Science-management Partnerships as Catalysts for Governance Reform of National Parks in China

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Abstract: Protected areas have long been considered a cornerstone of biodiversity conservation by policy-makers and the conservation community. Yet, despite ongoing efforts, many countries, including China, continue to face persistent challenges in effectively managing these areas. Here we examine how science-management partnerships, particularly those headed by Chinese Academy of Sciences (CAS), have catalyzed governance reforms of protected areas in China. The integration of scientific research with policy action has enabled the establishment of a unified national park system, mitigating management inefficiencies and enhancing ecosystem resilience. We propose strategies for CAS to consolidate its leadership in this domain. These partnerships might offer global insights into evidence-based protected area management.

Keywords: Science-policy interface; biodiversity conservation; environmental sustainability; cross-sector collaboration

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Introduction

The world is facing unprecedented environmental challenges, including climate change, biodiversity loss, pollution, and threats to food security (Crist *et al.*, 2017) These threats are multifaceted, incurring ecological and social risks imperiling human well-being and sustainable development. China, as one of the largest economies in the world, has contended with the unintended environmental consequences of rapid industrialization and urbanization, which have led to biodiversity loss, ecosystem degradation, and adverse effects on human wellbeing (Liu *et al.*, 2018).

China's environmental challenges are well-documented. For example, the endangered status

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of species, such as Chinese Pangolin and Siberian tiger, underscores the severity of biodiversity loss. Meanwhile, air quality issues in cities like Beijing have long raised public concern, while deforestation and cropland expansion in southern China have led to significant habitat fragmentation and declines in wildlife populations. These escalating environmental issues demand robust national interventions to secure China's sustainable development (Bryan *et al.*, 2018).

In response, China has enacted far-reaching governance reforms since the 18th National Congress of the Communist Party of China (CPC) in 2012. These reforms, underpinned by key policy frameworks like the *Decision on Major Issues Concerning Comprehensively Deepening Reforms* (November 2013) and the *Integrated Reform Plan for Promoting Ecological Progress* (September 2015), have yielded notable progress. Improvements in air quality, wildlife population recovery, and substantial investments in natural capital highlight China's emerging leadership in this regard (Chen *et al.*, 2019; Wei *et al.*, 2021; Zheng *et al.*, 2019).

A key catalyst of these reforms has been the integration of scientific research into governance, led by CAS. As China's premier research institution for natural sciences and a key science and technology advisor, CAS has been instrumental in research related to China's national ecosystem assessment, territory spatial planning, biodiversity conservation, and ecological restoration (Fan *et al.*, 2023; Fu *et al.*, 2023; Xu *et al.*, 2017). Its role in conducting large-scale and organized scientific research programs has been pivotal in reforming China's protected area governance system. The collaboration between research institutions of CAS and central government agencies has fostered evidence-based decision-making, leading to more effective governance nationwide. Further investments and intensified efforts are required, while China's science-management partnerships might inspire similar policy frameworks in other countries.

