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Challenges and opportunities for paleo-informed ecosystem conservation in Asia

Qiaoyu Cui[1], C. Kulkarni[2], E. Razanatsoa[3], Y. Li[4], J. Wu[5], M. Ji[6] and L. Zhou[4]

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Eastern Asian countries (including China, Mongolia, Korea and Japan) will face unprecedented socio-environmental challenges in the coming decades (IPCC 2021). Moreover, regional climate changes, together with land-use intensification and increasing livelihood demands, continue to represent a "perfect storm" in regions among the most populated in the world (Beddington 2009). A prime challenge for Asian countries is to identify a more sustainable, inclusive and spatially coherent approach to ecosystem management – a lack of which often results in conflicts between restoration targets and people's needs (e.g. Colombaroli et al. 2021).

The hybrid workshop (pastglobalchanges.org/calendar/129272) organized by the DiverseK working group (WG) (pastglobalchanges.org/diversek), with a focus on Asian ecosystems through a combined paleoscience-policy lens, offered opportunities to delve deeper into the issue and brainstorm a practical role of paleoscience in addressing it. The in-person component of the workshop was held in Beijing, China, which happens to be the first-ever Past Global Changes (PAGES) workshop held in China. The workshop spoke to the scientific goals of the DiverseK WG, i.e. to provide a new integrative, cross-disciplinary evidence base to enable better decision-making on pressing environmental issues and local struggles. The steps toward implementing the "Paleoscience for Policy" approach were discussed in great detail at the workshop. The synthesis of ideas during two discussion sessions included: i) the development of a network among paleoecologists and stakeholders in Asia with a common goal of effective ecosystem management; ii) a dedicated discussion on the cross-comparison of management solutions under different national schemes within Asia (e.g. the steppe in China/Mongolia, fire management across India and China); and iii) the identification of best conservation approaches from the respective regions in light of the paleo-evidence base (pollen, macrofossils, disturbance regime indicators, and tree rings).

Two case studies presented at the workshop exemplified the existing challenges for conservation at species/community levels in forest and grassland ecosystems, highlighting the potential for integrative long-term studies in East Asia (Fig. 1):

1) *Pinus yunnanensis* forests in southwest China are considered an intermediary stage of succession toward evergreen broad-leaved forest (Tang et al. 2013). However, population dynamics (e.g. to what degree human impact is detrimental to the forest ecosystems) and the factors promoting forest succession (e.g. what drives *P. yunnanensis* succession?) need to be contextualized in light of long-term ecological changes. The paleodata can shed light on such socio-environmental aspects, acting as a critical asset for identifying best management practices in the wake of environmental changes (Jackson 2007).

2) Low biodiversity patterns across the woodland-steppe ecotone of southern Mongolia are considered to be the result of historical landscape fragmentation (Liu and Cui 2009). Yet, this information needs to be assessed from a longer-term ecological perspective (e.g. Whitlock et al. 2018). This information is critical for understanding the "baseline", including the nature and degree of which ecological processes (grazing, fire, and other disturbance regime processes) are relevant for maintaining (or affecting) biodiversity in Asian steppe environments.

Workshop participants identified potential management issues that can be addressed by a collaboration between paleoecologists and protected areas members/ stakeholders in Yunnan and conservancy in Mongolia, for instance. In the future, the DiverseK community will continue to build collaborations in terms of publications, project applications, data sharing and field work, based on the networking that was established during the workshop.

The workshop provided a communication and exchange platform for the establishment of sustainable ecosystem management programs in Asia. This DiverseK WG effort has been a step towards enhancing dialogues among policymakers and paleoecology researchers on China's ecosystem management, thereby laying the foundations for future Sino-foreign collaborative research, including attracting early-career and developing-country researchers, to work on all-encompassing sustainable ecosystem management, through the lens of paleosciences.

Figure 1: (Top left) Grassland ecosystem in north China. (Top right) The logo of the workshop. (Bottom left) *Pinus yunnanensis* forest in southwest China exhibiting fire-adapted traits: serotiny, thick bark, etc. (Bottom right) Macro-charcoal and burned phytolith (found in Xingyun lake sediment) were used to explore the long-term fire history of the forest ecosytem in Yunnan, China. Photo credits: J. Ming and Q. Cui. Logo image credit: X. Liu.

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AFFILIATIONS

[1]Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China
[2]Independent researcher, India
[3]Plant Conservation Unit, University of Cape Town, South Africa
[4]Peking University, Beijing, China
[5]Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
[6]Yuxi Normal University, Yunnan, China

CONTACT

Qiaoyu Cui: qiaoyu.cui@igsnrr.ac.cn

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