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封里照片 高黎贡山西坡大塘附近稻田, 照片提供 文军 J. Wen.
Ptyas mucosus—a large, harmless, and widespread snake in
southern Asia, by H. Bradley Shaffer. Inner-cover photograph:
An agricultural valley near Datang at the western base of the
Gaoligongshan Mountains, by Jun Wen.

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INSTITUTIONAL PROFILES

The Field Museum

The Field Museum is a collections-based research and educational institution devoted to natural and cultural diversity. Combining the fields of Anthropology, Botany, Geology, Zoology, and Conservation Biology, museum scientists research issues in evolution, environmental biology, and cultural anthropology. Environmental and Conservation Programs (ECP) is the branch of the museum dedicated to translating science into action that creates and supports lasting conservation. With losses of natural diversity accelerating worldwide, ECP's mission is to direct the museum's resources—scientific expertise, worldwide collections, innovative education programs—to the immediate needs of conservation at local, national, and international levels.

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Center for United States-China Arts Exchange

The Center for United States-China Arts Exchange at Columbia University was established through a formal agreement with China before the normalization of relations between the two countries and has been carrying out major projects since 1979. Founded by Chou Wen-chung, Fritz Reiner Professor of Musical Composition (Emeritus), the Center has sponsored programs, partnerships and collaborations in the arts, education and conservation that have included participants from the entire Asian-Pacific region as well as the United States and Europe.

The main focus of the center since 1990 has been a broadly defined cultural and environmental conservancy program for the indigenous peoples in Yunnan Province, known as the minority nationalities. Designed to create a comprehensive strategy for the continuation of their traditional cultures and for the preservation of their unique ecology, this program has involved hundreds of specialists from China, the United States, Europe and Asia, and has mobilized thousands of local cultural and environmental workers.

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Southwest Forestry College

Southwest Forestry College (SWFC) is located in Kunming, China and is under the joint administration of the Provincial Government of Yunnan and the State Forestry Administration. SWFC is the only institute of higher learning in forestry located in the western provinces of China. Its major tasks are to foster forestry professionals, to carry out forestry research and to provide technical support, especially in the southwest region. Currently, over 6,000 students, including a high percentage of ethnic minorities, are studying in the college's 13 departments and 10 research institutes. Major fields of study of the college include forestry science, resource management, rural planning, wildlife and nature reserve management, water and soil conservation, ecotourism, and wood processing. SWFC is actively involved in completing inventories to promote or establish nature reserves in Yunnan Province.

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Gaoligongshan National Nature Reserve Baoshan Management Bureau

The Gaoligongshan National Nature Reserve Baoshan Management Bureau was established in 1993. It has jurisdiction over approximately 25% (99,675 hectares) of the reserve. It is responsible for: (1) protection and maintenance of the reserve, including law enforcement; (2) education and research, in partnership with outside institutions; and (3) sustainable development of ecotourism. The bureau has management centers in Longyang District and Tengchong County, as well as eleven management stations and two forestry police precincts. Its staff includes forestry professionals, technical specialists, and rangers who patrol the reserve.

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Openlands Project

Openlands Project is a private non-profit organization that protects, expands and enhances open space—land and water—to provide a healthy natural environment and a more livable place for all the people of the Chicago metropolitan region. Founded in 1963, Openlands has helped ensure the preservation of over 50,000 acres of parks, natural habitat, forest preserves, bicycle trails, wetlands, urban gardens and places to observe nature. In 1982, Openlands founded the Canal Corridor Association, which led the initiative to create America's first National Heritage Corridor.

Gerald Adelman, Executive Director of Openlands Project, also serves as a Board member of the Center for United States-China Arts Exchange, and brought together the Center with the Field Museum and volunteers from Skidmore, Owings and Merrill to visit the Gaoligongshan region.

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The Yunnan Provincial Association for Cultural Exchanges with Foreign Countries

The Yunnan Provincial Association for Cultural Exchanges with Foreign Countries is the largest non-governmental organization in Yunnan engaged in a wide spectrum of exchanges with many countries. Its goals are to make Yunnan better known internationally, to enhance friendships with the peoples and the nations of the world, and to exchange knowledge and experience through visitation and collaborative projects.

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Skidmore, Owings & Merrill LLP (SOM)

Founded in 1936, SOM is one of the world's leading architecture, urban design, engineering, and interior architecture firms. Since its founding, SOM has completed more than 10,000 projects in more than 50 countries around the world. The firm has received over 800 awards, including the first Firm Award from the American Institute of Architects in 1961.

As a concerned leader within the environmental design community, SOM has sustained a commitment to creating great and lasting projects for both commercial and non-profit clients. Through partnerships with both governmental agencies and non-profit advocacy groups, SOM has brought both conceptual and technical expertise to a variety of national and international pro-bono work including the Yunnan Initiative.

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ABOUT THE YUNNAN INITIATIVE

This report is a demonstration project of the Yunnan Initiative of the Center for United States-China Arts Exchange at Columbia University. In conjunction with its Chinese Committee of Specialists, the Yunnan Initiative brings international experts to Yunnan to collaborate with local professionals, leaders, and citizens on recommendations for sustaining and protecting the province's remarkable environments and cultures.

THE GUIDING PRINCIPLES OF THE YUNNAN INITIATIVE ARE

- Conservation* Development should proceed without damage to culture, ecology, and society.
- Inclusion* Development and conservation strategies must be inclusive of all nationalities, and must build on local cultural heritage, in keeping with Yunnan's policy to develop the province into "a great province of nationalities cultures."
- Education* Public awareness of cultural and environmental values must become commonplace to ensure the long-term success of sustainable programs.
- Tourism* Development of tourism, which is a potential engine for economic development, must enhance Yunnan's culture and ecology, and must provide direct social and economic benefits to indigenous people.
- Collaboration* Strategies to integrate conservation and development should build on local, regional, national and international collaboration.

THESE PRINCIPLES GUIDE THE RECOMMENDATIONS IN THIS REPORT, WHICH SUMMARIZES THE FIELDWORK OF AN INTERDISCIPLINARY TEAM OF SCIENTISTS, ARCHITECTS, PLANNERS AND HERITAGE TOURISM EXPERTS IN JUNE AND JULY 2002. IT JOINS A REPORT ON THE WEISHAN HERITAGE VALLEY (CENTER FOR UNITED STATES-CHINA ARTS EXCHANGE, 2001) AS A YUNNAN INITIATIVE DEMONSTRATION PROJECT.

ACKNOWLEDGEMENTS

Since 1990, Professor Chou Wen-chung, Founder and Director, Center for United States-China Arts Exchange and Fritz Reiner Professor Emeritus of Musical Composition, Columbia University, has provided unwavering vision for conservation in Yunnan province. His leadership built the foundation for these rapid biological and social inventories in Yunnan, and continues to set the stage for conserving and reinvigorating Yunnan's indigenous resources.

Working with Professor Chou to lead the Yunnan Initiative are Gu Poping, Director of the Yunnan Association of Social Sciences, who has opened the door for international collaboration in Yunnan, and Professor Fan Jianhua, General Office Yunnan Provincial Committee. Professor Fan's incomparable knowledge of the people, cultures and history of Yunnan, his boundless energy, and the respect he commands, make him the linchpin of the Yunnan Initiative.

The Gaoligongshan rapid inventory teams received invaluable support from Mr. Yang Wenhui, Director, Department of Information and Publicity, Baoshan Municipality, Yunnan Province. He provided indispensable municipal support, and organized and participated in the Gaoligongshan Rapid Inventory Findings Briefing Conference.

Professor Yang Yuming, Vice President and Professor, Southwest Forestry College provided unparalleled knowledge of the botany of Gaoligongshan. His recognition of the importance of international cultural and scientific collaboration made him the ideal person to lead the Chinese participants, including many of his junior academic colleagues and graduate students.

Professor Wu Deyou, Southwest Forestry College, took up the unenviable but essential task of overseeing the organization and preparation of the Southwest Forest College rapid inventory teams. His careful and meticulous planning made the collaborative inventory proceed as planned under trying field conditions.

Professor Guo Huijun, Deputy Director, Xishuangbanna Tropical Botanical Gardens, is one of the top international experts in the conservation and botany of

Yunnan. His briefing to the American teams on Yunnan and Gaoligongshan was invaluable.

Mr. Li Zhengbo, Deputy Director, Yunnan Gaoligongshan National Nature Reserve, provided tremendous assistance with logistics. We thank Mr. Li and all local park managers for sharing their deep knowledge of the region with all of us. All Chinese scientists were extraordinarily gracious and forgiving of the lack of Chinese language skills in their U.S. counterparts. Dr. Jun Wen was extremely generous with translations and constant problem solving.

Bringing the Field Museum into the Yunnan initiative would not have happened without the leadership of John W. McCarter Jr., who made an initial exploratory visit and continues to provide enthusiastic support.

Alaka Wali, Director of The Field Museum's Center for Cultural Understanding and Change, made it possible for the social asset inventory to take place, both financially and thanks to her pioneering research. She contributed her expertise from conducting research of this kind in South America and Illinois by advising the Baihualing Village study team.

Robin Groesbeck of The Field Museum provided helpful advice on possible exhibition ideas and curator Ben Bronson advised on possible exhibitions and research. International heritage tourism expert Cheryl Hargrove, of the Heritage, Tourism and Communications (HTC) Group, provided important guidance and advice to the team.

Thanks to the support and leadership of Philip Enquist, AIA, Skidmore Owings & Merrill provided invaluable pro bono services to recommend a design concept for an ecologically sensitive lodge and visitor center.

Funding for these rapid inventories came from The John D. and Catherine T. MacArthur Foundation, the Center for United States-China Arts Exchange, and The Field Museum.

