	Reference
			N	P	N	P			
1	121.51	50.83	A	A	A	A	500	2008	Su, 2009
2	128.10	42.70	A	A	A	A	515	2001	Xiao et al., 2002
3	130.71	46.42	A	A	A	A	550	2008	Liang et al., 2010
4	117.02	40.51	A	A	A	A	636	1999,2005	Liu et al., 2001; Tian, 2007
5	128.87	47.18	A	A	A	A	676	2006,2008	Wu et al., 2008; Wu, 2009
6	94.02	29.16	A	A	A	A	716	2006-2007	Jin, 2008
7	115.47	40.02	A	A	A	A	717	1994	Chen, 1997
8	104.50	32.91	A	A	A	A	825	2002-2003	Gong et al., 2005
9	103.89	31.69	U	A	U	A	945	2005-2006	Chang, 2007
10	117.34	31.80	A	A	A	A	1011	2008-2011	Zhang, 2010; Zeng, 2012
11	108.50	33.50	A	A	A	A	1130	2013	Liu et al., 2014
12	110.93	30.83	A	A	A	A	1150	2006	Wan et al., 2010
13	111.51	30.65	A	A	A	A	1200	1997	Wang et al., 2000
14	104.57	28.60	A	A	A	A	1214	2012-2013	Zhang et al., 2014
15	108.69	24.42	A	A	A	A	1248	1990-1991	Huang and Liang, 1994
16	115.07	26.75	A	A	A	A	1389	1999-2002	Cai et al.,2003;Chen et al.,2003
17	114.5	27.67	A	A	A	A	1400	1985-1987	Ma, 1989
18	109.75	26.83	A	A	A	A	1407	1995-2002	Tian, 2002; Kang et al., 2006
19	113.03	28.11	A	A	A	A	1411	2007-2008	Luo and Wen, 2010
20	110.05	25.83	A	A	A	A	1538	1990-1991	Huang and Liang, 1994
21	112.90	27.83	A	A	A	A	1549	2003-2004	Chen et al., 2006
22	111.15	23.07	A	A	A	A	1582	1990-1991	Huang and Liang, 1994
23	117.75	30.38	A	A	A	A	1609	2008-2009	Zhang, 2010
24	117.35	30.02	A	A	A	A	1626	2010-2011	Zeng, 2012
25	113.20	22.85	A	A	A	A	1629	2002-2003	Chen et al., 2004
26	117.55	29.58	A	A	A	A	1750	2010-2011	Zeng, 2012
27	106.32	24.28	A	A	A	A	1778	1990-1991	Huang and Liang, 1994
28	112.88	22.67	A	A	A	A	1801	1996	Liu et al., 2000
29	101.02	24.53	A	A	A	A	1931	1991-1993 1997-1999 1998-1999	Gan et al., 1997; Mo et al., 2002 Liu et al., 2002
30	102.12	29.63	A	A	A	A	1947	2006	Sun and Wang, 2009
31	112.57	23.17	A	A	A	A	1968	1999-2000 2009-2010	Liu et al., 2003; Zhang et al., 2011
32	113.83	23.70	A	A	A	A	2084	2006-2008	Zhou et al., 2009
33	108.83	18.73	A	A	A	A	2905	1989-1992 1990-1993	Chen et al., 1998 Zeng et al., 1997

Note: BP and TF indicates bulk precipitation and throughfall, respectively. A and U indicate the availability and unavailability of the targeted data on total N or P concentrations, respectively.