Progress

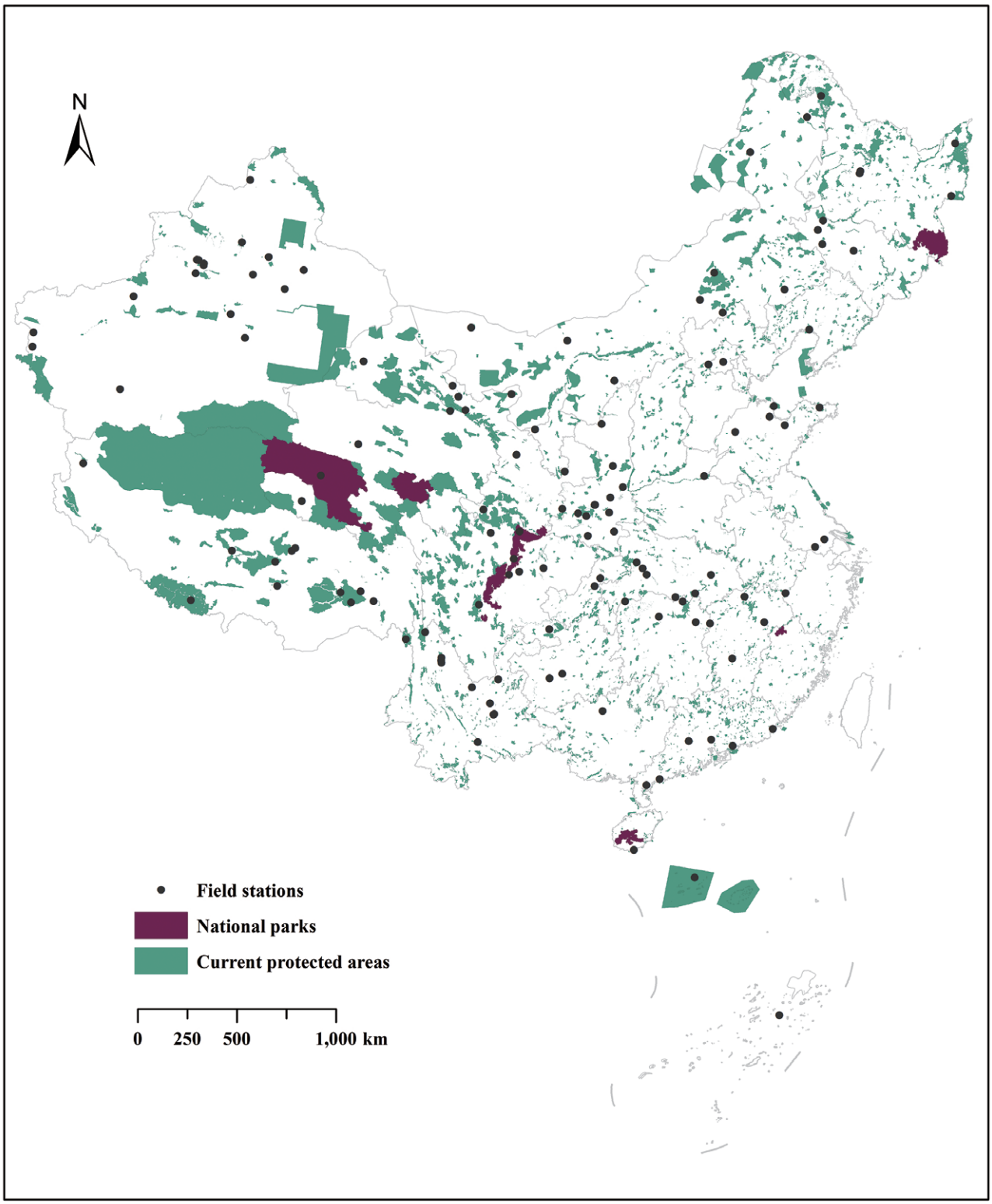
China's efforts to build a comprehensive national park system demonstrate its commitment to biodiversity conservation and environmental governance. This effort dates back to 1956, when China's first nature reserve was set up and managed by CAS. By 2017, China had created over 11,800 protected areas, covering more than 18% of its mainland. Yet, many of these areas remained ineffective due to fragmented management, overlapping jurisdictions, weak legal frameworks, and inadequate funding (Huang *et al.*, 2018).

Recognizing these systemic inefficiencies, national park reforms were initiated in 2013 during the Third Plenary Session of the 18th CPC Central Committee. These reforms sought to centralize management and refine the spatial planning of protected areas. Pilot programs launched in 2015 across ten regions laid the groundwork for comprehensive national park reforms. By 2021, the first batch of national parks, including Three-Rivers-Source, Giant Panda, Wuyi Mountain, Tropical Rainforest, and Northeast Tiger and Leopard parks, were officially established. Although China's national park system was developed later than those in the United States and France, its progress has been remarkable. Today, China's national parks cover an area of 230,000 square kilometers, with plans to expand to approximately 1.1 million square kilometers by 2035, making them among the largest national park system in the world.

