Table S1 Summary of the main characteristics of three study sites.

Study sites	Position	Soil parent material	Bedrock	MAP (mm)	MAT (°C)	Sampling elevation (m)		Dominant species		Soil type	
						Tree	Shrub	Tree	Shrub		
Subtropical Mt.	102°52′-103°24′E,8.4 30°45′-31°25′N	Moraines sediments	limestone	883–1146	2.8–5.8	2860, 3290, and 3670	2840, 3160, and 3590	*Abies faxoniana*	*Quercus aquifolioides*	Umbric Cambisols	Cryic
Dry-temperate Mt.	102°58′-103°01′E, 37°14′-37°20′N	Slope deposit	conglomerate	363–550	-4.6–1.6	2540, 2870, and 3250	3020, 3250, and 3540	*Picea crassifolia*	*Salix gilashanica*	Calcaric Cambisols	Ustic
Wet-temperate Mt.	126°55′-129°00′E, 41°23′-42′36°N	Alluvial deposit	trachyte	811–1154	-4.8–0.3	1700, 1860, and 2030	1430, 2000, and 2380	*Betula ermanii*	*Vaccinium uliginosum*	Andic Cambisols	Gelic

Table S2 Correlation analyses (*R* values) of soil base cations and available micronutrients with soil physicochemical parameters of treeline or shrubline for each sampling site.

		Treeline						Shrubline					
		Ca	Mg	K	Fe	Mn	Zn	Ca	Mg	K	Fe	Mn	Zn
Subtropical Mt.	pH	**0.47**	0.37	0.54*	0.05	-0.13	-0.35	0.87**	-0.13	-0.56*	-0.60**	**-0.40**	**-0.43**
	SOC	0.31	**0.47**	0.40	0.64**	0.67**	0.78**	**0.43**	0.63**	-0.18	0.15	-0.08	0.36
	TN	0.34	0.49*	0.35	0.57*	0.68**	0.72**	0.55*	0.57*	-0.25	-0.07	-0.19	0.26
	C:N	0.04	0.09	0.27	0.34	0.12	0.27	-0.52*	0.00	0.29	0.72**	0.34	0.23
	NO_3^-	0.52*	0.51*	0.63**	0.38	0.11	0.16	0.62**	-0.16	-0.51*	-0.35	-0.17	0.10
	NH_4^+	0.08	0.08	-0.21	0.02	**0.43**	0.02	0.00	0.07	0.22	0.13	0.37	0.07
	TIN	0.55*	0.54*	0.51*	0.39	0.33	0.16	0.61**	-0.15	-0.48*	-0.34	-0.14	0.10
	Olsen P	**0.40**	**0.67****	0.54*	0.29	0.31	0.49*	-0.21	-0.08	0.37	0.24	-0.09	-0.28
Dry-temperate Mt.	pH	-0.85**	-0.79**	0.63**	**-0.43**	-0.12	-0.40	-0.07	0.07	0.38	0.35	0.49*	-0.13
	SOC	0.59*	0.60**	-0.36	0.08	-0.09	0.22	0.64**	**0.45**	-0.37	-0.20	-0.25	0.10
	TN	0.95**	0.94**	-0.72**	0.63**	0.38	**0.46**	0.01	0.09	0.22	-0.03	-0.35	0.01
	C:N	-0.52*	-0.49*	0.53*	-0.70**	-0.57*	-0.32	0.79**	0.48*	-0.63**	-0.21	-0.04	0.07
	NO_3^-	-0.48*	-0.38	0.32	-0.18	-0.12	-0.39	-0.51*	-0.01	0.32	0.26	0.28	-0.05
	NH_4^+	0.19	0.30	-0.19	0.24	0.36	0.32	**0.46**	0.13	0.03	-0.33	-0.30	-0.09
	TIN	**-0.43**	-0.31	0.27	-0.12	-0.04	-0.30	-0.26	0.10	**0.44**	0.04	0.10	-0.14
	Olsen P	0.48*	0.53*	-0.28	0.20	0.12	0.47*	-0.33	-0.25	0.67**	**0.46**	0.39	-0.14
Wet-temperate Mt.	pH	0.03	-0.22	0.13	-0.57*	**0.41**	0.15	0.66*	0.49*	**-0.46**	-0.53*	0.65**	**0.41**
	SOC	-0.09	0.15	0.56*	0.91**	-0.57*	0.07	0.67**	0.83**	0.36	0.61**	**0.41**	0.54*
	TN	**0.43**	0.65**	**0.44**	0.71**	-0.32	**0.43**	0.78**	0.88**	0.22	0.47*	0.53*	0.55*
	C:N	-0.70**	-0.58*	**0.42**	0.66**	-0.61**	**-0.42**	-0.48*	-0.50*	0.09	0.06	**-0.40**	-0.24
	NO_3^-	-0.07	-0.20	-0.32	-0.21	0.18	-0.12	-0.25	-0.32	0.02	-0.07	-0.30	-0.16
	NH_4^+	0.09	0.19	0.61**	-0.07	-0.29	0.49*	-0.29	**-0.43**	-0.09	-0.32	-0.22	-0.20
	TIN	-0.03	-0.11	-0.08	-0.23	0.06	0.07	-0.28	-0.37	-0.02	-0.15	-0.29	-0.18
	Olsen P	0.01	0.12	0.49*	0.18	0.04	**0.44**	0.27	0.48*	0.49*	0.17	0.20	0.34