REPORT AT A GLANCE

Dates of field work	Biological inventory: 17 - 26 June 2002; social inventory: 1-14 July 2002
Region surveyed	Three areas in Gaoligong Mountain National Nature Reserve, at the southern end of the Gaoligongshan range (Baoshan District, Yunnan Province, China) at the border with Myanmar: (1) the Baihualing Station on the eastern slope of the Gaoligong mountains, along the Southern Silk Road, from 1,500 m to 3,100 m at the pass; (2) Datang, on the western slope, between 1,850 m and 2,700 m; and (3) Nankang, a pass at the south end of the reserve, between 2,000 m and 2,200 m (figure 3).
Human communities surveyed	Eight hamlets in the Baihualing village: Hanlong, Dayutang (Upper, Lower), Bangwai-Guxingzhai, Taoyuan, Laomengzhai-Baihualing-Malishan, Manggang, Manghuang. These hamlets directly abut the perimeter of the Gaoligong Mountain National Nature Reserve and form the primary gateway for access to the reserve from the east (figure 3).
Organisms surveyed	Vascular plants, macrofungi, amphibians and reptiles, birds, large mammals
Highlights of results	<p>The Gaoligongshan region is ecologically unique; a major crossroads of north and south, east and west, temperate and subtropical. The continuous belt of forest from east to west and over the crest of the mountains provides an unparalleled opportunity to conserve the spectacular mix of ecological communities and also to maintain conditions that both create new species (mountain ranges separated by deep valleys) and prevent the extinction of old ones (e.g., absence of drought). In nine days in the field, the biological team found an extremely rich fauna and flora, with several new records for the reserve. Outside the reserve, the forest is almost gone.</p> <p>The human communities living at the foothills reflect the enormous cultural diversity in Yunnan. In 14 days in the field, the anthropological team identified resources and capacities in the hamlets immediately adjacent to the reserve on the eastern slope. These assets will serve as entry points for working with the communities to develop economic activities, such as ecotourism, that are compatible with the local ecology and culture. We summarize the highlights of our results below.</p> <p>Social resources and capacities: Our brief survey, the first of its kind in the area, focused on Baihualing village, one of the 109 villages documented in Gaoligongshan (Baoshan Management Bureau, 2002). We estimate that 2,100 people and more than 450 families live in Baihualing. Six ethnic groups are represented: Han, Lisu, Bai, Dai, Yi, and Hui. As a whole, Yunnan province has 25 out of the 55 ethnic minority groups recognized in China (Population Census Office of Yunnan, 1992). Expression of ethnic identity through native dress,</p>

crafts, language, festivals and customs is not as pronounced here as in other areas of Yunnan. The principal income (up to 85%) of this agrarian society comes from cultivating sugarcane, rice, and coffee. Fuel is an overriding concern: we were told that over 90% of families have adopted the new fuel-efficient stove, resulting in over 60% savings in energy. We found that each hamlet has distinct social assets. Cultural assets include historic sites dating from the Ming dynasty up to World War II. Modern assets include the ability to produce traditional crafts such as embroidered shoes (figure 8E), wicker stools and traditional foods. Other assets include the presence of local organizations, such as the Gaoligongshan Farmers' Biodiversity and Conservation Association and its demonstration and pioneer families, a very small tourism organization in Dayutang, and a women's association in Manghuang. Education is a pervasive priority of residents.

Vegetation and flora: The botany team identified ca. 1000 species of plants during the nine-day field survey, collected about 300 species, and photographed 250 (figure 4). About ten percent of the flora is endemic, i.e., it occurs only in Gaoligongshan. The variation in flora among sites is substantial. Datang, on the geologically distinct west slope, has a remarkably different flora. We found at least three species new to science (two Araliaceae, one Vitaceae). The diversity of ferns (pteridophytes) is also high (Appendix 2); we recorded a number of new species and genera for Gaoligongshan.

Macrofungi: The mycology team observed over 200 species of macrofungi (between 1,500 m – 2,400 m) and collected vouchers of about 150 (Appendix 1). Only 22 of the 200 species had been recorded previously in Gaoligongshan. We found a number of north temperate species mixed in with species from tropical Asia and species endemic to China. And we found species with disjunct distributions in eastern North America and eastern Asia. Macrofungi, crucial for the maintenance of high-quality natural communities, are also an important component of the local diet and the local market.

Amphibians and reptiles: The herpetology team found seven species of snakes, four species of lizards, one species of salamander and 15 to 21 species of frogs (pending confirmation of identifications; see figure 5; Appendix 3). Among these findings, three species of snakes and two of frogs were new records for the region, and one high-elevation frog is endemic to Gaoligongshan. We found the abundance of common amphibians to be 2-10 times higher in the reserve than in the rice patties near Datang (figure 3D). The use of chemicals in agricultural areas around the reserve has a severe detrimental impact on frogs.

REPORT AT A GLANCE

Birds: The ornithology team found 179 species of birds (Appendix 4) during the nine-day survey, of which 23 were new records for the region. Gaoligongshan has a rich forest avifauna, especially below 2,400 m. The elevation turnover of individual species is extensive, but we found no sharp differences in communities across elevation. We registered 43 species (25% of our total) with restricted ranges, including species representing two distinct endemic bird areas (EBA), the Yunnan Mountain and Eastern Himalayan EBAs. The reserve's current bird list includes at least 19 species that are threatened or near-threatened with extinction.

Large mammals: The mammalogy team registered 42 species (Appendix 5) through direct sightings and indirect evidence (tracks, scat, local interviews). Of these, 13 are nationally protected species, including four primates and the lesser panda. One of our significant findings was evidence of lesser pandas down to 2,000 m, well below the 3,000 m level to which they are typically thought to be restricted.

Main Threats

The primary direct threats to Gaoligong Mountain National Nature Reserve are (i) agricultural activities—including the use of chemical fertilizers—along the lower edge of the reserve (with associated disruption of streams and rivers and drift of pollutants); (ii) continued expansion of crop, pasturelands, and grazing into the reserve; and (iii) local needs for fuel given the few affordable alternatives to burning wood. Lack of basic information on environmentally safe alternatives to current farming practices threatens to extend these damaging activities into the future. Deforestation of the lower slopes places an enormous diversity of plants and animals—many of them restricted to the region—at risk of extinction. Eventual disappearance of these lower-elevation species would affect the dynamics of higher-elevation communities protected inside the reserve. Finally, the introduction of ecotourism in the region, while a tremendous opportunity, will threaten the reserve's integrity if not developed and managed carefully, with strict attention to the vulnerability of both natural and human communities.

Current Status

Gaoligong Mountain National Nature Reserve protects 405,549 hectares of the higher (upper and mid) slopes in the southern range of Gaoligongshan. The lower edge of the reserve varies from 1,500 to 2,500 m. The highest areas have been designated as an inviolate core, with no visitors allowed (figure 3). The exception is along the Southern Silk Road, which has been placed outside of the core area and allows visitor access to the highest elevations in the reserve. Land below the reserve boundary receives no formal protection and is a mixture of small-scale croplands, pastures, and disturbed forests (figures 2B, 2E, 3C, 3E). In 1994, the Chinese Ministry of Forestry allotted 8,550 hectares in the Gaoligong Mountain National Nature Reserve (6.8% of the total; all outside the core area) for tourism development.

REPORT AT A GLANCE

Principal recommendations for protection and management

- 1) *Extend conservation management beyond the Gaoligong Mountain National Nature Reserve, from river to river (figure 3).* Expand the limits of the reserve, as possible, down the mountains to reach the lower slopes (figures 2B, 2C, 3D). Here an enormous array of plants and animals will face extinction with the continued conversion of remaining pockets of unprotected forests to agriculture. Beyond the reserve, collaborative programs with neighboring villages for ecologically compatible economic activities would stretch the effective area of conservation from the Nujiang to the Longchuanjiang Rivers, protecting both lower-slopes and highland communities.
- 2) *Keep the core of the reserve untouched, with a few areas open to researchers; extend the core area to lower elevations where possible.* Because of the strong human pressure all around the reserve, we recommend that a significant portion of the reserve (the “core” area, see figure 3) remain completely off-limits, as it is now, and that the core be extended to cover lower elevations wherever possible.
- 3) *Restore and protect remaining lower-slope forests at the base of the reserve; extend currently isolated forest patches eventually to link one to the other and to form conservation corridors among the larger protected areas.* For the long-term survival of global biological treasures in the lower-slope forests, we recommend developing collaborative programs with the neighboring villages (figure 3B) to restore degraded patches of forest and to reforest (with native species) denuded stretches surrounding forest islands to increase and connect available habitat.
- 4) *Strengthen Baihualing village’s infrastructure and capacity.* One opportunity to ensure that local residents are involved in planning and benefit from tourism activities would be to establish a vigorous village ecotourism association (in the fashion of the Farmers’ Biodiversity and Conservation Association) representing the eight hamlets. This association would work with the existing village committee to discuss and implement plans and policies related to tourism. To be successful, this tourism association would function at a larger scale than the existing small committee in Dayutang, and would represent all hamlets.
- 5) *Research and implement less ecologically damaging agricultural practices in the valleys and seek opportunities for ecological restoration.* Increase options for farmers to diversify crops and to reduce use of polluting fertilizers and pesticides (which are also extremely expensive).
- 6) *Increase affordable options for fuel.* Currently, wood is the primary source of fuel. Tourism will increase pressure on the forests by increasing demand for fuel. Local villagers are unable to afford alternatives such as methane.

REPORT AT A GLANCE

Principal recommendations for ecotourism

- 1) *Ensure that revenues from ecotourism activities directly benefit the reserve and the neighboring villages.*
- 2) *Research carrying capacity for visitors in the reserve and carefully manage visitor loads accordingly (see Appendix 8).*
- 3) *Design ecotourism activities and infrastructure to minimize impact on the sensitive biological communities and to strengthen neighboring villages; keep infrastructure outside the reserve.* Create a Gateway Lodge and Visitor Center—which builds on existing infrastructure and is compatible with local design traditions—as the headquarters for strictly managed tourism (see Appendix 8).
- 4) *Limit and monitor activities that can damage biological communities.*
Principal measures include (i) proper disposal of waste, (ii) no use of firewood for cooking and heating, (iii) restriction of activities to well designed trails (which are managed for minimal erosion), (iv) minimal use of pack animals, (v) limited overnight trips.
- 5) *Approach the Gaoligong Mountain National Nature Reserve as one of a constellation of tourism destinations within this part of Yunnan Province.*
This will reduce pressure on the reserve and will create a rich visitor experience, while strengthening communities and preserving indigenous cultures and landscapes.

Long-term conservation benefits

- 1) A globally important nature reserve—from the lower slopes up to the rugged crests at 4,000 m—protecting a unique mixture of biological communities.
- 2) Restored habitat for a remarkable diversity of lowland plants and animals—many of them restricted to the region—that are currently at risk; sustained management of locally valuable natural resources.
- 3) A replicable model for successful ecotourism that is ecologically and culturally sensitive, brings direct income to the local villages and to the nature reserve, is a collaborative project managed by the local villages, and introduces Chinese and foreign visitors to the biological and cultural riches of the region.
- 4) Integrated management between the reserve and the surrounding villages to implement practices that protect the watersheds and reduce the use of damaging chemicals.

Why Gaoligongshan?

A lush crossroads of north and south, east and west, temperate and subtropical, the Gaoligong Region in southwestern China, at the border with Myanmar (Burma), is a unique blend of biological realms and biogeographic provinces (figure 2). The continuous belt of forest from east to west over the crest of the Gaoligong mountains provides pathways for an extraordinary mix of the flora and fauna from the Himalayas, the Palearctic, and the tropical elements of the Oriental realm of southeastern Asia. The conditions in Gaoligongshan that allow for a complete transition from temperate to tropical forests are unparalleled in the world. The region is a primary center of diversity and endemism and a top priority for the conservation of Earth's biological riches.

Gaoligong is an equally dynamic crossroads of culture and history. The valleys of the major north-south flowing rivers, the Nujiang and Longchuanjiang, have been farmed since ancient times. The Southern Silk Road, which crosses the southern portion of the mountain range, has connected India, Afghanistan, and Pakistan with central China since the 4th century B.C., serving as a conduit for commerce, trade, and culture. Today, approximately 450 families live in the eight hamlets that comprise Baihualing village, which is adjacent to the Gaoligong Mountain National Nature Reserve, the focus of our inventory (see figure 3). These villages reflect the remarkable cultural diversity of Yunnan, including Han, Bai, Lisu, Yi, Hui, and Dai ethnic cultures.

