

Enhancing the resilience of coupled human and natural systems of alpine rangelands on the Qinghai-Tibetan Plateau

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Abstract. This special issue covers a wide range of topics on the protection and sustainable management of alpine rangelands on the Qinghai-Tibetan Plateau (QTP), including Indigenous knowledge of sustainable rangeland management, science-policy interface for alpine rangeland biodiversity conservation, adaptations of local people to social and environmental changes and policy design for managing coupled human-natural systems of alpine rangelands.

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Background

The Qinghai-Tibetan Plateau (QTP), known as the ‘Roof of the World’ and ‘Water Tower in Asia’, is one of most important eco-regions in the world (Fig. 1). Rangelands/grasslands cover ~60% of this vast land mass and provide critical ecosystem services to humans at local, regional and global scales (Table 1). However, these high-elevation rangeland ecosystems are under threat from recent environmental and land-use changes, and nearly half of the alpine rangelands of the QTP have been degraded over the past 40 years with degradation rates increasing at a greater rate in recent decades (Dong *et al.* 2011). As a consequence, many of the ecosystem services provided by these rangelands, such as water supply and flow regulation, carbon storage and sequestration, biodiversity and livestock production along with Tibetan socio-cultural grazing traditions, also are being degraded (Li and Huang 1995; Ma *et al.* 1999; Wang and Cheng 2001; Ma *et al.* 2002; Shang and Long 2005; Dong *et al.* 2010a). The adverse effects of rangeland degradation have far-reaching socio-economic impacts that range from local pastoralists to downstream populations along the Tarim, Yangtze, Yellow, Lancang-Mekong, Nu-Salween, Dulong-Irrawaddy, Yalung Zaugbu-Brahmaputra, Ganges and Indus rivers (Fig. 1). The livelihoods of the more than 12 m pastoralists and agro-pastoralists who live on the QTP will be directly impacted by rangeland degradation, but the health and well being of hundreds of millions more who live in agricultural and urban areas downstream also will be affected indirectly through dust-storms, floods and droughts (Harris 2010). Given the magnitude of the situation, Chinese scientists and authorities are challenged to develop innovative technical interventions and management strategies to halt the degradation and promote the resilience and sustainable use of the rangeland ecosystems of the QTP.

The relatively new science of coupled human-natural systems offers a promising framework to tackle the complex problems of

rangeland degradation on the QTP by recognising the integrated and coupled nature of human and ecological systems (Lassoie and Sherman 2010; Dong *et al.* 2010b, 2011). In this sense, we organised a symposium, ‘Building the coupled human-nature systems for restoring degraded rangelands in the developing world’, at the 5th World Conference on Ecological Restoration held in Madison, Wisconsin, USA, 6–11 October 2013. The symposium brought together social, biological and physical scientists from China, USA, Africa and Europe to address the issue of promoting the resilience of coupled human and natural systems of rangelands worldwide in the era of global change, particularly on the QTP. The cause and effects of land degradation, biodiversity loss, climate change and socio-economic transformations of pastoral systems, and possible solutions to these environmental and social problems, were discussed in depth. We selected symposium papers that best highlighted the coupled human and natural systems approach for addressing issues of rangeland degradation of the QTP to publish as a special edition issue in *The Rangeland Journal*.

The selected papers cover a wide range of topics on the protection and sustainable management of alpine rangelands on the QTP, including indigenous knowledge of sustainable rangeland management, science-policy interface for alpine rangeland biodiversity conservation, adaptations of local people to social and environmental changes and policy design for managing coupled human-natural systems of alpine rangelands. We addressed the following questions: (1) what are the environmental and socio-economic drivers of rangeland degradation (Su *et al.* 2015; Wang *et al.* 2015a; Wu *et al.* 2015a); (2) how do social and natural pastoral systems respond to environmental changes (Zhang *et al.* 2015a; Zhao *et al.* 2015; Liu *et al.* 2015; Wu *et al.* 2015b); (3) what adaptive strategies are being used by local people to cope with global changes (Shi *et al.* 2015; Wu *et al.* 2015b); (4) how can scientific knowledge be

