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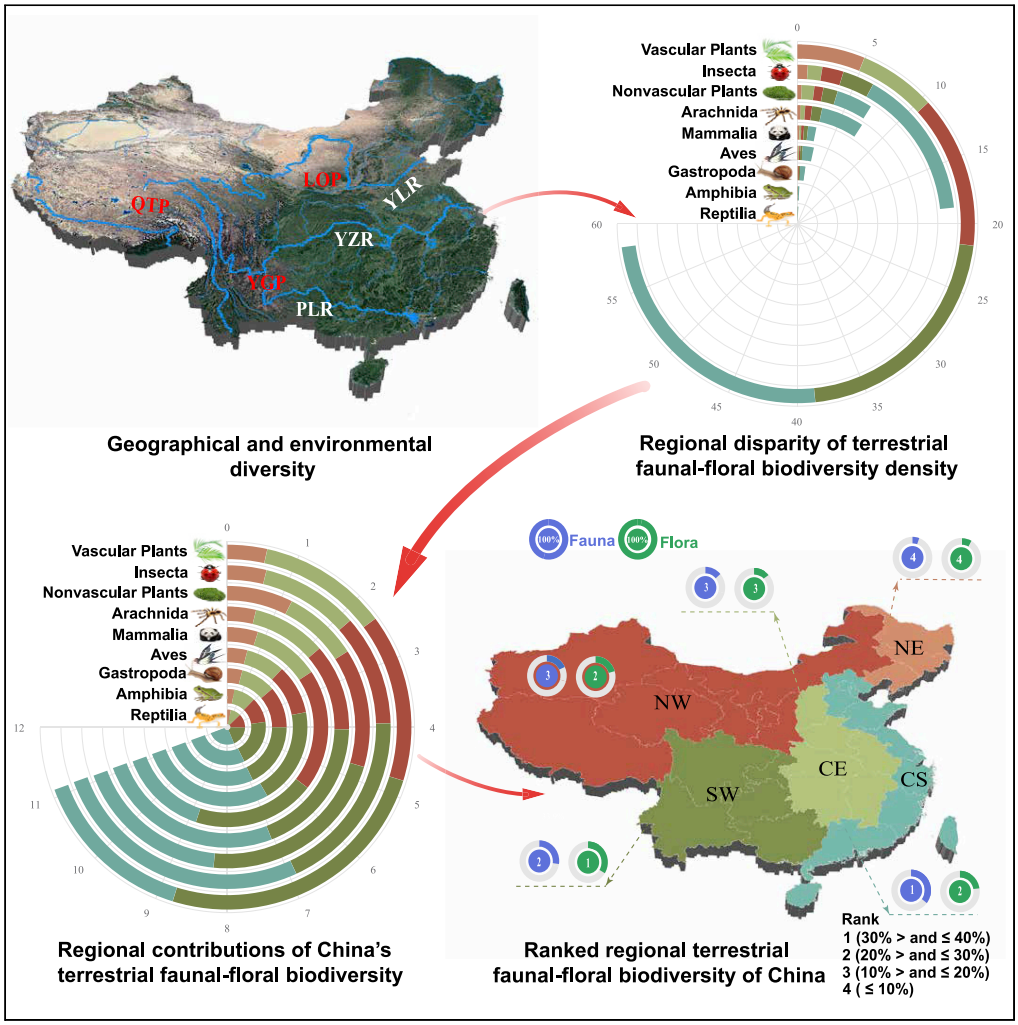

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Highlights

Terrestrial faunal-floral biodiversity (TFFB) in China

Regional variation assessment of TFFB in China

China's regional disparity in human impact and evolutionary development

Regionalized conservation strategies in China

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Regional fauna-flora biodiversity and conservation strategy in China

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SUMMARY

Evolutionary and historical development and current profiles are essential to generating a tangible conservation strategy. It is also critical to distinguish the regions with vigorous potential growth from those meeting evolutionary development bottlenecks and those whose development has been severely devastated. We used two sizeable national data repositories of terrestrial fauna and flora of China to approach the issues. The results indicate that the Southwest and Coastal regions have the most significant terrestrial faunal-floral biodiversity (TFFB). Thus, they should be prioritized in conservation for great potential promotions. Although there has been remarkable evolutionary development, the Central region has been severely devastated. A solution is to uphold a balanced association between social-economic development and TFFB sustainability. As for the Northeast and the western Northwest, there is no need to invest heavily in conservation measures. This study sheds light on exploring more practical conservation strategies regionally, nationally, and globally to achieve pragmatic goals.

INTRODUCTION

The formation of conservation and environmental protection strategies has to refer to the environmental and ecological quality, faunal-floral biodiversity, sustainability supporting social-economic development, evolutionary development history, and resilience to external factors. Several appraisal methods have been applied up to now: (1) System index, a measurement of environmental quality and capacity, based on the variables relevant to the topography, soil components, vegetation, natural disasters, and potential social-economic development (Peng et al., 2016); (2) Ecological footprints, measuring natural resource capacity, the balance between environmental material consumption and restoration (Wackernagel and Rees, 1996); (3) Energy analysis, qualitatively and quantitatively gauging the ability of generating renewable energy, balance between energy production and sustainability, and environmental loadings (Jung et al., 2018); (4) Environmental dynamics, evaluating changing trajectories of climate, carbon cycle, economy, population growth, land use and agriculture, hydrological cycle, water quality and usages (Davies and Simonovicb, 2011); (5) Optimized development, appraising whether the designed sustainability between social-economic development and biodiversity maintenance are the best solution, referring to the balances of natural resources, water and energy provided by the environments, and atmospheric capacity of tolerating air pollution (Wang and Zeng, 2013); and (6) Environmental sustainability, assessing whether there are balanced consumption and restoration relationships for different kinds of natural resources, referring to environmental assimilative ability, ecosystem durability, and supporting power from the society (Liu and Borthwick, 2011).

Those assessments, however, rely on the horizontal level of contemporary environmental and biodiversity parameters without considering the vertical (evolutionary) development. Such evolutionary processes compose some critical issues needed to be clarified while designing a tangible conservation strategy, such as how the environment and biodiversity have been developed, shaped, and damaged; how the resilience to natural and human-induced disasters has evolved, weakened, or lost; and how the regional disparity of the biodiversity can be referred. On the other hand, the diversities of the fauna and flora are analyzed separately and evaluated at a lower scale, without an integral picture showing crucial evidence and information to estimate regional conservation profiles. In other words, relying on current environmental and biodiversity parameters and considering faunal or floral biodiversity alone likely offers incomplete or misleading information to predict the potential integrity of environmental development and conservation prospects.