Although designated a Biosphere Reserve by UNESCO in October 2000, and designated a National Nature Reserve by the State Council of China, the spectacular environment of the Gaoligong range continues to suffer intense pressure. The unprotected lower slopes of the mountains contain great biological diversity, which is increasingly threatened as the forest cover rapidly disappears (figure 2C). The Chinese Government has selected a portion of the reserve for ecotourism development. Long-term survival of the Gaoligongshan natural treasures depends on full integration of resident communities in the management and stewardship of the reserve. Ecologically and culturally sensitive economic options—including carefully planned ecotourism—that directly benefit the region's human and biological communities are critical to protect Gaoligongshan's globally unique natural riches.

Overview of Results

ECOLOGICAL PROFILE

The Gaoligong mountain range in southwestern China is a dynamic blend of extremes—at once, an imposing geographical barrier and a major migratory passageway for plants and animals from east and west, north and south. With ancient peaks that rise abruptly to 4,000 m, Gaoligongshan is a hotbed of speciation. The lack of drought and minimal impact of glaciation offer conditions that allow primitive species to survive, especially in the low and mid elevations. Ecologically, Gaoligongshan is complex and unique: it is the one region on Earth where an intact and extensive transition from moist tropical to temperate forests still exists. In Gaoligongshan, the conditions that create new species and that prevent the extinction of old ones have persisted over a vast expanse of geography and time, in a region that is also home to ancient trading routes and a rich melding of cultures.

In the extreme southern portion of the range, the Gaoligong Mountain National Nature Reserve protects 405,549 hectares of forests along the border with Myanmar (Burma) (figures 2, 3). The reserve and its immediate surroundings were the target of our rapid biological and social inventories during the monsoon season of 2002, and of our focused analysis of physical structures to support ecologically and culturally sensitive ecotourism in the region. Surrounding, but not inside the reserve, live close to 300,000 people of 16 different ethnic groups: Han, Dai, Lisu, Hui, Bai, Miao, Yi, Zhuang, Nu, Achang, Jingpo, Wa, De'ang, Naxi, Drung, and Tibetan.

The Southern Silk Road (figures 8G, 9B), which traverses the Gaoligong mountains (figure 2), linked China, as far back as 300 BC, with India, Afghanistan and further west. The Road starts in Chengdu, Sichuan Province, crosses Yunnan, reaches the City of Baoshan and then scales the Gaoligong mountains, from Baihualing, before going into Myanmar. The Southern Silk Road was accessible year round because of the warm climate of the regions it traversed, and brought traders from as far away as Rome. Today, numerous historic sites survive along this ancient trade road in the Baihualing area, including an ancient stone arch bridge known as Huangxinshu, and the town of Jiujie, a major trading post until the first highway bypassed it in 1958.

The Gaoligongshan region was a focus of activity during World War II, when Allied soldiers and local Chinese laborers built the Burma Road which made it possible to transfer supplies from British-controlled Burma into China. Landmarks of this era, when Chinese and Americans pushed back the Japanese invasion of China, include the Zhaigongfang battlefield at one of the major mountain passes between the eastern and western slope of the Gaoligong mountains.

Despite the steady and once-heavy traffic along the picturesque cobble Silk Road (figures 8F, 9B), the character of the vegetation it traverses is essentially intact above 2,000 m. The exception may be at Nan Zhaigongfang, the pass over the mountains at ca. 3,200 m (figure 3E), where the low, scrubby vegetation is 1,000 meters below the characteristic treeline. The scrub is the result of steady disturbance, grazing by pack animals, and collection of firewood by travelers over the millennia.

Below the 2,000 m limit of the reserve, local residents have exploited the forests heavily for timber and pasture over the years (figures 2B, 2C, 3D). Even the remaining wooded patches are degraded. Yet these pockets of forest still maintain a large fraction of the diversity found historically in the region. These lower elevations are rich in species, and contain several of the interesting and range-restricted species of plants and animals that we found during our inventory, including three species of plants new to science.

Gaoligongshan is largely a granitic range that has been heavily eroded. The vegetation on the eastern slopes is characteristic of the acidic (granite) substrates. On the west side, layers of volcanic ash provide a different, less acidic geochemical environment for the development of vegetation communities. We found major differences in species composition along the eastern and western slopes for all organisms we sampled (plants, fungi, and animals). The change in species with elevation also adds to the impressive richness of the reserve.

Gaoligongshan is cool and dry in the winter months (November—April), and warmer and much wetter during the summer (May—October). The forests

cloaking the slopes are mainly monsoonal broadleaf evergreen forests. Patches of coniferous forest and scattered conifers within the broadleaf forest increase the diversity of habitats in the reserve. Abundant species of *Rhododendron* (figures 1, 4A), especially on the acidic soils of the eastern slopes, are a magnificent element of the Gaoligongshan understory during the flowering season. At high elevations, bamboos dominate the understory (figure 2F) and elsewhere bamboo species invade disturbed areas.

Streams cascade down the Gaoligong mountainsides, cutting deep valleys and creating majestic waterfalls (figure 2A). These fast-flowing streams (figure 2E) are crucial habitat for a number of animals, including several birds and amphibians restricted to the region. The valleys also provide habitat for different plant communities. Most valley-bottom plants rely on birds for seed dispersal, while plants that rely on mammals or wind to disperse their seeds dominate the ridges between the valleys.

Even during our brief sampling in three areas of the reserve, we added several new records to the existing species lists, highlighting the biological richness of the region, and how much more there is to be found in the reserve. In our brief social survey, the first of its kind in the Baihualing village gateway to the reserve, we confirmed the cultural richness of the local villages, along with the high potential for ecotourism and the need to strengthen local villages before tourism activities can be successful. Our visit also gave us the opportunity to develop preliminary designs for an ecotourism lodge and visitor center that can (1) share infrastructure with the existing ranger station, (2) be sensitive to the environment, and (3) be attractive to the ecotourist market.

In the following sections we summarize the highlights of our results and outline our recommendations for conservation action and for ecotourism development.

CONSERVATION HISTORY

In the first few decades of the 20th century, two of the world's best-known naturalists—Joseph Rock, who often worked for the National Geographic Society, and George Forrest, who worked for the Edinburgh Botanic Gardens—made important discoveries during their investigative trips to Gaoligongshan and the Baihualing area.

The Gaoligong Mountain National Nature Reserve was first designated by the provincial government in 1983 and the national government in 1986. In 2000, it became a UNESCO World Biosphere Reserve. Also in 2000, the boundaries of the National Reserve expanded significantly, and discussions are currently underway about further expansion. The following timeline provides additional detail.

1983: Provincial government designates a Reserve with boundaries including parts of the Baoshan District and the Nujiang Prefecture.

1986: State Council of China establishes the Gaoligong Mountain National Nature Reserve with somewhat different boundaries than the provincial reserve. The National Reserve includes 123,900 hectares (306,033 acres), and is 135 km (83.85 miles) long from north to south, and 9 km (5.59 miles) wide from east to west.

1994: State Council of China designates small portions of the reserve—8,550 hectares (21,119 acres) total—for tourism development. The tourism area includes three sections: Pianma (3,649 hectares) in the north, Rhododendron (270 hectares) in the west, and Baihualing (4,361 hectares) in the east. Baihualing is selected to be the first for tourism development.

2000: State Council of China triples the size of the reserve to 405,549 hectares (1,001,706 acres), largely by including the previously designated provincial reserve in the Gaoligongshan range (Nujiang prefecture) to the north.

2002: Discussions proceed on extending the boundaries of the reserve from the Nujiang River on the east to the Longchuanjiang River on the west (figure 3).

BAIHUALING VILLAGE : RESOURCES AND CAPACITIES

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We conducted a social survey with the help of a local guide and an interpreter over 13 days. Baihualing village consists of eight hamlets: Hanlong, Upper Dayutang, Lower Dayutang, Bangwai-Guxingzhai, Taoyuan, Laomengzhai-Baihualing-Malishan, Manggang, and Manghuang (Appendix 6 Table 1). Each of these hamlets has its own leader. In each hamlet, we interviewed the leader and his family, and another local family. Our goal was to understand the community's capacity to support, and benefit from, tourism. Appendix 6 provides the list of questions along with detailed tables summarizing the inventory results.

The composition of the hamlets seems to have undergone many changes over the years. In some cases, single hamlets have split into multiple hamlets as a result of population growth. In other cases, small neighboring hamlets have expanded and combined to form one hamlet. Baihualing village has approximately 2,100 people and more than 450 families. Each hamlet has both wetlands and dry lands for farming. The leader of Baihualing village (Head of the Village Committee) is also the Communist Party Representative, with an office in Baihualing hamlet.

ETHNIC CULTURES

The major ethnic groups living today in the Baihualing area are the Han, Dai, Bai, Lisu, Yi and Hui (Muslim). Although these ethnic groups maintain separate cultural identities, cultural diffusion has occurred over time, accelerated in the last two decades with the end of the social stigma against intermarriage. We found tremendous flexibility in expression of individual ethnic identity. Individual children can decide whether to adopt the ethnicity of their father or mother, which often are different. Residence patterns also vary greatly, as the composition of multi-generational families often

changes after a marriage. A man can move in with the family of his wife, if the wife's family has no sons and wishes to keep land within the family.

Most people choose to speak Chinese rather than their traditional language, although some people remember how to speak Lisu and Yi. Individuals may decide to retain their traditional language if there are perceived benefits. For example, some people learn Lisu to engage in economic transactions more effectively. Missionaries introduced the Lisu written language; the Bibles used in the Manggang church are in Lisu. Economic challenges—including farming and other ways of making a living in the rugged, mountainous terrain of Gaoligongshan—have led people to drop customs such as wearing of traditional clothing, preparation of specific food dishes, and production of traditional crafts. Most families celebrate Han festivals such as the Spring Festival or Chinese lunar New Year. But most families here also celebrate a traditional Yi festival, the Torch Festival. More in-depth research in the area will reveal additional customs and beliefs that distinguish the different ethnic groups.

NATURAL ASSETS AND CHALLENGES

Each hamlet faces the challenges of making a living with a distinct set of social assets (Appendix 6 Table 2). We estimate that the annual income per family for Baihualing village as a whole ranges from c. 300 to 20,000 Chinese dollars, with an average of c. 2,000 dollars. Farming is stressful for all families. People from every hamlet told us that they wish there were more means to invest in better technology and fertilizers. Low-lying hamlets have more water and wetlands available for rice. Most families grow some rice for their own subsistence, but depend heavily on sugarcane as the cash crop, from which they derive up to 85% of their income. The families' welfare is tied to the state-run factory nearby that buys the cane and also provides the seeds. Transportation of goods and people is difficult; the roads are steep and made worse by the frequent rains. Most people walk between hamlets; there are few cars, trucks, or other forms of transportation.

