Supporting Information

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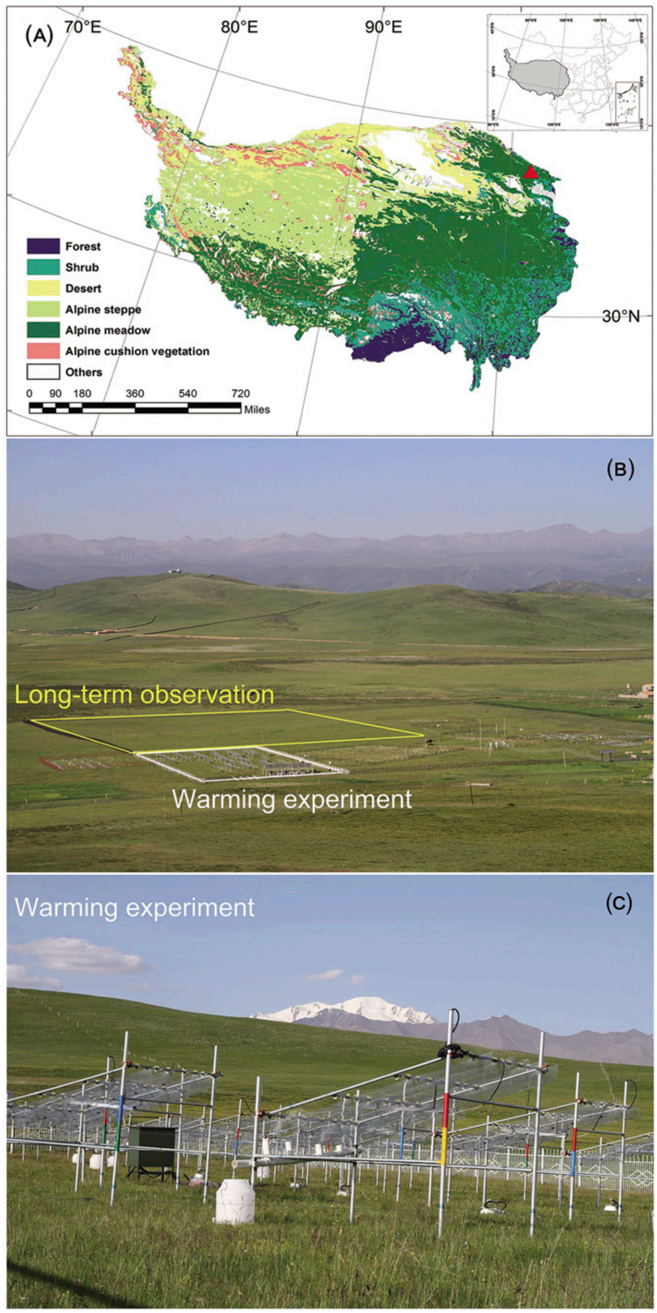

Fig. S1. Geographical location of the study site against the background map of the vegetation of the Tibetan Plateau (*A*), the landscape of the permanent field site at the Haibei National Field Research Station of the Alpine Grassland Ecosystem (*B*), and the warming and precipitation experiment site (*C*). In *B*, the yellow lines represent the long-term monitoring area, and the white lines represent the warming and precipitation experiment site.

