LANDSCAPE ECOLOGY GEOGRAPHIC INFORMATION SYSTEMS LABORATORY
The University of British Columbia

1. Zhao Xianying, Secretary-General of the China MAB (Man and the Biosphere Programme) National Committee[1]
2. Gordon Brent Ingram, Assistant professor, Department of Forest Resources Management[2]
3. Zhao Yong, China MAB National Committee[1]
4. Sun Dunyuan, Research Director, Fanjingshan Biosphere Reserve[3]
5. Xie Zhi Xin, Director, Wuyishan Biosphere Reserve[4]
6. Zhang Quanyi, Director, Shennongjia Biosphere Reserve[5]
7. Roderick F. J. McFarland, Landscape Ecology Geographic Information Systems Laboratory[2]

July 1993

Conservation of biological diversity in the biosphere reserves of subtropical China:
Obstacles and opportunities

buffer zone, Mount Fanjingshan Biosphere Reserve, December, 1991, photograph by Gordon Brent Ingram

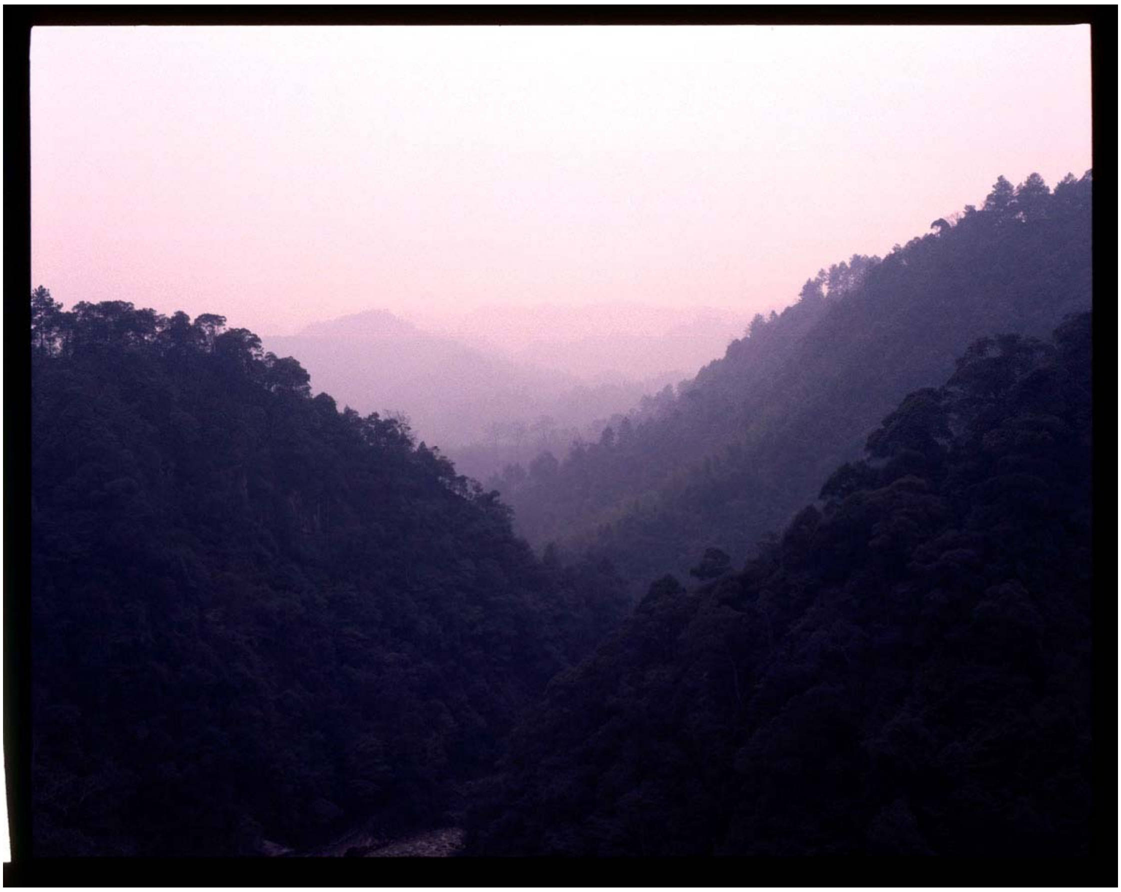
[1] Chinese Academy of Sciences, 52 Sanlihe, 100864 Beijing China, fax +86 1 80 11 095