References

- 5 Cai, T.J., Li, F., Li, J.Y., Chen, Y.R., Li, H.T., Zhang, H.Z. 2003. A study on rainfall chemistry of artificial forests in red earth hilly area. *Journal of Natural Resources*, 18(1), 99–104.
- Chang, Z.Y., 2007. Comparison on capability of water holding and nutrition preserving in artificial hybrid forest and second shrub-forest. Master Dissertation, Southwest University.
- Chen, B.F., Zeng, Q.B., Huang, Q., Zhou, G.Y., Wu, Z.M., Li, Y.D. 1998. Ecohydrological effect of tropical mountain rain forest on Jianfengling, Hainan Island—canopy leaching and hydrochemical storage. *Acta Ecologica Sinica*, 18(4), 364–370.
- Chen, Y.R., Liu, Y.F., Lin, Y.M., Li, J.Y., Zhang, H.Z. 2003. Hydrological process and nutrient dynamics of *Schima superba* stand in Qianyanzhou experimental area, Jiangxi Province. *Scientia Silvae Sinicae*, 39(4), 145–150.
- Chen, B.F., Chen, Y., Ying, G.T., Ye, S.S., Ouyang, W., Lin, M.X. 2004. Study on the water quality of urban forest ecosystem in the Pearl River Delta. *Forest Research*, 17(4), 453–460.
- 15 Chen, L.Z. (eds) 1997. Study on structure and function of warm temperate forests. Science Press, Beijing, China.
- Chen, W. H. 2006. Hydrochemical characteristics of throughfall in different layers of *Cinnamomum camphora* plantation. *Chinese Journal of Ecology*, 25(7), 747–752.
- Gan, J.M., Xue, J.Y., Xie, S.C. 1997. The precipitation chemistry of the moist evergreen broadleaved forest at the Ailao Mountain in Yunnan Province. *Journal of Northeast Forestry University*, 25(1): 8–11.
- 20 Gong, H.D., Wang, K.Y., Yang, W.Q. 2005. Nutrient characteristics of throughfall and stemflow in three forests at the subalpine of western Sichuan. *Scientia Silvae Sinicae*, 41(5), 14–20.
- Huang, C.B., Liang, H.W. 1994. Stemflow of main forest types in Guangxi subtropics. *Journal of Plant Resources and Environment*, 3(4), 10–17.
- 25 Jin, Z.T. 2008. Study on hydrological effect of Nyingchi spruce virgin forest in Tibet. Master Dissertation, Xizang University.
- Kang, W.X., Deng, X.W., Zhang, Z.H. 2006. Effects of canopy interception on water and nutrient cycling in the Chinese fir plantation ecosystem. *Scientia Silvae Sinicae*, 42(12), 1–5.
- Liang, X.D., Sun, X.H., Sun, Z.H., Zhang, Y.D. 2010. Nutrient characteristics of throughfall in *Larix olgensis* plantation. *Journal of Northeast Forestry University*, 38(7), 22–24.
- 30 Liu, J.X., Wen, D.Z., Zhou, G.Y. 2000. Chemical properties of the rainfall in the coniferous and broadleaved forests in acid rain area of Heshan, Guangdong. *China Environmental Science*, 20(3), 198–202.