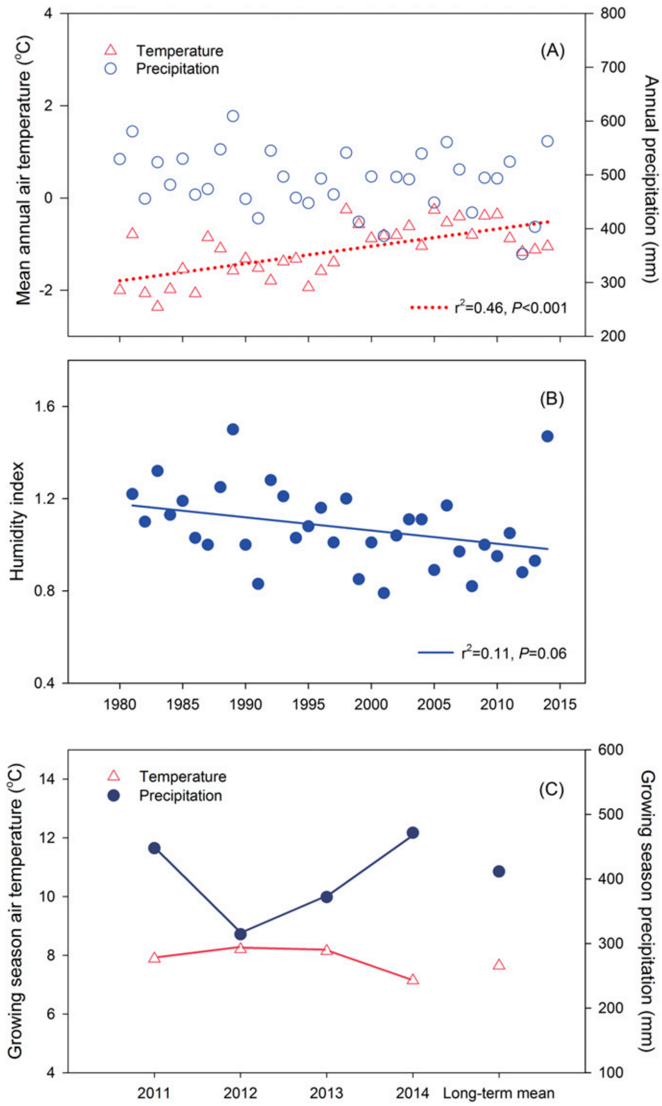

Fig. S2. Changes in climate-related variables long-term and from 2011 to 2014 when the experiment was conducted. Variations in mean annual air temperature, annual precipitation (*A*) and humidity index (*B*) over 1980–2014, and growing season (May–September), mean air temperature and precipitation over 2011–2014 (*C*). The humidity index was calculated as the ratio of precipitation to PET (potential evapotranspiration).

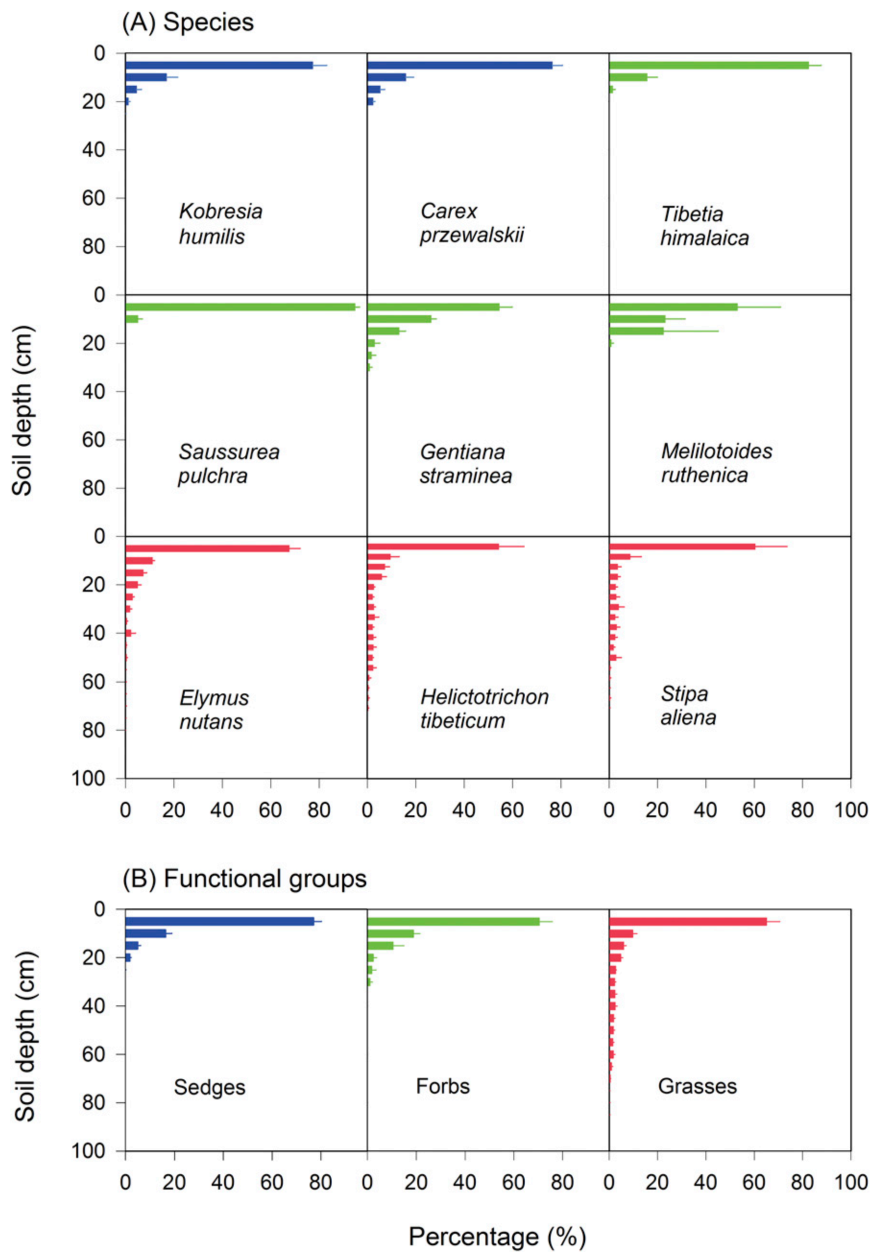

Fig. S3. Vertical distributions of roots for nine common plant species (*A*) from three functional groups (*B*), which account for about 72% of community ANPP. Different colors denote different functional groups (blue = sedges; green = forbs; red = grasses).

