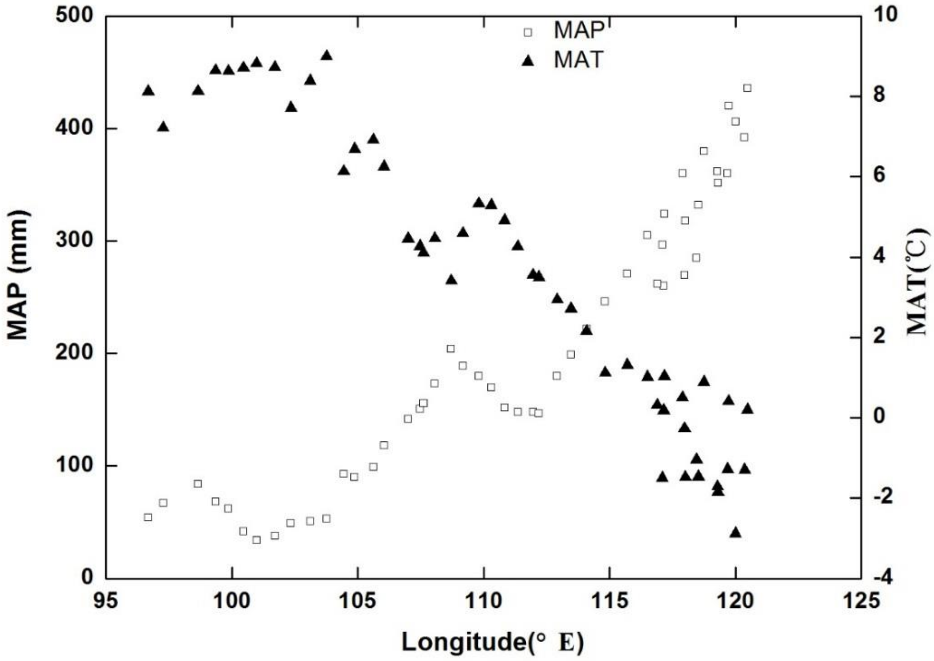
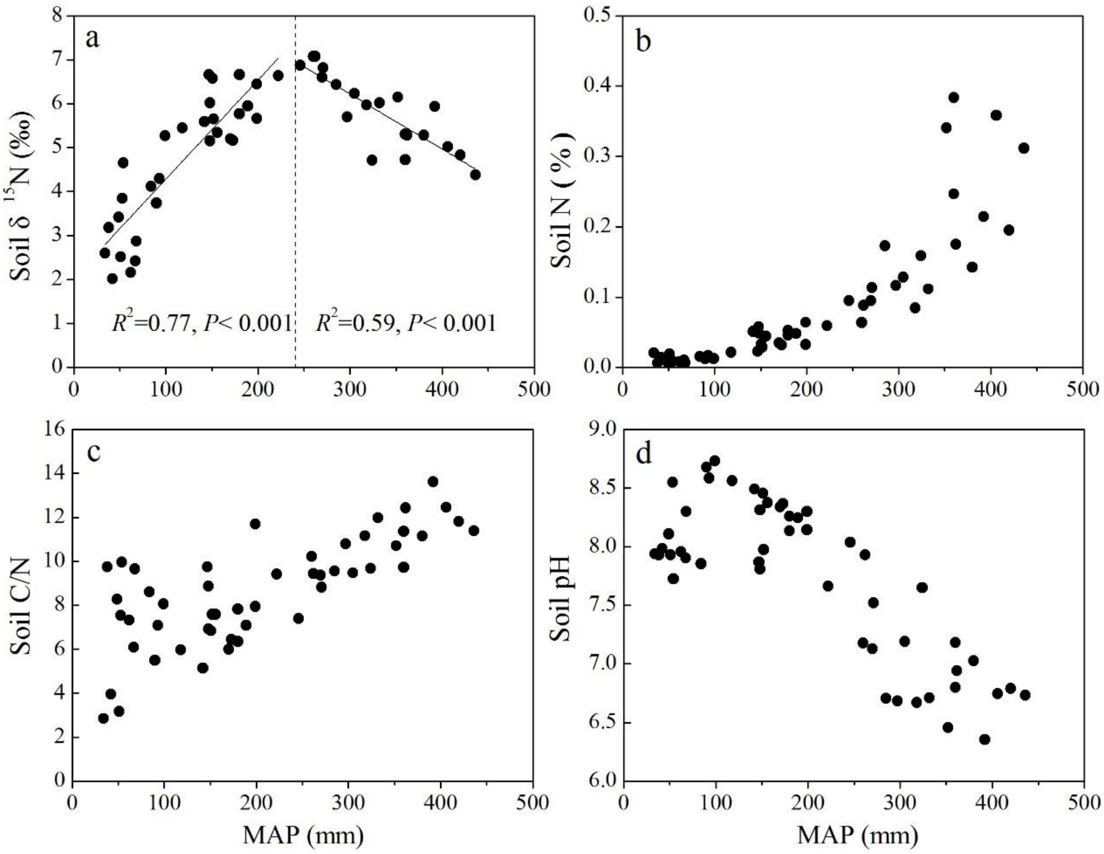