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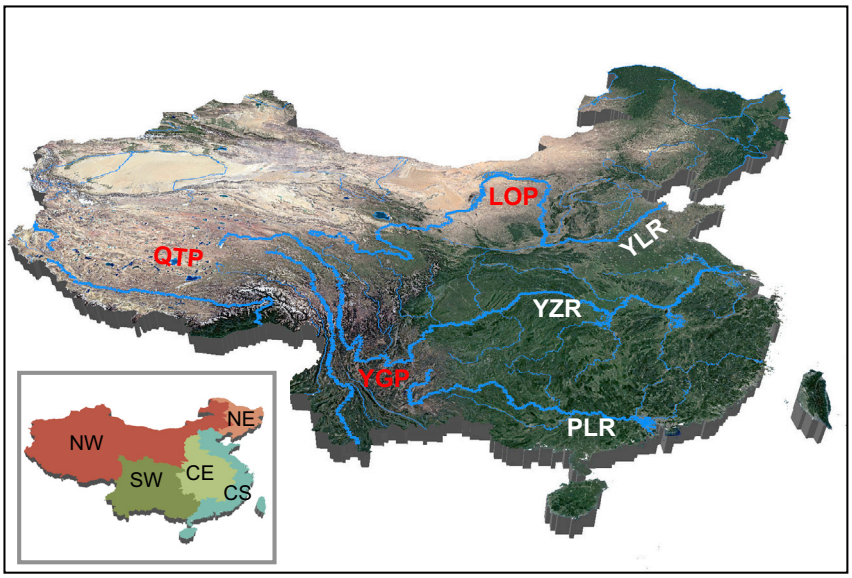

Figure 1. China's geographic and environmental diversity profiles and regionalization

NW:Northwest (Inner Mongolia, Ningxia, Gansu, Shaanxi, Qinghai, Xinjiang, and Tibet); SW:Southwest (Sichuan,Chongqing. Yunnan, Guizhou, and Guangxi); CE:Central (Shanxi, Henan, Anhui, Hubei, Hunan, and Jiangxi); CO:Costal (Hebei, Shandong. Jiangsu, Zhejiang. Fujian, Guangdong, Hainan, and the three metropolis cities of Beijing, Tianjin, and Shanghai); NE:Northeast (Heilongjiang. Jilin, and Liaoning). For more details about regional differences in geography, ecology, and habitats, please see (Huang et al., 2021).

Evolutionary developing forces of environment and biodiversity in China have played considerable roles in creating and maintaining greatly diversified topography, ecology, habitat, climate, and water resources (Figure 1). The current profiles are a consequential balance between evolutionary development, restoration, natural disasters, and human interruption (Hendry et al., 2010). Thus, we must identify whether a region's environmental quality and biodiversity profile are primarily the consequence of the development and resilience of evolution or human devastation. Such identification is vitally required for environmental protection and biodiversity conservation to tangibly achieve goals based on available financial resources and human powers. Such a research model can be set up with remarkably varied regional fauna-flora biodiversity archives in China, referring to what is illustrated in Figure 1, developed and shaped since the Cambrian more than 500 mya (Chen et al., 2001) so that it is now one of the global mega biodiversity centers.

It is recognized that the significant changes in the terrestrial faunal and floral biodiversity (TFFB) in China appeared since the Quaternary following the accelerated lifts of the Qinghai-Tibet Plateau in the west of Northwest, Yun-Gui Plateau in the Southwest, and Loess Plateau in the north (Figure 1), resulted in the severe monsoon in East Asia that promoted glacial development (Harris et al., 2018; Li, 1991). This was followed by increasing shifts of the tropical and subtropical forests from north to south that considerably altered faunal and floral structures (Jablonski, 1998). Thus, Quaternary climate fluctuations and geographic modification significantly shaped the current distributions of many animal and plant species (Deng et al., 2019).

However, the considerable impacts on TFFB came from the increasing anthropogenic devastation to the environment following the speeding up of human extension and agricultural expansion that occurred in recent China history, which can be generally categorized into two eras: ancient China and modern China.

Ancient China, before 1800, according to (Duan et al., 1998), was primarily rural: Most Chinese communities depended on small farming villages for agriculture, mostly dominating northern China and beginning to expand into the Yangtze basin to southern China. The environment, especially in the south and southwest, was primarily similar to that of the Early Holocene – the most essential tropical and subtropical regions, bearing important fauna and flora, were still primitive (Ren et al., 2007). Although there were some social riots and disturbances, the threats to biodiversity and the environment were quite limited.

In modern China, after 1800, anthropogenic impacts on the environment increased significantly, such as the war with westerners – the first Opium Wars – in the Qing Dynasty from 1839-1842 (Antony, 2003). Simultaneously, China entered a period of chaos and turbulence: Many massive rebellions in south and southwest China occurred, conquering Central China after 14 years of battles. The threats to society and nature were catastrophic (Ouchterlony, 1844).

From 1850 to 1899, apart from the Second Opium War (1856 to 1860) (Phillips, 2011), the significant threats to China's society and environment mainly came from the Taiping Rebellion (1850–1864). It involved the most prosperous regions of the Central and Coastal, killing approximately 20 million Chinese, regarded as one of late imperial China's most subversive social uprisings and environmental devastations (Yeung, 2007b). It is described as "with rampant natural calamities, widespread social unrest, deadly military conflicts, and finally, large-scale population collapses" (Lee and Zhang, 2012).

Between 1900 and 1949, the Chinese completed the final territorial occupation by expansion, with a population size of 450 million, and the domain of the habitat and environment in Southwest and Central reached the maximum (Laves, 2011). However, the environmental damages principally came from the modern wars: The Sino-Japanese War (1937–1945), part of the Second World War, involved all parts of China except for Xinjiang and Tibet in the Northwest, with about 35 million Chinese killed and injured (Coble, 2007). The Civil War between the Kuomintang and the Communist parties from 1945 to 1949 (Coble, 2007) involved the whole nation and caused another wave of social and environmental devastation; nearly two million people were displaced from the continent to Taiwan (Fan, 2010), apart from severe damage to nature repositories (Li et al., 2020). Such threats were further made prominent because of chemical and modern destructive weapons (Li et al., 2002).

From 1950 to 1999: This was a post-war period in which China embraced the planned economic and social development under a one-party administration, which led to an unprecedented acceleration in many aspects (Gabriel, 1998), particularly agricultural expansion and rapid economic and social growth, especially over the last 40 years (Jiang et al., 2018), characterized by a significant population increase – 552.0 million in 1950 and 1.253 billion in 1999 (https://www.macrotrends.net/countries/CHN/china/population). Following a once-and-for-all upheaval in Chinese history—nationalized land ownership in the early 1950s—the current regime has successfully carried out a series of social and political campaigns to convert an agricultural country into a modern industrialized nation. Unfortunately, such effort has been at the cost of depleting natural resources, land conversion, and environmental contamination by applying a nature resource-and-carbon extensive emission developmental model, driven by the policy of establishing a world manufactory for the goods labeled *Made in China* (Cui et al., 2019; Li, 2018; Pan et al., 2016).

Between 2000 and 2020, even though natural resource depletion has been limited to some magnitude (Xiao et al., 2020), land conversion has significantly increased for urbanization and residential building demands, with an increasing rate of 17.92% in 1978 to 57.35% in 2016 (Ya-Feng et al., 2020). Several ongoing mega artificial projects have been implanted, such as the *South-North Water Transfer Project*, involving Northern, Eastern, Central, and Western China (Berkoff, 2003; Yang and Zehnder, 2005), *The Western Development Project*, and *One Belt and One Road Initiative* in Northwest China (Lahtinen, 2022; Lu and Deng, 2011). In other words, the threats to biodiversity and ecology are still very prominent.

Although recently the Chinese Government has started to envisage problems in the environment and biodiversity by investing considerable resources in protection and conservation, it is still a long way from reaching the goals of effectively and efficiently carrying on the programs and management (Yu and Czarnezki, 2013; Zhang et al., 2017). A lack of an endeavor proposed in this study might be one of the significant causes.

We thus explored variation patterns of TFFB to address regional disparity to propose a conservation strategy, which aims to set up the guidelines to effectively and tangibly invest financial resources and measures – the regions with significant TFFB backed with strong evolutionary resilience must be prioritized. To do so, we analyzed the congruence of the two biological kingdoms, clarifying whether the diversities of fauna and environment (represented by floral taxa) integrally and tightly co-existed to reflect the regional disparity of biodiversity. We provided regional-specified biodiversity profiles of the fauna and flora and discussed regional evolutionary development and human devastation processes.