[2] Landscape Ecology Geographic Information Systems Laboratory (LEGIS), 344 - 2357 Main Mall, University of British Columbia, Vancouver Canada V6T 1Z4, fax + 1 (604)822-8640

[3] Fanjingshan Nature Reserve, China Department of Forests, Jiankon County, Guizhou Province 554400 China, telephone: +86 851 177

[4] Fujian Wuyi Mountain National Nature Reserve, Sangang, Wuyishan, 354315 Fujian, China, telephone: +86 32382

[5] Shennongjia Nature Reserve, Muyu Town, Shennongjia, Hubei 442421, China



relatively intact woodland, Fanjingshan Biosphere Reserve, Guizhou Province, China, December 1991, photograph by Gordon Brent Ingram

abstract

The six biosphere reserves of subtropical China extend across the transitions from the warm temperate to the tropical zones. While there are hundreds of other smaller protected areas, in this region of over one half billionpeople, these relatively large biosphere reserves hold particularly key roles in the conservation of biological diversity and procurement of the germplasm of wild species with genetic resources. However, the linkages between biological inventorying, monitoring, management, tourism, utilization of biological resources, and economic benefits have been poorly explored. A typology of strategies for linking research, conservation, and "sustainable development" are outlined for southern China.

Introduction

The subtropical and tropical regions of China support some of the most densely populated parts of the planet. The toll from the rapid increases in human numbers, in recent centuries, on the biological resources of this relatively rich area has been staggering, though poorly documented except for the status of the larger vertebrates. It is, however, dangerously simplistic to correlate the loss of local biological diversity (Wilson 1988, Ingram 1989, IUCN et al. 1990, pages 58 to 67, World Resources Institute et al. 1992) to human population levels. There have been a number of other factors; including huge losses of forest due to national campaigns particularly in the period of 1950 to 1975 and continued declines in natural forest with the subsequent economic expansion (Smil 1992); excessive hunting and collecting of particular species, especially those with medicinal properties; and poor regional and site planning decisions as part of modernization programmes and expansion of tourism.

What is the significance of biological diversity to a nation of over 1 billion people, with many regions suffering from chronic underdevelopment? How can biological diversity from the remaining natural areas be used to contribute to economic development? How can conservation be made part of integrated programmes of "sustainable development" (Redclift 1987) in a time of growing demands for consumer goods? How can genetic resources from protected wild populations, as part of broader conservation programmes, be used for the development of new domesticated species and improved varieties? This discussion considers these questions in terms of the best protected natural areas in southern China: the six biosphere reserves (Batisse 1982, UNESCO 1984) which are part of the global network of internationally recognized sites and administered through national committees of UNESCO.

This paper is part of a collaborative review to ascertain the viability of a long-term expansion of monitoring and the use of geographic information systems in China. The focus of the data bases would be on aiding monitoring and management for the conservation of biological diversity. A number of activities are particularly crucial for this decade: monitoring of fragmentation and the status of endangered species, improved site planning, enhanced capabilities for setting criteria for sustainable development in areas adjacent to protected zones, ecosystem restoration, and inventorying and procurement of species with genetic resources.

The 1992 *Convention on Biological Diversity*, (UNEP 1992) of which China is a signatory, provides some fundamentally superior approaches to the exchange of data on biological resources as part of conservation efforts. However, these possibilities remain largely unexplored as of the present. There are still few examples of biosphere reserves which have comprehensive inventorying and monitoring frameworks, let alone linkages to land management decision-making, for genetic resources.