This rapid development has been driven by decades of scientific research and technological innovation (Huang, 2024). Technologies like satellite-based remote sensing have enhanced our understanding of ecosystem dynamics. CAS's interdisciplinary research on ecosystem services, biodiversity, and climate change has laid a robust basis for effective governance. *The Spatial Layout Plan for National Parks* exemplifies how science-management partnerships have shaped governance frameworks. Comprehensive biodiversity dynamics and ecosystem services assessments conducted by CAS have informed spatial planning decisions (Zheng *et al.*, 2019), ensuring that high-priority conservation areas were protected.

CAS has cultivated long-term cross-sector collaboration with various levels of governments and departments through strategic partnerships and research station networks. The Academy and its branches have established a substantial number of field observation stations (Fig.1), which are important to support nationwide resource monitoring, environmental change detection, and biodiversity conservation efforts. Since the launch of the national park pilot system, there has been a significant rise in research articles focused on national park and protected area governance (Bai *et al.*, 2024; Wu and Wang, 2024). Research from CAS-affiliated institutions represents a large portion of this body of work and has been conducive to governance reforms in China's national parks.

Fig.1 Spatial distribution of China's protected areas and key field observation stations of CAS (Map Approval Number: GS(2024)0650)



These knowledge supply can be categorized into three primary areas, foundational surveys and research, spatial planning and zoning, and institutional and management reform strategies (Table 1). Foundational research contributions include long-term biodiversity surveys and assessments by CAS institutes such as the Institute of Zoology and the Institute of Botany. These efforts have significantly contributed to the development of China's Red List of Species, and the mapping and control of invasive species. The CAS Research Center for Eco-Environmental Sciences has offered substantial expertise on natural capital and ecosystem services, gaining considerable attention for its role in identifying priority conservation areas. A collaboration between CAS and the Chinese Ministry of Ecology and Environment, initiated with Remote Sensing Survey and Assessment of Decadal Changes in China's Ecological Environment (2000–2010) and followed by periodic assessments every five years, has established a robust framework for evaluating natural capital and ecosystem services (Ouyang *et al.*, 2016). The CAS Institute of Geographic Sciences and Natural Resources Research has also provided critical insights for integrating and optimizing protected area systems, on both regional and national levels through spatial planning and territorial function zoning. Notably, the research of the CAS Institutes of Science and Development on ecological civilization, national park governance, and grassroots innovation has provided valuable information from several aspects of institutional design related to national-level protected area governance reforms, such as the *Overall Plan for the Establishment of National Park System*. Its collaborative efforts with the National Development and Reform Commission have provided substantial support for national park pilot programs and broader reforms.

These partnerships have bridged the gap between research and policy-making, aligning scientific advancements with governance and decision-making needs. CAS's roles, particularly in ecologically sensitive regions like the Qinghai-Tibet Plateau, the Loess Plateau and Southwest Mountains in China, have been instrumental in identifying conservation priorities, assessing environmental capacities, and evaluating the effectiveness of conservation efforts (Feng *et al.*, 2016; Sun *et al.*, 2020; Wu *et al.*,

Table 1 Supply of scientific knowledge for protected area management by CAS-affiliated institutes