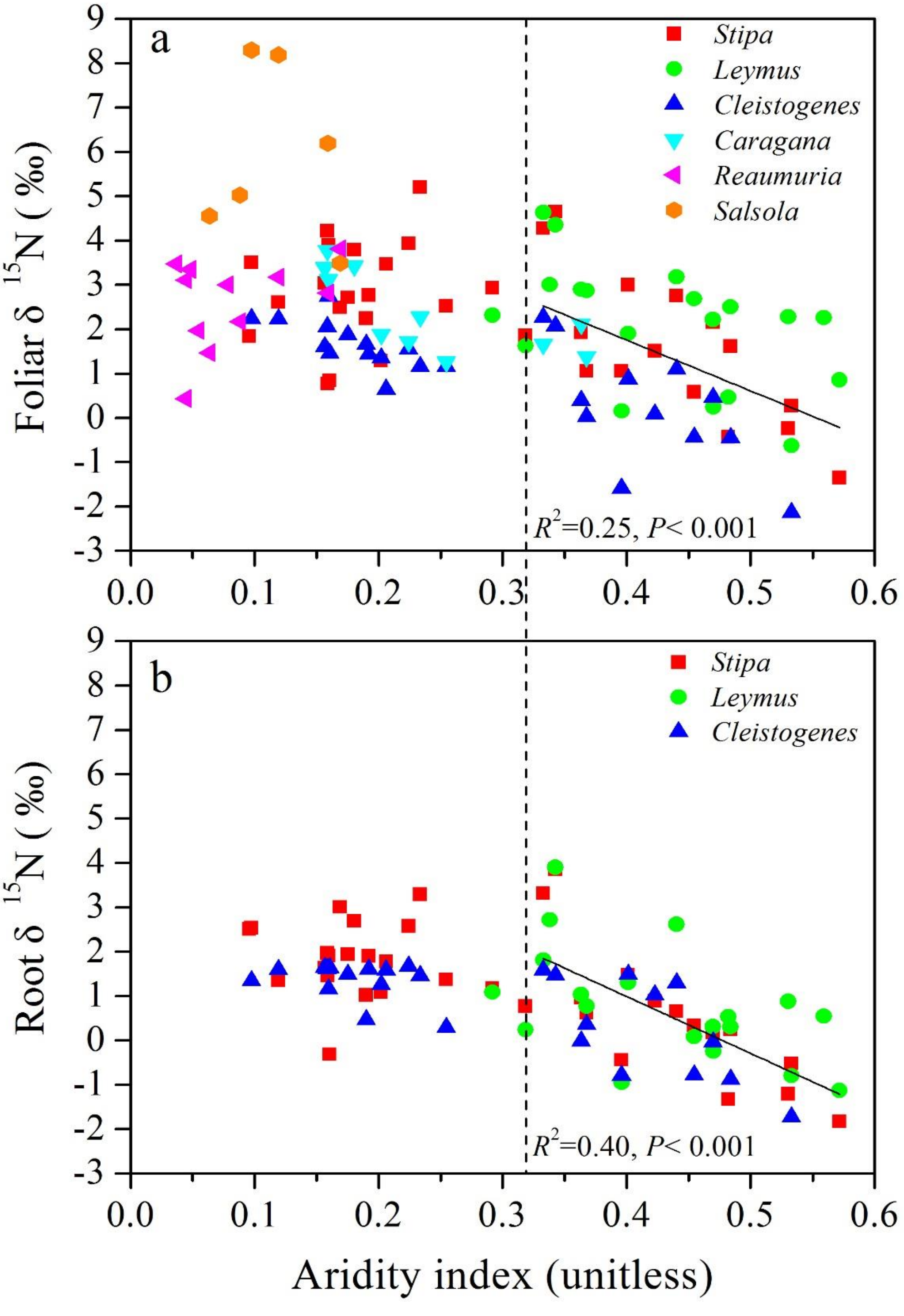


