

799 **Supplementary Table S1** The belowground biomass, soil nutrition, and microbial
 800 characteristics in 0–10 cm depth soil profile under the control, long-term and moderate, and
 801 short-term and acute warming treatments (mean \pm SE, n = 3-6).

Soil variables	Control	Moderately Warmed	Acutely Warmed	<i>F</i>	<i>P</i>
BB (g soil-collar ⁻¹)	1.91.0 \pm 0.81	0.93 \pm 0.56	11.5 \pm 0.80	0.44	0.66
SOC (g·kg ⁻¹)	13.41 \pm 0.70	12.06 \pm 1.22	11.18 \pm 0.62	1.85	0.21
NH ₄ ⁺ -N (mg·kg ⁻¹)	7.18 \pm 0.78	8.54 \pm 1.05	6.69 \pm 1.27	0.74	0.51
NO ₃ ⁻ -N (mg·kg ⁻¹)	6.72 \pm 1.13	6.43 \pm 1.53	8.43 \pm 1.74	0.48	0.63
MBC (mg·kg ⁻¹)	165.53 \pm 25.07	175.49 \pm 38.96	170.95 \pm 36.27	0.03	0.97
MBN (mg·kg ⁻¹)	11.17 \pm 2.23	13.44 \pm 4.04	12.88 \pm 4.50	0.15	0.86

802 BB, SOC, NH₄⁺-N, and NO₃⁻-N represent belowground biomass, soil organic carbon, ammonium- and
 803 nitrate-nitrogen concentrations, respectively; and MBC and MBN represent soil microbial biomass carbon,
 804 and nitrogen concentrations, respectively. The BB dry weight was determined with a precision balances (its
 805 readability \geq 0.001 g), and soil dry sample weight was measured on an analytical balance (readability \geq
 806 0.0001 g) semi-analytical balance, respectively.

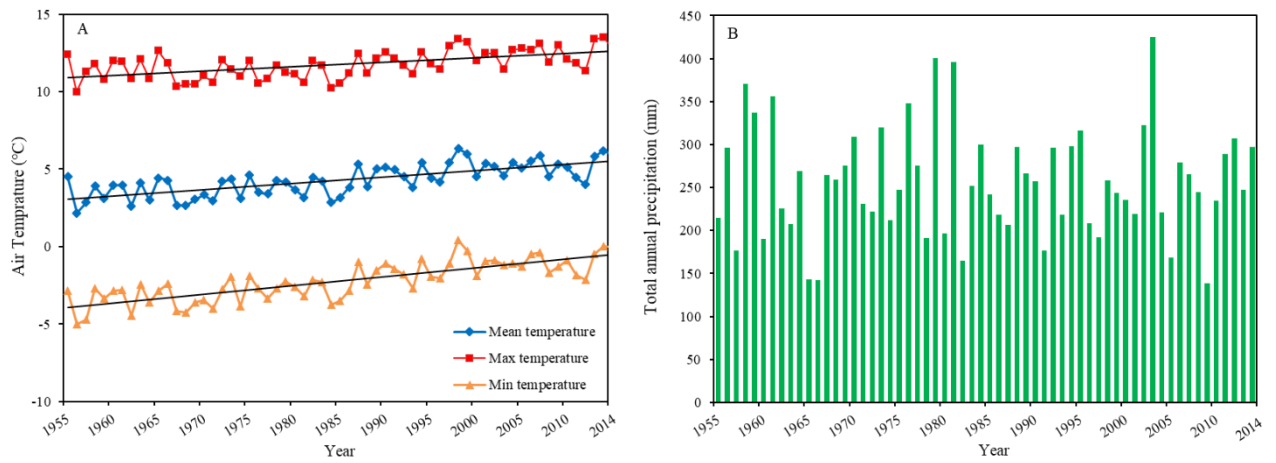
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808 **Supplementary Table S2** Path analysis between soil respiration (R_s) and key factors.

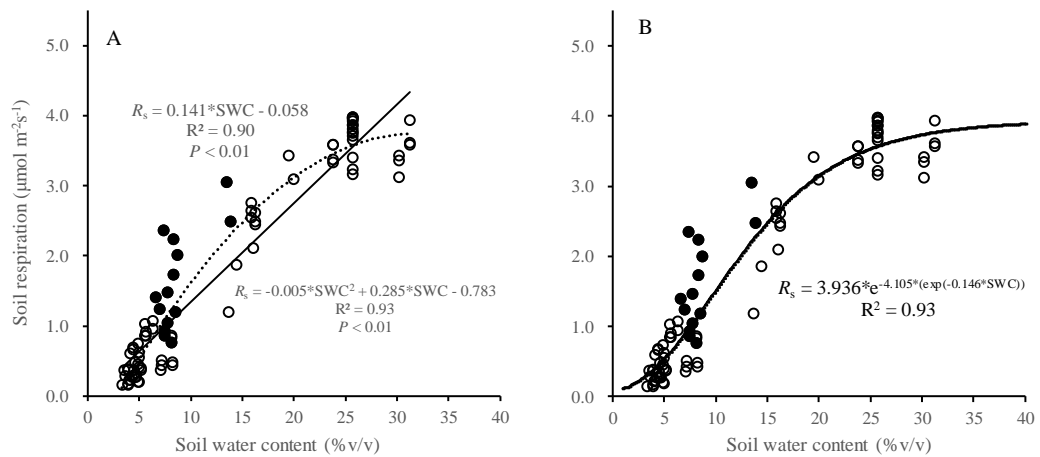
Variables of the key factors	Correlation coefficients with R_s	Path coefficients (direct effects)	Indirect path coefficients (indirect effects)				
			X_1	X_2	X_3	X_4	Total
Soil moisture (X_1)	0.78**	0.72		0.08	0.03	-0.06	0.06
Soil temperature (X_2)	0.69**	0.55	0.11		0.04	-0.01	0.14
Belowground biomass (X_3)	0.48	0.12	0.21	0.20		-0.06	0.36
Soil organic carbon (X_4)	0.47	-0.10	0.44	0.06	0.07		0.57

809 *, $P < 0.05$; ** $P < 0.01$, $n = 12$.

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811 **Supplementary Figure S1.** Long-term air temperature (A) and total annual precipitation (B)
 812 records from 1955 to 2014 in the experiment site in the desert steppe ecosystem, Damao
 813 Banner, Nei Mongol, China.



814 **Figure S2** Relationship between R_s and soil water content based on a linear (black line) and a
 815 quadratic (dotted line) functional model (A), and Gompertz functional model (B). Close and
 816 open circles denote the data in 2014 and 2017, respectively. The close red circles indicate data
 817 used for the initial R_s response to SWC. The functional fitting does not substantially affect
 818 despite a slight improvement with greater R^2 values when the outlier point was removed (ref.
 819 Figure 2). Note, we measured the R_s during 9:00-10:00 in the cloudless days with calm/gentle
 820 wind in order to maintain other environmental factors such as soil temperature and radiation
 821 to relatively stable and constant ($n = 91$).