* and ** indicate significant level at $P < 0.05$ and 0.01, respectively. Bold type represents $P < 0.1$.

Table S3 Correlation analyses for base cations and available micronutrients in soil and plant tissues of leaf, root, shoot and stem sapwood across sampling sites, plant life form and elevation position.

Base cations and micronutrients	Correlation analyses				
Ca		Soil Ca	Leaf Ca	Root Ca	Shoot Ca
	Leaf Ca	0.60**			
	Root Ca	0.56**	0.37**		
	Shoot Ca	0.56**	0.37**	0.54**	
	Stem Ca	0.56**	-0.01	0.24*	0.43**
Mg		Soil Mg	Leaf Mg	Root Mg	Shoot Mg
	Leaf Mg	0.66**			
	Root Mg	0.10	-0.09		
	Shoot Mg	0.44**	0.44**	0.21*	
	Stem Mg	0.10	-0.41**	0.17	-0.09
K		Soil K	Leaf K	Root K	Shoot K
	Leaf K	-0.06			
	Root K	0.34**	-0.08		
	Shoot K	0.32**	0.07	0.44**	
	Stem K	0.21*	-0.46**	0.55**	0.20*
Fe		Soil Fe	Leaf Fe	Root Fe	Shoot Fe
	Leaf Fe	-0.17			
	Root Fe	-0.07	0.37**		
	Shoot Fe	-0.43**	0.38**	0.27**	
	Stem Fe	-0.39**	0.35**	0.13	0.53**
Mn		Soil Mn	Leaf Mn	Root Mn	Shoot Mn
	Leaf Mn	0.30**			
	Root Mn	0.28**	0.67**		
	Shoot Mn	0.35**	0.61**	0.89**	
	Stem Mn	0.32**	0.46**	0.19*	0.22*
Zn		Soil Zn	Leaf Zn	Root Zn	Shoot Zn
	Leaf Zn	0.52**			
	Root Zn	0.57**	0.69**		
	Shoot Zn	0.62**	0.86**	0.88**	
	Stem Zn	0.44**	0.11	0.53**	0.48**

* and ** indicate significant level at $P < 0.05$ and 0.01, respectively.