Supplementary Figure 1. MAP and MAT of study sites. Mean annual precipitation (MAP) and mean annual temperature (MAT) along the grassland transect. Data for MAP and MAT were from database of WorldClim[1] (data from 1950-2000).

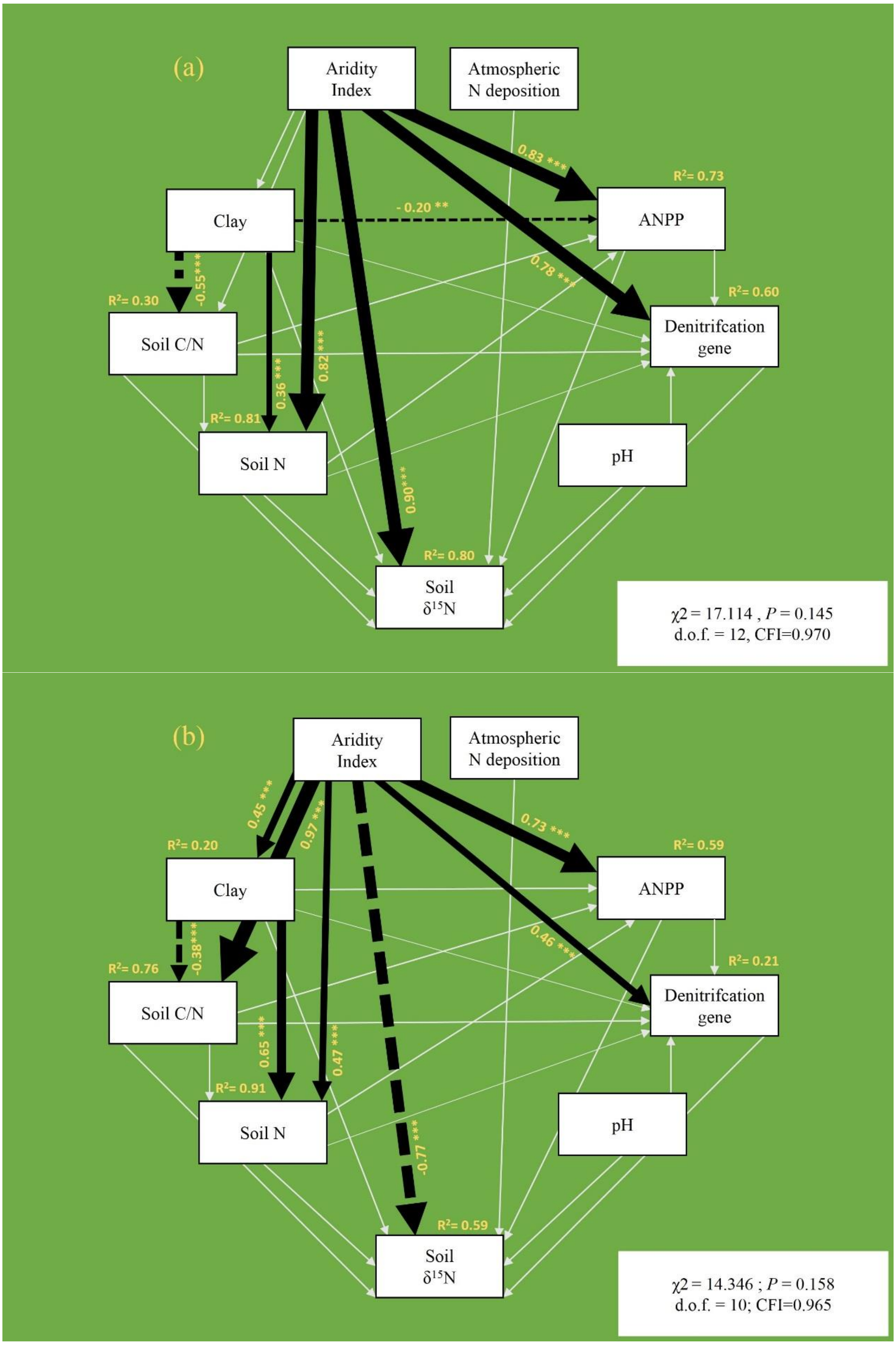


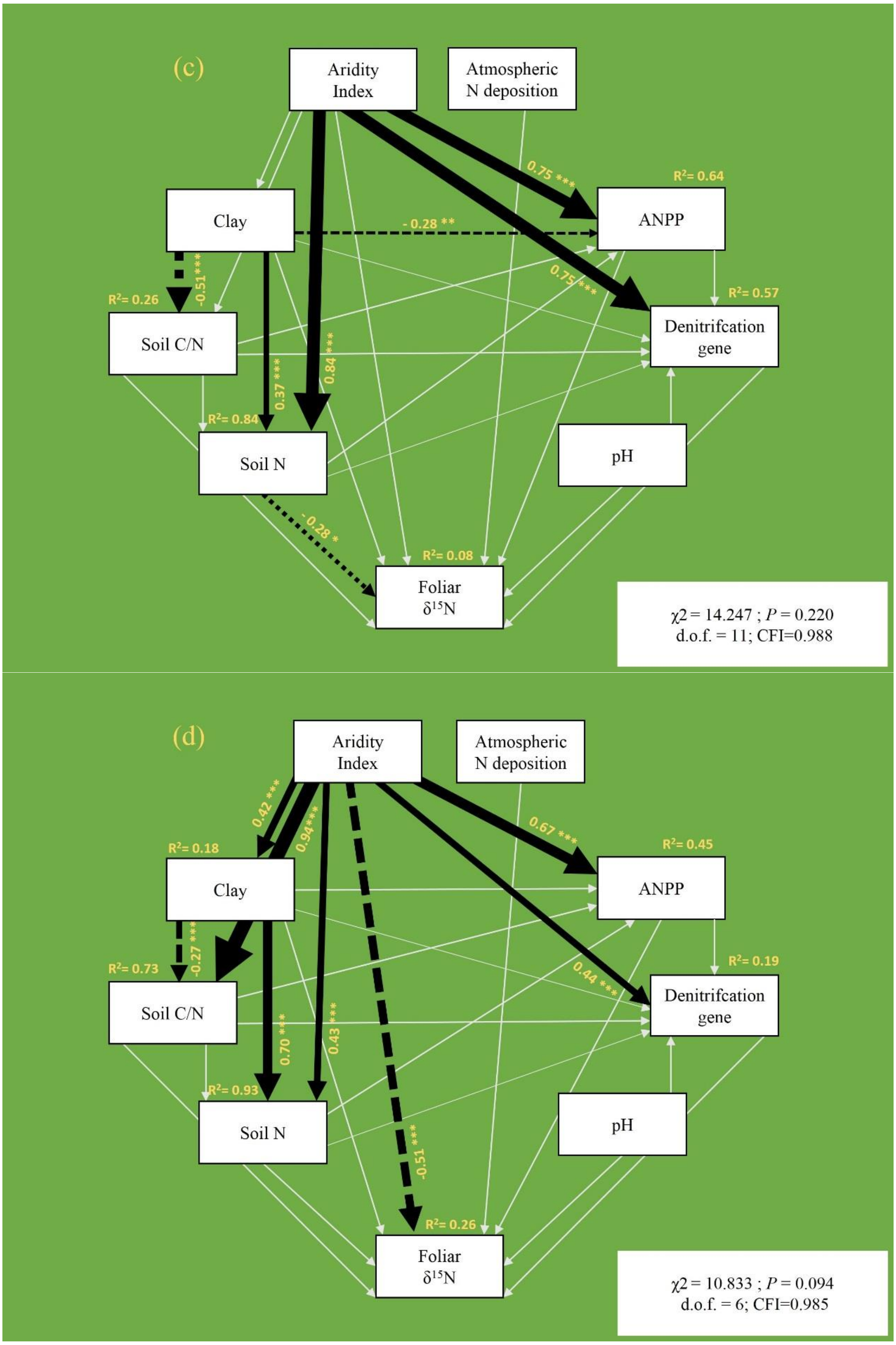
Supplementary Figure 2. Soil N isotopes and edaphic characters. (**a**) A positive relationship between soil $\delta^{15}N$ and mean annul precipitation (MAP) was observed in areas with MAP < 246 mm and negative relationship was observed in areas with 246mm < MAP < 436 mm. Soil N concentration (**b**), C/N ratio (**c**) and pH (**d**) showed different patterns with increasing MAP above and below the threshold MAP = 246 mm.