Table 1. Pearson correlation coefficients (*r*) of RSDIs among faunal and floral groups

Class	Gastropoda	Arachnida	Insecta	Amphibia	Reptilia	Aves	Mammalia
Arachnida	**0.98****						
Insecta	**0.99****	**0.99****					
Amphibia	**0.97****	**0.98****	**0.99****				
Reptilia	**0.96****	**0.97****	**0.97****	**0.97****			
Aves	**0.97****	**0.98****	**0.99****	**0.96****	**0.95****		
Mammalia	0.57**	0.66**	0.61**	0.62**	0.68**	0.60**	
Vascular plant	0.71**	0.80**	0.76**	0.75**	0.77**	0.77**	**0.91****
Nonvascular plant	0.69**	0.78**	0.75**	0.71**	0.75**	0.77**	0.78**

Note: ** indicates $p < 0.01$; the coefficients with a value greater than 0.90 are bolded.

RESULTS AND DISCUSSIONS

Congruence of the fauna and flora

Table 1 presents a significant positive correlation between the groups based on *regional species density* index (RSDI). The strongest correlation, with a coefficient greater than 0.90, was found between Gastropoda and Arachnida, Insecta and Arachnida, Amphibia and Arachnida, Reptilia and Arachnida, Reptilia and Insecta, and Aves and Insecta. Vascular plants display very high correlation with Mammalia ($0.91 \leq |r| < 1.0$).

What is illustrated in Table 1 indicates that each faunal group has a significant relationship with floral ones based on RSDIs, implying that fauna and flora have established a symbiotic environmental and ecological association bridged by shelter-food provision and seed-weed dispersal through microorganisms; a hologenome theory in evolutionary development (Herrera and Pellmyr, 2009). Such a mutual interaction is more prominent among Gastropoda, Arachnida, Insecta, Amphibia, Reptilia, and Aves — they are lower vertebrates and individually have a higher than 0.95 coefficient. These groups are less resilient, tending to decline with diminishing floral biodiversity (Dai et al., 2016). They form strong inter-taxa solid ecosystem interactions, particularly regarding the Amphibia, Reptilia, and Aves, which rely heavily on the Gastropoda, Arachnida, Insecta, and marine animals in their food chains, forming part of a co-dependent ecosystem (Adite et al., 2018).

Thus, an extraordinarily strong congruence indicated in Table 1 declares that the TFFB studied can be integrally used to assess the environmental and ecological quality and the variety adopted by alternative faunal and floral groups during evolutionary development.

Regional TFFB variation

Figure 2 shows species density (RSDIs) variation scales in different regions and a regional variation of the *regional spatial distribution* (RSTDs), the combined RSDIs of all groups in each region. The former, (**a**), emphasizing *species density* variation among the groups, indicates that vascular plants present the highest density in each region, followed by Insecta, nonvascular plants, Arachnida, Mammalia, Aves, Gastropoda, Amphibia, and Reptilia. The latter, (**b**), emphasizes regional disparity of biodiversity density *at a national scale*. Coastal China demonstrates a relatively stable density among the groups and bears the highest TFFB, followed by Southwest, Northwest, Central, and Northeast.

Figure 3 illustrates a regional variation of the ranked TFFB of China; a shared proportion of the national total – fauna and flora are separated – for each region, scaled with four ranks: 0–09, 10–19, 20–29, and 30–39 of the national percentage. The Southwest is ranked first regarding floral biodiversity, followed by Coastal-Northwest and Central. Northeast China shows the lowest scale. As for the faunal biodiversity, Coastal is scaled first, followed by Southwest, Northwest-Central, and Northeast.

Coastal China shows the first and second floral biodiversity grades (Figure 3), with 35.55% and 23.41% national terrestrial floral and faunal repositories, respectively. It is characterized by a higher national proportion of the lower animals (more than 35% of Gastropoda, Arachnida, Insecta, Reptilia, and more than 40% of Aves). It also contains more than 20% of vascular and nonvascular plants and Mammalia. Its RSDIs indicate a higher environmental and ecological quality, especially considering vascular and nonvascular plants, Insecta, and Arachnida (Figure 2A).

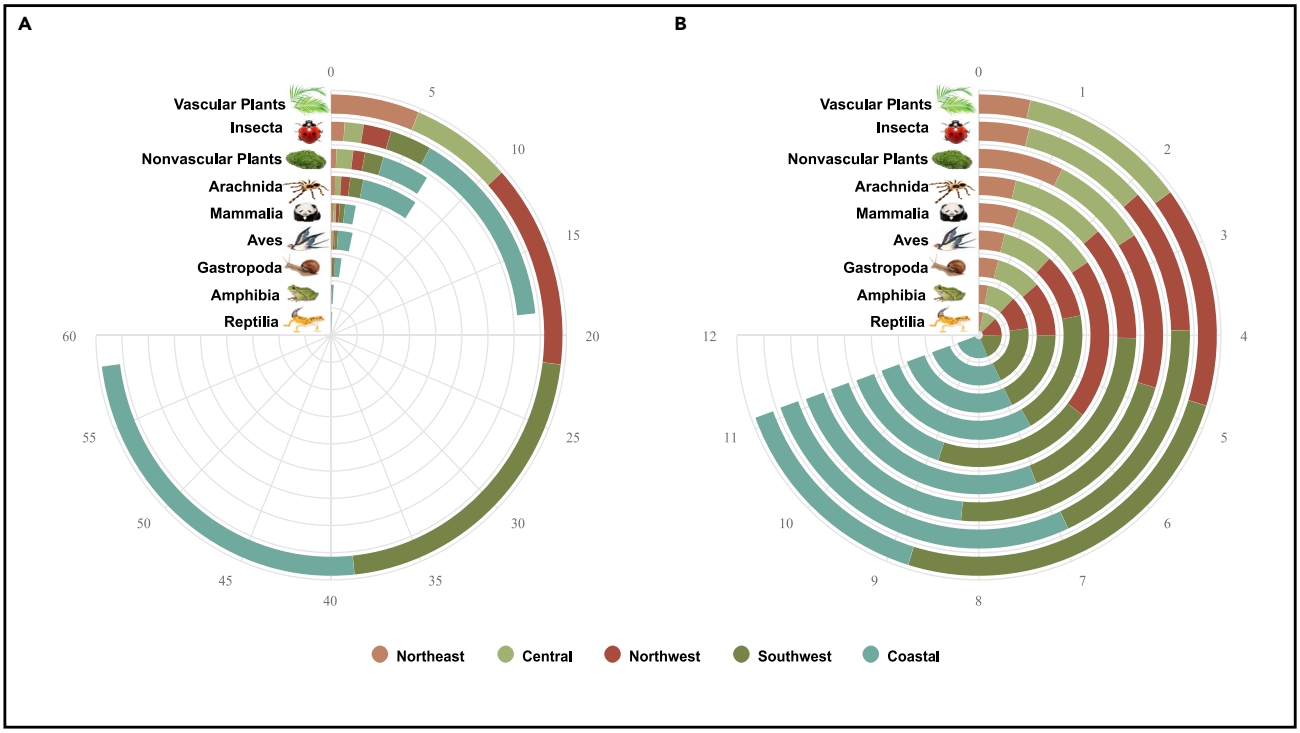

Figure 2. Regional RSDI variation patterns (species/km^2×10$^{3)}$ (A); and RSTD variation among the groups within each of the regions (B).