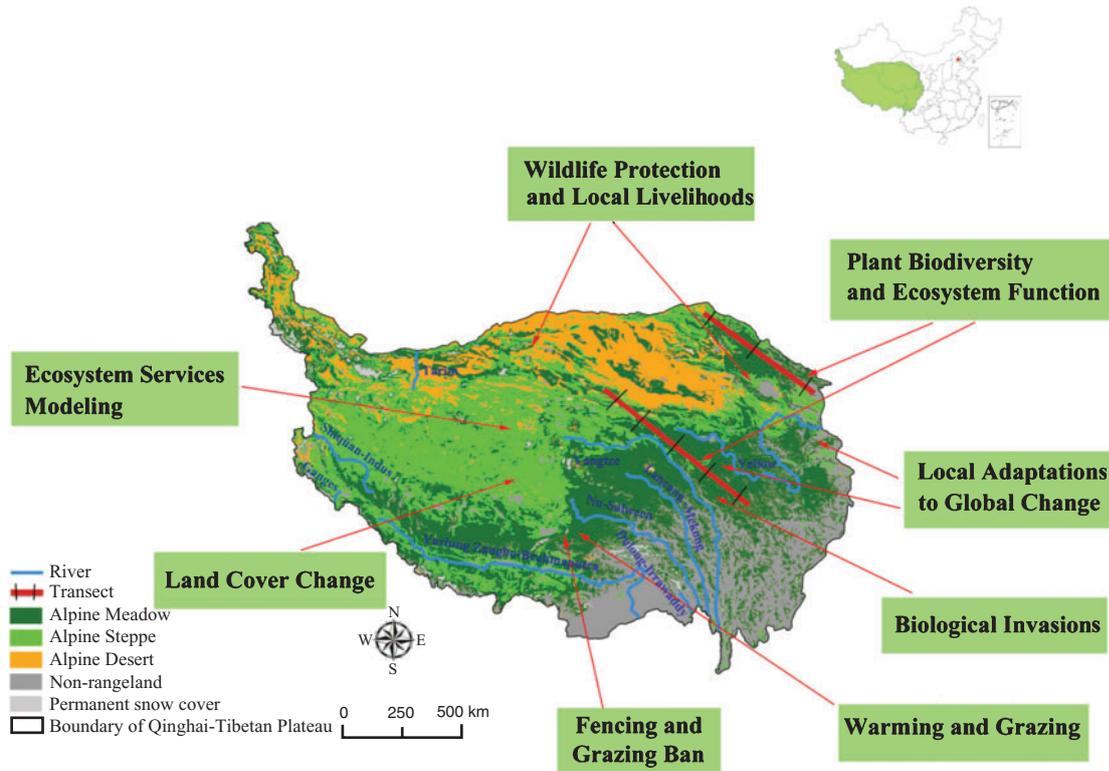


Fig. 1. Rangelands of the Qinghai-Tibetan Plateau and study sites of different topics in this Special Issue.

Table 1. Ecosystem services of well managed rangelands (modified from Dutilly-Diane *et al.* 2007)

Level	Ecosystem services	Benefits	Beneficiaries
Local	Improved hydrologic function Improved soil health Higher plant biomass	Higher pastoral productivity	Local pastoralists and agro-pastoralists
Regional	Underground water recharge Flood reduction Dust-storms reduction	Increased water availability Less damage to infrastructure, agricultural lands and human lives Improved health, lower maintenance costs for infra-structure and industry, reduced damage to farming systems	Water users, hydropower industries State (public infrastructure), downstream populations Urban populations, governments
Global	Carbon sequestration Plant and animal biodiversity	Mitigation of global climate change Healthier resources for future generations	Global population Conservation groups, tourism industry