Conservation of biological diversity and the utilization of respective germplasm, on an indefinite basis from *in situ* populations, requires a level of inventorying and monitoring of which few developing countries are capable. This paper reviews the status of the research in these biosphere reserves in order to choose priorities for biodiversity research. While Chinese ecologists and conservation biologists have made great strides in recent years in the use of geographic information systems, it will be another 5 to 10 years before databases with current, precise and high quality information can be organized in order to inform spatially oriented and prescription-oriented decision-making. Organization of data from each biosphere reserve for capabilities of "biodiversity visualization" (Hamilton and Flaxman 1992) and for compilation into geographic information systems provide potentials for more precise spatial planning and impact simulation. Such techniques could be used in management of biosphere reserves for the problematic but crucial balancing of needs for some expansion of economic activities with habitat conservation.

The subtropical and tropical zones of China and threats to regional biological diversity

The forests of southern China (Hou et al. 1979, Hou 1983) supported the most biological rich transitions between the *Indomalayan Realm* and the *Palaearctic Realm* (Udvardy 1978, 1984). However, there are very few large areas of natural habitat left in southern China and much of the tropical (Collins et al. 1991, pages 116 to 125) and subtropical forest (Hou et al. 1982, Hou 1983) has been highly "fragmented" (Merriam and Wegner 1992).

Loss of primary forest in China has involved a 5,000 year process that was greatly acclerated by the seventeenth century with its burst in human population (Murphey 1983). The relatively small remaining areas of tropical rain forest (Zhu et al. 1980) in far southern China amounts to less than 0.26 per cent of the total area of China (Collins et al., page 117). Subtropical China, formerly dominated by forest, is home to approximately one half billion people: nearly ten per cent of the total human population. Most of the remaining forests are protected under the 1979 *Forestry Act*, though there still is considerable poaching (Wang 1990).

As well as clearing and expansion of agriculture, the loss of forest, south of the Yangtze River over the last century, has been due to the cutting of fuelwood for the factories of World War II and the iron smelters of *The Great Leap Forward*. The period of the greatest loss of primary subtropical forest was between 1959 and 1961, and this was an "economic and ecological failure" (Collins et al. 1991). The political turbulence of 1967 to 1976 brought further violation of such protected areas as Xishuangbanna Nature Reserve, and disrupted the traditional patterns of tenure and culturally based conservation. In southern China, older conservation legacies were dominated by Buddhism, which for several decades was discouraged. Compounding the increase in human impacts from tourism, the surge of entrepreneurialism of the last decade, has negated whatever remained of locally based conservation ethics.

Much of modern nature conservation in China has been dominated by U.S.-based efforts for the conservation of the panda. This powerful metaphor for the need to conserve large areas of forest, with dynamic successional mosaics that would have sufficient area to allow for a range of conditions, allowed China to increase the total number of protected areas in 120 in 1983 (Li and Zhao 1984, page 216) to 600 in 1988. However, little of the total area in protection has been initiated, actively supported and managed by local authorities. The most successfully managed protected forests, in terms of conservation of biological diversity, are still in Taiwan and Hong Kong.

The Chinese MAB Programme

Launched by Unesco in 1971, the Man and the Biosphere Programme(MAB) is an interdisciplinary research programme aimed at providing a scientifically sound foundation for the rational use and conservation of natural resources. The 14 major project areas identified by the International MAB Programme are also areas needing research and attention in China. The guiding ideologies by the International MAB Programme have made a significant contribution to the development of research work in China. In order to strengthen its working relationship with the international MAB Programme, China established its own national committee for MAB in 1978. The Committee is attached to the Chinese Academy of Sciences and is responsible for carrying out the MAB programme in China. The China's National Committee of the MAB consists of members representing ten state ministries including resources, environment, science and education; leading scientists in the fields of resource and environmental sciences; and 8 National Academic Associations.

To further develop the MAB Programme, the Committee, based on the existing projects, selected five key field, i.e. forest ecosystems, urban ecosystems, ecological agriculture, ecosystems of arid and semi-arid zones and nature conservation, and set up specialized groups for each to promote and advise research, to undertake training and publication, and other activities.

The Chinese National Committee for MAB makes its efforts to make full use of the MAB framework for international exchange and cooperation with international organizations and governments to benefit China's research in the field of natural resources and environment. For example, the Cooperative Ecological Research Project(CERP) is jointly sponsored by China, Germany and UNESCO. The Main Phase of CERP has been carried out successfully and the continuous phase is still under the way.

