Social Sciences in China, 2023
Vol. 44, No. 1, 73-97, http://dx.doi.org/10.1080/02529203.2023.2192088

Ecosystem Protection in China: A New Paradigm under Ecological Civilization*

Xu Jiangmin

Guanghua School of Management, Peking University

Abstract

This paper establishes a theoretical framework to study the fundamental changes in the concept and mechanism of China's ecosystem protection under the paradigm of ecological civilization, and its major implications for global sustainable development. We first examine the damage to the ecosystem of the standard economic growth model, and provide empirical evidence that the traditional ecosystem protection paradigm based on the concept of industrial civilization has been unable to curb serious ecological degradation on a global scale. We then build a new theoretical model to reveal China's new ecosystem protection paradigm based on the concept of ecological civilization, and analyze how it forms a mutually beneficial relationship with economic development by changing the content and mechanism of economic growth. Furthermore, we conduct an empirical analysis of the paradigm shift of China's ecosystem protection and show that there is a significant synergy between China's ecological conservation and economic development under the new paradigm. Finally, we use a game theory model to reveal the significant implications of China's new ecosystem conservation paradigm for global ecological protection, especially for the realization of the expected goals of the post-2020 global biodiversity framework.

Keywords: ecological civilization, industrial civilization, ecosystem protection, economic growth, sustainable development

I. Introduction

An ecosystem is the sum of the ecological complex formed by organisms and the environment and the various ecological processes related to it. Ecosystems are the condition for human survival and the foundation of sustainable economic and social development. Since the industrial revolution, the traditional development model of "resource-intensive, high carbon

* This study was sponsored by the youth project "Climate Risks to the Agricultural Economy and Adaptation to Climate Risks through Financial Markets" (No. 20CJY021) of the National Social Science Fund of China.

emissions, and high ecological cost" has greatly increased productivity and promoted industrial civilization on an unprecedented scale. However, this development model has brought about a global crisis of unsustainability, including massive loss of biodiversity and severe degradation of ecosystems. At the Fifteenth Conference of the Parties (COP15) to the Convention on Biological Diversity (CBD) in Kunming, China, in October 2021, the Conference Declaration called on countries around the world to take "urgent and comprehensive actions" to address biodiversity issues.

Although a broad consensus has been reached on the importance of biodiversity and it has become an issue of great importance for governments and the international community, the destruction of the global ecosystem has not been effectively curbed. At the Tenth Conference of the Parties to the Convention on Biological Diversity held in 2010, member countries adopted the 2011-2020 Biodiversity Strategic Plan and 20 Aichi Biodiversity Targets for the implementation of the plan. However, a decade after the Strategic Plan was developed, there has been little success in meeting the Aichi Biodiversity Targets, with the exception of the 2014 Nagoya Protocol.[1] An important reason why no progress has been made in the ambitious goal of slowing down and eventually reversing the loss of global biodiversity is that ecosystem protection is not only an ecological issue, but more importantly, an issue of transformation of the economic development model.

The traditional ecological protection paradigm is rooted in the traditional industrialization model and development philosophy, where ecosystem conservation and socioeconomic growth are in profound conflict.[2] Therefore, ecological conservation aims to maximize the space for compromise between ecosystems and development in order to achieve higher levels of economic growth. However, as long as ecological protection and economic development are in conflict, there is limited room for compromise. Even if this space can be expanded through better technology or management, ecosystem conservation will always be dominated by and subordinated to economic development. Therefore, if we want to fundamentally solve the problem of global ecosystem degradation and at the same time achieve sustainable economic growth, we must abandon the traditional paradigm of ecosystem protection and economic development based on the concept of industrial civilization, and embrace the new ecosystem conservation paradigm and sustainable growth model based on the concept of ecological civilization.[3]

At present, mainstream research on ecosystem protection and economic development mainly focuses on analyzing the trade-off between ecological protection and economic growth. Existing literature regards ecological protection as a constraint on economic growth,

1 E.J. Green *et al*., "Relating Characteristics of Global Biodiversity Targets to Reported Progress"; *Nature* Editorial, "The United Nations Must Get Its New Biodiversity Targets Right."

2 G. Hardin, "The Tragedy of the Commons"; N.L. Stokey, "Are There Limits to Growth?"; C.I. Jones, "The Costs of Economic Growth."

3 S. Polasky *et al*., "Role of Economics in Analyzing the Environment and Sustainable Development"; P. Dasgupta, *The Economics of Biodiversity: The Dasgupta Review*.

and its research goal is to make an optimal compromise between growth and protection.[4] The main limitation of this mainstream research is that it has not fundamentally resolved the conflicting relationship between economic development and ecosystem protection. Its guiding ideology is the development concept of industrial civilization, rather than the sustainable development model under the concept of ecological civilization. Therefore, this paper studies China's new ecosystem protection paradigm using the concept of ecological civilization and its connection with sustainable development, so as to fill the gaps in the existing literature on ecosystem protection under the development model of ecological civilization. More specifically, we use models and empirical research to analyze how the new ecosystem protection paradigm promotes a mutually beneficial relationship between ecological conservation and economic growth under the development model of ecological civilization, hence achieving both ecosystem conservation and sustainable growth.

China's ecological protection has gone through a difficult process of exploration. From the 1980s to the 2000s, China's real GDP grew at an average annual rate of more than 9 percent. However, this rapid economic growth has come at the expense of natural resources and the environment, which has resulted in severe biodiversity loss and ecosystem degradation.[5] Facing increasingly severe ecological problems, the 18th National Congress of the Communist Party of China raised ecological civilization to an unprecedented height—it was written into the Constitution of the People's Republic of China and the Constitution of the Communist Party of China as a pillar of the "Five-sphere Integrated Plan." After the 18th National Congress of the Communist Party of China, the development concept based on ecological civilization has brought about corresponding changes in the thinking of China's ecosystem protection. Under the guidance of Xi Jinping Thought on Ecological Civilization, China adheres to ecological priority and green development, and constantly improves its ecosystem governance mechanism; its ecosystem protection has thus entered a new historical period.[6]

Under the guidance of the new ecosystem protection paradigm, China is actively promoting international cooperation on ecological protection. The second phase of the 15th Conference of the Parties to the Convention on Biological Diversity, under the presidency of China, recently concluded in Montreal, Canada. Under the active leadership of China, the conference adopted the "Kunming-Montreal Global Biodiversity Framework." The Framework sets four long-term goals for global biodiversity conservation and 23 action goals that are planned to be completed by 2030 at the latest. This ambitious, pragmatic, and balanced Framework draws a new blueprint for global ecological governance until 2030 and beyond. In addition, under the impetus of China, the conference also adopted a series of decisions related to the Framework monitoring system, resource mobilization, and technical and scientific cooperation.

This paper aims to establish a theoretical framework to demonstrate the fundamental

4 W.D. Nordhaus, *Managing the Global Commons: The Economics of Climate Change*; E. Ostrom, "A General Framework for Analyzing Sustainability of Social-ecological Systems."

5 Y. Lu *et al*., "Forty Years of Reform and Opening Up: China's Progress toward a Sustainable Path."

6 W. Wang. *et al*., "Biodiversity Conservation in China: A Review of Recent Studies and Practices."

changes in the concept and mechanism of China's ecosystem protection under the paradigm of ecological civilization, and its significance to global sustainable development. We make two contributions. First, we use theoretical models to directly address the relationship between ecosystem conservation and economic growth. Second, we establish a new theoretical model of economic growth based on the concept of ecological civilization, and put forward theoretical insights into the fundamental differences between the new model of ecological civilization and the traditional model of industrial civilization in terms of ecosystem protection. Under the concept of ecological civilization, the new paradigm of ecosystem protection can make ecological value and sustainable growth coexist for the long run.