Fuel is a serious problem for everyone.

There are few options beyond collecting dead wood and brush. Pressure for development of alternative sources such as methane is increasing. A factor that limits accessibility of natural fuel sources is ownership—or rights to the use—of land. The people in Hanlong, the hamlet closest to the Ranger Station and to tourist trails, pay the most attention to the protection of forests in the reserve. Some families here collect wild mushrooms and herbs to supplement their incomes (figures 8A, 8C), while others collect wild honey. Over 90% of families in Baihualing have adopted the new fuel-efficient stove, resulting in over 60% savings in energy. Apparently some families in Malishan continue to use the old “tiger stove” that wastes fuel. The development of tourism in the area will put even greater pressure on fuel resources.

Residents say that the Nujiang River is cleaner than it has been for years. However, heavy use of chemical fertilizers for farming and chemical pesticides for killing mice and rats in homes continue to affect water quality.

Basic expenses are a strain for everyone: fertilizers for farming, pesticides, education, health care, marriage, and funerals. People in each hamlet have devised creative methods of supplementing their family incomes (Appendix 6 Table 3). Perceptions vary about which hamlets have the most economic disadvantages, although more people in Laomengzhai and Malishan felt that their greatest need was for farming assistance. Some individuals recognize a connection between agricultural diversification, environmental protection, and financial well-being. Some families have shown that it can be very productive to grow a variety of fruits such as mango, lychee, and orange.

CULTURAL AND HISTORICAL ASSETS

Modern cultural and historical assets vary by hamlet (Appendix 6 Table 4). The earliest recorded human settlements in the area of the present Gaoligong Mountain National Nature Reserve date back at least

2500 years, to the Ailao people. The Ailao Kingdom, centered in Baoshan, flourished between 500 to 100 BC.

The earliest known physical traces of past peoples in the area come from the Ming period (1368-1644). An especially significant spot is a partially standing wall on a portion of the Southern Silk Road, near Hanlong. Another notable relic is a group of broken stone tablets bearing writing from the Ming period, at the site of the current Guangyin temple. According to local residents, these tablets come from an earlier temple dedicated to Guangyin. A study of records from the Ming period about the Gaoligongshan area should be made in the future. The museum established by Mr. Wu in Hanlong about the war against Japan is certain to interest visitors, although it will require additional preparation, especially because it contains unexploded bombs. Some individuals continue to make attractive hand-embroidered shoes (figure 8E) and aprons, baskets, gourd scoops, wicker stools, horsehair rain capes, and horsehair saddles.

SOCIAL ASSETS

Established groups in Baihualing village already work to improve economic conditions and promote conservation (Appendix 6 Table 5). The MacArthur Foundation funded the Gaoligongshan Farmers Biodiversity and Conservation Association (GFBCA) program in 1995. It was the first program of its kind in China. The purpose is to promote greater protection of the environment. More families would like to be chosen as demonstration or pioneer families so that they too can be involved in the process. Individuals in Baihualing have initiated other creative organizations, such as the tourism association in Upper Dayutang.

Education is a priority among people in most hamlets (Appendix 6 Table 6). Few people can attend and finish senior high school or university, since it is difficult to raise funds for the tuition. Family members are willing to make substantial sacrifices with respect to saving cash or replacing labor for farming so that a young person can attend school. After graduation, however, there are few options for

young people to work outside the village, with the exception of a government job. Some people saw a connection between education, economic development, and conservation.

OPINIONS ABOUT TOURISM

Some people also recognize a relation between tourism, conservation, and economic development (Appendix 6 Table 7). However, very few villagers have experience with tourists, and there is little understanding of how tourism will affect them. People who are eager to provide services to tourists will need start-up funds to invest in such ventures. People indicated that they want to preserve the unique natural features of the area. Production of traditional crafts and food must take environmental conservation into account. People welcome training seminars about tourism and its relationship to conservation, and education will be a priority to help residents understand and benefit from tourism. Residents want to have a voice in the development of their area and are concerned about topics such as the location and management of potential markets for tourists (to sell foods and crafts), and continued protection of the reserve as tourism increases.

VEGETATION AND FLORA

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The vegetation in southern Gaoligongshan is extremely complex. In addition to elevation, plant composition is directly related to history, especially colonization following major disturbance. Plant composition is also related to soil, especially with regard to the occurrence of mid-elevation elfin forests. The three major sites we inventoried—Baihualing, Datang, and Nankang (figure 3)—had remarkably different plant communities. We noted vegetation composition in relation to elevation, substrate (rock, soils), topography, and disturbance.

The changes we found in plant composition from low to high elevations and from east to west slopes are striking. The mountains act as a barrier to species dispersal between east and west slopes, although it may be possible for species to migrate around the southern end of the mountain range. Geological substrates also explain much of the difference between east and west: the eastern slopes of Gaoligongshan are acidic granite, while the western slopes have a deep volcanic sediment on top of the granite and are consequently more alkaline. As an example, the genus *Rhododendron* (figure 4A) has many more species and larger populations on the acidic eastern slopes. The genus *Acer* had different species on eastern and western slopes.

On a finer scale, isolated pockets of substrates increase Gaoligongshan's overall plant diversity by allowing different species to grow on each "island." For example, while species richness is low in the Ericaceae elfin forests covering ridges of quartz sand mixed with clay, the composition of species differs among the scattered, isolated islands of elfin forests. The trail to the waterfall at Baihualing (figure 2A) contains a dramatic example of the effects of substrate: 90% of the flora on the ridge slope before the waterfall is different from the previous ridge slope.

Along the gradient of elevation, changes in vegetation are mostly associated with frequency of cloud contact and relative lack of drought (figure 3A). On the mountain slopes above Baihualing there appeared to be two important altitudinal transitions in the vegetation: one near 2,000 m and another between 2,600 and 2,700 m. These represent average cloud contact during winter at the higher elevation and during summer at the lower elevation. Some mixing of plant communities occurs at the same elevation, depending on ridge exposure and ravine moisture. At the highest elevations and mountain crests, temperature, wind, and lightning become important factors shaping the vegetation. On exposed ridges, conifers and other emergent trees had a high frequency of lightning damage.

As expected, we found much higher species richness in the lower slopes than in the highlands.

Interestingly, these lower slopes are also where we found unusual or new records (see below). The lower elevations fall outside the protected zones in the Gaoligong Mountain National Nature Reserve, and are under severe and increasing pressure by surrounding human populations (figure 2C, see threats).

Landslides in Gaoligongshan appear to be relatively infrequent and small in scale, reducing what is often a major source of natural disturbance in other montane forests. Although also rare, fires do seem to have influenced forest dynamics, especially on the mountain crests and in elfin forests during years of extreme drought. Animal dispersal of seed has had a strong influence on plant composition. On the higher ridges and slopes we found primarily mammal- and wind-dispersed species, while on the lower slopes and valley bottoms we found plants that are primarily dispersed by birds. The more abundant species of plants, and the seasonality of their reproduction, have a major effect on the composition of the fauna and vice-versa.

Single species can dominate in areas besides the Ericaceous elfin forests. In mid-elevation ravines, we found extensive, dense, even-aged stands of *Strobilanthes* (Acanthaceae), a genus known to flower and die synchronously after growing for 10 to 20 years. We also observed many dense patches of bamboo, which has a similar ecology and colonizes landslides during fruiting years.

FLORISTIC RICHNESS AND COMPOSITION

Species richness and endemism are high in the flora of Gaoligongshan (figure 4). The botany team estimates a minimum of 5,000 species in the Gaoligong range, of which close to 4,500 have been recorded and described to date (210 families, 1,086 genera, and 4,303 species and varieties, Xue et al. 1995, Li et al. 2000). In Datang, we found at least three species that are new to science (two Araliaceae and one Vitaceae—see *Panthenocissus* sp. nov., figure 4G). About 10% of the flora—434 species—are known to occur only in Gaoligongshan. During our nine days in the field, we

identified about 1,000 species of vascular plants (including six new records for the reserve), collected 300 species, and photographed more than 250 species. Most undescribed or unrecorded species are likely to be in poorly known plant groups, especially pteridophytes (ferns), Orchidaceae, Rosaceae, Ericaceae, Asclepiadaceae, Vitaceae, Urticaceae, Labiatae, Gesneriaceae, and Theaceae.

Ferns (pteridophytes) are very diverse in the reserve (see Appendix 2) and had not been previously surveyed systematically. Many of the species grow in mid-elevation evergreen forests. We collected 30 families (including five that are new records for Gaoligongshan: Equisetaceae, Adiantaceae, Drynariaceae, Loxogrammaceae, and Azollaceae) and 52 genera (8 new for the region: *Equisetum*, *Cheilanthes*, *Aleuritopteris*, *Adiantum*, *Woodwardia*, *Drynaria*, *Loxogramme*, and *Azolla*). The new records all came from Datang. Species richness in Pteridaceae, Dryopteridaceae, and Polypodiaceae are especially high, and we expect a large number of new species to be present in these complex families.

THE THREE REGIONS SAMPLED

Baihualing. On the eastern side of the Southern Silk Road, an almost complete elevational transect of plant communities stretches from the Nujiang (or Salween) River to the high mountains near Nan Zhaigongfang (figures 2, 3). In our transect along this road, from the Baihualing research station at 1,525 m to the crest of the mountains at 3,100 m, we recognized at least three major vegetation zones associated with elevation and/or topography. Each of the three vegetation zones had two or more highly distinct plant communities that were based on different geological substrates.

Near the hot spring close to the research station, monsoon evergreen broadleaf forests cover the lower foothills. Around Huangzhuhe (2,000-2,800 m), the first overnight camp structure along the Southern Silk Road, the mid-elevation wet evergreen forests are rich in epiphytes (Orchidaceae, Araliaceae, and

Polypodiaceae). This area is highly diverse in Fagaceae, Lauraceae, Magnoliaceae, and Ericaceae. Dominant species include *Lithocarpus variolosus*, *Illicium simonsii*, *Juglans regia*, *Castanopsis* sp., *Cyclobalanopsis lamellosa*, *Elaeocarpus* spp., *Manglietia insignis*, *Acer* sp., *Michelia floribunda*, *Hydrangea* sp., *Fargesia edulis*, *Brassaiopsis palmipes* (figure 4F), *Brassaiopsis hainla*, *Merrillioanax listeri*, *Symplocos* spp., *Vaccinium* spp., *Pteris* spp., and several species of *Rhododendron*. On the high mountain slopes around Nan Zhaigongfang, at 2,800-3,200 m—the camp at the pass (figure 3E)—the main species in the mountaintop shrublands are *Rosa* sp., *Rubus* sp., *Sorbus* sp., *Gentiana* sp., *Pedicularis* spp., *Rhododendron* spp., *Lithocarpus craibanus*, *Lithocarpus hancei*, *Fargesia* spp., *Mahonia polyodonta*, *Schefflera shweliensis*, *Daphne* sp., *Rumex nepalensis*, and *Caltha palustres*.