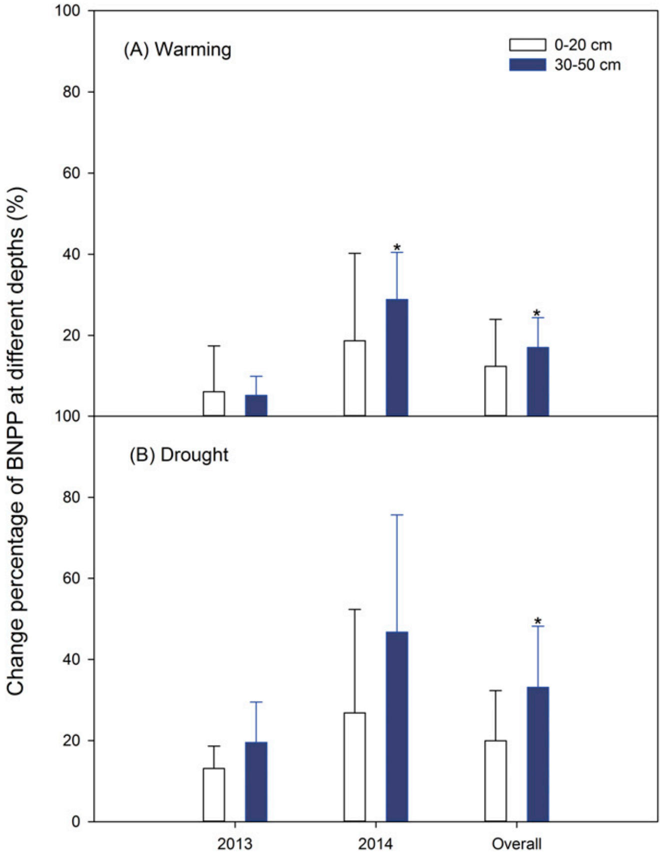

Fig. S4. Warming (*A*) and drought (*B*) effects on change percentage ((warming/drought − control)/control × 100) of belowground net primary production (BNPP) at different soil depths using minirhizotron. Vertical bars represent the SEMs ($n = 4$). Asterisks indicate significant differences between treatments and control ($P < 0.05$), or the change percentage is statistically different from zero ($P < 0.05$).

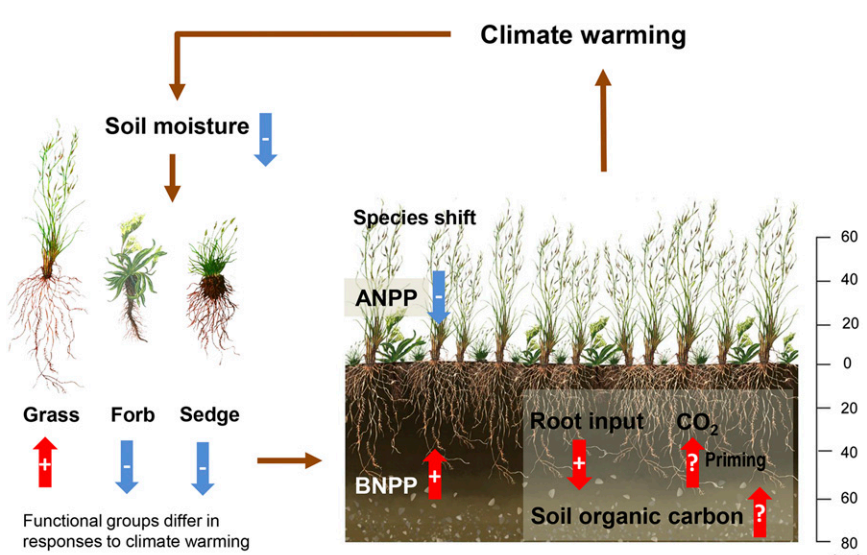

Fig. S5. A conceptual model of the impact of warming on ecosystem processes and the potential feedbacks to climate warming in the alpine ecosystem on the Tibetan Plateau. Red arrows with "+" indicate increase, blue arrows with "−" indicate decrease, and arrows with "?" indicate uncertainty. Our data show that climate warming reduces soil moisture, which leads to species shift (i.e., increase in grass abundance at the cost of forbs and sedges). This species shift does not affect total NPP, but changes NPP allocation (i.e., decrease in ANPP and increase in BNPP). As a result, root carbon inputs to subsoil increase, the CO_2 flux from subsoil decomposition (accelerated by possible priming effect) also may increase, but the storage of subsoil soil organic carbon remains uncertain because of the uncertainty in the relative change of root input vs. subsoil decomposition.