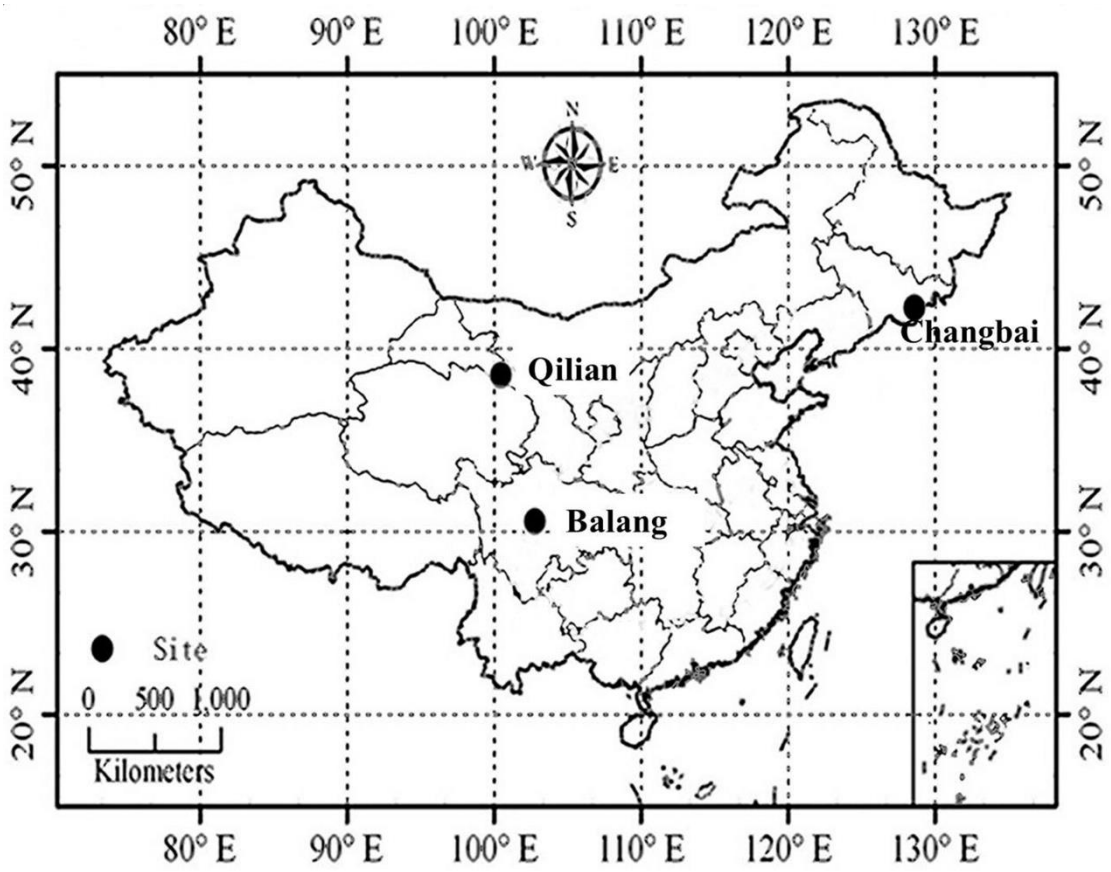

Fig. S1 Location of three sampling sites of Balang (subtropical Mt.), Qilian (dry-temperate Mt.) and Changbai (wet-temperate Mt.).