Datang. Datang, on the western slope of the Gaoligong Mountain National Nature Reserve (figure 3), has been less studied than Baihualing. Despite the severe disturbances it has undergone (from logging, cultivation and drying of tobacco, cattle, collection of firewood) Datang's flora is still very rich in species. We found an impressive number of unique or unusual plants, including three species new to science. Among the range-restricted species we recorded are the endangered *Rhododendron protistum* var. *giganteum*, *Taiwania flousiana*, and *Alsophila spinulosa*, as well as *Tetracentron sinense*, *Panax variabilis*, and *Aralia pausiloculata*. The dominant species we recorded are *Lithocarpus* spp. *Prunus nepalensis*, *Acer davidii*, *Daphniophyllum chartaceum*, *Pieris formosa*, *Evodia* sp., *Lindera communis*, *Decaisnea insignis*, *Tetracentron sinense*, *Manglietia insignis*, *Michelia* sp., *Edgeworthia gardneri*, *Embelia floribunda*, *Parthenocissus* spp., *Tetrastigma* spp., *Cladrastis sinensis*, *Ternstroemia gymnantheca*, *Akebia trifoliata*, *Oleandra* sp., *Rosa omeiensis*, *Pyrularia edulis*, *Iris tectorum*, and several species of *Elaeocarpus*.

Nankang. Nankang is at the pass, along the southern tip of the Gaoligong Mountain National Nature Reserve (figure 3). A relatively low-elevation

pass for the region at 2,150 m, Nankang is an important biological corridor between the eastern and western slopes of Gaoligongshan. We found that Nankang shares many plant species with both Baihualing (east slope) and Datang (west slope). The mid-elevation wet evergreen forests in this foggy, high-rainfall site are rich in epiphytes such as orchids and ferns. Dominant species in the forest include *Lithocarpus variolosus*, *Schima khasiana*, *Phoebe* sp., *Castanopsis lamellosa*, *Michelia velutina*, *Cinnamomum caudiferum*, *Rhododendron delavayi*, *Rhododendron decorum*, *Schefflera elata*, *Manglietia insignis*, *Helicia shweliensis*, *Illicium macranthum*, and *Maianthemum purpureum*.

FUNGI

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Gaoligongshan is extremely rich in macrofungi. Despite limited sampling, more than 300 species have been recorded in the reserve to date. During our nine days in the field, we registered over 200 species (of which we documented 148 with voucher specimens and color photographs; see Appendix 1, figure 7), even though we were able to inventory only a few of the vegetation types at a very limited elevational range. Only 22 species we found were among the 132 previously listed for the reserve. Although it is difficult to estimate the total number of macrofungal species—large ascomycetes, agaricales (mushrooms and relatives), aphylophorales (bracket fungi, coral fungi, others)—that occur in the reserve, based on the diversity of plants, vegetation types, and altitudinal range, we estimate that the Gaoligong Mountain National Nature Reserve protects 1,500–2,000 species of macrofungi.

The remarkable mixing of species from different realms in Gaoligongshan underscores the global importance of the region for the conservation and further study of macrofungi. We observed two species of *Dictyopanus*, a tropical genus, in juxtaposition with a number of north temperate species that appear to be at the southern end of their distribution

(*Oudmansiella yunnansis*, *Lactarius lignyotus* and *Laccaria bicolor*). We found species of temperate Asia (*Amanita rubrovolvata*, figure 7D, and *Leccinum virens*) mixed in with species of temperate Europe (*Oudmansiella muscida*). And we recorded species that appear to occur in disjunct populations in eastern North America and eastern Asia (*Xerula furfuracea*). We also collected species endemic to China, like the large and showy *Boletus sinoaurantiacus* (figure 7E) that is restricted to the southern portion of the country.

Of the 148 species collected, we found only two in all three localities. We cannot determine the extent to which the lack of overlap reflects geography and site specificity, or limited sampling. However, each site clearly contains a unique assemblage of species. Distribution of fungi is strongly linked to vegetation, soil type, and available moisture among other variables. The geologically complex Gaoligongshan range, with its rich vegetation, should harbor many distinct macrofungal communities.

We sampled opportunistically during our brief period in the field, relying on local guides to take us to different sites known for their fungi. Fruiting of macrofungi is highly seasonable; sampling during different months of the rainy season would result in different records. We also know from experience that there is high year-to-year variation in fruiting of macrofungi, so we would find a number of different species if we re-sampled the same sites in subsequent years. We recommend much more extensive surveys. Although we were not able to collect quantitative data (which would have required three to five days at each subsite), we recommend that such samples be undertaken at least twice per year—at the beginning and end of the wet season—for several years. Such data will allow for comparisons in diversity and abundance among sites, within and outside of Gaoligongshan.

Macrofungi play a central role in forest and grassland communities. Preserving their diversity and populations is critical for the maintenance of plant and animal communities. Macrofungi play vital roles in nutrient cycling and absorption, water regulations,

plant-to-plant interactions, and interactions among other soil-associated organisms. Many macrofungi form a symbiosis with Fagaceae, Pinaceae, and other trees, dominant elements of the canopy in Gaoligongshan's forests. These ectomycorrhizal associations are essential and mutually beneficial to both tree and fungus. While trees provide sugar to the fungi, the fungi provide the trees with minerals and water and protect them from root pathogens. The fungi can even link trees together below ground, enabling trees to share carbohydrates and minerals and creating a dynamic, interacting community. Other macrofungi are crucial decomposers: macrofungi, along with some bacteria, are the only organisms capable of decomposing cellulose and lignin, the two primary constituents of plant material. These fungi are the primary recyclers in plant communities. A few macrofungi are pathogens of plants, and promote important age diversity in forests.

Wise management and use of macrofungi can become an important component of the ecologically compatible economic alternatives for Gaoligongshan. People in the region use macrofungi for food and medicine; these fungi constitute an important component of the local diet and also supplement family income. The beauty of mushrooms and other macrofungi (figure 7) will add significantly to the experience of ecotourists, as will the delicious (and for foreign visitors, exotic) mushroom dishes.

Fungi can provide a crucial link between human communities and biological communities in Gaoligongshan. Studies in the northwestern United States and southwestern Canada have documented that the economic value of non-timber crops (primarily mushrooms, ferns, and greenery for the florist market) can exceed the economic value of trees as timber. Fungi, thriving in high-quality well-managed natural communities, may become a valuable, renewable resource directly benefiting neighboring human communities.

AMPHIBIANS AND REPTILES

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The herpetological team registered 30 species of amphibians and reptiles during less than seven days of sampling (Appendix 3). We found seven snakes, four lizards, one salamander, and 18 frogs (with possibly 15 to 21 frogs; determination awaits more careful studies in collections; figures 5 and 6). Even with our limited sampling efforts, we found at least five species not reported among the 72 previously registered for Gaoligongshan (Xue 1995). These are the snakes *Pytas mucosas*, *Rhabdophis nuchalis* (figure 6C), and *Rhabdophis subminiatus*, and the frogs *Chrixalus doriae* and *Micrixalus liui*. With 15% of our records new for the region, we expect that many more unrecorded species exist in the Gaoligong Mountain National Nature Reserve. Based on species known for Gaoligongshan and species registered in Yunnan and in the southwestern mountains of Yunnan, we expect some 60 reptiles (with a predominance of snakes) and 60 amphibians (with a predominance of frogs) to occur in the reserve. This is a high number even relative to the species-rich Amazonian tropics. Because of their often-cryptic habits, we believe that this undiscovered species richness will be most extreme for snakes and lizards. We probably only scratched the surface of the true diversity of snakes in the reserve. We also suspect that many of the supposedly wide-ranging species of frogs contain cryptic species with more restricted distributions.

We conducted night surveys for frogs based on their calling at streams, ponds, pools, and rice fields. Generally, three individuals worked at different stretches of the habitat, and we attempted to locate all species that were calling. We also conducted visual surveys for non-calling individuals using flashlights and headlamps. During the day, we conducted one or two visual surveys by walking along or adjacent to trails, turning logs and rocks, and searching in trees and bushes for lizards and snakes. We also walked along streams and pools in search of adult and tadpoles of frogs and toads.

The Gaoligong mountains represent an important mixture of mid-elevation subtropical species (1,500-2,400 m) and high-elevation species (above about 2,700 m). The high-elevation species of amphibians are the most geographically restricted, with frogs of the family Pelobatidae showing the smallest geographic ranges. For example, the frog *Scutiger gongshanensis* is restricted to the Gaoligongshan region above 2,500 m, where we found it in clear, fast-flowing headwater streams. The frogs *Leptobrachium chapaense*, *Rhacophorus gongshanensis* and the lizard *Japalura yunnanensis* are also restricted to the region, but we did not find them during our short visit. We expect that several of these mid-to-high elevation taxa are actually composed of several distinct species, and that more intensive field collections will reveal additional species that occur only in Gaoligongshan.

At approximately 2,700 m, the composition of amphibian and reptile communities shifts abruptly from lowland to montane species. We heard *Megophrys minor* (figure 5D) at least up to 2,500 m, and probably up to about 2,700 m, at which point we ceased to hear its call. At 3,100 m at the top of the Southern Silk Road, we heard the distinctive call of *Scutiger gongshanensis* in the types of small headwater streams where we heard *M. minor* calling at lower elevations. We heard at least one other species of frog (whose identity we were not able to confirm) calling at 3,100 m that we did not hear at lower elevations. The habitat shift that we observed at 3,100 m, both in terms of climate and forest structure, made this elevation unsuitable to the mid-elevation species, such as the large snakes *Zaocys nigromarginatus* and *Pytas mucosas*.

Although our fieldwork was brief, our sampling confirmed several impressions. First, the Gaoligong mountains themselves appear to be a major biogeographic barrier to dispersal of several species of amphibians. In addition to our samples of amphibians, we were able to census populations by calls during our wet-season survey. For example, at the Baihualing Station on the Southern Silk Road (eastern slopes), the frog *Megophrys minor* (figure 5D) called from virtually

every stream narrower than about 1 m, from 1,400-2,500 m. This was the case during rainy days or at night. However, we never heard this species in similar small streams in Datang, on the west side. If the species is present on the west slope, it is clearly much less abundant than on the east side, and our guess is that it does not occur at all on the western slopes. Similarly, the frog *Rana pleuraden* (figure 5F) was extremely abundant at Datang and Nankang but appeared to be absent at Baihualing. Finally, the salamander *Tylostotriton verrucosus* (figure 5A) was abundant in the east (Baihualing; including in exceedingly disturbed habitats in the village), was present at Nankang (at a pond site), but was absent from appropriate habitats at Datang. Because these species were abundant when found and occurred in both undisturbed and disturbed habitats, we feel confident that if they had been present at all three sites we would have discovered them.

We believe that the mountains also serve as a major biogeographic barrier for reptiles. Our reptile sampling was not as complete as for amphibians, however, so more fieldwork is needed to confirm this impression. We found a pattern of patchy distribution for many of the reptiles similar to the pattern observed for frogs, but the low numbers of individuals we found makes us less certain that absences in our samples represent true absences at a site.

