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Supplement of

Variations of leaf N and P concentrations in shrubland biomes across northern China: phylogeny, climate, and soil

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1 Supplement

2 The Supplement for this manuscript consists of three figures and three tables. The
3 figure captions including methodology are given below.

4

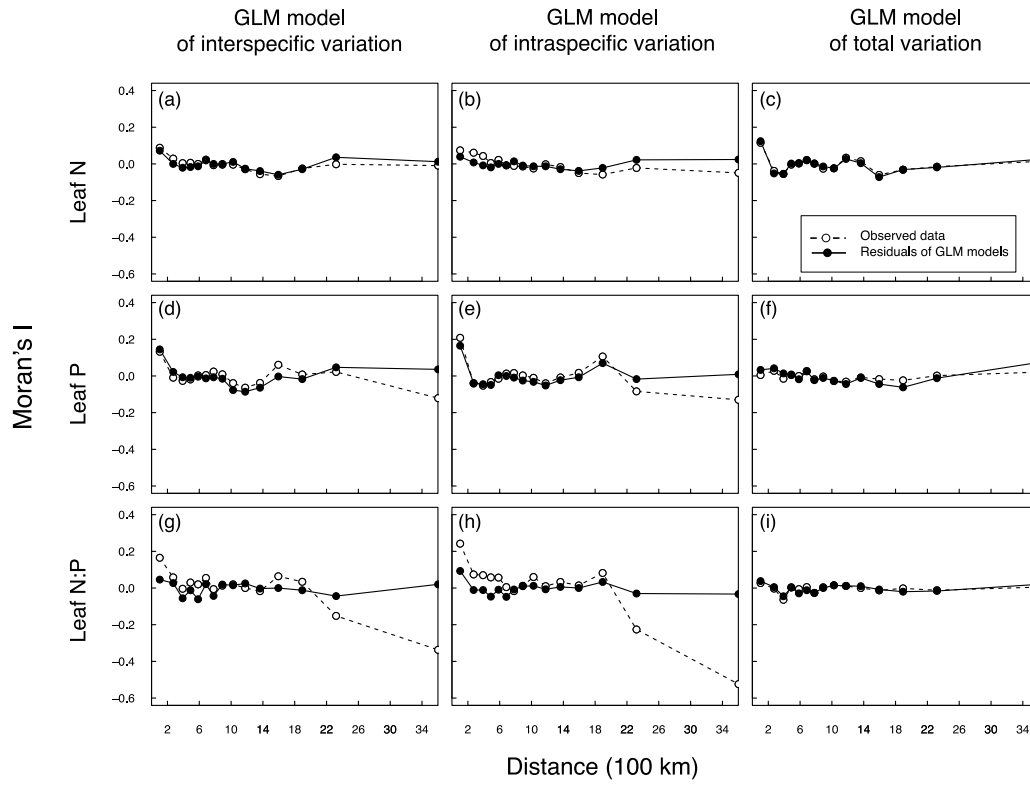
5 **Fig. S1.** Variation of Moran's I along distance bands for observed (black open) and
6 residuals in general linear models (black dot), for inter-specific (left column, a, d, g),
7 intra-specific (central column, b, e, h), and total (right column c, f, i) variations in the
8 leaf nitrogen (upper row, a-c), phosphorus (middle row, d-f) concentrations and leaf
9 N:P (lower row, g-i).

10 **Fig. S2.** Histograms showing the distributions of leaf N (a) and P concentrations (mg
11 g^{-1}) (b) and N:P ratios (c) for all observations.

12 **Fig. S3.** Decomposition of total variation in leaf N (a, d) and P (b, e) concentrations
13 and N:P ratios (c, f) of shrubs in temperate shrubland (a-c) and desert shrubland (d-f).
14 Grey shading corresponds to interspecific variation, and open part corresponds to
15 intraspecific variation. Black bar denotes total variation. The space between the top of
16 the column and the black bar corresponds to the covariance between interspecific and
17 intraspecific variations.

