CHAPTER 3

Peek into a Home for Pandas and People

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3.1 Introduction

The world is currently experiencing numerous challenges related to sustainability, including climate change, food security, and ecosystem degradation. The coupled human and natural systems (CHANS) approach is an effective means of studying such urgent issues as it accounts for the continually evolving human–nature interactions that may improve or threaten sustainability. Case studies in model coupled systems (Chapter 2) offer in-depth understanding of human–nature interactions and the opportunity to evaluate long-term sustainability in response to various challenges.

In this chapter, we provide an overview of our model coupled system: Wolong Nature Reserve. Wolong was chosen as a model system because it is globally important, spatially diverse, and temporally dynamic with respect to the evolving human–nature interactions. The system also encapsulates the shared challenges experienced worldwide with sustainability issues (e.g., balancing human livelihoods and conservation). It is an area that encompasses a wide range of geophysical variation and biological diversity and is a crucial area with respect to conservation of one of the most famous endangered species, the giant panda. Similar to most nature reserves in developing countries, Wolong is also home to a dynamic human population. This population interacts with the natural environment in a number of complex ways, all mediated by a multifaceted governance system that has evolved over time.

Since 1996, Wolong has served as an excellent laboratory for scientific investigation of coupled systems. We have also applied many ideas and methods developed in Wolong to many other parts of the world (Chapters 15–18; see also Liu et al., 2003a, Liu and Diamond, 2005, Liu et al., 2007). For example, our findings on household dynamics in Wolong have led to a paper that documented similar patterns in 141 countries (Liu et al., 2003a). Our observations on ecological degradation in Wolong, even after establishment of the protected area, were a catalyst to rethink the efficacy of protected areas worldwide (Liu et al., 2001). Insights from Wolong provided the foundation for the development of the coupled system framework (Liu et al., 1999, Liu et al., 2007). Lessons and experiences gained from Wolong helped improve the management of other protected areas in China (e.g., Liu et al., 2003b) and beyond (e.g., Liu et al., 2003a).

3.2 Historical and geographic context

Wolong Nature Reserve was founded in 1963 in Sichuan Province of China (31°04′30″ N, 103°13′41″ E, Figure 3.1). Wolong was initially 200 km^2 in area but expanded to 2000 km^2 in 1975 (Ministry of Forestry, 1998). The name Wolong translates as "crouching dragon" and originates from local folklore. The story goes that a dragon once flew over the area and was inspired to make a home there after being enraptured by the beautiful mountains, where it still rests (Schaller, 1994). Wolong is one of the first nature reserves established in China, in response to a

Pandas and People. Edited by Jianguo Liu, Vanessa Hull, Wu Yang, Andrés Viña, Xiaodong Chen, Zhiyun Ouyang, and Hemin Zhang. © Oxford University Press 2016. Published 2016 by Oxford University Press.

Remote sensing and geospatial analyses have been ongoing since the inception of the project. We have collected and analyzed remotely sensed data at different resolutions (from 0.6 m to 250 m) acquired between 1965 and 2010 by several satellite systems such as Corona, Landsat TM, ETM +, MODIS, IKONOS, and Quickbird. Analyses have relied on several techniques, including unsupervised classification, supervised classification, generation of vegetation indices, analysis of phenological signatures, and artificial neural networks (Liu et al., 2001, Tuanmu et al., 2010, Viña et al., 2007, 2008, 2010). Such analyses have sought to characterize changes in quantity and quality of forests and giant panda habitat over time in Wolong. This objective has involved prediction of forest cover and type and prediction of bamboo presence using cutting-edge procedures developed by our team (Tuanmu et al., 2010, Viña et al., 2008). We have in turn integrated such dynamics in forest cover and giant panda habitat with information about changes in human population and policies to identify linkages between different components of the coupled system.