The rest of this paper is organized as follows. Section II conducts a literature review, puts forward the limitations of the mainstream literature, and reveals the value of our study. Section III gives a theoretical analysis of the fundamental problems of the traditional ecosystem protection paradigm in the standard economic growth model of industrial civilization, and provides empirical evidence of global ecosystem degradation under the traditional paradigm. Section IV builds a new theoretical model of economic growth based on the concept of ecological civilization, and demonstrates the mutually beneficial relationship between the new ecosystem protection paradigm and economic growth under the ecological civilization model. Section V conducts an empirical analysis of China's new paradigm of ecosystem protection, and proves the effectiveness and achievements of the new paradigm. Section VI uses a game theory model to reveal the important implications of China's new ecosystem protection paradigm for global ecological protection work. Section VII provides the conclusion.

II. Literature Review

In this section, we review the mainstream literature on economic growth and ecosystem conservation. In summarizing the literature, we point out the analytical focus and limitations of the mainstream literature, thus revealing the contribution of this paper to existing research as well as its own research value.

Currently, the mainstream literature on growth and ecosystems tends to focus on the conflicting trade-offs between ecosystem protection and economic growth. Existing literature treats ecosystem protection as a constraint on economic growth, and explores the construction of an optimal compromise between growth and protection. For example, the seminal work of Nordhaus proposed a dynamic model of climate change and the economy that added equations representing emissions and climate change as costs/constraints.[7] Recent studies such as those of Stern, Weitzman, Dasgupta, Nordhaus and Mendelsohn focus on measuring the cost of ecological degradation for economic growth.[8] Based on assessments of risk, discounting, and

7 W.D. Nordhaus, *Managing the Global Commons: The Economics of Climate Change*.

8 N. Stern, *The Economics of Climate Change: The Stern Review*; M.L. Weitzman, "A Review of the Stern Review on the Economics of Climate Change" and "On Modeling and Interpreting the Economics

related issues, the literature formulates policy actions for ecosystem conservation, as set out in Greenstone *et al*. and Besley and Dixit.[9] However, these studies have not fundamentally resolved the conflicting relationship between economic development and ecosystem protection.

Another strand of literature studies the interaction between ecological conservation and technological change. For example, Stokey, Jones, and Aghion and Howitt have examined how the cost of protecting ecosystems limits technological progress.[10] Van der Zwaan *et al*. and Acemoglu *et al*. studied the impact of different types of ecological protection policies and regulations on technological innovation and directional change.[11] However, those studies primarily focus on how advances in technology can help balance the conflicting relationship between ecosystem conservation and economic growth. They do not provide a theoretical framework for systematic analysis of how conservation and growth can form a mutually beneficial relationship. Therefore, this paper will propose a systematic theoretical framework to directly address the issue of how to foster a synergistic relationship between ecosystem protection and economic growth, in order to fill in the research gaps in the mainstream literature on the relationship between the two.

In recent years, the literature on sustainable growth and ecological governance has begun to shift its research focus from simple ecosystem governance to more integrated approaches of simultaneously improving material well-being and maintaining ecological quality, e.g. Polasky *et al*.[12] This sustainability literature seeks to develop a methodology for the valuation of natural capital and ecosystem services, and integrate them into a comprehensive framework for analyzing sustainable development. For example, Polasky and Segerson brought together ecology and economics in the study of ecosystem services, while Goldstein *et al*. integrated ecosystem service values into land use decisions.[13] Arrow *et al*., Dasgupta, and Polasky *et al*. examined how new systems for measuring wealth can help with achieving sustainable development.[14] Ostrom established a comprehensive framework called the Institutional Analysis and Development Framework (IAD) for analyzing the sustainability of social-

---

of Catastrophic Climate Change"; P. Dasgupta, "Commentary: The Stern Review's Economics of Climate Change" and "Discounting Climate Change"; W.D. Nordhaus, "A Review of the Stern Review on the Economics of Climate Change"; R.O. Mendelsohn, "A Critique of the Stern Report."

9 M. Greenstone, E. Kopits and A. Wolverton, "Developing a Social Cost of Carbon for US Regulatory Analysis: A Methodology and Interpretation"; T. Besley and A. Dixit, "Environmental Catastrophes and Mitigation Policies in a Multiregion World."

10 N.L. Stokey, "Are There Limits to Growth?"; P. Aghion and P. Howitt, *Endogenous Growth Theory*; C.I. Jones, "The Costs of Economic Growth."

11 B.C.C. van der Zwaan *et al*., "Endogenous Technological Change in Climate Change Modelling"; D. Acemoglu *et al*., "The Environment and Directed Technical Change."

12 S. Polasky *et al*., "Role of Economics in Analyzing the Environment and Sustainable Development."

13 S. Polasky and K. Segerson, "Integrating Ecology and Economics in the Study of Ecosystem Services: Some Lessons Learned"; J.H. Goldstein *et al*., "Integrating Ecosystem-service Tradeoffs into Land-use Decisions."

14 K. Arrow *et al*., "Sustainability and the Measurement of Wealth"; P. Dasgupta, "Measuring the Wealth of Nations"; S. Polasky *et al*., "Inclusive Wealth as a Metric of Sustainable Development."

ecological systems through her research on the "tragedy of the commons."[15] The limitation of this strand of literature is that it mainly concentrates on gradual change in the traditional ecosystem protection model under the developmental concept of industrial civilization rather than the transitional changes in the concept and mechanism of ecosystem protection under the development model of ecological civilization. Therefore, our paper will utilize a theoretical economic growth model to reveal the leapfrog transformation of ecosystem protection from the traditional development paradigm to the development paradigm of ecological civilization. Hence we aim to supplement the lack of research on the paradigm of ecosystem protection under the concept of ecological civilization in the sustainability literature.

In addition to the theoretical literature, another important type of literature on ecosystem protection is research on ecological protection policies. China's policy research on ecosystem protection began after reform and opening-up. Although it started a bit late compared with developed countries, China has made outstanding contributions to biodiversity research in recent years.[16] The Chinese Academy of Sciences established the Biodiversity Committee in 1992 and has organized a national conference on biodiversity conservation and sustainable use every two years since 1994.[17] At the same time, many Chinese experts have carried out relevant research at the levels of genes, species, and ecosystems, making significant contributions to global ecosystem conservation methods.[18]

After joining the Convention on Biological Diversity in 1992, the former State Environmental Protection Administration of China and other relevant departments issued the "China Biodiversity Conservation Action Plan" in 1994. In 2010, the former Ministry of Environmental Protection of China, together with more than twenty ministries and commissions, updated the "China 2011-2030 National Biodiversity Conservation Strategy and Action Plan."[19] The plan defines the strategic goals, tasks, priority areas and actions for China's biodiversity conservation in the twenty years after 2010. Thereafter, the Eighteenth National Congress of the Communist Party of China raised ecological civilization to an unprecedented level. Under the concept of ecological civilization, China's ecosystem protection policies have also undergone corresponding changes. In 2016, the Outline of the Thirteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China emphasized the need to "strengthen ecological protection and restoration" and implement major ecosystem protection measures, including the creation of a new national

15 E. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action*; "A General Framework for Analyzing Sustainability of Social-Ecological Systems"; "Beyond Markets and States: Polycentric Governance of Complex Economic Systems."

16 W. Wang *et al*., "Biodiversity Conservation in China: A Review of Recent Studies and Practices."

17 K. Ma, Z. Lou and R. Su, "Review and Outlook of Biodiversity Research in the Chinese Academy of Sciences."

18 B. Fu and Y. Lü, "The Progress and Perspectives of Landscape Ecology in China."

19 Ministry of Environmental Protection of the People's Republic of China, *China National Biodiversity Conservation Strategy and Action Plan 2011-2030 (NBCSAP 2011-2030).*

park system and the Ecological Conservation Red Line. The formulation and implementation of these new ecosystem protection policies have had a very positive effect on China's ecosystem restoration.

These research papers on ecological protection policies focus on the formulation and practice of ecosystem governance policies, so they have little discussion of the relationship between ecosystem protection and economic development models. China still faces many developmental problems such as climate change, economic growth, and the increase in middle-class consumption. These problems will bring pressure to the ecological environment and new challenges to China's ecosystem protection. Since ecosystem protection is not only an issue of ecological governance, but also an issue of development paradigm shift, research on ecological protection policies should be combined with research on economic development models. Thus our paper will examine how the ecosystem protection paradigm changes with the transformation of the economic development model, so as to provide new inspiration for the formulation of ecological protection policies.