18 **Fig. S4.** Different leaf N (black) and P (grey) concentrations among life forms (a)
19 and different leaf N concentration among functional groups (b) in China. In (a), data
20 for "tree" and "shrub" were from Han *et al.* (2005); data for "herb" were from Han *et*
21 *al.* (2005) and He *et al.* (2006); data for "shrub*" were from this study. Letters above
22 the error bars show the results of multiple comparisons tests. Life forms and
23 functional groups with same letters are not significantly different, while different
24 letters are significantly different ($p < 0.05$).

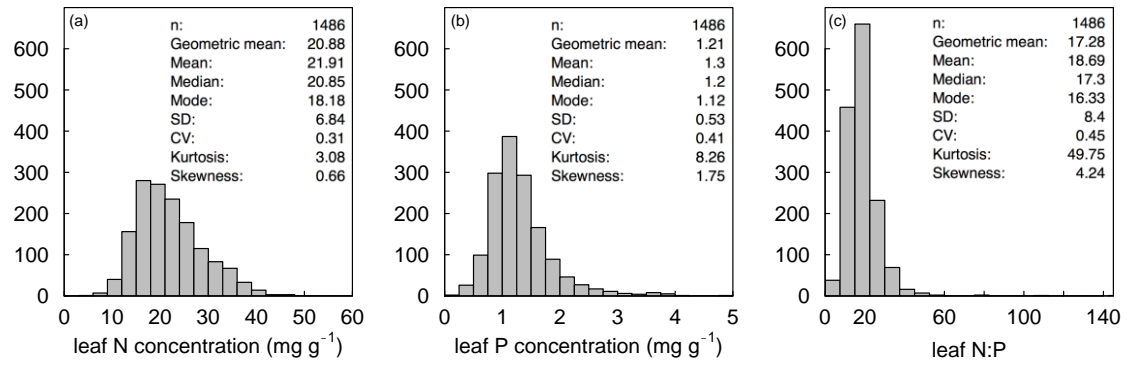
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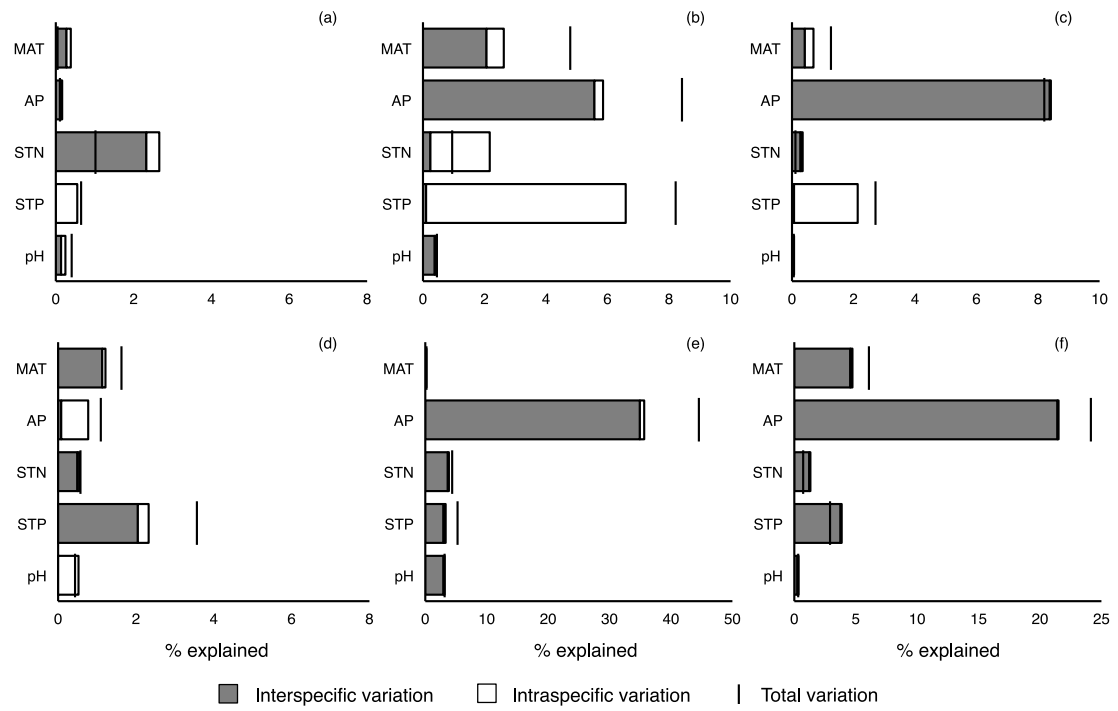
3 Fig. S1