Another important task of the Chinese MAB is to establish materials for the benefit of scientists, decision makers, administrators, educators and the general public. As a "channel" and "window", the Chinese MAB Committee lays particular emphasis in publication on serving as a link between China and other countries.

The Chinese MAB programme is one of the most extensive national efforts to conserve and monitor the biological diversity of sub-tropical forest anywhere on Earth (Li and Zhao 1989, Man and Biosphere Programme of UNESCO 1991, Zhou 1989); however, the first meeting of the managers of the 8 biosphere reserves, 6 of which are tropical or subtropical (Figure 1) was only held in June of 1991. The meeting emphasized increased cooperation with local communities and the better integration of biosphere reserves into regional development.

The biosphere reserve programme of China poses the most promising possibilities for the conservation of biological diversity, but the network is oriented toward larger areas. There are chronic difficulties in maintaining better protected natural portions of reserves (Batisse 1982, Verhnes 1989) and conditions least disturbed by humans. The biosphere reserve concept has evolved over the last quarter century to include:

1. the reserve core, with relatively undisturbed ecosystems;
2. the buffer zones, with some exploitation or experimentation within the context of monitoring and management; and
3. the transition zones, with extensive land use along with monitoring and special planning and management measures.

The problem with applying this trinity in China is that few cores are sufficiently large and undisturbed to afford much human disturbance in buffer zones. It has rarely been possible to influence regional planning to develop monitoring frameworks or regulatory constraints in transitional zones.

Biosphere Reserves for the *in situ* conservation of genetic resources

There is a growing body of discussion monitoring (Ingram 1990a, Dallmeier et al. 1992) and protection of the genetic diversity (Ingram 1990b) in the core, buffers and transition areas of biosphere reserves. There is a growing pool of data on the wild (Hoyt 1988), weedy, and traditionally cultivated plant species (Altieri 1988, Brush 1988, Brush 1991, Wilkes 1991, Gregg 1991) which are in the genepools of crops and which can therefore be considered "genetic resources" (Harlan 1976, Williams 1988, Prescott-Allen and Prescott-Allen 1990).

The MAB Action Plan (UNESCO 1984) mentioned the conservation of the genetic diversity of crop relatives in biosphere reserves (Ingram and Williams 1984, Ingram 1990b); however, there has been little elaboration on the nature of the prescriptions for populations with potential genetic resources within the core and buffer areas of biosphere reserves (Ingram 1990a), nor consideration for traditional varieties of crops in buffer and transition areas. Multi-genepool "ecogeographical surveys" (1990a) are needed for each region associated with a biosphere reserve. Areas with high species richness and environmental heterogeneity, which have indications of early crop domestication, such in the vicinity of Shennongjia Biosphere Reserve, are particularly worthy of intensive research. Higher levels of conservation, aimed at particular species and populations, are necessary (Wang and Chen 1990, World Conservation Monitoring Centre 1992, pages 546 to 549). Southern China is remarkable in its diversity of tree species, with numerous sites for *in situ* conservation (Riggs 1990) and uniquely available for seed collection.

With the initial internationalist vision of the 1992 *Convention on Biological Diversity*, there are now new possibilities for funding the inventorying, monitoring and management of "genetic reserves" (Jain 1975, World Conservation Monitoring Centre 1992) and related infrastructure. Even with the relatively advanced level of inventorying and monitoring in some of the south China biosphere reserves such as Dinghushan, new methodologies, practices, and cooperative relationships reflecting a more international character must be formed.

The following are outlines of the six biosphere reserves of southern China. For each, a biophysical and cultural description is followed by a discussion of directions for monitoring, management and the sustainable and equitable utilization of genetic resources (Ingram 1987, Juma 1989, Keystone International Dialogue 1991).

Opportunities for more secure levels of conservation

While there have been considerable accomplishments over the last decades, a large portion of respective populations of species are at risk. There is an extremely low ratio of wildland to human population, with some similarity to India. By overcoming the obstacles to better inventorying, monitoring, and management which have been mentioned in the previous reserve outlines, more secure levels of conservation can be attained.