Such phenomena must be associated with its exceptional evolutionary development through the *Cambrian Explorations* and the later progress of five major animals and plant biotas, resulting in the basic framework of faunal and floral structures in East Asia about 500 mya (Erwin et al., 2011). A famous one was located in the Miocene Shanwang basin in Shandong. Taxonomically, it is the most diversified and extraordinarily well-preserved lacustrine fossil deposit globally, containing more than 500 fossil species, including diatoms, ostracodes, fish, amphibians, reptiles, insects, birds, and mammals, as well as terrestrial plants (Yang and Yang, 1994). Within the region, Shanghai is unique, featuring abundant lake nets, riverine, lacustrine, reservoirs, and pond wetlands, accounting for 23.5% of the Coastal size. The Dongtan Nature Reserve, one of the largest nature reserves in East Asia, was regarded as one of the world's prioritized protection sites in 2001(Tian et al., 2008). In other words, the Coastal climate, environment, and ecology are suitable for culturing highly diversified TFFB. They have collectively refined humid and semi-humid temperate, warm temperate, subtropical, and tropical zones (Huang et al., 2017), drastically promoting TFFB, especially for invertebrates and lower vertebrates, such as Gastropoda, Arachnida, Insecta, Reptilia, and Aves as found in this study, as well as small mammals (Jiang et al., 2017). On the other hand, the Coastal, especially Hainan and its neighbor regions, is an area with higher floral phylogenetic diversity (Zhang et al., 2022).

Significant anthropogenic impacts on the Coastal region in recent Chinese history, as addressed above, mainly during 1850–1899 from the Second Opium War and Taiping Rebellion; during 1990–1949 caused by the Sino-Japanese War and Civil War (Coble, 2007); and over the last decades through playing a leading role in unprecedented economic reform, created significant environmental devastation (Sun et al., 2020). However, the results found in this study imply that, compared with the other regions, Coastal China still maintains a robust evolutionary resilience.

Southwest China has the highest floral (33.90%) and second faunal (27.3%) national TFFB levels (Figure 3), showing slight spectrum variation among groups, except for the vascular plants (Figure 2B) because of their higher species density (Figure 2A). The region has been refugia for fauna and flora since the Late Miocene or Early Pliocene, particularly during the Quaternary (Sun et al., 2017). It has experienced accelerated orogenic movements, resulting in significant uplifts of the Yun-Gui Plateau and the formation of numerous rivers (Figure 1). As a result, 8 of the 14 Natural Heritage Sites in China are located there (UNESCO: https://whc.unesco.org/en/statesparties/cn), along with 9 of China's top 10 endemic floral cradles (López-Pujol and Ren, 2009b).

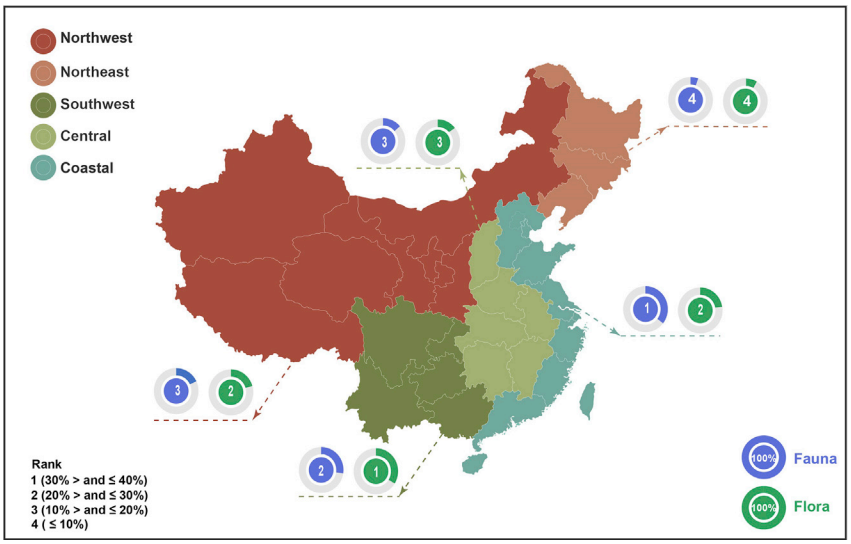

Figure 3. Regional variation of terrestrial faunal and floral biodiversity (TFFB), the summed RSTDs of the groups analyzed, in China, based on which regions are ranked for designing conservation strategy.

Like the Coastal region, the Southwest has been considered an essential early animal origin and radiation center in East Asia since the Cambrian (Erwin et al., 2011). The most famous is the *Chengjiang Biota* in Yunnan, one of the most noticeable Cambrian evolutionary explosions, a World Heritage Site for studying faunal and floral origins, evolutionary and ecological development, featured by the first fossil chordates and earliest vertebrates, and covering 34 localities in which 22,038 fossil specimens of early vertebrates were recorded (Hou et al., 2017).

Another uniqueness of the region is that it has provided an irreplaceable convergence-divergence center for faunal migration and floral exchanges between Western and Eastern Asia, particularly for the animals that migrated from Africa via Europe (He et al., 2022; Li et al., 2020). On the other hand, among nine endemic centers of the floral genera in China, three are located in the Southwest, owing to the considerable generic richness and phylogenetic diversity of angiosperm flora (Zhang et al., 2022).

Compared with the other regions, the Southwest has been less impacted by the events addressed above in recent China because of its higher mountainous contours of the plateau (Figure 1) until recently (please see below).

Thus, the Coastal and Southwest regions present significant national faunal and floral biodiversity repositories, retaining strong evolutionary resilience and great potential for TFFB promotion.

Like the Coastal region, the Northwest is ranked second according to its national faunal biodiversity (20.5%), but third considering the floral profile (18.0%, Figure 3). This region displays pretty different environmental and geological patterns compared with the Coastal region (Figure 1). It bears the Qinghai-Tibet and Loess plateaus, which appeared in the Miocene, having been dominated by a desert environment and ecology since the Miocene or Early Pleistocene (Meng and Zhang, 2013), responding to uplifting plateaus and the increasing monsoon (Favre et al., 2015). The western parts of Xinjiang and Tibet form the eastern margin of arid Central Asia (Figure 1), cold, dry, and backgrounded by meadows, montane subalpine and alpine ecosystems (Lehmkuhl and Haselein, 2000). That explains why this region, with the largest land size among the five, displays a small proportion of Aves, Amphibia, Insecta, Gastropoda, Arachnida, and Reptilia (Figure 2B), ranging from only between 14.50% and 18.55%. It also shows extremely low species density for Amphibia and Reptilia (less than 0.1species/km^2 × 10^3) compared with the Costal and Southwest regions (Figure 2A).

However, its eastern part, primary southern Shaanxi and Gansu, and east Qinghai, linking with the Qinling and the Southwest, is quite different from the west, forming one of China's biodiversity hotspots. The southeastern Qinghai and eastern Tibet of the region, where the upper reaches of the four major Asia's rivers – Salween, Mekong, Yangtze, and Yellow – originate, are unique for remarkable TFFB (Huang et al., 2021; Jiang et al., 2017), making this region contain almost the same Mammalia repositories as the Southwest (Figure 2B). Furthermore, like the Southwest, the southeast parts of the Northwest have been refugia for faunal and floral taxa since the glaciation (Ma et al., 2017).

Owing to its great geographic separation hedged by the plateaus, the Northwest avoided significant anthropogenic devastations in recent Chinese history until the beginning of this century, following the implementation of the *Western Development Project* and *One Belt and One Road Initiative* (Lahtinen, 2022; Lu and Deng, 2011).