Table S1. Relative abundance of different plant functional groups in control, warming and drought plots from 2011 to 2014

Year	Treatment	Grass	Forb	Sedge
2011	Control	64.86 ± 1.19	31.25 ± 1.96	3.89 ± 1.79
2011	Warming	69.83 ± 6.33	24.37 ± 4.95	5.80 ± 4.95
2011	Drought	60.65 ± 7.55	34.63 ± 4.06	4.72 ± 3.52
2012	Control	59.09 ± 0.67	37.26 ± 1.26	3.66 ± 1.02
2012	Warming	75.76 ± 3.31	21.89 ± 2.80	2.35 ± 0.57
2012	Drought	74.94 ± 0.81	22.81 ± 1.00	2.25 ± 0.32
2013	Control	52.92 ± 3.36	40.53 ± 3.19	6.54 ± 0.38
2013	Warming	67.18 ± 1.01	29.82 ± 2.04	2.99 ± 1.23
2013	Drought	64.46 ± 2.10	32.39 ± 2.60	3.14 ± 0.93
2014	Control	63.66 ± 3.21	29.51 ± 3.98	6.82 ± 1.98
2014	Warming	66.46 ± 2.99	27.90 ± 3.45	5.62 ± 1.54
2014	Drought	70.76 ± 2.48	23.34 ± 3.08	5.90 ± 0.85

Values are mean ± SEM (n = 6).

Table S2. Contributions of aboveground biomass of nine dominant species (which we had data on the vertical distribution of root biomass in Fig. 4) to ANPP from control plots in 2014

Species	Functional group	Contribution, %
Stipa aliena	Grass	37.51
Elymus nutans	Grass	11.99
Helictotrichon tibeticum	Grass	7.94
Gentiana straminea	Forb	3.79
Tibetia himalaica	Forb	3.26
Saussurea pulchra	Forb	1.61
Medicago ruthenica	Forb	1.12
Kobresia humilis	Sedge	4.17
Carex przewalskii	Sedge	0.79

Table S3. Research sites included in the meta-analysis in the alpine grasslands on the Tibetan Plateau

Location	Longitude	Latitude	Method	Duration (a)	Source
Hongyuan	101°51′	31°51′	OTC	2	53
Haibei	100°51′	36°57′	OTC	4	54
Haibei	101°12′	37°37′	OTC	5	25
Haibei	101°01′	37°01′	OTC	2	55
Naqu	92°10′	31°26′	OTC	2	56
Niaodao	99°44′	36°57′	OTC	2	57
Fenghuoshan	92°53′	34°43′	OTC	2	58
Damxung	91°03′	30°30′	OTC	5	59
Damxung	91°05′	30°51′	OTC	1	60
Guoluo	100°22′	34°25′	OTC	3	61
Kakagou	103°33′	32°51′	OTC	2	62
Haibei	101°00′	37°00′	Greenhouse	1	63
Beiluhe	92°55′	34°49′	IH	3	64
Haibei	101°12′	37°37′	IH	5	24
Haibei	101°19′	37°36′	IH	4	This study

OTC, open top chamber; IH, Infrared heaters.

Table S4. Mechanisms underlying the plant responses to climate change at each of the nine sites

Site	MAT	MAP	Grass	ANPP or Coverage	Mechanisms reported	Ref(s).
Fenghuoshan	−5.3	270	↓	↑	Graminoids (grasses and sedges) decreased and forbs increased under warming. Warming stimulated ANPP because the direct warming effect on plants overrides the indirect warming effect on soil moisture at this temperature-limited site.	58
Beiluhe	−5.2	290		↑	Warming tended to stimulate ANPP at this temperature-limited site.	64
Guoluo	−3.9	513	↑	↑	Warming stimulated ANPP at this temperature-limited site.	61
Damxung	−2.8	372		↓	The reduced ANPP was largely due to the indirect warming effect on soil moisture at low elevation.	59, 60
Haibei	−1.2	488	↑	—	Different results were observed in different studies. The overall neutral response of primary production was mainly because the positive warming effect on plants offset the negative effect of soil moisture.	24, 25, 54, 55, 63
Naqu	−1.2	431	↑	↑	Warming stimulated ANPP when soil moisture at deeper depth was not affected by warming.	56
Niaodao	−0.7	322	↑	↑	Warming increased community coverage at restoring alpine steppe.	57
Hongyuan	0.6	660	↑	↓	The reduced ANPP was related to the warming-induced water limitation.	53
Kakagou	2.8	717	↑	↓	The reduced ANPP was related to the warming-induced water limitation.	62

MAT, mean annual air temperature; MAP, mean annual precipitation; grass, relative abundance of grass. ↑ indicates increase; ↓ indicates decrease; – indicates no change.