Clearly, to understand the extent of these community shifts will require much more extensive surveys, particularly for the reptile species. Virtually the only way to sample lizard and snake species effectively is to use drift-fences with associated traps. These fences are simple to install and census, but they require that a trained person, either from the reserve or from the local community, check the traps, identify individuals captured, and release the animals. Monitoring each set of drift-fences would require 1-2 hours per day, and they need to be checked daily. Fortunately, when it is inconvenient to check the traps, the drift-fences can be closed down to allow animals to pass by them freely. Reopening the traps when personnel are available requires only a few minutes.

Several members of our expedition noted that amphibians have declined in some areas around Gaoligongshan, particularly in the lowland agricultural areas. This observation is consistent with the worldwide trend in amphibian declines. One of the key reasons for these dramatic declines is the application of pesticides and herbicides, which kill amphibian adults, tadpoles, and eggs. Gaoligongshan has wetland ponds, pools and streams that are not subject to these agrochemicals, and the resulting high densities of common amphibians within the reserve is striking compared to adjacent agricultural regions. For example, in Datang, we found the same set of species in the rice fields (figure 3D) as we did at our field camp (about 5 km away) and at our sampling site at Nankang. However, in the rice fields species numbers were very low, with only 1-5 individuals per species found in two hours of intensive nighttime collecting. At the pools near our Datang field camp, we found 2-5 times as many individuals in the same time, and at Nankang, in the undisturbed botanical garden, we found 5-10 times as many individuals. The Gaoligong Mountain National Nature Reserve, protected from the application of deadly agrochemicals, is extremely important as a safe haven for frogs.

Gaoligongshan is a superb reserve for the amphibians and reptiles that live at mid-to-high elevations. At lower elevations, we believe that most species still exist, but in reduced numbers because of intense human activities. Species that inhabit the lower slopes appear to be recoverable if human activities are reduced, or if people change the ways that they interact with the landscape. Important changes include: reducing the use of agricultural chemicals; ending the practice of killing large snakes, lizards, frogs, turtles and tortoises; ceasing the clearing of trees particularly near any streams or rivers; and reducing the extent of cattle and goat grazing. Convincing people not to kill snakes can be particularly challenging, and might benefit from an educational element on the value of snakes for pest control.

BIRDS

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We estimate that the Gaoligongshan region supports over 600 species of birds—nearly one-half of all species known in China. The bird team registered 179 species in the Gaoligong Mountain National Nature Reserve (Appendix 4) during the nine days in the field: 121 in Baihualing (east slope), 104 in Datang (west slope), and 54 in Nankang (pass, at south). Approximately 350 species had been recorded previously in the reserve (Xue 1995), of which many are lowland species (below 1,500 m), waterbirds, or open-habitat species not expected to occur in significant numbers within the reserve. We added 23 species to the list, 18 of them forest species. Three of the new records represent significant range extensions: *Clamator jacobinus* (registered at the Southern Silk Road) represents a range extension to the east, previously known in China only from southern Xizang; *Enicurus immaculatus* (found in Datang and Baihualing) is also a range extension to the east, previously known in China from a single record at Tengchong; and *Tickellia hodgsoni* (found at Baihualing) fills a gap in range between Xizang and southeastern Yunnan.

The reserve supports an impressive montane avifauna (above 1,500 m), which we estimate at 355 forest species. Close to 225 forest-based breeders already have been recorded. Based on ranges of thus far unrecorded species, we expect that an additional 100 species breed in the Gaoligong forests. We estimate that 30 additional land bird species winter in or migrate through these forests (16 already have been recorded). In the surrounding lowland and disturbed areas, at least 130 additional species have been recorded and we estimate that future surveys will find at least twice that number.

The lower slopes of Gaoligongshan, below about 2,400 m, have a particularly rich array of species, many with small geographic ranges. At the three sites visited, we observed substantial differences in the

avifaunas at equivalent elevations, even in the very common, easily observed elements of the avifaunas.

During our inventory, we were able to evaluate turnover of species with elevation only along the forested stretch of the Southern Silk Road (Baihualing Station to the pass at 3,100 m, figure 3). Each of the three subsites along the Southern Silk Road (1,500 m-2000 m; 2,000 m-2,800 m; 2,800 m-3,100 m) had distinct avifaunas and no species was found across the entire elevational range (although with further study, undoubtedly some species will range that widely). In a few genera, for example *Alcippe*, *Yuhina*, and *Aethopyga*, we found altitudinal replacement of species. However, this replacement was not as sharp as is regularly the case in tropical montane avifaunas. In general, elevational ranges seemed broader in subtropical to temperate Gaoligongshan than in avifaunas of the tropical Americas or Africa. And populations at some elevations may be maintained through immigration from other elevations. Specifically, the richness of species at about 2,000 m may be maintained by movements from lower elevations. If the forests at the lower elevations (see figures 2B, 2C, 3D), which are outside the reserve and face much pressure, are lost, much of the diversity higher in the mountains may be lost as well.

Almost one-quarter of the forest birds registered at Gaoligongshan have restricted ranges and therefore are likely to be at risk. Gaoligongshan has a number of very narrowly endemic species (range smaller than 50,000 sq km) representing two Endemic Bird Areas (EBA) as defined by Birdlife International (Yunnan Mountains and Eastern Himalayas, Stattersfield et al. 1998). We recorded five such species during our nine days in the field: two of the three narrowly endemic birds of the Yunnan Mountain EBA (*Sitta yunnanensis* and *Paradoxornis brunneus*; both at Datang), and three of the 22 narrowly endemic birds of the Eastern Himalayas EBA (*Tickellia hodgsoni*, *Sphenocichla humei*, and *Heterophasia pulchella*). The first three of these five species are new for the Gaoligongshan list. Three additional species from the

Himalayan EBA—*Lophophorus sclateri*, *Harpactes wardi*, and *Actinodera waldeni*—have been recorded from Gaoligongshan, but were not observed by us. In total, eight narrowly endemic species have been recorded from the Gaoligong range. We recorded another 37 species (22% of our total) with ranges in the order of 100,000 sq km or less.

Birdlife International has applied IUCN (International Union for Conservation of Nature) criteria to rate the degree of threat to all birds of the world (Collar et al. 1994). Based on this ranking we found 10 species that are threatened or near threatened with extinction. An additional nine species in these categories were recorded previously from Gaoligongshan. Habitat loss is the major threat for these birds. Seven species of pheasants, including five considered at risk by Birdlife, are a particularly important set of vulnerable birds. Current hunting pressure seems to be low, but the pheasant populations should be monitored. We must act now to ensure that those species that are “near threatened” do not become threatened, and to keep those that are threatened from becoming extinct. Gaoligongshan is tremendously important as a refuge, and it must be sufficiently large to maintain bird populations in the long-term.

Gaoligongshan is a rich biogeographic cross-roads, as indicated not only by the presence of species representing two endemic bird areas, but also by the mixture of elements from the avifaunas of the Himalayas, central China highlands, southeast Asia, and the Palearctic. Gaoligongshan is also near the center of diversity for the babbler family (Timaliidae, the taxonomy is currently in flux), which is mostly an Asian radiation. The reserve has 60 species of babblers, of which we saw 43. The babblers, a very diverse group ecologically, range across almost the entire array of shapes, sizes, and bill morphologies. Large genera at Gaoligongshan include the laughing-thrushes (*Garrulax*, 12 species recorded), fulvettas (*Alcippe*, 7 species), and yuhinas (*Yuhina*, 7 species).

We cannot yet evaluate the effect of seasonality on Gaoligongshan’s avifauna. We observed

a number of species with dependent young (Appendix 4), suggesting that we surveyed at the end of the breeding season for most species of forest passerines. Gaoligongshan has significant numbers of species that only winter in the region (about 35 species). It also has many species that breed in the area but winter elsewhere (about 45 species). In addition, a number of the birds at Gaoligongshan make seasonal elevational movements. These migratory patterns mean that successful conservation of Gaoligongshan's avifauna depends on careful management not only of the reserve but also of its surrounding areas.

LARGE MAMMALS

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We found direct or indirect evidence of 42 species of large mammals in Gaoligongshan during our survey (see Appendix 5): 34 along the Southern Silk Road at Baihualing, 28 in Datang, and 21 in Nankang. We estimate that the Gaoligong Mountain National Nature Reserve supports about 150 species of mammals. The fauna is complex, with dominant elements from the Oriental region but with several species from the Palaearctic. The reserve is rich in endemic species (about 40) and in forest species (over 85% of fauna).

Our survey relied on direct evidence of animals through visual sightings or sounds, and indirect evidence through tracks, droppings and semi-structured interviews with villagers, especially hunters. To ensure reliable information in our interviews, we ran several trials with photographs of animals that do not occur in the region.

One of our most significant findings was that the lesser panda (*Ailurus fulgens*) occurs in areas around 2,000 m in Gaoligongshan. This species was believed to be restricted to alpine areas, above 3,000 m. We also found indications that the population sizes of the endangered *Hylobates hoolock* and *Cervus unicolor* are increasing and that their distribution within the reserve is increasing as well.

Gaoligongshan protects several rare and endangered mammals. In all, 27 species known from the Reserve are listed as first- or second-grade nationally protected species. We found tracks or individuals of 13 of them: *Macaca mulatta*, *Semnopithecus phayrei*, *Hylobates hoolock*, *Macaca arctoides*, *Selenarctos thibetanus*, *Ailurus fulgens*, *Catopuma temmincki*, *Cervus unicolor*, *Budorcas taxicolor*, *Capricornis sumatraensis*, *Naemorhedus caudatus*, *Ratufa bicolor*.

As with the other taxa, turnover of species with elevation was most evident in Baihualing, where there is a continuous stretch of forest from 1,500 m to the crest. Although Datang has large patches of forest, human disturbance is ever-present and severe in several places, especially in the lower elevations. Nankang also has had great impact from human activities that have essentially eliminated the understory. As expected, the smaller-sized large mammals (primates, muntjacs, hares) are more abundant than the larger ones (pangolins, black bears, and large cats).

THREATS

The Gaoligong Mountain National Nature Reserve protects a spectacular array of natural communities in the southern portion of Gaoligongshan. Through proper planning, the reserve can also offer concrete opportunities for integrated management with the culturally rich human communities living at the base of the mountains. Nonetheless, pressures inside and outside the reserve, if unmitigated, threaten the stability and long-term survival of the reserve and of its neighboring human and biological communities. Below we list these primary threats to the region.

1. *Continued degradation or complete loss of lower elevation habitats.* The lower slopes and valleys adjacent to the reserve are unprotected and are under extreme threat (the reserve reaches its lower limits at ca. 1,500 m). Only pockets of forest remain, most of them already degraded (figures 2B, 2C, 3D). Yet even in these degraded and increasingly isolated

pockets we found a surprisingly high number of rare, range-restricted, and/or endangered species. These lower-slope forests provide crucial habitat for species that do not occur elsewhere, and they help maintain populations of animals at higher elevations. All three plants new to science in our inventory came from the lower elevations at Datang.