III. The Traditional Ecosystem Protection Paradigm under the Paradigm of Industrial Civilization

In this section, we first introduce the traditional economic growth model under the concept of industrial civilization. We then use this model to demonstrate the paradoxical relationship between ecosystem conservation and economic growth, and to explain why the traditional ecosystem conservation paradigm will ultimately fail.

The fundamental issues between traditional economic growth and ecosystem protection can be briefly summarized as follows. In the traditional economic growth model, final output is determined by known production technologies in the economy. But production technologies cause damage to the ecosystem. In this model, the ecosystem has no additional production value to the final output. Thus the sole effect of ecosystem conservation is to depress output and economic growth. As a result, ecosystem protection cannot be maintained and ecosystem degradation cannot be avoided if long-term economic growth rates are to be sustained.

We now introduce the traditional economic growth model under industrial civilization. Consider a continuous-time model with a continuum of infinitely lived individuals. The representative agent in the economy has the lifetime utility function:

$$W = \int_0^{\infty} e^{-\rho t} u\,(c, E)\, dt, \tag{1}$$

where $c(t)$ is the time path of consumption per head, $E(t)$ is an aggregate indicator for ecosystem quality, and ρ is a positive discount rate of time preference. $u(c, E)$ is the instantaneous utility function. For simplicity, the utility function $u(c, E)$ is assumed to have an additive isoelastic form:

$$\frac{\partial u\,(c, E)}{\partial c} = c^{-\varepsilon}, \quad \frac{\partial u\,(c, E)}{\partial E} = (-E)^{\omega}, \tag{2}$$

with parameters $\varepsilon > 0$, $\omega > 0$.

The economy is subject to the accounting identity that consumption (C) plus investment (I) equals aggregate output (Y):

$$I = \frac{dK}{dt} = \dot{K} = Y - C, \tag{3}$$

where K is tangible capital. Throughout this paper we use the dot operator on top of a variable to denote the derivative with respect to time, i.e., the change between this period and the next period. The ecosystem indicator E can be regarded as an ecological good that behaves similarly to the capital good K: E is depleted over time due to ecosystem degradation from human activities, and has some small regenerative capabilities. The flow of aggregate ecosystem degradation is $P(Y, z)$, which is an increasing function of the level of output (representing the total scale of human activities) and the intensity of degradation z (representing the intensity of damage to the ecosystem).

Suppose there is a finite upper limit to the ecosystem quality, which is the optimum quality without any human activities. We measure E as the difference between the actual quality and this upper limit, so that E is always negative. The evolution of ecosystem quality over time takes the form:

$$\dot{E} = -P(Y, z) + \theta E, \tag{4}$$

where θ is a small parameter representing the natural regenerative capability of the ecosystem. There is a **critical ecological threshold**, denoted by E^{min}, which is a finite lower limit to the ecosystem quality. If the ecosystem quality ever falls below this threshold at any time $t < \infty$, then the economy will reach the point of no return and an ecological disaster will occur, i.e., the ecosystem quality E will spiral down to negative infinity. Since agents in the economy value ecosystem and their marginal utility for the ecosystem quality becomes infinitely large when an ecological disaster occurs, breaking through the critical ecological threshold cannot be part of a welfare-maximizing allocation for any finite discount rate ρ.

1. Why the traditional ecosystem conservation paradigm cannot prevent ecosystem degradation

The traditional ecosystem conservation paradigm was established based on the industrial civilization model. Under the paradigm of industrial civilization, ecosystem conservation and economic growth in the mainstream development model have always been regarded as conflicts of interest. We now use the traditional economic growth model to show that, under this conflict paradigm, ecosystem protection in the traditional model will fail to prevent ecological crises unless the long-term economic growth rate is zero.

In the traditional economic growth model, it is assumed that final output Y can be produced by a variety of known techniques which differ in their damage to the ecosystem. Let $z \in [0,1]$ be a measure of the ecological degradation effect of the existing techniques (i.e., degradation intensity), then the flow of aggregate ecosystem degradation is $P(Y, z) = Y z^{\beta}$, where $\beta > 0$. For simplicity, let us assume a standard AK production technology for output, that is

$$Y = zAK, \tag{5}$$

where A is total factor productivity. This aggregate production function captures the essential conflict between economic growth and ecosystem conservation in the traditional development paradigm under industrial civilization. The production function says that the use of a more ecological-friendly technique entails a higher cost of production. For ecosystem conservation, we need to lower the degradation intensity and use ecological-friendly techniques with a lower value of z, but this means less output will be obtained per unit of input, which would reduce economic growth. Thus to maintain economic growth, a higher z needs to be chosen, but this entails less ecosystem conservation and more damage to the ecosystem. More importantly, since the rate of aggregate ecosystem degradation is $Y z^{\beta} = z^{\beta+1} AK$, we will show next that in the traditional growth model, ecosystem protection will inevitably fail and an ecological disaster will assuredly occur unless economic growth in the long run is zero.

The optimality conditions of the traditional model imply that consumption (and the economy) must grow according to:

$$\frac{\dot{c}}{c} = (\frac{1}{\varepsilon})\,(\frac{\beta}{\beta+1} Az - \rho), \tag{6}$$

where the term $\frac{\beta}{\beta+1} Az$ can be interpreted as the social marginal product of capital; that is, the marginal product of capital net of the associated ecosystem damage. The long-run economic growth rate from the above equation implies that, for any positive discount rate, if the growth rate is positive, then we must have

$$z > \frac{\rho}{A}\frac{\beta+1}{\beta} > 0. \tag{7}$$

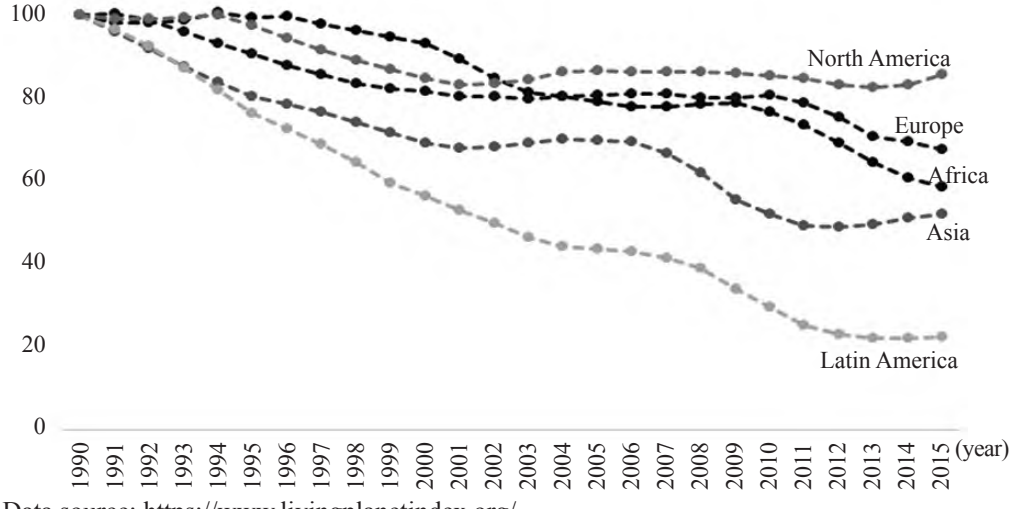
But this means the ecosystem is degrading at the speed of $P\,(Y, z) = Y z^{\beta} \gg 0$ in the long run, so that it inevitably leads to the ecosystem quality E falling below the critical threshold, triggering an ecological disaster to the economy. This result says the traditional ecosystem conservation paradigm based on the concept of industrial civilization ultimately cannot prevent ecological crises. Moreover, by sacrificing ecosystems, the traditional development model results in unsustainable growth in the long run, since an ecological disaster cannot be a part of any welfare-maximizing allocation. Yet this profound problem with the traditional model is unsolvable since ecosystem conservation always conflicts with economic growth. To see this in the model, note that for ecosystem protection, a rather small value of z must be chosen. But this means the condition $\frac{\beta}{\beta+1} Az - \rho > 0$ cannot be satisfied, so that the long-run economic growth rate can only be zero or negative. This is certainly not tolerated in the traditional development model, so ecosystem conservation must give way to economic growth. As a result, under the concept of industrial civilization, the traditional conservation paradigm will fail and ecological crises will occur, due to the conflicting relationship between ecosystem protection and economic growth.