General upgrading of the levels of conservation in the reserves could involve the following phases in conjunction with a geographic information system:

1. review of the decades of inventory data;
2. compilation of layers of spatial data and relation to particular elements of local biological diversity data;
3. construction of models for tasks related to reserve management and planning;
4. integration of remote sensing data and in some cases procurement of fresh data;
5. ground visits and related field work on particular sites, communities and species;
6. the conversion of some maps into digital form; and
7. computation and simulation as related to specific needs for reserve planning and management.

These computations can lead to more site-specific conservation, management, and regulatory interventions. This is in the context of increasing relaxations and loss of species as fragmentation progresses and protected area cores have forms of ecosystem disintegration.

Unfortunately, this process will only identify the species with very small populations and with problematic management requirements. There is still the conundrum of the recent decades: by the time conservation prescriptions for these species and habitats can be developed, it may be too late to avoid, at the very least, genetic bottlenecks. Development of new solutions to this persistent problem is becoming the core of new conservation strategies which are inevitably more quantitative both in terms of populations and space.

Conclusions: Increasing the relevance of biosphere reserves and other conservation programmes to Chinese society.

The code word "sustainable development" has many possible meanings depending on context. This is certainly also the case with more scientifically based ideals such as "conservation of biological diversity." The realities vary with socially based obstacles and opportunities. The most immediate social values for the biosphere reserves of subtropical China are related to the gathering and hunting of wild species, often at unsustainable levels, and Buddhist observances. Biosphere reserves for procurement of germplasm will probably not have broad-based social support until the benefits of the genetic variation of rapidly dwindling populations are repeatedly demonstrated and where the benefits of genetic resources are partially channelled back to those social groups who have lost development options through preservation - but such economic restructuring requires more capital than is usually available in most World Bank projects and "joint ventures." Long-term investment in conservation infrastructure is necessary. These 6 fragments of regional ecosystems have been relatively well-funded, by Chinese government norms, but additional technologies such as geographic information systems could fill crucial gaps in fostering benefits to both local communities and respective regions.

The central contradiction in this situation is that there are literally hundreds, if not thousands, of species which are are could be used as genetic resources, both in the Chinese economy and elsewhere. But at the same time, there are literally hundreds, if not thousands, of species, such which are genetic resources, whose effective population sizes are well below those for viable levels of fitness. This situation, in turn, has a direct relationship to the amount of alleles available for development of new varieties and breeds and for introductions into cultivation.

These biosphere reserves also have the potential of becoming centres for more coordinated national programmes of conservation of biological diversity though few examples of such efforts currently exist (Blockstein 1989). These tiny fragments of formerly vast forests will become centres for the exploration of bioregionalism (Cheney 1989) for southern China. The reverence of nature and natural ecosystems has been a major theme in Chinese culture for millennia. Most of these areas had been identified as important points for spiritual renewal by 1500 A.D. While Buddhist festivals pose significant ecological threats, the religious significance of these mountains can play a role in linking scientific and economic concerns for more prescriptive and fine-scaled management of natural habitats.

Due to their extremely high religious, tourist, and biological values, these reserves will be more carefully monitored and managed in the coming decades; but continued degradation, particularly from tourism and largely illegal plant and animal harvesting, is inevitable. Geographic information systems provide various tools for information compilation and making better spatial decisions and prescriptions for landscape management if the quality of field data, indicated on maps with scales from 1:1,000 to 1:50,000, continues to improve. But if management is to be more effective, new decision-making frameworks, which link a range of local, national and international researchers, are needed to evolve with the richer supply and ecogeographic data.

As China successfully stabilizes its population and improves its standard of living, the social importance of these biosphere reserves will quickly increase. But if biological diversity is to be successfully conserved, with at present time well over 1,000 species are seriously at risk, these relatively small fragments must become part of broader regional networks for conservation, local management, economic development, cultural renewal, and ecosystem restoration. The management of these "sacred mountain" areas is shifting back to the (bio)regionalism of earlier times while enriching the knowledge base for ecological processes and global development of biotechnologies.

