CHAPTER 5

Quantifying Human Dependence on Ecosystem Services

Wu Yang, Thomas Dietz, Wei Liu, and Jianguo Liu

5.1 Introduction

5.1.1 General background

Human society directly and indirectly benefits from various goods and services provided by nature—ecosystem services (ES; Daily, 1997, Millennium Ecosystem Assessment, 2005). These benefits range from things such as clean water, timber, food, air purification, and carbon sequestration to aesthetic enjoyment, spiritual encouragement, nature-based tourism (e.g., ecotourism), and recreation. Such substantial dependence on ES dates back to the dawn of human history when human subsistence was based on hunting and foraging for plants. Over human history, and especially during the past few decades, the human use of ES has been escalating due to the unprecedented scale of population growth, household proliferation, affluence, and technology advances (Dietz et al., 2007, Liu et al., 2003, Millennium Ecosystem Assessment, 2005). Conceptually, the scientific community has recognized the associated consequences of these changes on ecosystems. But systematic assessments of the temporal and spatial patterns, causes, and associated environmental and socioeconomic impacts at global, national, regional, and local scales were largely missing until the completion of the Millennium Ecosystem Assessment (MA).

Launched in 2001, the MA has issued a series of reports that assess the consequences of ecosystem change. The methods and results of the MA also provide guidance for sustainable management of ecosystems for human well-being (Millennium Ecosystem Assessment, 2005). Perhaps the key finding of the MA is about the relationship between ES and human well-being. The MA revealed that over the past five decades, the overuse of ES substantially contributed to net gains in human well-being. Nevertheless, this trend also increased risks of abrupt changes in ecosystems and further marginalized some groups of the population. Unless significant changes in institutions, policies, and practices can be made, the degradation of ES and exacerbation of poverty for marginalized groups may get even worse. This prospect poses a huge barrier to achieving environmental and socioeconomic sustainability (Millennium Ecosystem Assessment, 2005).

The influence of the MA has been substantial, but it is only an initial effort toward systematic understanding of how ecosystem change affects human well-being (Carpenter et al., 2006). A robust theory linking biodiversity to ecosystem dynamics, the provision of ES, and changes in human well-being is lacking (Carpenter et al., 2006, Yang et al., 2013a, b). When attempting to formulate such a theory, many important questions remain unanswered. For instance, how does human dependence on ES change across time, space and among different population groups such as households at various income levels? To address this question, a quantitative, longitudinal approach is urgently needed. This chapter primarily is based on a published article describing our work (Yang et al., 2013b) and intends to adopt a quantitative approach to understanding human dependence on ES. Specific objectives include (1)

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

Thanks for your interest!

We aren't able to show the entire chapter. To buy "Pandas and People, Coupling Human and Natural Systems for Sustainability" please visit:

Oxford University Press

or

Amazon.com

Scroll down to view the chapter's summary and citation list.

households' dependencies on ES. The index also captured changes in ES dependencies across time, space, and different access levels of natural, human, manufactured, and social capital. With the index system, we confirmed the proposition that the poor are more dependent on ES. We further generalized this proposition by demonstrating that those disadvantaged groups who have lower levels of access to other forms of capital (i.e., human, financial, manufactured, and social capital) are more dependent on ES. Thus, these groups are more vulnerable to degradation or decline of corresponding ES.

The conceptual basis and methods of the IDES system were designed, based on the MA framework, to be generalizable across different sites and units of analysis. Due to the different contexts at various sites, it is possible that the classification of various net benefits into different categories of ES may be different and should be adjusted according to the specific context. But the overall index and subindices, based on the MA framework, should be comparable across contexts. Given that it is impractical to assess all benefits and costs, in practice the most important benefits and costs in each context should be estimated to reflect the general pattern of dependence on ES. We believe that further applications and elaborations would improve the estimates of human dependence on ES and its linkages with human well-being.

We also note a distinction between dependence on ES and dependence on PES programs. The PES programs often compensate for only one or a few but not all the forgone benefits of local households. In the case of Wolong Nature Reserve, NFCP payment is mainly intended to buy an expected increase in regulating services (e.g., soil erosion control, carbon sequestration, and water conservation) while offsetting the forgone provisioning services (e.g., timber). The payment therefore did not cover benefits from cultural services (e.g., recreation and ecotourism); thus we took benefits from ecotourism and recreation into account separately.

Besides methodological innovation, the IDES system also has many theoretical contributions and management implications for understanding and managing ES for human well-being. First, the quantification of human dependence on ES hopefully can be integrated into decision-making. Such a step can rectify the current tendency of overlooking the linkages between poor people and ES in statistical reports (e.g., statistics yearbooks), poverty assessments, and natural resource management. Thus, the IDES system may avoid strategies that ignore or overlook such dependence and lead to further marginalization of disadvantaged groups. As a result, it could reduce the pressure and negative impacts that disadvantaged groups place on ecosystems. Second, this index system may help with establishing priority settings in conservation and development planning (e.g., PES program enrollment and poverty alleviation). This goal can be achieved by targeting priority population groups such as those having low access to capital and high dependence on provisioning services. Third, this index system may help to draw stakeholders' attention to and manage the previously unmanaged risks and unrealized opportunities associated with dramatic changes in ecosystems and their provision of services. Rapid global changes such as climate change and land-use change have dramatically altered the Earth's ecosystem structure and functions and have threatened the sustainable provision of ES. People and organizations that heavily depend on ES are also those who are most vulnerable to the degradation or decline of ES. Finally, future research may involve the construction of integrated models that combine IDES with indicators of indirect drivers, direct drivers, and human well-being. Hopefully such advances can improve the theoretical understanding and management of feedback loops in coupled human and natural systems. Consider the poverty alleviation and biodiversity conservation traps as an example. Poverty forces disadvantaged people to extract ES in an unsustainable way and leads to biodiversity losses, which reduce the provision of ES, further aggravating poverty, and creating vicious circles. Later in this book, we make an initial attempt to construct such integrated models (Chapter 12).