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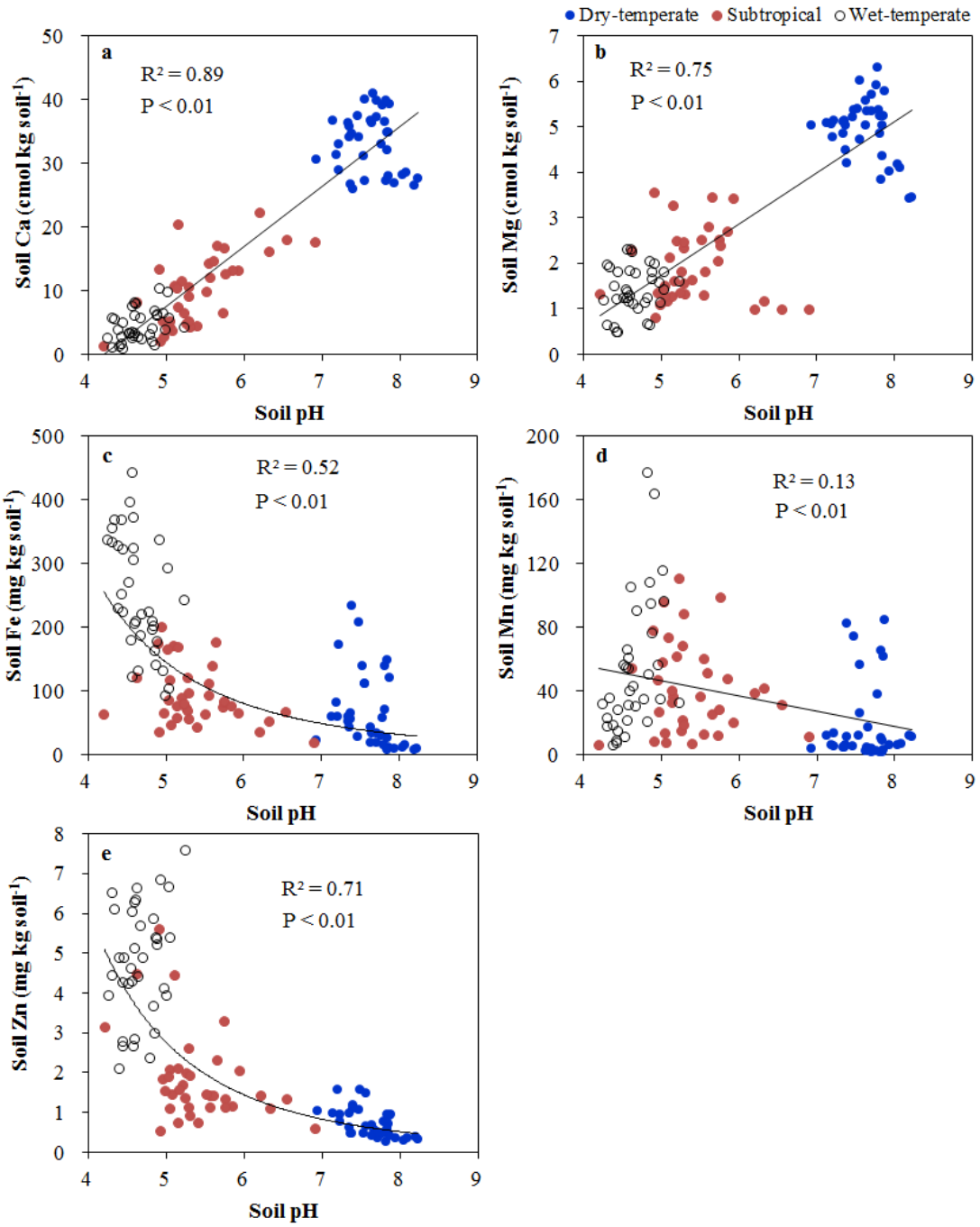

Fig. S2 Correlation analyses between soil pH and soil exchangeable base cations of Ca (a) and Mg (b) and available micronutrients of Fe (c), Mn (d) and Zn (e) under trees and shrubs across three sampling sites.