Modeling and simulation have played central roles in our study. We have integrated our various sources of data to create a variety of different models, including land-cover change models (Chapters 6 and 7; see also Linderman et al., 2006, Liu et al., 2001), animal resource selection models (Chapter 4; see also Bearer et al., 2008), agent-based models of human behavior (Chapter 8; see also An et al., 2005), econometric models (Chapter 9; see also Chen et al., 2009a), censored regression models (Chapter 11; see also Yang et al., 2013c, Chen et al., 2009b), causal inference models (Chapters 11 and 13; see also Yang et al., 2013c, Chen et al., 2012), and ecosystem service and human well-being models (Chapters 5 and 12; see also Yang et al., 2013b, Yang et al., 2015). Many of these models were spatially explicit, which was accomplished by integrating remote sensing data and GPS data on various natural and human components into a GIS prior to model construction. Simulation also has allowed us to test hypotheses about how the system may change in the future under different policy or management scenarios (Chapter 14). They include conditions under which local residents would switch their energy source from fuelwood to electricity (An et al., 2002), re-enroll in a conservation program (Chen et al., 2009b), and plan for maximizing the effectiveness of a conservation program (Viña et al., 2013). Other scenarios pertain to the effects of various potential household growth patterns and resident behavior patterns on panda habitat in the future (Linderman et al., 2006). Such analyses have been made possible by the availability of long-term data and aid in understanding system functioning and guiding policy and management of this system in the future.

3.10 Summary

Research on human–nature interactions benefits from in-depth and long-term case studies in model coupled human and natural systems. In this chapter, we introduced the model coupled system we have studied since 1996—Wolong Nature Reserve. Wolong is a high-profile protected area that covers 2000 km^2 in Sichuan Province of southwestern China. It is globally important as a UNESCO MAB Reserve and a World Heritage Site. The reserve contains diverse ecosystems along an elevational range of 1150 m to 6250 m, including thousands of plant and animal species, most notably over 100 endangered giant pandas. Wolong also is home to a growing human community of nearly 5000 people (mostly farmers). There are complex interactions and feedbacks (e.g., crop production, timber harvesting, raising livestock, and road construction) among local residents, forests, and wildlife. These interactions are also influenced by government policies, contextual factors originating from other systems (e.g., tourism), and natural disasters (e.g., the 2008 Wenchuan earthquake and associated subsequent disasters that destroyed or damaged the majority of the infrastructure). To understand our model coupled system in an integrated manner, we have drawn on diverse natural and social sciences to design field and social surveys, build systems models that integrate various sources of data, and run simulations to understand and predict complex processes and patterns across space and over time. Ultimately, we aim to make our work useful in understanding and helping govern sustainably not only the model coupled system, but also many other coupled systems around the world.

References

An, L., Linderman, M., Qi, J., et al. (2005) Exploring complexity in a human-environment system: an agent-based spatial model for multidisciplinary and multiscale integration. *Annals of the Association of American Geographers*, **95**, 54–79.

An, L., Lupi, F., Liu, J., et al. (2002) Modeling the choice to switch from fuelwood to electricity: implications for giant panda habitat conservation. *Ecological Economics*, **42**, 445–57.

Bearer, S., Linderman, M., Huang, J., et al. (2008) Effects of fuelwood collection and timber harvesting on giant panda habitat use. *Biological Conservation*, **141**, 385–93.

Chen, X., Frank, K.A., Dietz, T., and Liu, J. (2012) Weak ties, labor migration, and environmental impacts toward a sociology of sustainability. *Organization & Environment*, **25**, 3–24.

Chen, X., Lupi, F., He, G., and Liu, J. (2009a) Linking social norms to efficient conservation investment in payments for ecosystem services. *Proceedings of the National Academy of Sciences of the United States of America*, **106**, 11812–17.

Chen, X., Lupi, F., He, G., et al. (2009b) Factors affecting land reconversion plans following a payment for ecosystem service program. *Biological Conservation*, **142**, 1740–47.

Ghimire, K.B. (1997) Conservation and social development: an assessment of Wolong and other panda reserves in China. In K.B. Ghimire and M.P. Pimbert, eds, *Environmental Politics and Impacts of National Parks and Protected Areas*, pp. 187–213. Earthscan Publications, London, UK.