5.7 Summary

Human society substantially depends on a variety of ecosystem services (ES). To improve the management of risks and opportunities related to ES, a quantitative understanding of human dependence on ES, as well as the patterns, causes, and effects of

its changes is essential. This chapter presented an index of dependence on ecosystem services (IDES) system to quantify human dependence on ES. The index is defined as the ratio of net benefits acquired from ecosystems to the absolute value of total net benefits, an amount calculated using economic valuation methods. We also demonstrated the construction of the IDES system and illustrated the patterns, causes, and effects of changes in IDES at Wolong Nature Reserve. Empirical analyses confirmed the validity of the index system in reflecting the general patterns of households' dependencies on ES. Households obtained approximately 45% and 61% of their total benefits from ecosystems in 1998 and 2007, respectively. Dependence on ES also shifted away from provisioning services and toward more regulating services and cultural services. This shift may have helped improve forests in Wolong and had mixed effects on human communities. Findings supported the proposition that disadvantaged groups who have less access to other forms of capital (i.e., human, financial, manufactured, and social capital) than those with greater control are more dependent on ES. It is promising that further applications and elaborations of the IDES system may be able to improve theoretical understanding and management of ES for human well-being in a rapidly changing global environment.

References

An, L., Liu, J., Ouyang, Z., et al. (2001) Simulating demographic and socioeconomic processes on household level and implications for giant panda habitats. *Ecological Modelling*, **140**, 31–49.

Barbier, E.B. (2011) Pricing nature. *Annual Review of Resource Economics*, **3**, 337–53.

Bateman, I.J., Mace, G.M., Fezzi, C., et al. (2011) Economic analysis for ecosystem service assessments. *Environmental & Resource Economics*, **48**, 177–218.

Boardman, A.E., Greenberg, D.H., Vining, A.R., and Weimer, D.L. (2006) *Cost-Benefit Analysis: Concepts and Practice* (third edition). Prentice Hall, Upper Saddle River, NJ.

Carpenter, S.R., DeFries, R., Dietz, T., et al. (2006) Millennium ecosystem assessment: research needs. *Science*, **314**, 257–58.

Chang, J., Wu, X., Liu, A.Q., et al. (2011) Assessment of net ecosystem services of plastic greenhouse vegetable cultivation in China. *Ecological Economics*, **70**, 740–48.

Chee, Y.E. (2004) An ecological perspective on the valuation of ecosystem services. *Biological Conservation*, **120**, 549–65.

Daily, G.C. (1997) *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, DC.

Dietz, T., Rosa, E.A., and York, R. (2007) Driving the human ecological footprint. *Frontiers in Ecology and the Environment*, **5**, 13–18.

Hanley, N., Shogren, J.F., and White, B. (2001) *Introduction to Environmental Economics*. Oxford University Press, New York, NY.

Kareiva, P., Tallis, H., Ricketts, T.H., et al. (2011) *Natural Capital: Theory and Practice of Mapping Ecosystem Services*. Oxford University Press, Oxford, UK.

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

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., Ouyang, Z., Yang, W., et al. (2013) Evaluation of ecosystem service policies from biophysical and social perspectives: the case of China. In S.A. Levin, ed., *Encyclopedia of Biodiversity* (second edition), vol. **3**, pp. 372–84. Academic Press, Waltham, MA.

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.

Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.

National Bureau of Statistics of China (2011) *Rural Household Survey Instrument*. Report for National Bureau of Statistics of China (Beijing) (in Chinese).

Nelson, E., Mendoza, G., Regetz, J., et al. (2009) Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment*, **7**, 4–11.

Ready, R. and Navrud, S. (2006) International benefit transfer: methods and validity tests. *Ecological Economics*, **60**, 429–34.

Richard, T.C., Nicholas, E.F., and Norman, F.M. (2001) Contingent valuation: controversies and evidence. *Environmental and Resource Economics*, **19**, 173–210.

Scott, M.J., Bilyard, G.R., Link, S.O., et al. (1998) Valuation of ecological resources and functions. *Environmental Management*, **22**, 49–68.

Shrestha, R., Rosenberger, R., and Loomis, J. (2007) Benefit transfer using meta-analysis in recreation economic valuation. *Environmental Value Transfer: Issues and Methods*, **9**, 161–77.

Wilson, M.A. and Hoehn, J.P. (2006) Valuing environmental goods and services using benefit transfer: the state-of-the art and science. *Ecological Economics*, **60**, 335–42.

Wolong Nature Reserve (2005) *Development History of Wolong Nature Reserve*. Sichuan Science and Technology Press, Chengdu, China (in Chinese).

Yang, W., Chang, J., Xu, B., et al. (2008) Ecosystem service value assessment for constructed wetlands: a case study in Hangzhou, China. *Ecological Economics*, **68**, 116–25.

Yang, W., Dietz, T., Kramer, D.B., et al. (2013a) Going beyond the Millennium Ecosystem Assessment: an index system of human well-being. *PLoS ONE*, **8**, e64582.

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. (2013c) Performance and prospects on payments for ecosystem services programs: evidence from China. *Journal of Environmental Management*, **127**, 86–95.

Yang, W., Liu, W., Viña, A., et al. (2013d) 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.