translated into practical applications of sustainable rangeland management (Wang *et al.* 2015b; Tang *et al.* 2015; Li *et al.* 2015); and (5) how can effective government policies of rangeland management be formulated within a framework of coupled social and natural systems (Zhang *et al.* 2015a, 2015b; Wu *et al.* 2015b; Su *et al.* 2015)? The papers presented in this special edition address these questions by examining diverse topics about alpine rangelands of the QTP across multiple spatial scales (site, watershed and region) and multiple disciplines (social, ecological, economic, cultural and political) within the context of coupled human-natural systems (Fig. 1).

Enhancing the resilience of human-natural systems of the QTP will demand an integrated effort by scientists, development organizations and government agencies alike who recognise that

human and ecological systems are interlinked, and that drivers of change include biophysical, economic, political, social and cultural elements that operate at different temporal and spatial scales. The papers presented highlight some of the complexities of these interactions, and anyone seeking sustainable solutions for resolving the complex issue of rangeland degradation on the QTP or elsewhere should find this Special Issue interesting and relevant.

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References

- Dong, S. K., Li, J. P., and Li, X. Y. (2010a). Application of design theory for restoring the “black beach” degraded rangeland at the headwater areas of the Qinghai-Tibetan Plateau. *African Journal of Agricultural Research* **5**, 3542–3552.
- Dong, S. K., Wen, L., Zhu, L., and Li, X. Y. (2010b). Implication of coupled natural and human systems in sustainable rangeland ecosystem management in HKH region. *Frontiers of Earth Science in China* **4**, 42–50. doi:10.1007/s11707-010-0010-z
- Dong, S. K., Wen, L., Yang, Z. F., Liu, S. L., Lassoie, J. P., Zhang, X. F., Yi, S. L., and Li, J. P. (2011). Vulnerability of world-wide pastoralism to global changes and interdisciplinary strategies for sustainable pastoralism. *Ecology and Society* **16**, 10. www.ecologyandsociety.org/vol16/iss2/art10/ (accessed 14 November 2014).
- Dutilly-Diane, C., McCarthy, N., Turkelboom, F., Bruggeman, A., Tiedemann, J., Street, K., and Serra, G. (2007). ‘Could payments for environmental services improve rangeland management in Central Asia, West Asia and North Africa?’ CAPRI Working Paper No. 62. (CGIAR: Washington, DC.)
- Harris, R. B. (2010). Rangeland degradation on the Qinghai-Tibetan plateau: a review of the evidence of its magnitude and causes. *Journal of Arid Environments* **74**, 1–12. doi:10.1016/j.jaridenv.2009.06.014
- Lassoie, J. P., and Sherman, R. E. (2010). Promoting a coupled human and natural systems approach to addressing conservation in complex mountainous landscapes of Central Asia. *Frontiers of Earth Science in China* **4**, 67–82. doi:10.1007/s11707-010-0007-7
- Li, X. L., and Huang, B. N. (1995). The cause of “Black Beach” degraded rangeland and its control measures. *Rangeland in China* **4**, 64–67.
- Li, X. W., Li, M. D., Dong, S. K., and Shi, J. B. (2015). Temporal-spatial changes in ecosystem services and implications for the conservation of alpine rangelands on the Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 31–43.
- Liu, S. L., Zhao, H. D., Su, X. K., Deng, L., Dong, S. K., and Zhang, X. (2015). Spatio-temporal variability in rangeland conditions associated with climate change in the Altun Mountain National Nature Reserve on the Qinghai-Tibet Plateau over the past 15 years. *The Rangeland Journal* **37**, 67–75.