Central China has the third faunal (13.6%) and floral (14.3%) national biodiversity levels (Figure 3), behind its neighbors Southwest and Coastal. Evolutionarily and environmentally, this region has also significantly contributed to TFFB development back to the Silurian, 443–491 mya, as indicated by the fossils of early invertebrates and vertebrates unearthed in Wuhan, and Hubei, containing more than 400 fossil species (Zong et al., 2017), and by the Lower Jurassic Anyao Formation in western Henan, a Mesozoic Jiyuan-Yima Basin (Buatois et al., 1996). Those found in Anhui and Shanxi had unique roles in dispersing early vertebrates and mammals in eastern Central and southern China during the Mesozoic, 256–66 mya (Chang et al., 2012). Another noticeable ecological biota is Huaibei Flora in the Early Permian (300 mya), a floral assemblage in a triangular area surrounded by northern Jiangsu, Anhui, and southern Henan (Mei et al., 1996). What followed was the mammalian development during the Paleocene (66–56 mya), confirmed by Danjiangkou environmental biota in Hubei (Huang et al., 2004), and several other mammal-fossil burying sites in the areas across the Yellow and Yangtze Rivers during the Neogene (23–2.6 mya) (Deng, 2006; Flynn et al., 1997).

Thus, unlike Southwest and Coastal China, a third TFFB national grade in the Central region must be associated with the significant anthropogenetic-induced activities, starting from the appearance of the modern Chinese; Hongshan men in Anhui, Central China, led to most of the populations in China on a large scale approximately 5,300 years ago, the significant development of Chinese history and civilization (Yu and Li, 2021); three capital cities (Luoyang, Kaifeng, and Anyang) among China's top seven ancient capitals were allocated in Henan (https://www.chinadiscovery.com/articles/top-7-ancient-capitals-of-china.html). Unfortunately, this modern human civilization brought significant environmental and ecological devastation, echoed by degraded TFFB: The shared proportion for each group is lower than those of Coastal, Southwest, and Northwest (Figure 2B). Furthermore, three of the 11 mammalian orders became extinct (Huang et al., 2021).

The Central has further been significantly devastated in recent Chinese history, such as the First Opium War during 1839–1842 (Antony, 2003), the Second Opium War, and Taiping Rebellion between 1850 and 1899 (Phillips, 2011; Yeung, 2007a), and the Sino-Japanese War and Civil War from 1900 to 1949 (Coble, 2007). Most recently, the Central has involved extensive human engagements through several gigantic artificial projects: the *South-North Water Transfer Project* and the *Three Gorges Dam* in Yichang, Hubei, the largest hydrologic project globally. The area used to be one of the TFFB hotspots in China, with more than 6,000 plant species, over 500 terrestrial vertebrates, and about 160 fish species recorded before the project (López-Pujol and Ren, 2009a). Unfortunately, such a magnificent faunal structure has been ravaged because of a drastically fragmented environment and ecology: More than 100 mountains previously linked by land are now isolated following the rising water level, particularly during the flood period (Wu et al., 2004).

In other words, the remarkable evolutionary development in the environment and ecology in Central China has been significantly wrecked by anthropogenic activities, which overpowered evolutionary resilience, a different scenario from the Coastal and Southwest regions.

Northeast China is the region with the lowest national TFFB profiles, both faunal (5.6%) and floral (7.9%) (Figure 3). Only nonvascular plants do share more than 10% of the national total (Figure 2B). The region also presents the lowest species density of vascular plants among the five regions, close to 8 ($7.98/km^2 \times 10^3$) (Figure 2A).

The most significant evolutionary contribution of the region is the discovery of the feathered dinosaurs, implying the origin of the birds in the Early Cretaceous, and it is where mammals originated in East Asia (Hu et al., 1997). Its Jehol Biota, widely distributed in other adjacent areas, including Magnolia, during the late Mesozoic, is featured by remarkable faunal and floral deposits of early invertebrates and vertebrates (charophyte algae, bivalves, gastropods, ostracods, shrimps, insects, spiders, fish, amphibians, reptiles, birds, and primitive mammals) (Zhou and Wang, 2017).

Regrettably, such environment and ecology grandeur started degrading during the Quaternary, rooted in the permafrost and periglacial environment with a dry and cold climate (Jin et al., 2016). The region's environment and ecology have experienced five successive negative changes from cold-temperate mixed coniferous and broadleaved forests to forest-steppe, steppe-woodland, steppe, and finally meadow-woodland featured with

alkaline or saline (Zhao et al., 2016). Such experiences have collectively constrained environmental and ecological development, and its evolutionary resilience has diminished dramatically.

Historically, the Northeast was significantly devastated during the Sino-Japanese War (1937–1945) (Coble, 2007), and the post-war period after 1950 suffered from significant deforestation, with an annual forest loss of 1,014 km^2 between 1958 and 1980, resulting in thousands of environmental fragmentations (Gao and Liu, 2012), making it be a leader in the logging industry in China since 1950, in which 5.21 million m^3 of the timbers were produced by 1977, half of the nation's total (Zhang, 2008).

Thus, the Northeast is the region that has been retarded in recent evolutionary development, with a lost resilience rooted in an evolutionary bottleneck and human-induced activities.

Strategies for conservation

China faces severe challenges in biodiversity conservation and environmental protection. Apart from others, the lack of a tangible managerial strategy is the primary cause; the current plan is to establish the protected areas (PAs) individually (Zhang et al., 2017). On the other hand, some environmental and ecological quality evaluations used to design the strategy were aimed at the current natural resource capacity and sustainability, accommodating increased social-economic growth (Liu and Borthwick, 2011; Peng et al., 2016), without considering the regional disparity of TFFB, which collectively provide both vertical (evolutionary) and horizontal (resilience) references, as provided by this study.

By 2017, China had established more than 2,750 PAs, sporadically disseminated to different regions (He and Cliquet, 2020). Between 2000 and 2013, the total areas of PAs increased from about 0.9 million km^2 to about 1.5 million km^2, covering about 15% of China's land (Yang et al., 2019). According to (Wang et al., 2014), among the 1,110 PAs analyzed, the Southwest has the most significant number of PAs, followed by the Central, Northeast, Coastal, and Northwest regions. Thus, referring to PA's number, rather than area size, Southwest China seems to have been regarded as a priority region but not Coastal.

Although the key ecological function zones and the priority areas for biodiversity conservation in China have been mapped (Cao et al., 2015), the integral guidelines and regulations on effectively organizing PAs within and among different regions have not been seen. Thus, it is not surprising to see the conflicts of interests among managerial authorities of different regions; without a precise authorized mechanism to allocate finance within and among the regions, especially facing insufficient budgets; the shortage of public participation with clearly designed purposes; and the conflicts between PA management and local communities (He and Cliquet, 2020).

Although the Chinese Government has started to envisage the conservation and protection difficulties by increasing funding for PAs through the projects of the *Wildlife Conservation and Nature Reserve Construction* and the *Special Fund for Capacity Building of National-level Nature Reserves* in 2001, the investment was only 53.5–114 dollars/km^2, less than one-tenth of the average level invested in the developed countries ($2074.3), and even lower than that of developing countries ($158.3) (Yang et al., 2019).

Thus, among the problems stated, scientifically and tangibly distributing financial resources is more urgent, given that 58.6% of 400 surveyed PAs are short of funding to support their daily management and conservation activities – 34% of which even have no adequate resources to meet their fundamental expenditure needs (Feng et al., 2021). As a result, some PAs are described as being *paper parks* (Yang et al., 2019).

Therefore, it is very critical that the resources for PAs in China be increased on the one hand, and a financial distribution scheme guided by regional TFFB profiles and referring to the potential ability and capacity of promoting biodiversity be established on the other hand. Thus, what China needs is not only to increase PAs individually and prioritize more areas isolatedly but also to rank conservation and protection *regions* so that the limited financial resources could be invested rationally to get the best achievements according to China's geographical characteristics, evolutionary developmental background, and the existing TFFB.