The degradation or outright destruction of the lower slopes and valleys comes primarily through (i) clearing for agriculture (with cultivation and drying of tobacco being one of the most damaging practices); (ii) production of charcoal; (iii) conversion to pasture for livestock; (iv) grazing by livestock (also a threat at higher elevations, inside protected areas); (v) use of trees for firewood and for construction; (vi) erosion; and (vii) use of agricultural chemicals (which is even more devastating to streams, wetlands, and ponds).

2. *Disruption of streams and rivers and destruction of sensitive watersheds.* A number of animal species—including several that are restricted to Gaoligongshan—depend directly on streams for their survival. An even greater number of species rely indirectly on these streams. In the agricultural areas around Gaoligongshan, streams have been all but destroyed (primarily by diversion for agriculture and chemical pollution). Destruction of sensitive watersheds is particularly dangerous for very small headwater streams, which harbor a large portion of Gaoligongshan’s amphibian diversity. Pollution of wetlands also affects the macrofungi, which in turn affects the plants and ultimately the structure of the vegetation and the availability of food for animals.
3. *Incursion of livestock in protected forests.* Cattle, pigs, and goats lead to fast deterioration of the forests. They cause direct damage to the vegetation, and also compact the soil, making it impossible for fungi and other organisms to live. The understory, and all creatures associated with it, will be the first to disappear if pressure from livestock remains high.
4. *Drift of pollutants (agricultural chemicals, others) into the reserve (see 2).*
5. *Overuse of resources: hunting, harvesting.* Over-harvesting of mushrooms may be or may become a problem, if not studied and managed so that sufficient fruiting bodies remain uncollected each season. Similarly, excessive hunting could become a problem for populations of large mammals and large birds, especially pheasants. While hunting and harvesting are controlled inside the reserve, and to a lesser extent in the collective land outside the reserve, there are areas that are not managed at all. All hunting and harvesting should be managed and the impact monitored.
6. *Pressure to generate income.* The pressure to develop income-generating activities inside or around the reserve—e.g., ecotourism—can open up excellent opportunities for collaboration with the neighboring human communities in ecologically compatible use of resources (see recommendations, below). However, unless managed carefully and adjusted based on a rigorous monitoring plan, such revenue-building initiatives may damage both natural and human communities through overuse, lack of infrastructure, increased pollution, and disturbance.
7. *Lack of information about and access to “green technologies.”* The Farmers Biodiversity and Conservation Association has made great strides, but most residents in the villages surrounding the reserve lack basic information about environmentally safe farming practices and fuel sources. Issues about education, health care, and sanitation are dominant in peoples’ minds and must be considered when approaching villagers about long- and short-term goals for conservation.

CONSERVATION TARGETS

The following species and communities are of primary focus for conservation in Gaoligong Mountain National Nature Reserve because of their (1) global or regional rarity, (2) influence on community dynamics, and/or (3) importance in ecosystem processes.

Organism Group	Conservation Targets
Biological communities	Low-elevation forests (below 2,000 m), even if disturbed Elfín forests and other communities on unusual geological substrates All intact forests and full elevational gradients (Southern Silk Road) All distinct vegetation communities on the eastern and western slopes Vegetation communities with different age structure and ample wood debris (to maintain fungi diversity)
Plants	Endemic taxa (plant species restricted to Gaoligongshan or with restricted ranges) Endangered species (<i>Rhododendron protistum</i> var. <i>giganteum</i> , <i>Taiwania flousiana</i> , <i>Alsophila spinulosa</i> , others) Plants used for medicine
Fungi	Fungi used for food and/or medicine Mycorrhizal fungi associated with each vegetation community and with particular plants (e.g., Fagaceae, Pinaceae) Decomposing fungi
Reptiles and Amphibians	High-elevation stream amphibians (especially above 3,000 m) Mid-elevation subtropical species (1,500 m—2,700 m) Species endemic to Gaoligongshan or ones with restricted geographic ranges Economically important species (e.g., monitor lizards, python, turtles and tortoises) Threatened low-elevation species
Birds	Montane evergreen broadleaf forest birds (especially below 2,000 m) Birds along (or using) fast-flowing streams Coniferous forest birds Large forest pheasants—seven species known from Gaoligongshan (three vulnerable and two near-threatened) Endemic taxa (especially narrowly endemic species) Threatened and near-threatened species

CONSERVATION TARGETS

Mammals

Primates: *Macaca arctoides* (stump-tailed macaque), *M. mulatta* (rhesus monkey), *Semnopithecus phayrei* (brow-ridged langur), *Hylobates hoolock* (white-browed gibbon)

Large carnivores: *Selenarctos thibetanus* (black bear), *Ailurus fulgens* (lesser panda), *Panthera pardus* (leopard), *Panthera tigris* (tiger)

Large ungulates: *Cervus unicolor* (sambar), *Budorcas taxicolor* (taklin), *Capricornis sumatraensis* (serow), *Naemorhedus caudatus* (goral)

Rare and endangered species

Gaoligong Mountain National Nature Reserve offers safe haven to a spectacular array of biological communities and to a large number of range-restricted, and/or endangered species. In just nine days in the field, we significantly expanded the list of organisms known to exist in the reserve, underscoring (1) the importance of the region for the long-term survival of global biological treasures that occur nowhere else, and (2) how much more there is to learn.

The reserve offers the opportunity to conserve an unparalleled mixture of ecological communities, while integrating the diverse cultures at the base of the mountains in the management and restoration of the highlands and of the surrounding, unprotected lower slopes and valleys. The reserve can become an international model for ecotourism that brings economic benefit to local people, instills local pride, fosters an ethic of stewardship, and preserves indigenous cultures. Below we highlight long-term benefits that conservation and integrated management of the reserve will bring to the region and to the world.

- 1) **A globally important nature reserve—from the lower slopes at 1,500 m up to the rugged crests at 4,000 m—protecting biological communities from the Oriental realm of China, the Himalayas, and the Palearctic.** The continuous stretch of forest from low to high elevation and from east to west over mountain crests conserves a blend of biological realms unique in the world and protects the processes that bring about speciation.
- 2) **Restored habitat for an enormous diversity of plants and animals currently at risk on the lower slopes.** Pockets of forest still standing in the lower elevations outside the reserve's present boundaries are highly diverse, with unusual and/or range-restricted species of plants and animals. Protection and expansion of these pockets of forest, along with appropriate management efforts, will restore crucial habitat for a currently neglected, large segment of the plant and animal diversity in Gaoligongshan.

CONSERVATION OPPORTUNITIES

- 3) **A model for successful ecotourism that is ecologically and culturally sensitive, and that benefits both the local communities and the nature reserve.** Adjacent to the nature reserve are communities that reflect the exceptional cultural diversity of Yunnan Province (figure 8). Visitors and residents have a unique opportunity to experience the diversity of both nature and culture. Carefully planned tourism, with full participation from the neighboring villages, has the potential to attract funds for long-term management of the reserve and to integrate local villagers in an ecologically sensitive economy.
- 4) **Successful collaboration among neighboring communities and with reserve personnel in the management and use of the nature reserve.** Local citizens can become excellent stewards of the reserve. Appropriate training programs in Baihualing can serve three complementary purposes: enhance the quality of life of neighboring villagers, reduce stress on the natural environment, and provide the necessary social foundation to handle increased tourism in the area.
- 5) **Protection of watersheds and of other resources used for food and medicine.** Effective conservation in the reserve and restoration of the lowlands provide direct and immediate benefits to the surrounding communities and to the economy of the region. Watershed protection in the mountains is crucial for the continued supply of water to agriculture in the valleys. Local residents harvest several natural resources for food, medicine and additional income. Fungi, especially, make up an important component of the local diet and also are sold to supplement income. Managed use of macrofungi can be an important component of sustainable harvesting in Gaoligongshan.
- 6) **Center for studies of evolution (speciation), ecology (migration, habitat use, recruitment and growth of dominant tree species), and conservation (amphibian decline, effects of pollution).** The continuous swath of forest on the eastern slopes of the Gaoligong Mountain National Nature Reserve, and the isolated patches of forest on the western slopes just outside the reserve, are excellent sites to study conservation and biodiversity issues such as speciation, habitat use, and causes of amphibian decline.

RECOMMENDATIONS

The Gaoligong Mountain National Nature Reserve offers vital protection to the montane flora and fauna of southern Gaoligongshan, primarily from 2,000 m and above. Yet to realize its potential as a worldwide resource of unique biological communities, we envision an expanded reserve that also protects the species-rich, lower montane slopes. In this vision, the buffer zone for the expanded reserve (1) stretches from the Nujiang River to the Longchuanjiang River (figure 3) and (2) connects the reconfigured reserve to protected areas to the north. Meanwhile, ecologically compatible economic activities, including sensitive ecotourism, thrive under integrated management activities that strengthen existing community assets and support the villages at the base of the mountains.

The following recommendations propose crucial steps toward realizing this vision. An active research and inventory program will sharpen and focus these conservation goals. In Appendix 7 we present detailed recommendations for development of an ecotourism lodge.

Protection and management

1) Keep the core of the reserve untouched, with a few areas open to researchers.

Because of the tremendous biological importance of Gaoligongshan's forests and the strong human pressure all around the reserve, we recommend that a significant portion of the reserve (the current "core area," which includes the higher elevations in the reserve, see figure 3) remain completely off-limits, as it is now.

2) Increase protection and strict patrol of the non-core areas of the reserve.

This increased protection in the lower elevations, where tourism also is allowed, will be crucial to maintain integrity of the forest.

3) Extend the core area of the reserve to lower elevations wherever possible.

There is an enormous diversity of plants and animals in the lower elevations of the reserve, including vulnerable species with restricted ranges. This diversity is at high risk of extinction because of continued invasion of the reserve and erosion of the isolated pockets of remaining forest outside the reserve (figure 2C).

4) Extend conservation-compatible management from river to river. Currently, discussions are underway about extending conservation-compatible management from the Nujiang River on the east to the Longchuanjiang River on the west. While preservation of the resources within the river valleys is critical, an expanded designation of protected status must take into account the approximately 300,000 residents of the river valleys. It may be appropriate to consider a "heritage area" designation outside the present reserve boundaries that allows for continued use of the living landscape with appropriate incentives to encourage cultural preservation and ecological restoration, and restrictions to limit development to ecologically sensitive sustainable activities. As an immediate next step, beyond the official boundaries of the reserve, collaborative

RECOMMENDATIONS

programs should be developed with neighboring villages to manage the natural resources outside the reserve in a manner that is compatible with the maintenance of biological and cultural diversity.