- Ma, Y. S., Lang, B. N., Li, Q. Y., Li, Y. F., and Li, F. J. (1999). The present status of the rangeland eco-environment at the headwater areas of Qinghai-Tibetan Plateau and resume strategies of degraded rangeland. *Rangeland in China* **6**, 59–61.
- Ma, Y. S., Lang, B. N., Li, Q. Y., Shi, J. J., and Dong, Q. M. (2002). Study on rehabilitation technologies for degenerated alpine meadow in the Changjiang and Yellow river source region. *Pratacultural Science* **19**, 1–5.
- Shang, Z. H., and Long, R. J. (2005). Formation reason and recovering problem of the “black soil type” degraded alpine rangeland in Qinghai-Tibetan Plateau. *Chinese Journal of Ecology* **24**, 652–656.
- Shi, J. B., You, W. Y., Lu, F. Y., Zhang, Z. H., and Li, X. W. (2015). Herdsmen’s attitudes towards rangeland fencing, protection of Przewalski’s gazelle and control of wolf predation on livestock. *The Rangeland Journal* **37**, 21–29.
- Su, X. K., Dong, S. K., Liu, S. L., Wu, Y., Zhao, H., Zhang, X., Weng, J., Tang, L., Wu, X. Y., and Hou, P. (2015). Changes in rangeland cover associated with livestock grazing in Altun National Nature Reserve, northwest Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 97–105.
- Tang, L., Dong, S. K., Sherman, R., Liu, S. L., Liu, Q. R., Wang, X. X., Su, X. K., Zhang, Y., Li, Y. Y., Wu, Y., Zhao, H. D., Zhao, C., and Wu, X. Y. (2015). Changes in vegetation composition and plant diversity with rangeland degradation in the alpine region of Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 107–115.
- Wang, G. X., and Cheng, G. D. (2001). Characteristics of Grassland and Ecological Changes of Vegetations in the Source Regions of Yangtze and Yellow Rivers. *Journal of Desert Research* **21**, 101–107.
- Wang, P., Lassoie, J. P., Morreale, S. J., and Dong, S. K. (2015a). A critical review of socioeconomic and natural factors in ecological degradation on the Qinghai-Tibetan Plateau, China. *The Rangeland Journal* **37**, 1–9.
- Wang, X. X., Dong, S. K., Sherman, R., Liu, Q. R., Liu, S. L., Li, Y. Y., and Wu, Y. (2015b). A comparison of biodiversity–ecosystem function relationships in alpine grasslands across a degradation gradient on the Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 45–55.
- Wu, R. X., Chai, Q., Zhang, J. Q., Zhong, M. Y., Liu, Y. H., Wei, X. T., Pan, D., and Shao, X. Q. (2015a). Impacts of burrows and mounds formed by plateau rodents on plant species diversity on the Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 117–123.
- Wu, X. Y., Zhang, X. F., Dong, S. K., Cai, H., Zhao, T. R., Yang, W. J., Jiang, R., Shi, Y. D., and Shao, J. L. (2015b). Local perceptions of rangeland degradation and climate change in the pastoral society of Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 11–19.
- Zhang, Y., Gao, Q. Z., Dong, S. K., Liu, S. L., Wang, X. X., Su, X. K., Li, Y. Y., Tang, L., Wu, X. Y., and Zhao, H. D. (2015a). Effects of grazing and climate warming on plant diversity, productivity and living state in the alpine rangelands and cultivated grasslands of the Qinghai-Tibetan Plateau. *The Rangeland Journal* **37**, 57–65.
- Zhang, W. N., Ganjurjav, H., Liang, Y., Gao, Q. Z., Wan, Y. F., Li, Y., Baima, Y. Z., and Xirao, Z. M. (2015b). Effect of a grazing ban on restoring the degraded alpine meadows of Northern Tibet, China. *The Rangeland Journal* **37**, 89–95.
- Zhao, H. D., Liu, S. L., Dong, S. K., Su, X. K., Wang, X. X., Wu, X. Y., Wu, L., and Zhang, X. (2015). Analysis of vegetation change associated with human disturbance using MODIS data on the rangelands of the Qinghai-Tibet Plateau. *The Rangeland Journal* **37**, 77–87.