2. Empirical evidence of ecosystem degradation under the traditional ecosystem conservation paradigm

In this sub-section, we provide empirical evidence showing that the mainstream traditional ecosystem conservation paradigm, which is based on the concept of industrial civilization, has not been able to protect ecosystems and has resulted in severe ecological degradation around the world.

In Figure 1, we show the evolution of the Living Planet Index (LPI) from 1990 to 2015 over different parts of the world (all indexed to 100 in 1990). The LPI is a comprehensive global biodiversity index that measures the state of global biological diversity based on population trends of vertebrate species from around the world. We can see that the LPI has been declining in every part of the world. The biodiversity index experienced the largest decline in Latin America, of about 80 percent. It fell by around 30 to 40 percent in Europe, Africa and Asia, and by 20 percent in North America. This clearly shows that all parts of the world are suffering from a serious loss of biodiversity.

Figure 1 Living Planet Index around the World

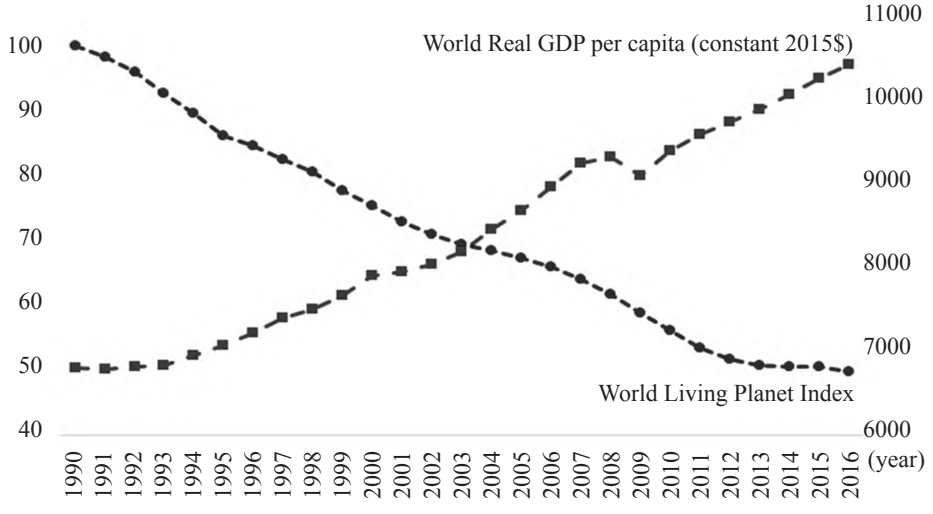


Data source: https://www.livingplanetindex.org/.

In Figure 2, we correlate the decline in the world LPI with world economic growth. We show the evolution of the world LPI from 1990 to 2016 (indexed to 100 in 1990, dot line, left axis) together with the evolution of world average real GDP per capita (measured in constant 2015 US dollars, square line, right axis). Figure 2 provides clear evidence that the decline in biodiversity around the world is strongly coupled with the rise in real GDP per capita, i.e., economic growth. Global average real GDP per capita rose by close to 50 percent during the period 1990 to 2016. At the same time, the global LPI fell by 50 percent. Thus a one percent annual increase in GDP

is associated with almost a one percent annual fall in biodiversity.

Figure 2 Evolution of World Living Planet Index and Real GDP Per Capita



Data source: https://www.livingplanetindex.org/ and World Bank.

We can also use a regression to further demonstrate the relationship between LPI decline and economic growth. We employ the following regression specification:

$$y_t = \alpha_0 + \alpha_1 x_t + trend_t + \epsilon_t, \tag{8}$$

where y represents the world LPI index, x represents the annualized growth rate of world real GDP per capita (in percentages), and *trend* represents the control variable for the linear time trend. Using the same data in Figure 2, we obtain an estimation result for the above regression with an estimate of −0.43 for the coefficient α_1 and a t-statistic of −6.7. Therefore, the world per capita GDP growth rate has had a serious negative impact on the LPI index, and the coefficient of the growth rate is statistically significant at the 0.1 percent level. This dramatic evidence shows that under the concept of industrial civilization, the traditional paradigm of ecosystem protection and economic development model are not sustainable. Economic growth is obtained at the cost of the large-scale degradation of ecosystems, while ecosystem protection does not play any positive role in improving ecosystem quality, and the traditional conservation paradigm has clearly been subordinated to economic growth.

IV. China's New Ecosystem Protection Paradigm under the Concept of Ecological Civilization

In this section, we will construct a new growth model and use it to analyze and explain China's new paradigm of ecosystem protection under the concept of ecological civilization, as

well as the fundamental changes in the issue of ecosystem protection. The essential difference between ecological civilization and industrial civilization is that under ecological civilization, ecosystem protection is no longer regarded as a force that contradicts economic growth. On the contrary, ecosystem protection and economic growth in the ecological civilization model have a mutually beneficial relationship. This synergistic effect replaces the conflicting effect of substitution between the two in the traditional development model. Therefore, China's new ecosystem protection paradigm based on the concept of ecological civilization can achieve better economic growth and ecological protection goals at the same time.

The idea of the new growth model traces its roots back to the endogenous growth theory of Aghion and Howitt, but their focus is on technological change and they did not develop an endogenous growth model for ecosystem conservation and sustainable growth.[20] Now we introduce our new growth model of ecological civilization as follows. In the new model, the final output Y is produced using labor L and a continuum of intermediate goods with different ecological values, according to the production function:

$$Y = L^{1-\alpha} \int_0^1 B(i)\, x(i)^{\alpha} di. \tag{9}$$

In the above equation, $x(i)$ represents intermediate goods. The ecological value of intermediate goods is treated as intangible capital. The quality of the intangible capital is captured by $B(i)$, which is a parameter measuring the ecological value of an intermediate input to the final output. This intangible ecological capital represents the fundamental shift in the view of ecosystem conservation within the development model of ecological civilization. In this model, because of the ecological value to output production, ecosystem conservation is no longer a cost to economic growth. Instead, protecting ecosystems can promote economic growth due to the value of ecological capital that is the $B(i)$ parameter. Thus ecosystem conservation and economic growth become complementary and mutually beneficial: higher growth requires ecosystem conservation for the production process, and in turn ecosystem conservation protects ecological value that can lead to higher growth.

Each intermediate good is produced according to the constant return to scale production function $x(i) = K(i) / B(i)$, where $K(i)$ is the amount of traditional tangible capital used to produce good i. This implies it is optimal to produce the same quantity of each intermediate good $x(i) = x = K / B$, where the parameter B measures the aggregate value of ecological quality: $B = \int_0^1 B(i) di$. Hence the production function for final output can be written as

$$Y = F(K, BL) = K^{\alpha} (BL)^{1-\alpha} \tag{10}$$

The evolution of the aggregate ecological value B is

$$\dot{B} = \sigma \eta n B, \tag{11}$$

where n represents the time spent on ecosystem conservation and we have the labor constraint $L + n = 1$, with η as a positive parameter representing the arrival rate of ecological

20 P. Aghion and P. Howitt, *Endogenous Growth Theory*.

innovation, and σ as a positive parameter measuring the size of each ecological innovation. The two parameters η and σ capture fundamental ideas regarding the benefits of ecosystem conservation for economic growth under the development concept of ecological civilization. First, by undertaking ecosystem conservation, new sustainable growth opportunities will arise, occuring at the rate of η. Such new opportunities can be related to ecological services such as eco-tourism or green products such as electric vehicles. Second, ecosystem conservation increases the size of green/ecological innovation, which leads to a higher sustainable growth rate. This is captured by σ, indicating the rate at which the flow of ecological innovations pushes out the economy's technological frontier. Therefore, in this ecological-civilization based new development model, ecosystem conservation is no longer a drag on economic production. Instead, the new development model views ecosystem conservation as being complementary and beneficial to economic growth since it brings about new sustainable growth opportunities via ecological innovations.