Category	CAS-affiliated institutes	Relevant research areas
Field survey and assessment	Institute of Botany, Institute of Zoology, Institute of Geographic Sciences and Natural Resources Research	1. Comprehensive field surveys of natural resources, vegetation, and ecosystems in ecologically important areas. 2. Biodiversity monitoring, including long-term assessments of species distribution, population trends, and the establishment of the Red List of Species in China. 3. Ecological assessments and habitat quality evaluation with significance to the design and management of national park systems.
Spatial planning and zoning	Research Center for Eco-Environmental Sciences, Institute of Geographic Sciences and Natural Resources Research, Institute of Mountain Hazards and Environment	1.Spatial analysis of land use patterns, habitat fragmentation, and ecological corridors using remote sensing and GIS technologies. 2.Studies on terrestrial ecosystem services, providing insights into water conservation, climate regulation, and key ecological zones for effective national park planning. 3.Zoning of national parks and other protected areas through natural capital assessments and identification of priority conservation areas.
Institutional and governance reform research	Institutes of Science and Development, Institute of Geographic Sciences and Natural Resources Research	1.Institutional analysis of governance structures and management systems of protected areas, with recommendations for governance efficiency, stakeholder participation, and integration of local communities. 2.Research on ecological civilization and grassroots innovation in national park management, contributing to reforms that integrate conservation goals with human well-being. 3.Studies on governance mechanisms and policy frameworks to improve national park management, focusing on long-term sustainability and resilience.

2023; Zhang *et al.*, 2023). This collaboration has strengthened practical application of scientific knowledge and driven continuous improvements in biodiversity conservation and environmental governance frameworks. Big data and technological advancements, such satellite-based remote sensing and "sky-ground" monitoring, have further empowered ecosystem management to respond to environmental changes, such as cropland reclamation and alpine lake expansion (Kong *et al.*, 2023; Xu *et al.*, 2024).

The Qinghai-Tibet Plateau National Parks Initiative exemplifies how science-management partnerships can transform governance. Since 2017, CAS has undertaken a series of strategic priority projects and conducted a comprehensive five-year field investigation. Drawing on systematic assessments of ecosystems, environmental carrying capacity, aesthetic values, and research on institutional mechanisms and smart national parks, the initiative for the Qinghai-Tibet Plateau National Park Cluster was proposed. This initiative has since been incorporated into the China's national spatial layout plan. The establishment of these national parks has been recognized by local governments as a crucial step toward sustainable development in Tibet Autonomous Region and Qinghai Province of China (Fu *et al.*, 2021).

Science-management partnerships have significantly accelerated evidence-based decision-making and implementation processes by incorporating a more diverse and interconnected social-ecological process perspective. In addition to field surveys on natural resources and environmental changes, social surveys of local communities have deepened the understanding of how these populations interact with and shape their environments, as seen in Wuyi Mountain and Qianjiangyuan National Parks (He and Wang, 2024; Zhang *et al.*, 2020). The rights and interests of local communities and indigenous peoples have been integrated into sustainable management strategies for protected areas, like "One household, one ranger" program in Three-River-Source National Park. By involving scientists in policy discussions, China is developing a governance structure that not only benefits biodiversity but also promotes local community participation. Such collaboration has gradually helped overcome historical barriers to effective protected area management in China, such as fragmented oversight and insufficient coordination among stakeholders.

The Way Forward: Policy Suggestions

As China prioritizes both high-level conservation and high-quality development, CAS has a unique opportunity to foster knowledge co-production in biodiversity conservation and environmental governance. What strategies can CAS employ to maintain its leadership in supplying knowledge for environmental governance, particularly in biodiversity conservation? Success in this endeavor relies on addressing cognitive, socioeconomic, and technological barriers, including a paradigm shift that recognizes the compatibility and mutual benefits of conservation and development, by promoting innovative management and technological solutions. Effective governance must establish pathways to engage the broader academic community and other stakeholders, applying an evidence-based framework to ensure that actions are aligned with both national and local interests.

Continued investment in scientific research and innovation infrastructure, especially in biodiversity monitoring, climate adaptation, and cross-SDG (Sustainable Development Goals) coordination, has been critical to governance reform outcomes of protected areas in China and the rest of the world. Future research should delve into the trade-offs between conservation and development, such as balancing protected area expansion with renewable energy targets. Synergies between biodiversity conservation and food security are equally critical, as China faces increasing pressure to enhance agricultural productivity while safeguarding biodiversity. A telecoupling perspective can guide interdisciplinary research to integrate Environmental, Social, and Governance (ESG) principles into environmental governance, thus advancing global sustainability goals.