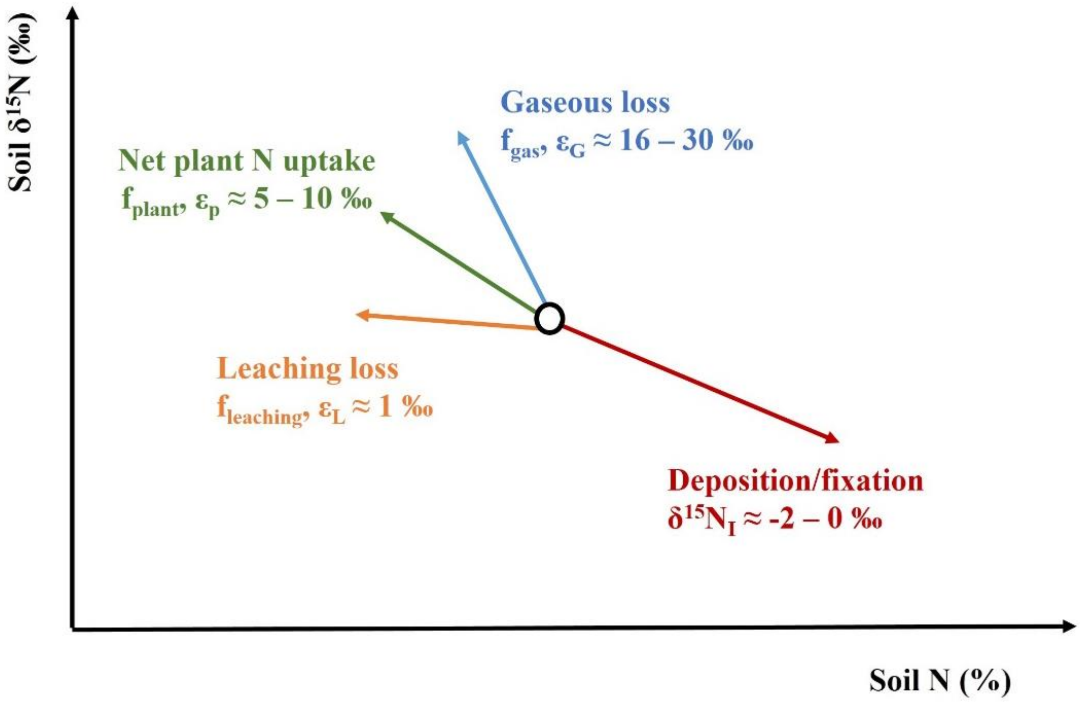
Supplementary Figure 3. Relationship between AI and foliar and root δ^{15}N.

When the six sampled genera were lumped, there was a significantly negative correlation between foliar δ^{15}N and AI (**a**) and root δ^{15}N and AI (**b**) in area with 0.32 < AI < 0.57 while no relationship was observed when AI < 0.32.