acknowledgements

Funding for this paper was from the International Development Research Centre of Canada, the British Columbia Scholars in China Programme, the Man and the Biosphere Programme of UNESCO, and the Man and the Biosphere (MAB) National Committee of the Chinese Academy of Sciences. The authors wish to thank the following individuals for their generous assistance: Stephen Tyler, IDRC; Han Qunli, UNESCO; Jane Robertson-Vernhes, UNESCO; Dr. J. S. Maini and Ted Cooke, MAB National Committee, Canada; Wang Siyu, Institute of Botany of the Chinese Academy of Sciences; Ren Xiao-dong, Guizhou Normal University; Chang Hsin-Shih, Institute of Botany of the Chinese Academy of Sciences; William Bleisch, Wildlife Conservation International; Kiang Chin, Institute of Botany of the Chinese Academy of Sciences; Kong Guo Hui, Institute of Botany of the Chinese Academy of Sciences; Professor Liao Jun-guo, China Commission for Integrated Survey of Natural Resources of the Chinese Academy of Sciences.

references

Altieri, M. 1988. Rethinking crop genetic resource conservation: A view from the south. *Conservation Biology* 3(1):77-79.

Batisse, M. 1982. The biosphere reserve: A tool for environmental conservation and management. *Environmental Conservation* 9 (2): 101 - 111.

Blockstein, D. E. 1989. Toward a federal plan for biological diversity. *Issues in Science and Technology* 5(4): 63 - 67.

Brush, S. 1988. Rethinking crop genetic resource conservation. *Conservation Biology* 3(1): 19-29.

Brush, S. 1991. A farmer-based approach to conserving crop germplasm. *Economic Botany* 45(2): 153-165.

Collins, N. M., J. A. Sayer and T. C. Whitmore (editors). 1991. Chapter 17 China and Taiwan. In *The Conservation Atlas of Tropical Forests: Asia and the Pacific*. pages 116 to 125. London, MacMillan (British Petroleum, IUCN, World Conservation Monitoring Centre).

Cheney, J. 1989. Postmodern environmental ethics: Ethics as bioregional narrative. *Environmental Ethics* 11: 117 - 134.

Dallmeier, F., M. Kabel and R. Rice. 1992. Methods of long-term biodiversity inventory plots in protected tropical forest. In *Long-Term Monitoring of Biological Diversity in Tropical Forest Areas: Methods for establishment and inventory of permanent plots*. F. Dallmeier (editor). 11 - 46. Paris, UNESCO.

Gregg, W. P. 1991. MAB Biosphere Reserves and conservation of traditional land use systems. In *Biodiversity: Culture, conservation and ecodevelopment*. M. L. Oldfield and J. B. Alcorn (eds.). 274 - 294. Boulder, Colorado, Westview.

Guangdong Institute of Botany. 1976. *Guangdong Vegetation*. Beijing, Chinese Academic Press.

Hamilton, M. P. and M. Flaxman. 1992. Scientific data visualization and biological diversity: new tools for spatializing multimedia observations of species and ecosystems. *Landscape and Urban Planning* 21: 285 - 287.

Harlan, J. R. 1976. Genetic resources in wild relatives of crops. *Crop Science* 16: 329-333.

Hou, H. Y., S. C. Sun, J. W. Chang, M. K. Ho, Y. F. Wang, D. C. Kong and S. C. Wang. 1979 (1982). *Vegetation Map of China Scale: 1: 4,000,000*. Map Publisher of the People's Republic of China.

Hou, H. Y. 1983. Vegetation Map of China 1: 14,000,000. *Annals of the Missouri Botanical Garden* 70 (3).

Hoyt, E. 1988. *Conserving the Wild Relatives of Crops*. Rome, IBPGR, WWF, IUCN.

Huang, W., Tu, Y., Yang, L. 1988. *Vegetation of Guizhou*. Guiyan, Guizhou People's Publishing House.

Ingram, G. B. 1987. Conservation of wild plants in crop gene pools and their intraspecific variation: Current needs and opportunities in the moist forest of southeast Asia. In *The Conservation and Management of Endangered Plants and Animals*. Proceedings of the Symposium on the Conservation and Management of Endangered Plants and Animals, Bogor, Indonesia, June 1986. C. Santiapillai and K.R. Ashby (eds.) 63-85. Bogor, Indonesia, South-East Asia Centre for Tropical Biology.

