

Commentary

Major advances in plant ecology research in China (2020)

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Plant ecologists are interested in dissecting the relationships between plants and their abiotic (physicochemical) and biotic environments. Plants assimilate carbon dioxide (CO₂) and produce oxygen (O₂), which are essential for our lives. Unlike animals, plants are sessile in nature and cannot physically escape predators, and are frequently exposed to changing environments, e.g. the availability of water, temperature, light, CO₂, nutrients, herbivore and pathogen, during their life cycles. Plants have evolved highly plastic and resilient strategies to tolerate and withstand the variable environmental dynamics. The environments where plants grow are also reshaped and can influence plant traits, performances and functions. Plants often live in a community and have to share/compete resources with other plants in the community. Therefore, plants together with their surrounding environment control water and biogeochemical cycles at the ecosystem scale providing ecosystem functioning and services to support and transform the earth system. There are diverse ecosystems with many distinct vegetation types in China. How these ecosystems respond and adapt to the changing environments is a main theme of contemporary plant ecology. Scientists in China have made great achievements on the topic in 2020 as evidenced by publications in highly regarded international journals. Here, we comprehensively summarized the major progresses of plant ecology research in 2020.

By assembling peer-reviewed articles from 35 journals (Table 1) published in 2020, a total of 266 papers were selected. Among the selected papers, 65.8% was funded by National Natural Science Foundation of China (NSFC), 24.4% by National

Key Research and Development Program of China (NKRDPC), 12.8% by Chinese Academy of Sciences (CAS), 5.3% by China Scholarship Council (CSC) and 4.1% by China Postdoctoral Science Foundation (CPSF), respectively (Fig. 1a). The top-five institutions in terms of publication numbers are University of CAS (19.1%), Institute of Botany CAS (12.8%), Peking University (11.7%), South China Botanical Garden CAS (7.9%), Institute of Geographic Sciences and Natural Resources Research CAS (7.1%) and Lanzhou University (7.1%), respectively (Fig. 1b). Among the selected 266 papers, the top-five journals in number of published papers are *Global Change Biology* (54 papers), *Journal of Ecology* (33 papers), *Global Ecology and Biogeography* (21 papers), *Functional Ecology* (20 papers), *Ecology* (13 papers) and *Oikos* (13 papers), respectively (Fig. 1c). We further detailed the important progresses in plant ecology based on the 49 studies (Fig. 1d) from 14 selected top international journals (Table 1), with the topics ranging from plant traits to ecosystem functioning.

Plant functional traits are thought to be the fundamental strategies to adapt to various environments and to be key indicators for ecosystem processes and functions. He *et al.* (2020) constructed a new plant trait networks and clarified complex relationships among plant traits using metrics for the topology of trait coordination. Their study provides an improved resolution of the multidimensional plant adaptation in facing with environmental changes across different scales. For leaf traits, a pitcher plant, *Nepenthes alata*, is a superior fog harvester in humid environment via its special peristome (Li *et al.* 2020e). Changes in leaf apex shapes from round to triangle and acuminate,

Table 1: Information on the journals from Web of Science (accessed by 02/01/2021)

Category (Web of Science)	Journal full name	Journal abbreviation (Journal citation reports)	ISSN	Impact factor	Top journal selected
Plant sciences	<i>Nature Plants</i>	NAT PLANTS	2055-026X	13.256	Selected
Multidisciplinary sciences	<i>National Science Review</i>	NATL SCI REV	2095-5138	16.693	Selected
	<i>Nature</i>	NATURE	0028-0836	42.778	Selected
	<i>Nature Communications</i>	NAT COMMUN	2041-1723	12.121	Selected
	<i>Proceedings of the National Academy of Sciences of the United States of America</i>	P NATL ACAD SCI USA	0027-8424	9.412	Selected
	<i>Science</i>	SCIENCE	0036-8075	41.845	Selected
	<i>Science Advances</i>	SCI ADV	2375-2548	13.117	Selected
	<i>Science Bulletin</i>	SCI BULL	2095-9273	9.511	Selected
	<i>Nature Geoscience</i>	NAT GEOSCI	1752-0894	13.566	Selected
Environmental sciences	<i>Nature Climate Change</i>	NAT CLIM CHANGE	1758-678X	20.893	Selected
	<i>Nature Sustainability</i>	NAT SUSTAIN	2398-6929	12.080	Selected
Ecology	<i>Advances in Ecological Research</i>	ADV ECOL RES	0065-2504	6.167	—
	<i>American Naturalist</i>	AM NAT	0003-0147	3.744	—
	<i>Annual Review of Ecology, Evolution, and Systematics</i>	ANNU REV ECOL EVOL S	1543-592X	14.041	Selected
	<i>Biological Conservation</i>	BIOL CONSERV	0006-3207	4.711	—
	<i>Conservation Biology</i>	CONSERV BIOL	0888-8892	5.405	—
	<i>Ecography</i>	ECOGRAPHY	0906-7590	6.455	—
	<i>Ecological Applications</i>	ECOL APPL	1051-0761	4.248	—
	<i>Ecological Monographs</i>	ECOL MONOGR	0012-9615	7.722	—
	<i>Ecology</i>	ECOLOGY	0012-9658	4.700	—
	<i>Ecology Letters</i>	ECOL LETT	1461-023X	8.665	Selected
	<i>Ecosystems</i>	ECOSYSTEMS	1432-9840	4.207	—
	<i>Frontiers in Ecology and the Environment</i>	FRONT ECOL ENVIRON	1540-9295	9.295	Selected
	<i>Functional Ecology</i>	FUNCT ECOL	0269-8463	4.434	—
	<i>Global Change Biology</i>	GLOB CHANGE BIOL	1354-1013	8.555	—
	<i>Global Ecology and Biogeography</i>	GLOBAL ECOL BIOGEOGR	1466-822X	6.446	—
	<i>Journal of Applied Ecology</i>	J APPL ECOL	0021-8901	5.840	—
	<i>Journal of Ecology</i>	J ECOL	0022-0477	5.762	—
	<i>Methods in Ecology and Evolution</i>	METHODS ECOL EVOL	2041-210X	6.514	—
	<i>Nature Ecology & Evolution</i>	NAT ECOL EVOL	2397-334X	12.541	Selected
	<i>Oecologia</i>	OECOLOGIA	0029-8549	2.654	—
	<i>Oikos</i>	OIKOS	0030-1299	3.370	—
	<i>Proceedings of the Royal Society B: Biological Sciences</i>	P ROY SOC B-BIOL SCI	0962-8452	4.633	—
	<i>Remote Sensing in Ecology and Conservation</i>	REMOTE SENS ECOL CON	2056-3485	5.000	—
	<i>Trends in Ecology & Evolution</i>	TRENDS ECOL EVOL	0169-5347	14.764	Selected