According to what has been found in this study, what we must do in conservation is to prioritize the regions still bearing remarkable wildlife and natural resource diversities, still with solid evolutionary resilience for prospective promotion. Otherwise, such advantages could be lost soon. Southwest and Coastal meet such criteria, confirmed

by the most significant TFFB. They accommodate the scenario of among 36 plant genetic diversity hotspots in China, likely the glacial refugia's representatives, primarily found in those two regions (Deng et al., 2019).

Because of the prominently impoverished environment, ecology, and lost resilience, there is no need to invest heavily in conservation measures in the Northeast and the western parts of the Northwest, whose aridification began much earlier, in the Early Miocene, and drastically accelerated during the Pleistocene, with significantly low floral phylogenetic diversity (Zhang et al., 2022).

Regarding Central China, a sustainable balance between social-economic development and TFFB maintenance requires special attention from the social-economic designers and conservationists. Such a sustained balance would gradually recover its resilience since significant evolutionary development continues to force back the region, like what happened to the Coastal and Southwest.

Limitations of the study

Although this study has integrally analyzed the TFFB and exposed the disparity among five geographic regions, most of the discussion on regional evolutionary development focuses on fauna, lacking more information and evidence from the floral background. In other words, further studies to systematically disentangle some essential issues associated with these two kingdoms are demanded, such as the sympatric distribution of the hot spots, endemic centers, and phylogenetic diversity of the fauna and flora during the evolution, and the disruptions and separation between them following geographic change since the Cambrian, especially during the Neogene in which significant tectonic modifications of the plateaux of Qinghai-Tibet, Yun-Gui and Loess occurred, whose uplifts were remarkably accelerated during the Quaternary. Obviously, cooperation between botanists and zoologists in China and overseas is required.

On the other hand, the conservation strategies proposed have to be discussed and improved through liaisons with Chinese government officials, especially those in the forests and conservation departments, conservationists, and social-economic development designers. Their feedback is critically important to finally form a national conservation strategy before it can be implemented.

STAR★METHODS

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SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.isci.2022.104897.

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AUTHOR CONTRIBUTIONS

B.L.: Conceiving project objectives; R.P.: Designing contents and drafting the manuscript; H.Z.: Data acquisition, analyses, and figures; K.H., G.H., S.G., R.H., and P.Z.: Providing comments and suggestions for modifying the manuscript; H.W., H.P., H.F., K.J., and X.W.: Reference searching.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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REFERENCES

Adite, A., Gbaguidi, H.M., Adjibade, N.K., Arame, H., Imorou, R.S., and Sonon, S.P. (2018). Food web structure in a sand-dragged man-made lake of Benin, West Africa: Implications for ecosystem management. International Journal of Fauna and Biological Studies *5*, 5–12.

Antony, R.J. (2003). The Opium Wars: The Addiction of One Empire and the Corruption of Another. History: Reviews of New Books *31*, 85. https://doi.org/10.1080/03612759.2003.10527954.

Berkoff, J. (2003). China: The South–North Water Transfer Project—is it justified? Water. Pol. *5*, 1–28.

Buatois, L.A., Mângano, M.G., Wu, X., and Zhang, G. (1996). Trace fossils from Jurassic lacustrine turbidites of the anyao formation (Central China) and their environmental and evolutionary significance. Ichnos *4*, 287–303.

Cao, M., Peng, L.I., and Liu, S. (2015). Analysis of the network of protected areas in China based on a geographic perspective: current status, issues and integration. Sustainability *7*, 15617–15631.

Chang, S., Zhang, H., Hemming, S.R., Mesko, G.T., and Fang, Y. (2012). Chronological evidence for extension of the jehol biota into southern China. Palaeogeogr. Palaeoclimatol. Palaeoecol. *344–345*, 1–5.

Chen, J.Y., Vannier, J., and Huang, D.Y. (2001). The origin of crustaceans: new evidence from the Early Cambrian of China. Proc. Biol. Sci. *268*, 2181–2187.

Coble, P.M. (2007). China's "New Remembering" of the Anti-Japanese War of Resistance, 1937-1945. The China Quarterly*No.190* (Cambridge University), pp. 394–410. https://www.jstor.org/stable/20192776.

Cui, Y., Liu, J., Xu, X., Dong, J., Li, N., Fu, Y., Lu, S., Xia, H., Si, B., and Xiao, X. (2019). Accelerating cities in an unsustainable landscape: urban expansion and cropland occupation in China, 1990–2030. Sustainability *11*, 2283.

Dai, P., Shi, X.Q., Liu, D.G., Ge, Z.H., Wang, D., Dai, X.J., Yi, Z.H., and Meng, X.X. (2016). Life-history trait plasticity and its relationships with plant adaptation and insect fitness: a case study on the aphid *Sitobion avenae*. Sci. Rep. *6*, 29974.

Davies, E.G.R., and Simonovicb, D.S.P. (2011). Global water resources modeling with an integrated model of the social–economic–environmental system. Adv. Water. Resour. *34*, 684–700.

Deng, T. (2006). Chinese Neogene mammal biochronology. Vert. PalAs. *44*, 143–163.

Deng, T., Abbott, R.J., Li, W., Sun, H., and Volis, S. (2019). Genetic diversity hotspots and refugia identified by mapping multi-plant species haplotype diversity in China. Isr. J. Plant. Sci. *66*, 136–151.

Duan, C.Q., Gan, X.C., Wang, J., and Chien, P.K. (1998). Relocation of civilization centers in ancient China: environmental factors. Ambio *27*, 572–575.

Erwin, D.H., Laflamme, M., Tweedt, S.M., Sperling, E.A., Pisani, D., and Peterson, K.J. (2011). The Cambrian conundrum: early divergence and later ecological success in the early history of animals. Science *334*, 1091–1097.

Fan, J. (2010). China's Homeless Generation: Voices from the Veterans of the Chinese Civil War, 1940s–1990s, 1st Edition, (London: Routledge). https://doi.org/10.4324/9780203838723.

Favre, A., Päckert, M., Pauls, S.U., Jähnig, S.C., Uhl, D., Michalak, I., and Muellner-Riehl, A.N. (2015). The role of the uplift of the Qinghai-Tibetan Plateau for the evolution of Tibetan biotas. Biol. Rev. Camb. Philos. Soc. *90*, 236–253.

Feng, C., Cao, M., Wang, W., Wang, H., Liu, F., Zhang, L., Du, J., Zhou, Y., Huang, W., and Li, J. (2021). Which management measures lead to better performance of China's protected areas in reducing forest loss? Sci. Total. Environ. *764*, 142895.

Flynn, L.J., Wu, W., and Downs, W. (1997). Dating vertebrate microfaunas in the late Neogene record of Northern China. Palaeogeogr. Palaeoclimatol. Palaeoecol. *133*, 227–242.

Gabriel, S. (1998). The structure of a post-revolutionary economic transformation: the Chinese economy from the 1949 revolution to the great leap forward. In Chinese Essay Series.

Gao, J., and Liu, Y. (2012). Deforestation in heilongjiang province of China, 1896–2000: severity, spatiotemporal patterns and causes. Appl. Geogr. *35*, 345–352.

Harris, S.A., Jin, H.J., He, R.X., and Yang, S.Z. (2018). Tessellons, topography, and glaciations on the Qinghai-Tibet Plateau. Sciences in Cold and Arid Regions *10*, 187–206.

He, M., and Cliquet, A. (2020). Challenges for protected areas management in China. Sustainability *12*, 5879.