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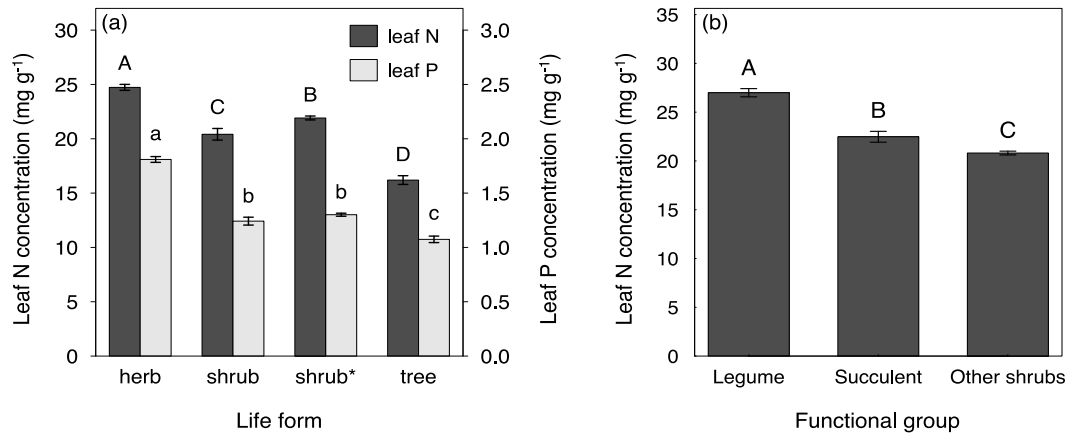
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3 Fig. S2



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2
3

Fig. S3



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2

3 Fig. S4

1 Table S1. Pearson correlation coefficients (R) of soil total nitrogen (STN) and
 2 phosphorus (STP) concentrations between different depth intervals.

STP \ STN	0-10	10-20	20-30	30-50	50-70	70-100
0-10		0.88 ^{***}	0.79 ^{***}	0.62 ^{***}	0.41 ^{***}	0.39 ^{***}
10-20	0.90 ^{***}		0.92 ^{***}	0.82 ^{***}	0.53 ^{***}	0.54 ^{***}
20-30	0.82 ^{***}	0.92 ^{***}		0.79 ^{***}	0.57 ^{***}	0.62 ^{***}
30-50	0.67 ^{***}	0.75 ^{***}	0.84 ^{***}		0.80 ^{***}	0.67 ^{***}
50-70	0.61 ^{***}	0.70 ^{***}	0.77 ^{***}	0.90 ^{***}		0.89 ^{***}
70-100	0.53 ^{***}	0.58 ^{***}	0.65 ^{***}	0.81 ^{***}	0.88 ^{***}	

1 Table S2. Summary of general linear models for leaf N and P concentrations and N:P
 2 ratios of shrubs in northern China with interaction terms.