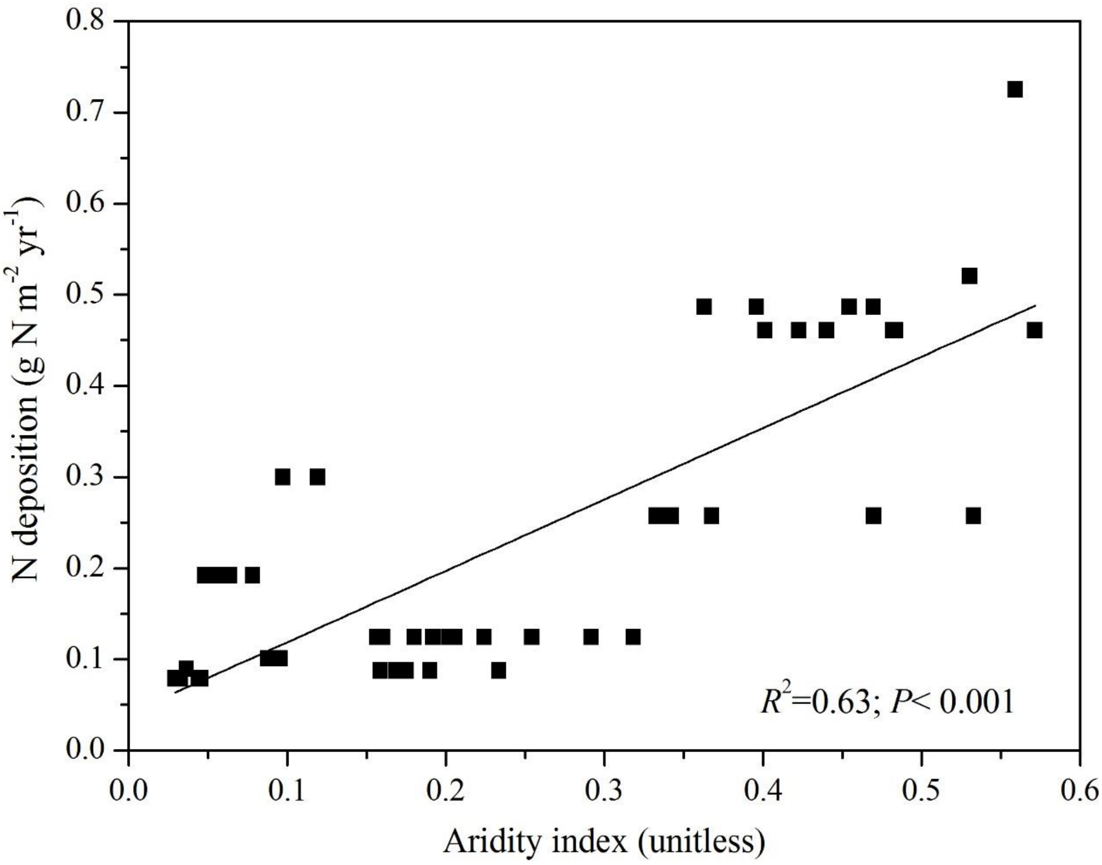

(a)
Aridity Index
Atmospheric N deposition
0.83 ***
R²= 0.73
Clay
- 0.20 **
ANPP
-0.55***
0.78 ***
R²= 0.30
R²= 0.60
Soil C/N
Denitrifcation gene
0.82***
0.36 ***
R²= 0.81
Soil N
pH
0.90***
R²= 0.80
Soil δ15N
χ2 = 17.114 , P = 0.145
d.o.f. = 12, CFI=0.970
(b)
Aridity Index
Atmospheric N deposition
0.45 ***
0.97 ***
0.73 ***
R²= 0.20
R²= 0.59
Clay
ANPP
0.46 ***
-0.38***
R²= 0.76
R²= 0.21
Soil C/N
Denitrifcation gene
0.65 ***
0.47 ***
R²= 0.91
Soil N
pH
-0.77 ***
R²= 0.59
Soil δ15N
χ2 = 14.346 ; P = 0.158
d.o.f. = 10; CFI=0.965


(c)
Aridity Index
Atmospheric N deposition
0.75 ***
R²= 0.64
Clay
- 0.28 **
ANPP
0.75 ***
-0.51***
R²= 0.26
R²= 0.57
Soil C/N
Denitrifcation gene
0.84 ***
0.37 ***
R²= 0.84
Soil N
pH
- 0.28 *
R²= 0.08
Foliar δ15N
χ2 = 14.247 ; P = 0.220
d.o.f. = 11; CFI=0.988
(d)
Aridity Index
Atmospheric N deposition
0.42 ***
0.94***
0.67 ***
R²= 0.18
R²= 0.45
Clay
ANPP
-0.27 ***
R²= 0.73
0.44 ***
R²= 0.19
Soil C/N
Denitrifcation gene
0.70 ***
0.43 ***
R²= 0.93
Soil N
pH
-0.51 ***
R²= 0.26
Foliar δ15N
χ2 = 10.833 ; P = 0.094
d.o.f. = 6; CFI=0.985