He, G., Zhang, H., Wang, H.T., Ji, X.P., Guo, S.T., Li, B.G., Hou, R., Hou, X.D., and Pan, R.L. (2022). Dispersion, speciation, evolution, and coexistence of East Asian catarrhine primates and humans in Yunnan, China. In World Archaeoprimatology: Interconnections of Humans and Nonhuman Primates in the Past, B. Urbani, D. Youlatos, and A. Antczak, eds. (Cambridge Cambridge University Press).

Hendry, A.P., Lohmann, L.G., Conti, E., Cracraft, J., Crandall, K.A., Faith, D.P., Häuser, C., Joly, C.A., Kogure, k., Larigauderie, A., et al. (2010). Evolutionary biology in biodiversity science, conservation, and policy: A call to action. Evolution *64*, 1517–1528. https://doi.org/10.1111/j.1558-5646.2010.00947.x.

C.M. Herrera, and O. Pellmyr, eds. (2009). Plant animal interactions: an evolutionary approach (John Wiley & Sons).

Hou, X., Siveter, D., Siveter, D., Aldridge, R., Cong, P., Gabbott, S., Ma, X., Purnell, M., and Williams, M. (2017). The Cambrian Fossils of Chengjiang, China: The Flowering of Early Animal Life, Second Edition (John Wiley & Sons Ltd).

Hu, Y., Wang, Y., Luo, Z., and Li, C. (1997). A new symmetrodont mammal from China and its implications for mammalian evolution. Nature *390*, 137–142.

Huang, J., Ma, K., and Huang, J. (2017). Species diversity distribution patterns of Chinese endemic seed plants based on geographical regions. PLoS One *12*, e0170276.

Huang, K., Zhang, H., Wang, C., Hou, R., Zhang, P., He, G., Guo, S., Tang, S., Li, B., Oxnard, C., and Pan, R. (2021). Use of historical and contemporary distribution of mammals in China to inform conservation. Conserv. Biol. *35*, 1787–1796.

Huang, X., Li, C., Dawson, M.R., and Liu, L. (2004). Hanomys malcolmi, a new simplicidentate mammal from the Paleocene of central China: its relationships and stratigraphic implications. Bull. Carnegie Mus. Nat. Hist. *36*, 81–89.

Jablonski, N.G. (1998). The response of catarrhine primates to pleistocene environmental fluctuations in East Asia. Primates *39*, 29–37.

Jiang, J., Luo, L., Xu, P., and Wang, P. (2018). How does social development influence life expectancy? A geographically weighted regression analysis in China. Publ. Health *163*, 95–104.

Jiang, Z., Liu, S., Wu, Y., Jiang, X., and Zhou, K. (2017). China's mammal diversity (2nd edition). Biodivers. Sci. *25*, 886–895.

Jin, H.J., Chang, X.L., Luo, D.L., He, R.X., Lü, Z.L., Yang, S.Z., Guo, D.X., Chen, X.M., and Harris, S.A. (2016). Evolution of permafrost in Northeast China since the late pleistocene. Sciences in Cold and Arid Regions *8*, 269–296.

Jung, C., Kim, C., Kim, S., and Suh, K. (2018). Analysis of environmental carrying capacity with emergy perspective of jeju island. Sustainability *10*, 1681.

Lahtinen, A. (2022). The Belt and Road initiative. In China's Global Aspirations and Confucianism (Palgrave Macmillan). https://doi.org/10.1007/978-3-031-03597-5_5.

Laves, E.W. (2011). Chinese civilization and society: a sourcebook. J. Asian Stud. *41*, 322–323.

Lee, H.F., and Zhang, D.D. (2012). A tale of two population crises in recent Chinese history. Climatic Change *116*, 285–308.

Lehmkuhl, F., and Haselein, F. (2000). Quaternary paleoenvironmental change on the Tibetan Plateau and adjacent areas (Western China and Western Mongolia). Quat. Int. *65–66*, 121–145.

Li, B., He, G., Guo, S., Hou, R., Huang, K., Zhang, P., Zhang, H., Pan, R., and Chapman, C.A. (2020). Macaques in China: evolutionary dispersion and subsequent development. Am. J. Primatol. *82*, e23142.

Li, J.J. (1991). The environmental effects of the uplift of the Qinghai-Tibet Plateau. Quaternary. Sci. Rev. *10*, 479–483.

Li, L. (2018). China's manufacturing locus in 2025: With a comparison of "Made-in-China 2025" and "Industry 4.0". Technol. Forecast. Soc. *135*, 66–74.

Li, B.G., Pan, R.L., and Oxnard, C.E. (2002). Extinction of Snub-Nosed Monkeys in China During the Past 400 Years. Int. J. Primatol. *23*, 1227–1244.

Liu, R.Z., and Borthwick, A.G.L. (2011). Measurement and assessment of carrying capacity of the environment in Ningbo, China. J. Environ. Manage. *92*, 2047–2053.

López-Pujol, J., and Ren, M.X. (2009a). Biodiversity and the three Gorges reservoir: a troubled marriage. J. Nat. Hist. *43*, 2765–2786.

López-Pujol, J., and Ren, M.X. (2009b). China: a hot spot for relict plant taxa. In book: Biodiversity hotspots, V. Rescigno, et al., eds. (Nova Science Publishers), pp. 123–137.

Lu, Z., and Deng, X. (2011). China's Western Development Strategy: Policies, Effects and Prospects (MPRA: Munich Personal RePEc Archive). https://mpra.ub.uni-muenchen.de/id/eprint/35201.

Ma, K., He, J.S., Bruelheide, H., Klein, A.-M., Liu, X., and Schmid, B. (2017). Biodiversity–ecosystem functioning research in Chinese subtropical forests. J. Plant Ecol. *10*, 1–3.

Ma, K., Ji, L., Qin, H., Liu, J.Y., Yao, Y., Lin, C., Yan, H., Wang, L., Qiao, H., and Li, R. (2015). Catalogue of life china in the catalogue of life. In: A. o. Science (ed.) (Beijing, China: The Catalogue of Life Partnership).

Mei, M., Huang, Q.C., Du, M., and Dilcher, D.L. (1996). The xu-huai-yu subprovince of the cathaysian floral province. Rev. Palaeobot. Palynol. *90*, 63–77.

Meng, H.H., and Zhang, M.L. (2013). Diversification of plant species in arid Northwest China: species-level phylogeographical history of Lagochilus Bunge ex Bentham (Lamiaceae). Mol. Phylogenet. Evol. *68*, 398–409.

Ouchterlony, J. (1844). The Chinese War: An Account of All the Operations of the British Forces from the Commencement to the Treaty of Nanking (Saunders and Otley).

Pan, R.L., Oxnard, C., Grueter, C.C., Li, B., Qi, X., He, G., Guo, S., and Garber, P.A. (2016). A new conservation strategy for China-A model starting with primates. Am. J. Primatol. *78*, 1137–1148.

Peng, J., Du, Y., Liu, Y., and Hu, X. (2016). How to assess urban development potential in mountain areas? An approach of ecological carrying capacity in the view of coupled human and natural systems. Ecol. Indic. *60*, 1017–1030.

Phillips, A. (2011). Saving civilization from empire: belligerency, pacifism and the two faces of civilization during the Second Opium War. Eur. J. Int. Relat. *18*, 5–27.

Ren, H., Li, Z., Shen, W., Yu, Z., Peng, S., Liao, C., Ding, M., and Wu, J. (2007). Changes in biodiversity and ecosystem function during the restoration of a tropical forest in south China. Sci. China C Life Sci. *50*, 277–284.

Sun, H., Zhang, J., Deng, T., and Boufford, D.E. (2017). Origins and evolution of plant diversity in the Hengduan Mountains, China. Plant Divers. *39*, 161–166.