We now demonstrate that the new ecosystem conservation paradigm based on ecological civilization can achieve long-term sustainable growth without compromising ecosystems. Adapting the production function $F(K, BL) = K^{\alpha}(BL)^{1-\alpha}$ with intangible ecological capital B in the new growth model for the ecological degradation problem yields the revised production function:

$$Y = zK^{\alpha}(BL)^{1-\alpha}. \tag{12}$$

As stated earlier, the evolution of ecological capital is governed by $\dot{B} = \sigma\eta nB$. The optimality conditions of the new growth model imply the following condition for long-run economic growth:

$$\frac{\dot{c}}{c} = \left(\frac{1}{\varepsilon}\right)\left(\alpha \frac{\beta}{\beta+1}\frac{Y}{K} - \rho\right). \tag{13}$$

The most important thing to notice about this new growth condition is that it allows tangible capital K and total output Y to grow at the same rate in the long run without a diminishing rate of return to capital. This is because of the value of ecological capital for growth, which is not captured in the traditional development model based on industrial civilization. The traditional model does not measure the intangible ecological capital that ecosystem conservation can provide to the economy, hence the ratio of output to tangible capital Y / K is equal to Az. Due to the presence of ecological degradation z, to prevent an ecological disaster, the growth rate of output (hence the ratio Y / K) in the traditional industrial civilization model eventually has to decline to zero. Otherwise, an ecological disaster will occur, severely reducing welfare for everyone. However, in the new ecological civilization model, the ratio of output to tangible capital Y / K is now equal to

$$(BL / K)^{1-\alpha}z. \tag{14}$$

With the presence of ecological capital B, this ratio does not need to decline at all and can remain unchanged indefinitely, as long as ecological capital B grows faster than tangible capital K to offset the fall in ecological degradation z.

The key implication of this result is that, based on ecological civilization, ecosystem conservation not only reduces ecological degradation, but also leads to new sustainable growth opportunities. The reduction in ecological degradation is captured by the fall in the degradation parameter z, while sustainable growth comes from the growth in ecological capital B. Since ecological civilization represents a fundamental shift to green and sustainable economic development, in the new growth model ecological capital B will grow faster than tangible capital K. As a result, when ecosystem conservation lowers degradation z, the increase in ecological capital B that comes from ecosystem conservation will offset the decline in z, so that $Y / K = (BL / K)^{1-\alpha} z > 0$. With a reasonable value for the discount rate ρ, the long-run economic growth rate in the new model will be strictly greater than zero:

$$(\frac{1}{\varepsilon})(\alpha \frac{\beta}{\beta+1} \frac{Y}{K} - \rho) \gg 0. \tag{15}$$

Therefore, under the concept of ecological civilization, the new ecosystem conservation paradigm will achieve long-run sustainable growth while protecting ecosystems at the same time. This is the fundamental transformation of ecosystem protection and sustainable growth from the traditional industrial civilization model to the new ecological civilization development model, showing how a mutually beneficial relationship between ecosystem protection and economic development is realized under the concept of ecological civilization.

For different countries, the transition from the traditional economic growth model to the new economic growth model and the resulting transformation of the ecosystem protection paradigm, would require the following main bases. First, changing the production mode. Under ecological civilization, the content of production needs to meet people's overall needs for material products as well as non-material products (ecological products). For enterprises, business models that differ from those of the industrial civilization age are needed to directly or indirectly realize the ecological value created by enterprises. Second, releasing the increasing-returns effect of ecological goods in production. The new economic growth model transforms "lucid waters and lush mountains" into "invaluable assets," and many of the ecological values they provide are intangible capital. Therefore, in the production process, all industries and enterprises need to incorporate ecological capital into their production factors, and change production decisions from the traditional development model. Third, improving the form of realization of the ecological value system. For the ecological value of intangible products, the pricing method of the traditional development model may not be feasible. Therefore, indirect pricing methods, such as revealed preference pricing and hedonic asset pricing, should be considered.

Under the new development paradigm based on the concept of ecological civilization, through the implementation of major ecological restoration projects, the establishment of a new national park system, and the delineation of the Ecological Conservation Red Line, China's ecosystem protection has undergone an all-round improvement. However, China's

ecosystem protection still faces new challenges, such as an incomplete funding mechanism, insufficient integration of ecological protection data, and insufficient attention to the integrity of ecosystem protection and economic development.[21] Therefore, based on the analysis of the earlier theoretical model, we can see that in the future China's ecosystem protection model should further improve the mutually beneficial relationship between ecosystem conservation and economic development. Ecosystem protection should strengthen its top-level design and management, promote synergy with economic development, and help China achieve its sustainable development goals. This would allow China to more effectively handle those new challenges facing its ecosystem.

V. Empirical Evidence for the Effectiveness of China's New Ecosystem Conservation Paradigm

In this section, we conduct empirical analysis to demonstrate the effectiveness and achievements of China's new ecosystem conservation paradigm in promoting sustainable growth and protecting ecosystems under the concept of ecological civilization. First, we use regression analysis to show that China has improved the overall state of its ecosystem without compromising economic development. Second, we use the theoretical growth model based on the concept of ecological civilization in the previous section to explain some key ecosystem protection measures implemented in China under the new conservation paradigm, and provide empirical evidence of their results.

1. Regression analysis

In this sub-section, we conduct empirical regression analysis to reveal the success of ecosystem protection in China under the guidance of ecological civilization. Our empirical results show that China has improved the overall condition of its ecosystem without compromising economic development.

To study the relationship between economic growth and ecosystems, we employ the following autoregressive distributed lag (ARDL) regression model:

$$y_t = \alpha + \beta x_t + \Gamma' Z_t + \lambda y_{t-1} + \theta x_{t-1} + \Phi' Z_{t-1} + \varepsilon_t. \tag{16}$$

ARDL models play an important role in time series econometrics. Compared with autoregressive (AR) models and distributed lag (DL) models, ARDL models are more versatile. In the economics literature, they are widely used to estimate the dynamic relationship between two variables. Since an ARDL regression contains autoregressive terms of the dependent variable and lag terms of the independent variable, the ARDL regression model can be used to explain the long-run general equilibrium relationship between the independent variable and the dependent variable, so the regression model has a solid

21 F. Wei *et al*., "Main Achievements, Challenges, and Recommendations of Biodiversity Conservation in China."

economic theory basis (see Phillips and Loretan, 1991). We adopt the ARDL (1,1) model to ensure the parsimony and tractability of our regression model. In order to ensure the robustness of the model, we also tried other specifications of the ARDL regression, including ARDL (2,2) and ARDL (3,3) models, but the basic results and conclusions did not change. Due to space limitations, we do not present these other results in the paper. These results are available from the author upon request.

In the above regression Equation (16), the dependent variable y represents a measure for China's ecosystem. We use five different measures: (a) natural resources depletion as a percentage of GNI (natdep); (b) total natural resource rents as a percentage of GDP (natrent); (c) log of PM 2.5 air pollution (pm25); (d) total forest area as a percentage of total land area (forest); (e) log of capture fisheries production (fishery). The first two measures of natdep and natrent depict degradation to the ecosystem. The third pm25 measure indicates pollution to the ecosystem. The last two measures of forest and fishery characterize biodiversity. x is the main explanatory variable, which is the growth rate of real GDP per capita (gdppcg). Z represents a vector of control variables, including overall population growth (popg), urban population growth (urbang), log of annual average temperature (temper), and log of annual cumulated precipitation (precip). ε is the error term. All variables are measured at the annual level, and the subscript t indicates year. For all of the dependent variables and the two control variables of temper and precip, we have done first-order difference processing to ensure stationarity. Temperature and precipitation data are from the China Meteorological Data Network. All other data are from the World Bank database. PM 2.5 and forest data are from 1990 to 2020, and all other data are from 1980 to 2020. The estimation results of regression model (16) are shown in Table 1 below.