3.1 Protected areas supporting multiple sustainable development goals

Understanding the synergies and trade-offs between the expansions of China's protected areas and the multiple SDGs could shape our actions to address pressing social-ecological challenges. CAS should further initiate strategic priority research programs in the following key areas:

Trade-offs between protected areas and renewable energy development. Balancing the "30×30" agenda (protecting 30% of land and sea by 2030) with the "30–60" goal (peak CO_2 emissions by 2030 and carbon neutrality by 2060) presents significant challenges, especially as renewable energy infrastructure expands. Research should focus on spatial planning strategies that optimize

biodiversity conservation while scaling renewable energy projects, ensuring that national land-use policies accommodate both objectives.

Biodiversity conservation and food security. As China expands protected areas, growing population pressures intensify the demand for agricultural production. We should think how biodiversity conservation can co-benefit agricultural sustainability, ensuring food security without compromising conservation goals. Innovative agricultural practices that support both objectives are essential.

Climate resilience and ecosystem restoration in protected areas. Protected areas will increasingly serve as critical refuges for species and ecosystems as climate change accelerates. However, their ability to adapt to changing environments remains uncertain at local, regional, and global levels. Future research should focus on enhancing climate resilience through targeted ecosystem restoration and the strategic expansion of conservation efforts.

3.2 Data reporting protocols for biodiversity and protected areas

Effective governance of biodiversity and protected areas requires accessible data. Current practices often result in fragmented data, hindering effective decision-making. Strengthening collaborations among governmental, non-governmental, and academic communities can improve data sharing and management outcomes.

Data sharing and access for protected areas. The absence of unified data service systems, both locally and nationally, weakens governance reforms and coordinated conservation efforts. CAS should allocate more resources to constructing and maintaining field stations that support the national park system and ecosystems management. Developing data disclosure frameworks and platforms is urgently needed to enhance adaptive governance.

Social survey network development. Current research station networks primarily focus on natural process observations and lack long-term, dynamic, and experimental social tracking platforms. Integrating social survey networks into existing stations would enhance understanding of interactions between social behaviors and biophysical processes, especially when aligned with policy interventions.

3.3 International cooperation for biodiversity and global synergies

China's national park and protected area governance is part of a broader global effort to address environmental challenges. International collaboration is needed to fully leverage China's role in global environmental governance.

Protected area network in the Belt and Road Initiative (BRI). The BRI offers an opportunity to establish a transnational network of protected areas. BRI Science Organizations Alliance (now the Alliance of National and International Science Organizations for the Belt and Road Regions) initiated by CAS, should be leveraged to strengthen collaborative research efforts. Such partnerships between China and international stakeholders can facilitate joint natural resource management and promote biodiversity conservation across borders.

Global research collaboration and knowledge sharing. CAS can promote and lead international cooperation through the Man and the Biosphere Programme, and the research agenda of biosphere reserves. These collaborations will reinforce the scientific basis for global conservation initiatives and agenda while facilitating the exchange of best practices and cutting-edge technologies.

Science-management partnerships have been integral to China's governance reforms for protected areas, with CAS at the forefront. By integrating research and technological advances into policy-making processes, China has taken significant steps in establishing a comprehensive national park system that addresses biodiversity loss, climate change, and environmental degradation. To accelerate progress toward building a world-class national park system that embodies ecological civilization and strengthens global environmental stewardship, CAS should align its research agenda with both national and global sustainability objectives. Looking ahead, it is essential for CAS to further expand these partnerships by investing in research infrastructure and promoting international collaboration to enable more inclusive and sustainable governance reforms. Such efforts matter in maintaining momentum in the global pursuit of biodiversity conservation and will support the Convention on Biological Diversity's strategic objectives.

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