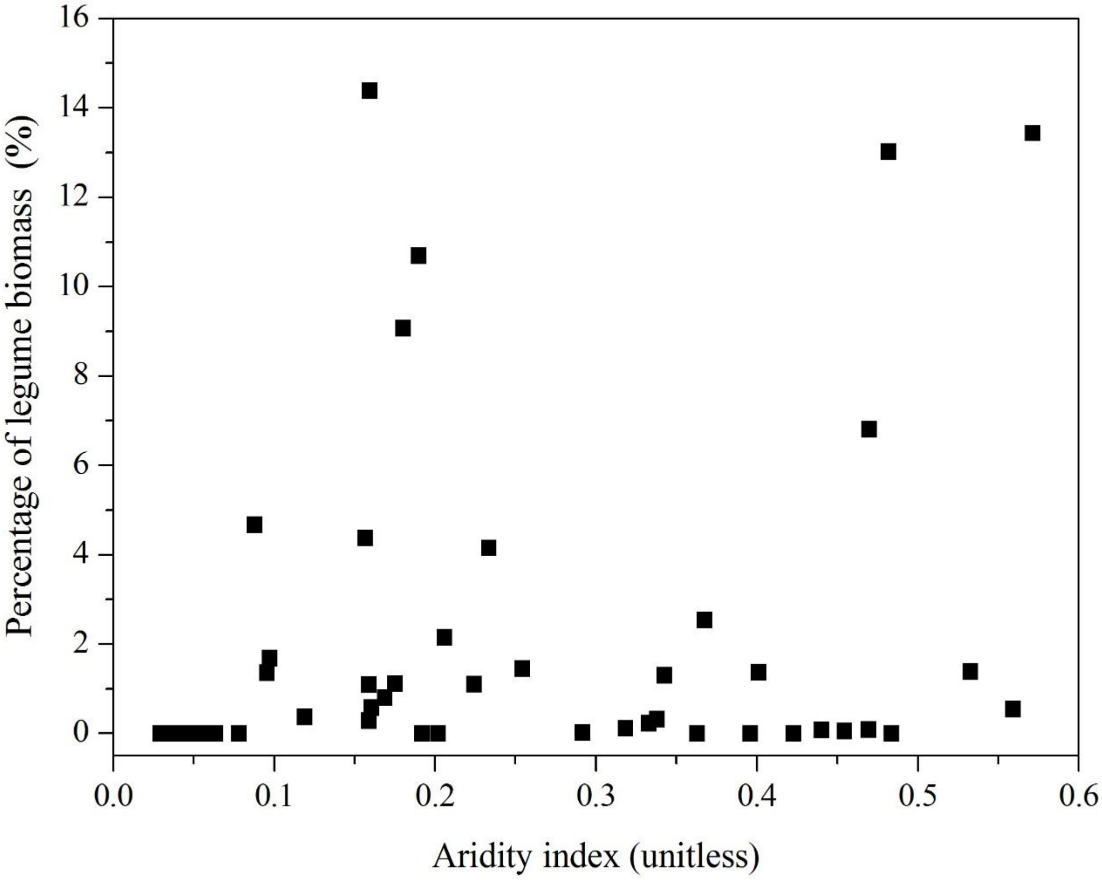
Supplementary Figure 4. Structure equation model (SEM). Using SEM to analyze factors influencing soil $\delta^{15}N$ changes in area with AI < 0.32 (**a**) and 0.32 < AI < 0.57 (**b**), as well as foliar $\delta^{15}N$ in area with AI < 0.32 (**c**) and 0.32 < AI < 0.57 (**d**). Numbers adjacent to arrows are standardized path coefficients, analogous to relative regression weights, and indicative of effect size of the relationship. Continuous and dashed black arrows indicate positive and negative relationship and white lines indicative no significant relationship. The thickness of the arrows is proportional to the magnitude of the standardized path coefficients or co-variation coefficients. SEM demonstrated that AI was the most significant factor influencing ecosystem $\delta^{15}N$ and had a positive effects on soil $\delta^{15}N$ in areas with AI < 0.32, whereas it had a negative effects on soil and foliar $\delta^{15}N$ in areas with 0.32 < AI < 0.57. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. χ^2, Chi-square; d.o.f, degrees of freedom; *p*: probability level; CFI: comparative fit index; nonsignificant χ^2 tests (p > 0.05) and CFI values over 0.90 are considered acceptable[2].



Supplementary Figure 5. Impacts of different processes on soil δ^{15}N and soil N concentration. f_{uptake}, proportion of net plant N accumulation out of total N losses; $f_{leaching}$, proportion of N leaching losses out of total N losses; f_{gas}, proportion of gaseous N losses out of total N losses, and $\delta^{15}N_I$, combined δ^{15}N of atmospheric deposition and biological fixation. $f_{uptake} + f_{leaching} + f_{gas} = 1$. ε_G, ε_L, and ε_P are the enrichment factor for gaseous N losses, leaching N losses and plant N uptake, respectively [ε (‰) = $({}^{14}k/{}^{15}k - 1) \times 1000$], where *k* is a rate constant.