Table 1 Estimation Results of Regression Model (16)

	(1) natdep	(2) natrent	(3) pm25	(4) forest	(5) fishery
gdppcg	-0.111	-0.198	-0.527	0.002	0.224
	(-1.09)	(-1.29)	(-1.31)	(1.97)	(0.90)
popg	-5.518*	-8.243*	-43.050***	-0.127**	7.620
	(-2.50)	(-2.50)	(-5.11)	(-2.98)	(0.95)
urbang	1.165	2.716	0.983	0.063***	5.654
	(0.89)	(1.29)	(0.31)	(7.02)	(1.70)
temper	-0.008	-0.012	0.022	0.000	0.026
	(-0.20)	(-0.19)	(0.22)	(0.03)	(0.37)
precip	0.005	0.008	-0.153	0.001*	-0.038
	(0.14)	(0.14)	(-1.98)	(2.20)	(-0.46)
Ldepvar	-0.229	-0.241	-0.628***	0.093	0.511**
	(-1.11)	(-1.10)	(-4.48)	(0.50)	(3.24)
Lgdppcg	0.135	0.224	0.659*	0.001	0.059
	(1.49)	(1.56)	(2.56)	(0.98)	(0.27)

Lpopg	4.134*	5.693	30.162**	0.032	-3.819
	(2.10)	(2.03)	(3.92)	(0.68)	(-0.53)
Lurbang	-0.717	-1.859	6.583	-0.031**	-4.865
	(-0.48)	(-0.83)	(1.25)	(-2.98)	(-1.64)
Ltemper	0.021	0.045	-0.163	0.000	0.061
	(0.60)	(0.76)	(-1.57)	(0.43)	(0.65)
Lprecip	-0.009	-0.012	-0.118	0.000	-0.047
	(-0.50)	(-0.41)	(-1.27)	(1.41)	(-0.78)

Note: *t*-statistics with Newey-West adjusted standard errors are shown in parentheses. ***, **, * indicate statistical significance at the level of 0.1 percent, 1 percent, and 5 percent respectively. The "L" in front of some of the variables denotes the lag operator for (*t*-1).

From Table 1, we can see that GDP growth rate does not have a significant damaging effect on China's ecosystem measures. In columns (1) and (2), the effects of GDP growth on natural resource depletion and rents are negative, and the total combined effects of lagged and contemporaneous GDP growth terms are around 0.025, which is almost negligible in terms of economic significance. In column (3), the overall effect of GDP growth on PM2.5 pollution is around 0.13, which has a tiny magnitude. In column (4), the overall effect of GDP growth on forest area is actually positive with a value of 0.003, indicating that economic growth actually has a positive effect on forest coverage. In column (5), GDP growth has some negative effect on marine biology, but the effect is neither economically nor statistically significant. To sum up, under the efforts and practices of China's new ecosystem conservation paradigm based on the concept of ecological civilization, we witness the achievement of the maintenance of China's ecological environment and biodiversity alongside economic growth. The empirical result demonstrates that under ecological civilization, ecosystem conservation and economic development can indeed be synergistic, and there is no need at all for their relationship to be conflicting.

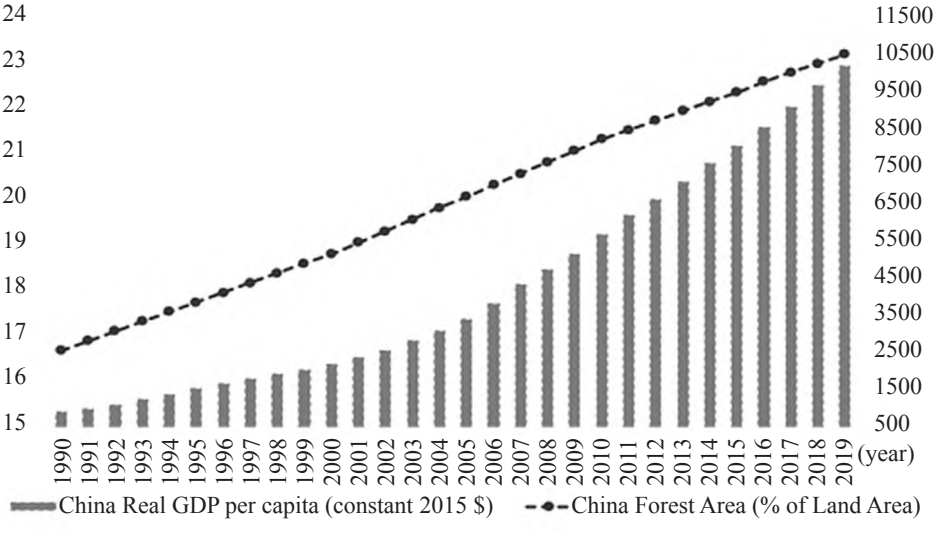
2. Empirical evidence for some key ecosystem conservation measures

In this sub-section, we present empirical evidence for the outcomes of some key conservation practices in China under the new ecosystem protection paradigm, and use our new theoretical growth model based on the concept of ecological civilization developed earlier to explain the working mechanisms of these conservation practices.

China has been developing a system of protected areas led by national parks. Since 2015, China has piloted ten national parks and established a system of protected areas with national parks as the mainstay and natural parks as the supplement. At the same time, China has also carried out large-scale conversion of farmland to forests and national ecological restoration projects. From Figure 3, we can observe the effectiveness of the implementation of these ecological protection plans and their relationship with economic development. We show the change in forest area (as a percentage of total land area) in China relative to real GDP per capita (measured in constant 2015 US dollars) from 1990 to 2019. We see that steady

economic growth coincides with a significant increase in forest area.

Figure 3 Evolution of China's Forest Area and Real GDP Per Capita



Data source: World Bank.

We can also use regression analysis to further demonstrate the synergistic relationship between China's economic growth and forest area increase. We employ the following regression model:

$$y_t = \gamma_0 + \gamma_1 x_t + trend_t + \epsilon_t, \tag{17}$$

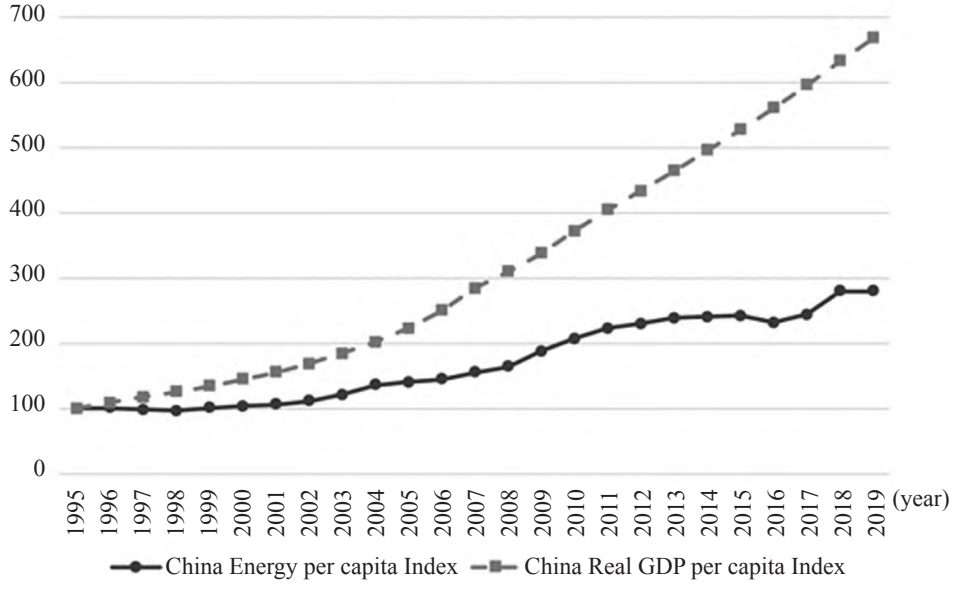
where y represents the forest area, x represents the annualized growth rate of real GDP per capita (in percentages), and *trend* represents the control variable for the linear time trend. Using the data in Figure 3 above, we obtain a regression result with an estimate of 0.02 for the coefficient γ_1 and a t-statistic of 5.4. The regression result clearly shows that China's per capita GDP growth has a significant positive synergistic relationship with forest area, and the coefficient of economic growth is statistically significant at the 0.1 percent level. This result proves that under China's new ecosystem protection paradigm, economic growth does not need to come at the expense of ecological degradation. Instead, a mutually beneficial relationship can emerge between ecosystem quality and economic growth.