Ingram, G. B. 1989. Planning district networks of protected habitat for conservation of biological diversity: A manual with applications for marine islands with primary rainforest. Ph. D. dissertation in Environmental Planning on file, University of California at Berkeley. Ann Arbor, Michigan, USA, University Microfilms International.

Ingram, G. B. 1990a. Multi-gene pool surveys in areas with rapid genetic erosion: An example from the Air Mountains, northern Niger. *Conservation Biology* 4(1): 78-90.

Ingram, G. B. 1990b. The management of biosphere reserves for the conservation and utilization of genetic resources: The social choices. *Impact of Science on Society*. 158: 133-141.

Ingram, G. B. and J. T. Williams. 1984. *In situ* conservation of wild relatives of crops. In *Crop Genetic Resources: Conservation and evaluation*. J. H. W. Holden and J. T. Williams (editors). 163 - 179. London, George Allen and Unwin.

IUCN (World Conservation Union), the United Nations Environment Programme (UNEP, and the World Wide Fund for Nature (WWF). 1990. *Caring for the World: A strategy for sustainability*. Second Draft. Gland, Switzerland.

Jain, S. K. 1975. Genetic reserves. In *Crop Genetic Resources for Today and Tomorrow*. O. H. Frankel and J. G. Hawkes (editors). 379 - 396. London, Cambridge University Press.

Ji, Z., Guangmei, Z., Huadong, W. and Jialin, X. 1990. *The Natural History of China*. London, Collins.

Jiang, H. Q. et al. 1976. *Basic knowledge of plant ecology and phytocoenology*. Science Press of China, Beijing.

Jiang, H. Q. et al. 1984. *Research on forest ecosystems of Ailao Mountain, Yunnan*, Kunming Science and Technology Institute of Yunnan.

Juma, C. 1989. *The Gene Hunters: Biotechnology and the scramble for seeds*. Princeton, New Jersey, Princeton University Press.

Keystone International Dialogue Series on Plant Genetic Resources. 1991. *Oslo Plenary Session: Final Consensus Report: Global Initiative for the Security and Sustainable Use of Plant Genetic Resources. Third Plenary Session*. Keystone Colorado, Keystone Centre.

Li, W., and Zhao X. (in Mandarin). 1984. *China's Nature Reserves*. Beijing, Foreign Languages Press.

Li, W., and Zhao X. (in English, trans. P. Edwards). 1989. *China's Nature Reserves*. Beijing, Foreign Languages Press.

Merriam, G. and J. Wegner. 1992. Local extinctions, habitat fragmentation, and ecotones. In *Landscape Boundaries: Consequences for biotic diversity and ecological flows*. A. J. Hansen and F. di Castri (editors). 150 - 169. New York, Springer-Verlag.

Murphey, R. 1983. Deforestation in modern China. In *Global Deforestation and the Nineteenth-Century World Economy*. R. P. Tucker and J. F. Richards (editors). 111 - 128. Durham, North Carolina, Duke Press Policy Studies.

Prescott-Allen, R. and C. Prescott-Allen. 1990. How many plants feed the world? *Conservation Biology* 4(4): 365 - 374.

Redclift, M. 1987. *Sustainable development: Exploring the contradictions*. London, Methuen.

Riggs, L. A. 1990. Conserving genetic resources on-site in forest ecosystems. *Forest Ecology and Management* 35:45-68.

Smil, V. 1992. China's environment in the 1980s: Some critical changes. *Ambio* WWI (6): 431 - 436.

Survey Bureau of Guizhou Province. 1985. *Maps of Guizhou Province*. Guiyang, Survey Bureau of Guizhou Province.

Udvardy, M. D. F. 1978. *World Biogeographic Provinces*. Sausalito, California, CoEvolution Quarterly.

Udvardy, M. D. F. 1984. A biogeographic classification system for terrestrial environments. In *National Parks, Conservation and Development*. J. A. McNeely and K. R. Miller (editors). 34 - 38. Washington, D.C., Smithsonian Institution.

UNEP (United Nation Environment Programme) (host). 1992. *Convention on Biological Diversity*. Conference for the Adaption of the Agreed Text of the Convention on Biological Diversity, Nairobi, 22 May, 1992. version: UNEP/Bio.Div/CONF/L.2. on file, UNEP, Nairobi, Kenya.