- 5) **Restore and protect the patches of low-elevation forests surrounding the reserve; extend currently isolated forest patches eventually to link one to the other and to the larger protected areas.** For the long-term survival of global biological treasures in the low-elevation forests—where we found species new to science during this brief inventory—we recommend working closely with the neighboring villages to develop and implement collaborative programs that (i) restore remaining patches and (ii) reforest denuded stretches among patches with native species to increase available habitat. We recommend that all remaining patches of forests outside the reserve—even the small ones in Nankang and the highly disturbed patches in Datang—be afforded protection.
- 6) **Strengthen Baihualing village's capacity to participate in the planning and implementation of ecotourism.** One opportunity to ensure that local residents are involved in planning and benefit from tourism activities would be to establish a vigorous village ecotourism association (in the fashion of the Farmers' Biodiversity and Conservation Association) representing the eight hamlets. This association would work with the existing village committee to discuss and implement plans and policies related to tourism. To be successful, this tourism association would function at a larger scale than the existing small committee in Dayutang, and would represent all hamlets.
- 7) **Research and implement ecologically compatible agricultural practices in the lower slopes and valleys and seek opportunities for ecological restoration.** Increase options for farmers to diversify crops and to reduce use of polluting fertilizers and pesticides (which are also extremely expensive) and to benefit economically from ecological restoration activities.
- 8) **Increase affordable options for fuel.** Currently wood is the primary source of fuel. Tourism will increase pressure on the forests by increasing demand for fuel. Local villagers are currently unable to afford alternatives such as methane.

RECOMMENDATIONS

Ecotourism

1) **Ensure that all ecotourism activities directly benefit the reserve and the neighboring villages.** The purpose of ecotourism, as well as of other ecologically compatible economic activities, is to bring revenues to the region that are consistent with the conservation of biodiversity and of the cultural and social assets of the neighboring villages. Tourism development should foster continuity of local cultural traditions, while recognizing and respecting the cultural change that continues to occur over time, and respecting the rights and privacy of local citizens.

Specific recommendations include (1) use of local guides, (2) use of local foods, (3) a substantial entry fee with revenues applied directly to protection and maintenance of the reserve and to strengthening of the communities, and (4) an ecologically sensitive infrastructure.

2) **Research carrying-capacity for visitors in the reserve and manage visitor loads accordingly.** The Gateway Lodge and Visitor Center (Appendix 8) is designed based on the assumption that 100 visitors is an appropriate maximum to protect the ecology of the reserve. Further research is needed to verify the appropriate maximum number of visitors entering the reserve and its environs at Baihualing as well as other future reserve gateways.

3) **Design all ecotourism activities and infrastructure to minimize impact on the sensitive biological communities and to respect and preserve local cultures.** Unplanned development will put at risk the natural and cultural resources that give the area its internationally unique character and picturesque landscape. To protect the biological riches of the reserve, the number and activities of tourists must be managed tightly (especially on the Silk Road), with a program designed to monitor impact and to fine-tune the activities and infrastructure accordingly. Local citizens should participate in making decisions about how visitor activities are managed, to ensure protection of privacy and quality of life.

a. **Create a Gateway Lodge and Visitor Center that minimizes consumption of limited natural resources, minimizes disruption to the reserve, is architecturally compatible with local design, builds on existing infrastructure including the Ranger Station, and keeps new infrastructure outside the reserve boundaries** (Appendix 8).

b. **Regulate the number of visitors and strictly control visitor activities** (Appendix 8).

RECOMMENDATIONS

c. **Limit and monitor activities that can damage biological communities.**

- i. **Limit overnight trips within the reserve.** These trips cause the highest impact, given the need for infrastructure and cooking inside the reserve, and the use of pack animals.
- ii. **Limit activities within the reserve to well-maintained trails.** Trails should be built, used, and maintained to reduce erosion while preserving historical integrity (e.g., Southern Silk Road).
- iii. **Properly dispose of waste.**
- iv. **Prohibit or severely limit use of firewood for cooking and heating.**
- v. **Limit the use of pack animals.**

4) **Approach the Gaoligong Mountain National Nature Reserve as one of a constellation of tourism destinations within this part of Yunnan Province.**

This will reduce pressure on the reserve and will create a rich visitor experience, while strengthening communities and preserving indigenous cultures and landscapes.

- a. **Develop regional ecotourism plans and interpretation techniques that promote a high-quality visitor experience from the moment visitors enter the area at the Baoshan and/or Luxi airport.**
- b. **Create a series of day trips to other regional attractions.**
- c. **Develop an interpretive plan for the reserve in conjunction with an analysis of sensitive areas that identifies appropriate access points to draw visitors to different parts of the reserve.** Identify the scenic and natural qualities that would draw visitors to each area and would provide a series of different educational experiences.
- d. **Develop a series of field guides and audio compact discs.** Audio CDs for birds and frogs would greatly enhance the visitor experience. Photo guides or short booklets should be developed for plants, mushrooms, amphibians and reptiles, and for surrounding historic sites.

RECOMMENDATIONS

- e. **Offer targeted but low-impact wildlife viewing experiences for heightened enjoyment.** For example, in areas of low sensitivity, create small (0.1–0.2 hectare), shallow ponds with seating and shelter where visitors can enjoy frogs calls at night, observe frogs and newts mating, and watch other wildlife attracted to water. (The pond at Nanking is an excellent example.)
- f. **Support development of amenities that serve local residents and tourists and that strengthen the social, cultural and historical assets of Baihualing.**

- 5) **Prepare residents of Baihualing village to participate effectively in and benefit from tourism development.** In addition to the measures to strengthen and build the capacity of the community, residents seek training and support to help them participate in a tourism economy. For example, classes in English and Japanese language, guiding/interpretation techniques, history, biological diversity and ethnic diversity will be required for guides and others who will work with tourists. Job training also will be needed for restaurant cooks, service people, drivers, storekeepers and others involved in the hospitality industry. All employees should be regarded as guides/cultural interpreters, regardless of the duties they perform. They must be from, and remain rooted in, the local communities and be intimately familiar with local culture and traditions. They should be made stakeholders, not just wage earners, thus changing the relationship between them and visitors from one of service provider/client to host/guest, allowing for spontaneous interaction and genuine and authentic experiences.

Research

- 1) **Determine the effects of pesticide/herbicide use in rice fields on amphibian populations.** For example, two separate, 10-to-20-hectare rice fields could be established in Datang and grown for 5-10 years with no agrochemical application. This would (i) provide an exceptional opportunity to determine the effects of these chemicals on amphibians that live and breed in the rice fields; (ii) bring local villagers and farmers of Datang into the process of conserving their natural heritage; (iii) provide important information on the relative importance of pesticides versus frogs for controlling pest insects (rice field frogs eat huge quantities of economically destructive insects); and (iv) provide an economic cost/benefit analysis of agriculture with and without agrochemicals. (Note: local farmers would need to receive financial support for the program.)

RECOMMENDATIONS

- 2) **Determine the impact of harvesting wild mushrooms and identify strategies to enable local people to use them for food and to generate income.** Once the impact is understood, develop appropriate management and monitoring plans to regulate this activity.
- 3) **Determine seasonal variation in the elevational distributions and abundance of forest and high-elevation scrub birds.** Although altitudinal migration occurs for a number of species, details are poorly known. Loss of low-elevation habitats may make the knowledge of such details crucial for successful conservation of the avifauna. In other tropical areas of similar latitudes, altitudinal migrations are more pronounced in frugivorous and nectivorous species, which may have implications for seed dispersal or pollination.
- 4) **Determine habitat-use patterns in mid-montane forest birds.** This may also have implications for management.
- 5) **Determine the basic ecology of threatened mammals, to develop appropriate conservation strategies.** Most important for such studies are *Macaca arctoides*, *M. mulatta*, *Semnopithecus phayrei*, *Hylobates hoolock*, *Selenarctos thibetanus*, *Ailurus fulgens*, *Panthera pardus*, *Panthera tigris*, *Cervus unicolor*, *Budorcas taxicolor*, *Capricornis sumatraensis*, and *Naemorhedus caudatus*.
- 6) **Conduct molecular systematic research in reptiles and amphibians to understand the levels of geographic variation and possible cryptic species.**
- 7) **Conduct detailed taxonomic research on the macrofungi growing in the region.** Many of the reported species listed under a name being used for European or North American fungi are in reality different, oftentimes new, species. This has important conservation implications since some currently unknown number of the reported Gaoligongshan species are likely to be either endemic to the region, or at least to Asia, and thus critical to maintain at healthy population levels. Additionally, the fungi of Gaoligongshan are critical to understanding the biogeography of macrofungi since the area has both tropical and temperate species and also species known only from further east or further west.
- 8) **Research phenology and fruit production of important tree species; study the recruitment and growth of economic species; study the spread of invasive plants.** These data will contribute to appropriate management plans.

RECOMMENDATIONS

9) **Conduct further research about the cultural and social traditions of local villagers.** More in-depth study of the history, culture and ethnic groups of Baihualing Village and of other villages at the base of the reserve, will provide a base of information for educating local residents and visitors and will provide background for cultural preservation strategies. In addition, records from the Ming Period about the Gaoligongshan area and archaeological investigation along the Southern Silk Road will reveal important information about the region's history and landmarks.

Further inventories

- 1) **Inventory cultural assets and historical resources in depth.**
- 2) **Inventory key organisms in the disturbed, lower elevations, to identify high-quality areas for investment in restoration and protection.**
- 3) **Take quantitative samples to estimate populations of key species.** This will be especially important for species vulnerable to disturbance. An understanding of population sizes will help guide management decisions.
- 4) **Fill the prominent gaps in geographic and taxonomic coverage of inventories to date.** Focus particularly on the following:
 - a. **Herpetological inventories, especially for frogs at high elevations and for snakes in the reserve.** Virtually the only way to sample lizards and snakes effectively is to use aluminum drift-fences with associated traps.
 - b. **Inventories of the avifauna above 3,000 m.**
 - c. **An expanded program of botanical exploration.** Areas away from Baihualing Station and the east slope along the Southern Silk Road are not known botanically. In particular, inventories should focus on the poorly known, west-facing slopes of the range, where soil conditions and rainfall patterns are different from the east.
 - d. **Macrofungal inventories.** Our limited collecting indicates that only a small portion of the macrofungal diversity has been documented. Inventories using both opportunistic and quantitative techniques also will reveal community composition, distribution patterns, and potential specificity of host, site, and substrate.

RECOMMENDATIONS

Monitoring

- 1) **Measure the effectiveness of ecologically sensitive ecotourism.** Variables to measure include impact on biological and cultural communities, economic gains to the reserve and neighboring communities, and sustainability of the program. Participation of village residents in planning and implementing these monitoring projects will be crucial to success.
- 2) **Monitor pheasant populations through regular censuses.** Hunting does not seem to be a pressure on these populations at present, but poaching could be a long-term threat.
- 3) **Monitor populations of forest birds (*Alcippe*, forest understory thrushes, flycatchers, laughing-thrushes) in disturbed buffer areas.**
- 4) **Monitor amphibians to determine population trends.** If populations are declining within the reserve, conduct research to determine why they are declining and build management plans to abate the causes.
- 5) **Monitor populations (abundance, size of fruiting bodies, fruiting season) of some of the macrofungi being harvested for food and market.** This will provide useful information to manage the harvesting of wild mushrooms to preserve the populations of economically important species.
- 6) **Monitor populations of threatened mammals.**