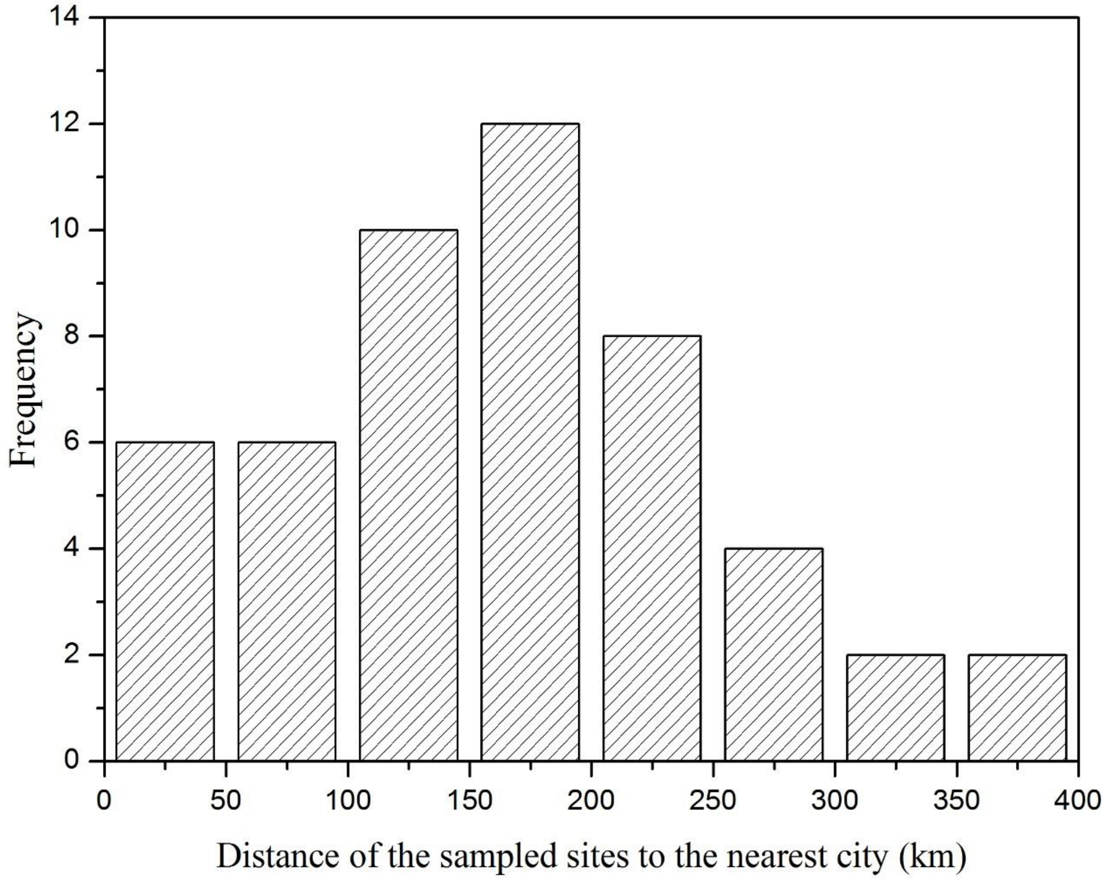


Supplementary Figure 6. Modeled N deposition rate along the transect. Data of N deposition data comes from Lelieveld and Dentener[3]. We obtained N deposition of each study sites using Spatial Analysis tool of ArcGIS software 9.3 (ESRI, Redlands, CA).



Supplementary Figure 7. Percentage of legume biomass along the transect (%).

Percentage was estimated using aboveground legume biomass divided by ANPP.



Supplementary Figure 8. Location of the study sites. The distance of sampled sites to the nearest city was obtained from Google Map, using Distance tool of ArcGIS 9.3 (ESRI, Redlands, CA). Most sampled sites had distance of > 100 km to the nearest city and therefore disturbance of human activities were not considered.

Supplementary Table 1.

Correlation analysis. Pearson product-moment correlation coefficients (r) between climatic factors (AI, MAP and MAT) and edaphic variables (soil N, C, C/N ratio, pH and soil clay content) along the grassland transect in northern China. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

	AI	MAP	MAT	Soil N	Soil C	Soil C/N	pH	Clay
AI	1							
MAP	0.996**	1						
MAT	-0.944**	-0.938**	1					
Soil N	0.866**	0.847**	-0.766**	1				
Soil C	0.869**	0.844**	-0.761**	0.990**	1			
Soil C/N	0.756**	0.743**	-0.718**	0.621**	0.670**	1		
pH	-0.831**	-0.803**	0.777**	-0.770**	-0.789**	-0.731**	1	
Clay	0.321*	0.308*	-0.272	0.641**	0.606**	0.040	-0.204	1

Supplementary References

1. Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G. & Jarvis, A. Very high resolution interpolated climate surfaces for global land areas. *Int. J. Climatol.* **25**, 1965-1978 (2005).

2. Shipley, B. *Cause and Correlation in Biology: A User's Guide to Path Analysis, structural equations and causal inference.* Cambridge University Press (2002).

3. Lelieveld, J. & Dentener, F. J. What controls tropospheric ozone? *J. Geophys. Res.* **105**, 3531-3551 (2000).