UNESCO. 1984. The Action Plan for Biosphere Reserves. *Nature and Resources* XX(4): 1 - 12.

Vavilov, N. I. 1951. *The Origin, Variation, Immunity and Breeding of Cultivated Plants: Selected writings*. translated from Russian by K. S. Chester. New York, Ronald Press.

Vernhes, J. R. 1989. Biosphere reserves: The beginnings, the present, and the future challenges. In *Proceedings of the Symposium on Biosphere Reserves, Fourth World Wilderness Congress*, September 14 -17, 1987, Estes Park, Colorado, USA. Atlanta, Georgia, U. S. Department of the Interior, National Park Service.

Wang, S. 1990. Conservation and exploitation of tropical forests in China. *Cathaya* 2: 199 - 206.

Wang, S. and L. Z. Chen. 1990. Future economic development and biological diversity conservation, sustainable utilization and research in China. In S. Wang and X. H. Du (editors). *Proceeding of the Symposium on Biological Diversity*. pages 6 to 11. Beijing, Bureau of Biosciences and Biotechnology, Chinese Academy of Sciences.

Wilkes, G. 1991. *In situ* conservation of agricultural systems. 86 - 101. In *Biodiversity: Culture, conservation and ecodevelopment*. M. L. Oldfield and J. B. Alcorn (eds.). 7 - 15. Boulder, Colorado, Westview.

Williams, J. T. 1988. Identifying and protecting the origins of our food plants. In *Biodiversity*. E. O. Wilson (editor). 240 - 247. Washington, D. C., National Academy Press.

Wilson, E. O. 1988. The current state of biological diversity. In *Biodiversity*. E. O. Wilson (ed.). 3 - 18. Washington, D.C. National Academy Press.

World Conservation Monitoring Centre. 1992. *In situ* conservation of crops and wild relatives of crops. In *Global Biodiversity: Status of the Earth's living resources.* 546 - 549. New York, Chapman and Hall.

World Resources Institute (WRI), The World Conservation Union (IUCN), and United Nations Environment Programme (UNEP). 1992. *Global Biodiversity Strategy: Guidelines for action to save, study, and use Earth's biotic wealth sustainably and equitably*. Washington, D.C., World Resources Institute.

Wuhan Institute of Botany, Chinese Academy of Sciences. 1980. Plants in Shennongjia Nature Reserve. Wuhan. Hubei Publication House.

Yan, C. D. 1988. Tree species of Fanjingshan. *Tongren Forest Magazine* (Tongren, Guizhou Province) 1988 (1): 1 - 133.

Zhou, Z. (Editor in chief). 1989. *Research on the Fanjing Mountain*. Forestry Bureau of Guizhou Province. The management of Fanjing Mountain Nature Reserve. Guiyan, Guizhou People's Publishing House.

Zhou, Z. and Chen, K. (editors). 1987. *Scientific Survey of the Maolan Karst Forest*. Guiyan, Guizhou People's Publishing House.

Zhou, H., Li, M., Zhou, Y., He, D., and Huang, Y. 1986. The vegetation map of Ding Hu Shan Biosphere Reserve with reference to its illustration. *Tropical and Subtropical Forest Ecosystem* (Ding Hu Shan Forest Ecosystem Station, Academia Sinica, Hainan People's Press) 4: 43 - 52.

Zhu, S. and Yang, Y. 1989. Forest types. In *Research on the Fanjing Mountain*. Forestry Bureau of Guizhou Province. The management of Fanjing Mountain Nature Reserve. Zhou, Z. et al. (editors). pages 17 to 21. Guiyan, Guizhou People's Publishing House.

Zhu, Y.C., H.C. Jiang et al. 1980. *China Vegetation*. Beijing, Science Press of China.

Zhu, Y.C., H.C. Jiang et al. 1987. *Yunnan Vegetation*. Science Press of China, Beijing.

Zhu, Z. 1992. The Current Situation of the Population of the Golden Monkey and Conservation in the Shennongjia Nature Reserve. In *Wildlife Animals*. Harbin. Northeast China Forestry University Press.