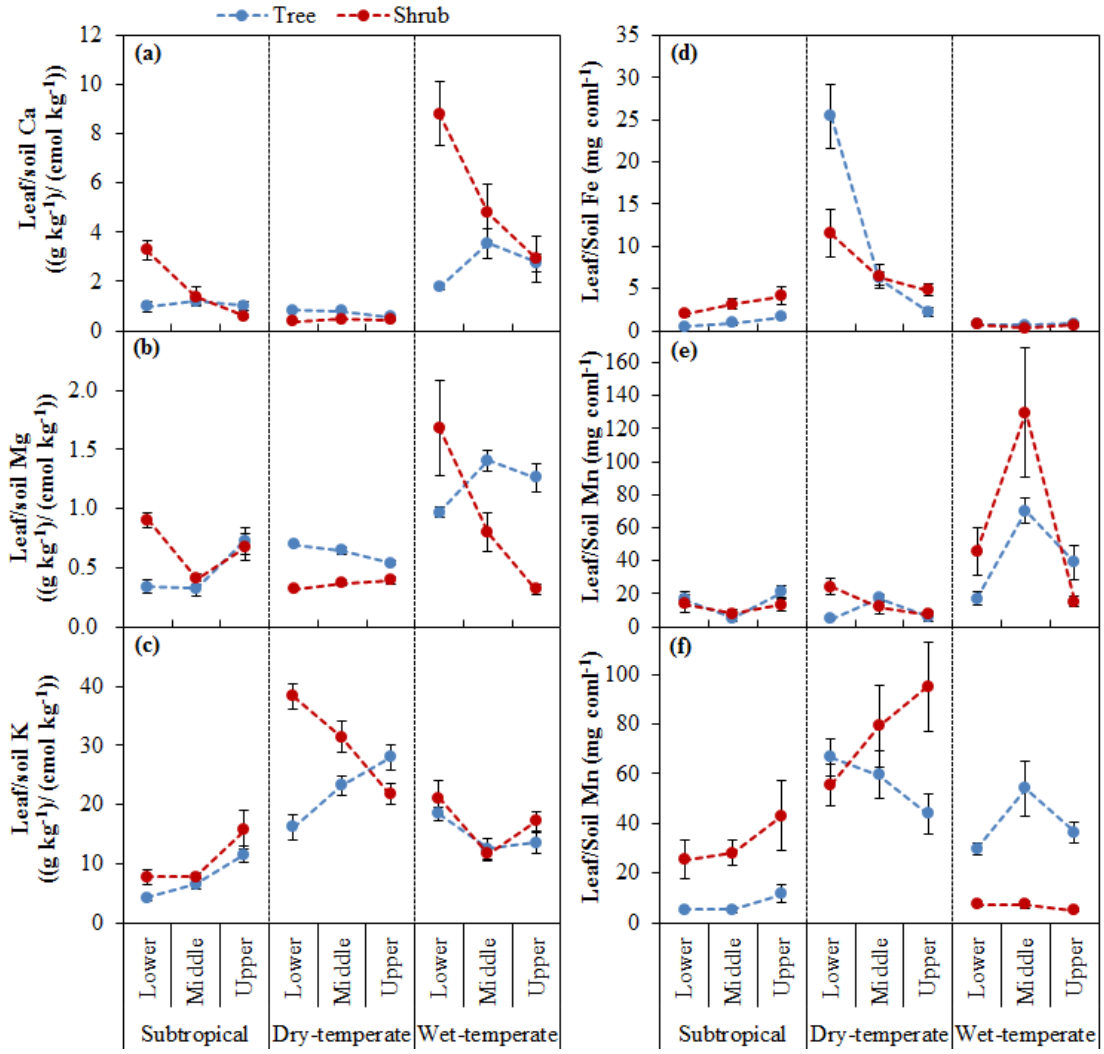

Fig. S3 The ratio of nutrient concentrations of Ca (a), Mg (b), K (c), Fe (d), Mn (e) and Zn (f) in plant leaves to their availabilities in soils at lower and middle elevations as well as at the upper limit of trees or shrubs for each of the three sites.

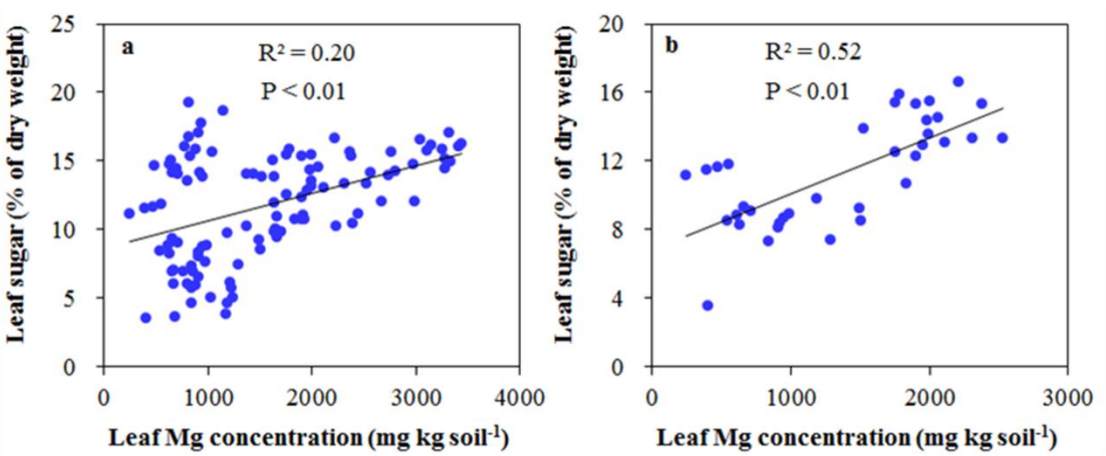

Fig. S4 Correlation analyses between Mg concentration and soluble sugar contents across three sampling sites (a) and at wet-temperate Mt. (b).