The working mechanism of this evolution, shown in Figure 3, can be explained by our new theoretical growth model based on the concept of ecological civilization. In our model, an increase in forest area represents an increase in the scale of ecological innovation from forest ecosystems. This increases the value of the parameter σ, which increases the growth rate of the overall ecological quality B. Thus, this allows the economy to maintain a positive sustainable growth rate while at the same time allowing for the success of the ecosystem

conservation paradigm.

In addition to carrying out ecological conservation and restoration practices, China has been making great efforts to promote green development. Under the concept of ecological civilization, China's economic development model is being transformed into a green development model. We can observe the effectiveness of green development practices from Figure 4 below. We show in Figure 4 the evolution of China's consumption-based per capita energy use index (index normalized to 100 in 1995) and China's real GDP per capita index (index normalized to 100 in 1995) from 1995 to 2019. We can see that in the past 25 years, China has been able to support a stable annual economic growth rate of 8 percent with just a 4.5 percent annual growth rate of energy consumption per capita.

Figure 4 Evolutions of Consumption-based Energy Use Index and Real GDP Per Capita Index in China



Data source: Our World in Data at https://ourworldindata.org/.

We can also use regression analysis to further illustrate the relationship between China's economic growth and energy consumption increase. We use the following regression model:

$$y_t = \delta_0 + \delta_1 x_t + \epsilon_t, \tag{18}$$

where y represents the annual growth rate of energy consumption per capita index (in percentages), and x represents the annual growth rate of real GDP per capita index (in percentages). Using the data in Figure 4 above, we obtain a regression result with an estimate of 0.79 for the coefficient δ_1 and a t-statistic of 4.7. The regression result

demonstrates that the elasticity coefficient of China's energy use increase to economic growth is significantly less than 1. Each unit of economic growth does not require the same unit of energy consumption as production input. This result provides clear evidence of China's green development achievements. Under the development paradigm of ecological civilization, China has strongly promoted the green transformation of all industries and enterprises in economic development, thus forstering ecological civilization. Therefore, China can support a stable long-term economic growth rate with a small annual rate of increase in energy consumption.

The green development concept and practice of building a mutually beneficial relationship between economic growth and ecosystem conservation can also be explained in our new growth model based on ecological civilization. In the model, green transformation and green development correspond to an increase in the parameter η, which is the rate of ecological innovation. Under the concept of ecological civilization, when the economy transits to a green growth path, the ecosystem protection paradigm will bring new growth opportunities based on ecological capital or green capital (such as electric vehicles). Therefore, the pace of ecological innovation will increase, which means that the parameter η will become larger. This leads to a higher growth rate in the ecological quality B, enabling the economy to improve ecological quality under the new ecosystem conservation paradigm while maintaining long-term economic growth.

VI. The Leadership Effect of China's New Ecosystem Protection Paradigm on Global Ecological Protection

Through our earlier analysis, we can see that under the concept of ecological civilization, the new paradigm of ecosystem protection and economic growth can form a mutually beneficial relationship. Because of this mutually beneficial relationship, China's new ecological civilization development model can bring important inspiration to global ecological protection work. Therefore, in this section, we use a game theory model to demonstrate that China's goal of realizing ecological civilization and its commitment to the new ecosystem conservation paradigm under the concept of ecological civilization can play an important leadership role in promoting global ecological protection cooperation.

Now we consider the game theory model in Figure 5 below. We have China as player A and the rest of the world as player B. The actions of A and B are shown in rows and columns respectively. "New conservation" refers to choosing the new ecosystem protection paradigm based on the concept of ecological civilization, while "old conservation" refers to sticking with the old protection paradigm under industrial civilization. The corresponding outcomes for each action pair are shown in boxes.

Figure 5 A Game Theory Model for Global Ecological Protection Cooperation

		B's action	
		New conservation	Old conservation
A's action	New conservation	1, 1	-1, 2
	Old conservation	2, -1	0, 0

In this global game, to achieve the best outcome (1, 1) for global ecosystems, A and B need to cooperate on choosing the new ecosystem conservation paradigm. However, if there is no leadership effort on committing to "new conservation" action then the best strategy for both players is choosing the "old conservation" action. This well-known result, prisoners' dilemma, characterizes the current situation in global ecosystem conservation, exemplified by the failure of the Aichi Biodiversity Targets. In this situation, if there was no way to enforce the new conservation paradigm, then countries would choose to remain in the old conservation paradigm based on industrial civilization, and would not contribute toward global biodiversity and ecosystem conservation goals. Thus the outcome (0, 0) is obtained, which means no achievement can be attained on global ecosystem conservation.

However, in this global game, the dilemma result would change drastically when one player can exert a leadership effort on committing to the cooperative strategy. Then the other player would also follow and choose the cooperative strategy. Due to the well-known result of the Folk Theorem in game theory, when this global game is infinitely repeated, as long as the discount rate is not too large, the best global outcome (1, 1) can be sustained the whole time when there is a creditable commitment mechanism for choosing the cooperative strategy "New Conservation."[22]

In our framework, this result means China's commitment to the ecological civilization development model and the new ecosystem conservation paradigm can act as a credible mechanism for cooperation on global ecological conservation. By transforming its development model and its ecosystem conservation paradigm under the concept of ecological civilization, China is exerting a leadership effort on global ecological protection. Through multilateral communication and exchanges, China and other countries can cooperate credibly on global ecosystem protection, so that the optimal global ecological outcome (1,1) can be achieved and maintained under the new conservation paradigm. In this regard, the new ecosystem protection paradigm under the concept of ecological civilization can transform the zero-sum global game into a mutually beneficial cooperative game where the best global ecological outcome can be realized. As a result, China's leadership effort on the new

22 D. Fudenberg and E. Maskin, "The Folk Theorem in Repeated Games with Discounting or with Incomplete Information."

ecosystem protection paradigm will play a vital role in promoting global cooperation on ecological conservation in the future.

We can see that under the new paradigm, China's leadership effort on global ecological protection cooperation has led to remarkable achievements. In the recently ended second phase of the COP15 to the CBD, under the presidency of China and under its leadership, the conference adopted the "Kunming-Montreal Global Biodiversity Framework." This Framework is an important contribution to the protection of global ecosystems and offers a new blueprint for global ecosystem governance for a long time into the future. The realization of this Framework and related achievements reflect China's strong commitment to global ecological protection cooperation and its responsible attitude towards global ecological governance. They also demonstrate China's consistent principle of solidarity in dealing with global issues.

As well as changing global cooperation strategies, the new paradigm of ecosystem protection led by China also has the following important implications for developing countries' embarkation on a path of ecological priority and green development that is different from developed countries. First of all, by providing support in technology, methods, capacity building and other aspects, China can help developing countries expedite the transformation of green development and improve the quality of ecosystems. Through the establishment of the "Belt and Road" Green Development International Alliance, China has actively cooperated with more than forty developing countries in ecosystem protection and green transformation. Second, in view of the regionality and particularity of natural resources and ecosystems in developing countries, China's ecological protection practices can help developing countries solve their ecological problems with local characteristics. Through the framework of "South-South Cooperation," China has provided local biodiversity protection support to more than eighty developing countries. Third, with the support of development funds from China, developing countries can better form a set of ecosystem protection mechanisms with their own characteristics. Using subsidies from biodiversity funds, developing countries can implement policies that prioritize ecological conservation and accelerate green and sustainable development.

VII. Conclusion

Since the industrial revolution, the traditional economic growth model under industrial civilization has greatly increased productivity and human wealth, but has also led to large-scale unsustainability and ecosystem crises around the world. In the traditional development model, ecosystem protection conflicts with economic development, and thus has to be subordinated to economic growth. In order to fundamentally resolve the global ecosystem problem and achieve sustainable development, a transformation from traditional industrial civilization to ecological civilization is inevitable. Therefore, escaping from the industrial

civilization model and embracing the ecological civilization development model will bring about a systemic change in the ecosystem protection paradigm.