Sun, X., Zhang, L., Lu, S.Y., Tan, X.Y., Chen, K.L., Zhao, S.Q., and Huang, R.H. (2020). A new model for evaluating sustainable utilization of coastline integrating economic output and ecological impact: a case study of coastal areas in Beibu Gulf, China. J. Clean. Prod. *271*, 122423.

Tian, B., Zhou, Y.X., Zhang, L.Q., and Yuan, L. (2008). Analyzing the habitat suitability for migratory birds at the chongming dongtan nature reserve in Shanghai, China. Estuar. Coast. Shelf. S. *80*, 296–302.

Wackernagel, M., and Rees, W. (1996). Our Ecological Footprint: Reducing Human Impact on the Earth Sharing Nature's Interest (New Society Publishers).

Wang, L.E., Zhong, L., Zhang, Y., and Zhou, B. (2014). Ecotourism environmental protection measures and their effects on protected areas in China. Sustainability *6*, 6781–6798.

Wang, W.Y., and Zeng, W. (2013). Optimizing the regional industrial structure based on the environmental carrying capacity: an inexact fuzzy multi-objective programming model. Sustainability *5*, 5391–5415.

Wu, J., Huang, J., Han, X., Gao, X., He, F., Jiang, M., Jiang, Z., Primack, R.B., and Shen, Z. (2004). The three Gorges Dam: an ecological perspective. Front. Ecol. Environ. *2*, 241–248.

Xiao, H., Tang, Z., Tan, Y., and Yi, L. (2020). The spatial distribution and potential for energy recovery of urban-rural wastes in Guangdong province, Southern China. IOP Conf. Ser. Earth Environ. Sci. *555*, 012042.

Ya-Feng, Z., Min, D., Ya-Jing, L., and Yao, R. (2020). Evolution characteristics and policy implications of new urbanization in provincial capital cities in Western China. PLoS One *15*, e0233555.

Yang, H., and Yang, S. (1994). The Shanwang fossil biota in eastern China: a Miocene Konservat-Lagerstätte in lacustrine deposits. Lethaia *27*, 345–354.

Yang, H., and Zehnder, A.J. (2005). the South-North Water transfer project in China. Water Int. *30*, 339–349.

Yang, H., Viña, A., Winkler, J.A., Chung, M.G., Dou, Y., Wang, F., Zhang, J., Tang, Y., Connor, T., Zhao, Z., and Liu, J. (2019). Effectiveness of China's protected areas in reducing deforestation. Environ. Sci. Pollut. Res. Int. *26*, 18651–18661.

Yeung, K.T. (2007a). Suppressing Rebels, Managing Bureaucrats: State -building during the Taiping Rebellion, 1850–1864 (New Brunswick ProQuest Dissertations Publishing: Rutgers The State University of New Jersey).

Yeung, K.T. (2007b). Suppression Rebels, Managing Bureaucrats State-Building during the Taiping Rebellion (Graduate School-New Brunswick (The State University of New Jersey The State University of New Jersey)), pp. 1850–1864. 244.

Yu, W.X., and Czarnezki, J.J. (2013). Challenges in China's natural resources conservation and biodiversity legislation. Environ. La. *43*, 125–144.

Yu, X., and Li, H. (2021). Origin of ethnic groups, linguistic families, and civilizations in China viewed from the Y chromosome. Mol. Genet. Genomics. *296*, 783–797.

Zhang, L., Luo, Z., Mallon, D., Li, C., and Jiang, Z. (2017). Biodiversity conservation status in China's growing protected areas. Biol. Conserv. *210*, 89–100.

Zhang, S.F. (2008). Northeast timber: the pillar of the new China. Chin. National Geogr. *576*, 240e247.

Zhang, X.X., Ye, J.F., Laffan, S.W., Mishler, B.D., Thornhill, A.H., Lu, L.M., Mao, L.F., Liu, B., Chen, Y.H., Lu, A.M., et al. (2022). Spatial phylogenetics of the Chinese angiosperm flora provides insights into endemism and conservation. J. Integr. Plant Biol. *64*, 105–117.

Zhao, C., Li, X., Zhou, X., Zhao, K., and Yang, Q. (2016). Holocene vegetation succession and response to climate change on the south bank of the heilongjiang-amur river, mohe county, Northeast China. Adv. Meteorol. *2016*, 1–11.

Zhou, Z.H., and Wang, Y. (2017). Vertebrate assemblages of the jurassic yanliao biota and the early cretaceous jehol biota: comparisons and implications. Palaeoworld *26*, 241–252.

Zong, R.W., Liu, Q., Wei, F., and Gong, Y.M. (2017). Fentou biota: a llandovery (silurian) shallow-water exceptionally preserved biota from wuhan, Central China. J. Geol. *125*, 469–478.

STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Deposited data		
China's fauna and flora data	Catalogue of Life China in the Catalogue of Life	https://www.gbif.org/dataset/b8e085cf-5f2c-47f8-9244-fd501202e475
Software and algorithms		
SPSS/PC	Statistical software for data science	version 20, IBM

RESOURCE AVAILABILITY

Lead contact

Further information and resource requests should be directed to the lead contact: Ruliang Pan (ruliang.pan@nwu.edu.cn).

Materials availability

This study did not generate new unique reagents.

Data and code availability

This study did not generate new codes. Any additional information required to reanalyze the data reported in this paper is available from Supplemental information: Data S1 and Data S2.

EXPERIMENTAL MODEL AND SUBJECT DETAILS

The animals studied include seven classes of 15,889 terrestrial species: Gastropoda (841 species), Arachnida (3,594), Insecta (8,728), Amphibia (302), Reptilia (390), Aves (1,360), and Mammalia (674). Plants analyzed include 31,006 vascular and 3,135 nonvascular species (Datas S1 and S2). They are the repositories of China's fauna and flora, compiling all recorded animal and plant species from the Life Catalogues (Ma et al., 2015). Plant and animal taxa were categorized as groups for simplicity. A small number of faunal (n = 213, 1.34%) and floral (n = 860, 2.52%) taxa were excluded from analyses because of incomplete species records and lack of information on geographical distribution. Except for Hainan Island, records from other islands such as Taiwan, Hong Kong, and Macao were excluded because of the ambiguity in defining marine or terrestrial taxa.

Our recent study demonstrates a remarkable biodiversity variation in Mammalia among the five geo-ecological regions of the mainland – Northeast, Central, Coastal, Northwest, and Southwest (Huang et al., 2021). A similar regional definition was applied in this study.

METHOD DETAILS

As for a given region, environmental and ecological quality and their changes were measured by a national proportion of the TFFB generated through the following three steps.

Regional species density (RSDI)

Regional species density (RSDI), biodiversity richness relative to its regional size for each group (Huang et al., 2021). It was calculated with the formula of RSDI = N/A, where N is the species number of a given group in a region, and A is the area of the same region (km^2). This index removes size influence in assessing the environment and ecology; there is a considerable regional land size variation. Thus, richer biodiversity for a specific faunal or floral group in a region could be because of the bigger land size instead of higher environmental and ecological quality. Pearson correlation analysis was used to explore the relationship of RSDIs among faunal and floral groups.

Regional biodiversity distribution (RSTD)

Regional biodiversity distribution (RSTD). It is the proportion of the national total for each group in each region, calculated with the formula: RSTD = N/T x 100, where N is the species number of a specific group in each region, and T is the total species number of the same group combing the five regions.

A region's TFFB profile

A region's TFFB profile is expressed by the sum of RSTDs, including all groups. SPSS/PC (version 20, IBM) was used for statistical analyzes and figure generation.

QUANTIFICATION AND STATISTICAL ANALYSIS

All results were repeatedly performed and confirmed by supplemental file Sets. Quantification and statistical analysis are presented in method details.