Harkness, J. (1998) Recent trends in forestry and conservation of biodiversity in China. *The China Quarterly*, **156**, 911–34.

He, G., Chen, X., Liu, W., et al. (2008) Distribution of economic benefits from ecotourism: a case study of Wolong Nature Reserve for giant pandas in China. *Environmental Management*, **42**, 1017–25.

Hu, J. (2001) *Research on the Giant Panda*. Shanghai Science and Education Publishing House, Shanghai, China (in Chinese).

Hubbard, J. and Shaw, J.H. (2009) Uplift of the Longmen Shan and Tibetan plateau, and the 2008 Wenchuan (M = 7.9) earthquake. *Nature*, **458**, 194–97.

Li, C., Zhou, S., Xiao, D., et al. (1992a) A general description of Wolong Nature Reserve. In Wolong Nature Reserve, Sichuan Normal College, eds, *The Animal and Plant Resources and Protection of Wolong Nature Reserve*, pp. 313–25. Sichuan Publishing House of Science and Technology, Chengdu, China (in Chinese).

Li, C., Zhou, S., Xiao, D., et al. (1992b) The history and status of Wolong Nature Reserve. Wolong Nature Reserve, Sichuan Normal College, eds, *The Animal and Plant Resources and Protection of Wolong Nature Reserve*, pp. 326–42. Sichuan Publishing House of Science and Technology, Chengdu, China (in Chinese).

Linderman, M.A., An, L., Bearer, S., et al. (2006) Interactive effects of natural and human disturbances on vegetation dynamics across landscapes. *Ecological Applications*, **16**, 452–63.

Liu, J., An, L., Batie, S.S., et al. (2005) Beyond population size: examining intricate interactions among population structure, land use, and environment in Wolong Nature Reserve, China. In B. Entwisle and P.C. Stern, eds, *Population, Land Use, and Environment: Research Directions*, pp. 217–37. National Academies Press, Washington, DC.

Liu, J., Daily, G.C., Ehrlich, P.R., and Luck, G.W. (2003a) Effects of household dynamics on resource consumption and biodiversity. *Nature*, **421**, 530–33.

Liu, J. and Diamond, J. (2005) China's environment in a globalizing world. *Nature*, **435**, 1179–86.

Liu, J., Dietz, T., Carpenter, S.R., et al. (2007) Complexity of coupled human and natural systems. *Science*, **317**, 1513–16.

Liu, J., Li, S., Ouyang, Z., et al. (2008) Ecological and socioeconomic effects of China's policies for ecosystem services. *Proceedings of the National Academy of Sciences of the United States of America*, **105**, 9477–82.

Liu, J., Linderman, M., Ouyang, Z., et al. (2001) Ecological degradation in protected areas: the case of Wolong Nature Reserve for giant pandas. *Science*, **292**, 98–101.

Liu, J., Ouyang, Z., Pimm, S.L., et al. (2003b) Protecting China's biodiversity. *Science*, **300**, 1240–41.

Liu, J., Ouyang, Z., Taylor, W.W., et al. (1999) A framework for evaluating the effects of human factors on wildlife habitat: the case of giant pandas. *Conservation Biology*, **13**, 1360–70.

Liu, W. (2012) *Patterns and Impacts of Tourism Development in a Coupled Human and Natural System*. Doctoral Dissertation, Michigan State University, East Lansing, MI.

Liu, W., Vogt, C.A., Luo, J., et al. (2012) Drivers and socioeconomic impacts of tourism participation in protected areas. *PLoS ONE*, **7**, e35420.

Liu, W., Vogt, C.A., Lupi, F., et al. (2015) Evolution of tourism in a flagship protected area of China. *Journal of Sustainable Tourism*. DOI: 10.1080/09669582.2015.1071380.

Mackinnon, J. (2008) Species richness and adaptive capacity in animal communities: lessons from China. *Integrative Zoology*, **3**, 95–100.

Ministry of Forestry (1998) *Wolong Nature Reserve Master Plan*. Ministry of Forestry, Beijing, China (in Chinese).