In this paper, we examine the fundamental principle of China's new ecosystem conservation paradigm under the concept of ecological civilization. First, using a theoretical model, we explain that the traditional ecosystem protection paradigm in the standard economic growth model under industrial civilization cannot prevent the occurrence of ecological crises. Then, we construct a new theoretical growth model to show that in the new growth model under ecological civilization, ecosystem protection and sustainable economic growth are mutually beneficial and can be achieved together. We also provide empirical evidence of the effectiveness of China's new ecosystem conservation paradigm under the concept of ecological civilization. In addition, we use a game theory model to reveal the significant implications of China's new conservation paradigm for global ecological protection, especially its vital role in achieving the expected goals of the post-2020 global biodiversity framework.

In developing a systematic theoretical framework, our paper shows the important meaning of the ecological civilization concept and development model for ecosystem protection. The ecosystem problem is not just a problem of ecological protection, but more importantly a problem regarding the transformation of the development model. Under the model of industrial civilization, ecosystem protection is a drag on economic growth. This is the fundamental issue associated with the industrial civilization development model. However, under the model of ecological civilization, the new paradigm of ecosystem protection can improve the quality of ecological capital and the speed of ecological (green) innovation, and provide new channels for economic growth. This changes the relationship between ecosystem protection and economic growth from the conflicting one of the traditional model to a mutually beneficial one. Therefore, the development model of ecological civilization has inherently altered the passive role of ecosystem protection in development, and fundamentally resolved the contradiction between ecological protection and economic growth.

To protect the global ecosystem, we need to shift from the traditional development model to a new development model based on ecological civilization, and this transformation will undoubtedly lead to many new research issues on ecological protection and sustainable economic growth. We leave these interesting questions for future research.

Notes on Author

Xu Jiangmin, PhD, is Associate Professor at the Guanghua School of Management, Peking University. His current research focuses on climate change and sustainability, climate economics, and climate finance. His research results have been published in top academic journals, and he has won the Best Paper Award at the China International Conference in Finance. His representative works include "Climate Risks and Market Efficiency" (coauthored, *Journal of Econometrics*, vol. 208, 2019, no. 1); "Inferring

Latent Social Networks from Stock Holdings" (coauthored, *Journal of Financial Economics*, vol. 131, 2019, no. 2); "Location Choice, Portfolio Choice" (coauthored, *Journal of Financial Economics*, vol. 138, 2020, no. 1). E-mail: jiangminxu@gsm.pku.edu.cn.

References

Acemoglu, D. *et al*. "The Environment and Directed Technical Change." *American Economic Review*, vol. 102, 2012, no. 1.

Aghion, P. and P. Howitt. *Endogenous Growth Theory*. Cambridge. MA: MIT Press, 1998.

Arrow, K. *et al*. "Sustainability and the Measurement of Wealth." *Environment and Development Economics*, vol. 17, 2012, no. 3.

Besley, T. and A. Dixit. "Environmental Catastrophes and Mitigation Policies in a Multiregion World." *Proceedings of the National Academy of Sciences*, vol. 116, 2019, no. 12.

Dasgupta, P. "Commentary: The Stern Review's Economics of Climate Change." *National Institute Economic Review*, vol. 199, 2007, no. 1.

——. "Discounting Climate Change." *Journal of Risk and Uncertainty*, vol. 37, 2008, nos. 2-3.

——. "Measuring the Wealth of Nations." *Annual Review of Resource Economics*, vol. 6, 2014.

——. *The Economics of Biodiversity: The Dasgupta Review.* London: HM Treasury, 2021.

Fu, B. and Y. Lü. "The Progress and Perspectives of Landscape Ecology in China." *Progress in Physical Geography: Earth and Environment*, vol. 30, 2006, no. 2.

Fudenberg, D. and E. Maskin. "The Folk Theorem in Repeated Games with Discounting or with Incomplete Information." *Econometrica*, vol. 54, 1986, no. 3.

Goldstein, J.H. *et al*. "Integrating Ecosystem-service Tradeoffs into Land-use Decisions." *Proceedings of the National Academy of Sciences*, vol. 109, 2012, no. 19.

Green, E.J. *et al*. "Relating Characteristics of Global Biodiversity Targets to Reported Progress." *Conservation Biology*, vol. 33, 2019, no. 6.

Greenstone, M., E. Kopits and A. Wolverton. "Developing a Social Cost of Carbon for US Regulatory Analysis: A Methodology and Interpretation." *Review of Environmental Economics and Policy*, vol. 7, 2013, no. 1.

Grossman, G. and A.B. Kruger. "Economic Growth and the Environment." *Quarterly Journal of Economics*, vol. 110, 1995, no. 2.

Hardin, G. "The Tragedy of the Commons." *Science*, vol. 162, 1968, no. 3859.

Jones, C.I. "The Costs of Economic Growth." Unpublished, 2009.

Lu, Y. *et al*. "Forty Years of Reform and Opening Up: China's Progress Toward a Sustainable Path." *Science Advances*, vol. 5, 2019, no. 8.

Ma, K., Z. Lou and R. Su. "Review and Outlook of Biodiversity Research in the Chinese Academy of Sciences." *Bulletin of Chinese Academy of Sciences*, vol. 25, 2010.

Mendelsohn, R.O. "A Critique of the Stern Report." *Regulation*, vol. 29, 2006, no. 4.

Ministry of Environmental Protection of People's Republic of China. *China National Biodiversity Conservation Strategy and Action Plan 2011-2030 (NBCSAP 2011-2030).* Beijing: China

Environmental Science Press, 2010.

Nature Editorial. "The United Nations Must Get Its New Biodiversity Targets Right." *Nature*, vol. 578, 2020, no. 7795.

Nordhaus, W.D. *Managing the Global Commons: The Economics of Climate Change.* Cambridge, MA: MIT Press, 1994.

——. "A Review of the Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, vol. 45, 2007, no. 3.

Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge, UK: Cambridge University Press, 1990.

——. "A General Framework for Analyzing Sustainability of Social-ecological Systems." *Science*, vol. 325, 2009, no. 5939.

——. "Beyond Markets and States: Polycentric Governance of Complex Economic Systems." *American Economic Review*, vol. 100, 2010, no. 3.

Phillips, P.C.B. and M. Loretan. "Estimating Long-Run Economic Equilibria." *Review of Economic Studies*, vol. 58, 1991, no. 3.

Polasky, S. and K. Segerson. "Integrating Ecology and Economics in the Study of Ecosystem Services: Some Lessons Learned." *Annual Review of Resource Economics*, vol. 1, 2009, no. 1.

Polasky, S. *et al*. "Inclusive Wealth as a Metric of Sustainable Development." *Annual Review of Environmental Resources*, vol. 40, 2015.

Polasky, S. *et al*. "Role of Economics in Analyzing the Environment and Sustainable Development." *Proceedings of the National Academy of Sciences*, vol. 116, 2019, no. 12.

Stern, N. *The Economics of Climate Change: The Stern Review*. New York: Cambridge University Press, 2007.

Stokey, N.L. "Are There Limits to Growth?". *International Economic Review*, vol. 39, 1998, no. 1.

van der Zwaan, B.C.C. *et al*. "Endogenous Technological Change in Climate Change Modelling." *Energy Economics*, vol. 24, 2002, no. 1.

Wang, W. *et al*. "Biodiversity Conservation in China: A Review of Recent Studies and Practices." *Environmental Science and Ecotechnology*, vol. 2, 2020.

Wei, F. *et al*. "Main Achievements, Challenges, and Recommendations of Biodiversity Conservation in China." *Bulletin of Chinese Academy of Sciences*, vol. 36, 2021, no. 4.

Weitzman, M.L. "A Review of the Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, vol. 45, 2007, no. 3.

——. "On Modeling and Interpreting the Economics of Catastrophic Climate Change." *Review of Economics and Statistics*, vol. 91, 2009, no. 1.

Zhang, Y. "Environmental Governance: A Perspective from Industrial Civilization to Ecological Civilization." *China Economist*, vol. 17, 2022, no. 2.

——*Edited by* Shu Jianjun *and* Ma Yuhong
Polished by Sally Borthwick