		Interspecific variation		Intraspecific variation		Total variation				
		<i>F</i> value	SS	<i>F</i> value	SS	<i>F</i> value	SS	SS%		
Leaf N	MAT	1.6	43.2	0.4	6.3	0.4	17.0	0.1		
	AP	27.8	737.2 ^{***}	2.6	38.7	10.4	450.0 ^{**}	3.3		
	STN	12.7	337.8 ^{***}	1.1	16.8	4.8	208.7 [*]	1.6		
	STP	0.2	5.6	2.1	31.4	0.3	11.5	0.1		
	pH	0.3	6.7	0.1	1.6	0.3	14.3	0.1		
	MAT:STP	0.1	2.1	0.8	11.3	0.1	2.8	<0.1		
	STN:STP	8.4	223.7 ^{**}	0.2	2.9	6.4	277.4 [*]	2.1		
	STN:pH	3.3	87.5	0.2	3.2	1.3	56.7	0.4		
	STP:pH	0.3	8.1	2.0	29.5	1.5	64.2	0.5		
	STN:STP:pH	8.0	211.9 ^{**}	0.5	7.7	6.7	289.8 ^{**}	2.2		
	Residual			7436.3				12057.8		
	Total			9100.1				4064.4	13450.2	10.4
	AIC			1792.9				1548.2	1933.5	
	AIC (main-effect)			1803.1				1542.1	1939.8	
Leaf P	MAT	9.5	1.1 ^{**}	2.6	0.3	11.7	2.5 ^{***}	2.6		
	AP	28.1	3.3 ^{***}	2.2	0.2	24.7	5.3 ^{***}	5.6		
	STN	7.9	0.9 ^{**}	9.2	1.0 ^{**}	<0.1	<0.1	<0.1		
	STP	0.6	0.1	30.0	3.3 ^{***}	11.0	2.4 ^{**}	2.5		
	pH	4.2	0.5 [*]	<0.1	<0.1	2.5	0.5	0.6		
	MAT:AP	20.9	2.5 ^{***}	0.2	<0.1	9.7	2.1 ^{**}	2.2		
	MAT:STN	6.0	0.7 [*]	9.0	1.0 ^{**}	15.2	3.3 ^{***}	3.5		
	MAT:STP	0.9	0.1	0.5	0.1	1.5	0.3	0.3		
	MAT:pH	2.2	0.3	2.2	0.2	4.5	1.0 [*]	1.0		
	AP:STN	5.0	0.6 [*]	0.6	0.1	1.7	0.4	0.4		
	AP:STP	8.0	0.9 ^{**}	8.5	0.9 ^{**}	17.0	3.7 ^{***}	3.9		
	AP:pH	5.2	0.6 [*]	<0.1	<0.1	2.8	0.6	0.6		
	STN:STP	6.1	0.7 [*]	24.6	2.7 ^{***}	28.3	6.1 ^{***}	6.4		
	STN:pH	7.7	0.9 ^{**}	0.7	0.1	8.2	1.8 ^{**}	1.9		
	STP:pH	1.7	0.2	2.6	0.3	<0.1	<0.1	<0.1		
	MAT:AP:STN	2.2	0.3	1.6	0.2	5.0	1.1 [*]	1.1		
	MAT:AP:STP	<0.1	<0.1	1.0	0.1	0.8	0.2	0.2		
	MAT:AP:pH	0.2	<0.1	3.5	0.4	0.8	0.2	0.2		
	MAT:STN:STP	6.1	0.7 [*]	0.3	<0.1	4.9	1.1 [*]	1.1		
	MAT:STN:pH	0.6	0.1	5.5	0.6 [*]	4.6	1.0 [*]	1.0		
	AP:STN:STP	0.4	<0.1	13.7	1.5 ^{***}	4.4	1.0 [*]	1.0		
	AP:STN:pH	4.8	0.6 [*]	<0.1	<0.1	3.3	0.7	0.8		
AP:STP:pH	6.9	0.8 ^{**}	2.2	0.2	9.0	1.9 ^{**}	2.0			