Myers, N., Mittermeier, R.A., Mittermeier, C.G., et al. (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**, 853–58.

National Bureau of Statistics of China (2010) *Sixth National Population Census of the People's Republic of China*. National Bureau of Statistics of China, Beijing (in Chinese).

People's Government of Sichuan Province (2012) *Sichuan Overview*. http://www.sc.gov.cn/10462/10758/11799/11800/2012/7/25/10219536.shtml (in Chinese).

Reid, D.G. and Hu, J. (1991) Giant panda selection between *Bashania fangiana* bamboo habitats in Wolong Reserve, Sichuan, China. *Journal of Applied Ecology*, **28**, 228–43.

Schaller, G.B. (1994) *The Last Panda*. University of Chicago Press, Chicago, IL.

Schaller, G.B., Hu, J., Pan, W., and Zhu, J. (1985) *The Giant Pandas of Wolong*. University of Chicago Press, Chicago, IL.

State Forestry Administration (2006) *The Third National Survey Report on the Giant Panda in China*. Science Publishing House, Beijing, China (in Chinese).

Tuanmu, M.-N., Viña, A., Bearer, S., et al. (2010) Mapping understory vegetation using phenological characteristics derived from remotely sensed data. *Remote Sensing of Environment*, **114**, 1833–44.

Viña, A., Bearer, S., Chen, X., et al. (2007) Temporal changes in giant panda habitat connectivity across boundaries of Wolong Nature Reserve, China. *Ecological Applications*, **17**, 1019–30.

Viña, A., Bearer, S., Zhang, H., et al. (2008) Evaluating MODIS data for mapping wildlife habitat distribution. *Remote Sensing of Environment*, **112**, 2160–69.

Viña, A., Chen, X.D., McConnell, W.J., et al. (2011) Effects of natural disasters on conservation policies: the case of the 2008 Wenchuan Earthquake, China. *Ambio*, **40**, 274–84.

Viña, A., Chen, X., Yang, W., et al. (2013) Improving the efficiency of conservation policies with the use of surrogates derived from remotely sensed and ancillary data. *Ecological Indicators*, **26**, 103–11.

Viña, A., Tuanmu, M.–N., Xu, W., et al. (2010) Range-wide analysis of wildlife habitat: implications for conservation. *Biological Conservation*, **143**, 1960–69.

Wolong Administration Bureau (2004) *The Chronicle of Wolong Nature Reserve*. Sichuan Science and Technology Press, Chengdu, China (in Chinese).

Wolong Administration Bureau (2009) *Wolong National Nature Reserve Post-earthquake Reconstruction Master Plan*. Wolong Administration Bureau, Wolong, China (in Chinese).

Wolong Nature Reserve (2008) *Wolong Nature Reserve Annual Agricultural Report 2008*. Wolong Administration Bureau, Wolong, China (in Chinese).

Xu, W., Ouyang, Z., Viña, A., et al. (2006) Designing a conservation plan for protecting the habitat for giant pandas in the Qionglai mountain range, China. *Diversity and Distributions*, **12**, 610–19.

Yang, W. (2013) *Ecosystem Services, Human Well-being, and Policies in Coupled Human and Natural Systems*. Doctoral Dissertation, Michigan State University, East Lansing, MI.

Yang, W., Dietz, T., Kramer, et al. (2015) An integrated approach to understanding the linkages between ecosystem services and human well-being. *Ecosystem Health and Sustainability*, **1**, 19.

Yang, W., Dietz, T., Liu, W., et al. (2013b) Going beyond the Millennium Ecosystem Assessment: an index system of human dependence on ecosystem services. *PLoS ONE*, **8**, e64581.

Yang, W., Liu, W., Viña, A., et al. (2013a) Performance and prospects of payments for ecosystem services programs: evidence from China. *Journal of Environmental Management*, **127**, 86–95.

Yang, W., Liu, W., Viña, A., et al. (2013c) Nonlinear effects of group size on collective action and resource outcomes. *Proceedings of the National Academy of Sciences of the United States of America*, **110**, 10916–21.