- Liu, W.Y., Fox, J.E.D., Xu, Z.F. 2002. Nutrient fluxes in bulk precipitation, throughfall and stemflow in montane subtropical moist forest on Ailao Mountains in Yunnan, south-west China. *Journal of Tropical Ecology*, 18, 527–548.
- Liu, Y.J., Dang, K.L., Wang, L.H., Liu, P. 2014. Ecological effects of canopies of two forest types on rainwater quality on the south slope of Qinling Mountains. *Journal of Northeast A&F University*, 42(7), 89–94.
- 5 Liu, S.H., Yu, X.X., Yu, Z.M. 2001. Properties of water chemical elements of *Castanea mollissima* forest in Miyun reservoir watershed. *Journal of Beijing Forestry University*, 23(2), 12–15.
- Luo, Z., Wen, S.Z. 2010. Canopy interception and changes in nutrient concentrations in a *Liquidambar formosana* plantation in Tianjiling forestry farm. *Journal of Central South University of Forestry & Technology*, 30(2), 55–59.
- Ma, X.H. 1989. Effects of rainfall on the nutrient cycling in man-made forests of *Cunninghamia Lanceolata* and *Pinus*
10 *Massoniana*. *Acta Ecologica Sinica*, 9(1), 15–20.
- Mo, J.M., Fang, Y.T., Zhang, D.J., Kong, G.H., Feng, Z.N. 2002. Effects of rainfall reallocation on nutrient dynamic of a pine forest in Dinghushan. *Guihaia*, 22(6), 529–533.
- Su, R.N., 2009. Study on Rainfall Hydrochemical Characteristics of *Larix gmelinii* Forest in Great Xing'an Mountains of Inner Mongolia. Master Dissertation, Inner Mongolia Agricultural University.
- 15 Sun, X.Y., Wang, G.X. 2009. The hydro-chemical characteristics study of forest ecosystem precipitation distribution in Gongga Mountain. *Research of Soil and Water Conservation*, 16(6), 120–124.
- Tian, P. 2007. Chemical properties of precipitation in *Pinus tabulaeformis* plantations. Master Dissertation, Beijing Forestry University.
- Tian, D.L. 2002. Nutrient contents in the rainfall inside and outside the stands of Guangping forest zone, Huitong. *Journal of*
20 *Central South Forestry University*, 22(3), 9–13.
- Wan, R., Wang, P.C., Zeng, L.X., Shi, Y.H., Pan, L. 2010. Chemical properties of the precipitation circulation in the forest of Lanlingxi small watershed in the Three Gorges Reservoir Area. *Journal of Nanjing Forestry University*, 34(3), 39–44.
- Wang, Q.C., Deng, H.B., Wang, Q.L., Pan, W.B. 2000. Redistribution of rainfall and nutrient cycling in *Cupressus funebris* forest in the Three-Gorge region. *Resources and Environment in the Yangtze Basin*, 9(4), 451–457.
- 25 Wu, X.J., Cai, T.J., Li, H., Sheng, H.C. 2008. Precipitation hydrochemical characteristic in virgin *Pinus koraiensis* forest and artificial *Larix gmelinii* forest in Liangshui National Nature Reserve. *Science of Soil and Water Conservation*, 6(6), 37–42.
- Wu, X.J. 2009. The study on hydrochemistry characteristics in the process of precipitation in the primitive Korean pine forest. Master Dissertation, Northeast Forestry University.
- 30 Xiao, Y.H., Dai, L.M., Niu, D.K., Tong, F.C., Chen, G., Deng, H.B. 2002. Influence of canopy on precipitation and its nutrient elements in broadleaved/Korean pine forest on the northern slope of Changbai Mountain. *Journal of Forestry Research*, 13 (3), 201–204.
- Zeng, L.M. 2012. The characteristics of hydrochemistry of precipitation in subtropical urban and rural forest ecosystems in Anhui. Master Dissertation, Anhui Agricultural University.

- Zeng, Q.B., Li, Y.D., Chen, B.F., Wu, Z.M., Zhou, G.Y. 1997. Tropical forest ecosystems research and management. Forestry Publishing House, Beijing, China
- Zhang, J., Liu, Y., Zhang, J., Ou, J., Cui, N.J. 2014. Rainfall redistribution by crown layer and variation characteristics of nitrogen and phosphorus in *Pinus massoniana* plantations. Chinese Journal of Ecology, 33(6), 1451–1458.
- 5 Zhang, Y.Q. 2010. The characteristics of hydrochemistry in subtropical urban and rural forest ecosystems in Anhui. Master Dissertation, Anhui Agricultural University.
- Zhou, G.Y., Tian, D.L., Qiu, Z.J., Deng, X.W., Wang, X., Liu, M. 2009. Crown effects on ion concentration in throughfall of a coniferous-broadleaved stand under acid deposition at Liuxihe, Guangzhou. Journal of Central South University of Forestry & Technology, 5, 32–38.