	STN:STP:pH	10.4	1.2**	1.9	0.2	2.1	0.5	0.5
	Residual		31.5		27.9		57.3	
	Total		48.8		41.4		94.7	39.5
	AIC	230.7		201.7		404.8		
	AIC (main-effect)	252.0		238.9		478.2		
Leaf N:P	MAT	0.1	2.0	0.6	11.6	0.7	22.5	0.14
	AP	166.2	3055.8***	0.1	1.9	93.4	3203.7***	20.6
	STN	1.4	25.5	0.1	1.5	0.5	16.0	0.1
	STP	0.3	6.2	9.3	167.1**	3.1	106.8	0.7
	pH	2.0	37.2	0.1	1.6	1.6	54.8	0.4
	MAT:AP	24.8	455.2***	0.2	2.9	15.1	519.2***	3.3
	MAT:STN	<0.1	0.1	4.1	73.5*	1.9	65.1	0.4
	MAT:STP	0.4	8.0	0.3	5	<0.1	0.6	<0.1
	MAT:pH	4.4	81.3*	4.3	78.1*	8.5	292.2**	1.9
	AP:STN	11.1	203.9***	0.7	13	7.5	257.1**	1.7
	AP:STP	5.1	93.2*	0.5	9.1	4.4	152.4*	1.0
	AP:pH	4.0	73.3*	0.1	1.9	1.9	66.0	0.4
	STN:STP	0.8	15.3	6.0	108.5*	5.5	189.9*	1.2
	STN:pH	0.4	6.8	0.8	15.1	1.8	61.2	0.4
	MAT:AP:STN	12.1	223.3***	1.6	28.4	14.3	490.5***	3.2
	MAT:AP:STP	4.2	77.7*	0.2	4.2	1.2	40.2	0.3
	MAT:AP:pH	1.9	34.7	2.3	41.5	3.7	128.0	0.8
	MAT:STN:STP	2.4	44.2	0.6	11.1	2.9	100.0	0.6
	MAT:STN:pH	7.1	130.1**	1.9	33.7	7.9	271.1**	1.7
	AP:STN:pH	12.5	229.1***	<0.1	0.4	6.3	216.5*	1.4
	Residual		4964.2		4637.7		9261.7	
	Total		9767.1		5247.8		15515.5	40.3
	AIC	1695.3		1615.3		1876.8		
	AIC (main-effect)	1730.0		1609.8		1904.8		

The effects of MAT, AP, STN, STP, Soil pH and all of their possible interactions on leaf N (a), P (b) concentrations and N:P (c) were analyzed using general linear models (GLM). Akaike information criterion (AIC) was used to select competing models. For each trait, effects that were selected in the any of the three models (interspecific, intraspecific and total variation) were included in the final model.

Abbreviations: MAT, mean annual temperature; AP, annual precipitation; STN, soil total nitrogen; STP, soil total phosphorus. *** $p < 0.001$, ** $p < 0.01$ and ^{NS} not significant.

1 Table S3. Summary of main-effect general linear models for leaf N and P
 2 concentrations and N:P ratios of shrubs in temperate shrubland (TS) and desert
 3 shrubland (DS).

		Interspecific variation		Intraspecific variation		Total variation		
		F value	SS	F value	SS	F value	SS	SS%
TS Leaf N	MAT	2.8	42.3 ^{NS}	0.1	1.0 ^{NS}	1	30.9 ^{NS}	0.5
	AP	1.1	16.0 ^{NS}	0.3	3.9 ^{NS}	0.1	4.1 ^{NS}	0.1
	STN	9.9	147.6 ^{**}	2.2	31.3 ^{NS}	1.5	43.5 ^{NS}	0.7
	STP	<0.1	<0.1 ^{NS}	3.8	52.5 ^{NS}	1.8	53.8 ^{NS}	0.9
	Soil pH	0.2	2.7 ^{NS}	<0.1	0.5 ^{NS}	0.2	5.8 ^{NS}	0.1
	Residual		2891.6		2660.3		5806.4	
	Total		3100.2		2749.6		5944.5	2.3
TS Leaf P	MAT	18	1.1 ^{***}	3.3	0.5 ^{NS}	15.1	3.0 ^{***}	5.7
	AP	60.3	3.6 ^{***}	1.4	0.2 ^{NS}	28.1	5.6 ^{***}	10.6
	STN	1	0.1 ^{NS}	9	1.4 ^{**}	4.2	0.8 [*]	1.6
	STP	0.7	0.1 ^{NS}	25.9	3.9 ^{***}	23.7	4.8 ^{***}	8.9
	Soil pH	2	0.1 ^{NS}	0.1	<0.1 ^{NS}	1.1	0.2 ^{NS}	0.4
	Residual		11.7		28.8		39	
	Total		16.7		34.8		53.5	27.1
TS Leaf N:P	MAT	1.7	12.4 ^{NS}	0.8	15.2 ^{NS}	2.2	54.0 ^{NS}	1
	AP	89.2	645.5 ^{***}	<0.1	0.5 ^{NS}	25.4	611.2 ^{***}	11
	STN	2	14.2 ^{NS}	0.1	2.7 ^{NS}	0.2	4.7 ^{NS}	0.1
	STP	0.6	4.0 ^{NS}	7.3	140.3 ^{**}	7.9	191.5 ^{**}	3.4
	Soil pH	0.7	5.4 ^{NS}	0.7	14.2 ^{NS}	1.5	35.8 ^{NS}	0.6
	Residual		1404.3		3664.4		4672.5	
	Total		2085.8		3837.3		5569.7	16.1
DS Leaf N	MAT	1	25.0 ^{NS}	0.8	11.5 ^{NS}	0.1	2.9 ^{NS}	<0.1
	AP	0.5	13.6 ^{NS}	0.1	0.7 ^{NS}	0.2	8.5 ^{NS}	0.1
	STN	8.7	218.1 ^{**}	2.1	29.4 ^{NS}	2.2	91.8 ^{NS}	1
	STP	<0.1	0.1 ^{NS}	3.8	52.1 ^{NS}	1.4	58.3 ^{NS}	0.6
	Soil pH	0.5	13 ^{NS}	0.7	9.1 ^{NS}	1	43.0 ^{NS}	0.5
	Residual		5460.5		2944.7		9149.4	
	Total		5730.3		3047.5		9353.9	2.2
DS Leaf P	MAT	14.5	1.3 ^{***}	2.4	0.3 ^{NS}	13.3	3.0 ^{***}	4.7
	AP	39.1	3.5 ^{***}	1.1	0.2 ^{NS}	23.4	5.2 ^{***}	8.3
	STN	1.6	0.1 ^{NS}	8.3	1.2 ^{**}	2.2	0.5 ^{NS}	0.8
	STP	0.7	0.1 ^{NS}	27.9	4.1 ^{***}	23.3	5.2 ^{***}	8.2
	Soil pH	2.6	0.2 ^{NS}	<0.1	<0.1 ^{NS}	1.2	0.3 ^{NS}	0.4

	Residual		19.7		31.3		48.9	
	Total		24.9		37.1		63	22.5
DS	MAT	2.4	31.5 ^{NS}	1.1	20.5 ^{NS}	3.3	100.9 ^{NS}	1.3
Leaf N:P	AP	48.9	636.6 ^{***}	<0.1	0.3 ^{NS}	20.2	612.7 ^{***}	8.1
	STN	1.6	21.3 ^{NS}	0.3	5.4 ^{NS}	0.2	6.1 ^{NS}	0.1
	STP	0.3	3.9 ^{NS}	8.7	159.3 ^{**}	6.9	210.9 ^{**}	2.8
	Soil pH	0.2	2.2 ^{NS}	<0.1	0.5 ^{NS}	0.2	4.6 ^{NS}	0.1
	Residual		2850.2		3889.7		6652.6	
	Total		3545.5		4075.7		7587.8	12.3

Abbreviations: TS, temperate shrublands; DS, desert shrublands; MAT, mean annual temperature; AP, annual precipitation; STN, soil total nitrogen; STP, soil total phosphorus; *** $p < 0.001$, ** $p < 0.01$ and ^{NS} not significant.

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