and from flat to bent can help leaves rapidly remove rain droplets to avoid damage (Wang *et al.* 2020e). By meta-analysis, Cui *et al.* (2020b) found that the positive relationships among three leaf economic traits (i.e. specific leaf area, leaf nitrogen content and net photosynthetic rate) still hold under simulated global environmental changes (warming, drought, elevated CO₂ and nitrogen enrichment). Plant traits (e.g. arbuscular mycorrhizal and ectomycorrhizal) also played critical roles in determining tree species coexistence in both temperate (Jia *et al.* 2020) and subtropical forests (Liang *et al.* 2020). In addition, independent of plant life forms, plant traits (e.g. leaf length and width of dicots) were positively correlated with forest ecosystem primary productivity in both China and North America (Li *et al.* 2020c). These findings provide promising means to estimate paleo-ecosystem primary productivity from fossil leaf records.

Plants and animals have similar evolution in terms of climatic-niche and often share comparable species richness patterns, biogeographic biomes and hotspots (Liu *et al.* 2020a), as well as the effects of birds' spatial location on seed dispersal (Li *et al.* 2020d). Lu *et al.* (2020) discovered that the average threatened proportion in higher plants was 7.71% lower than that of animals in China. Agathokleous *et al.* (2020), for the first time, confirmed that ozone is a threat to biodiversity. The cumulative effects of drought can increase the mortality of gymnosperms (Li *et al.* 2020b). In aquatic ecosystems, elevated CO₂ caused the reduction in the motility of three typical phytoplankton, polar marine *Microglona* sp., euryhaline *Dunaliella salina* and freshwater *Chlamydomonas reinhardtii*, suggesting the decreases in reproduction and survival of microalgae under increasing CO₂ conditions (Wang *et al.* 2020a). Warming likely induced loss of marine biodiversity across latitudinal gradient during the Permian–Triassic mass extinction event (Song *et al.* 2020a). Wan *et al.* (2020) reported that a higher plant species richness was associated with a lower herbivore abundance and damage while plant diversity generally enhanced abundance and performance of predator, parasitoid and plant across major terrestrial ecosystems. They conclude that plant diversity facilitates beneficial trophic interactions via natural enemy effects, thus contributing to ecosystem functioning and services. A timely spatial meta-analysis, with identified conservation priority zones and cost-effective zones for protected areas designation, was conducted to

support the post-2020 global biodiversity framework (Yang *et al.* 2020). Some edaphically extreme habitats that have been suggested to act as refugia and edaphic islands are now exposed to multiple anthropogenic threats (Corlett and Tomlinson 2020). Moreover, an emerging priority for transboundary biodiversity conservation (Liu *et al.* 2020b), especially across the belt and road initiative countries (Hughes *et al.* 2020), has been proposed.

Vegetation maps can provide basic information for national strategic decision making, and are of important significance for ecological research and biodiversity conservation. A new criterion is proposed to identify multistable states for biocrusts in global drylands (Chen *et al.* 2020c). A projection of land use in China was developed based on plant functional types, with a temporal resolution of 5 years and a spatial resolution of 5 km (Liao *et al.* 2020). An updated version of Vegetation Map of China (1:1 000 000) including 12 vegetation-type groups, 55 vegetation types/subtypes and 866 vegetation formation/subformation types was completed (Su *et al.* 2020a). With the updated Vegetation Map, it has been shown that 3.3 million km² of Chinese vegetation has experienced drastic alterations during the past three decades. In addition, using plant fossils records in the Tibetan Plateau, paleo-vegetations were constructed, i.e. a Middle Eocene humid subtropical ecosystem, which is affinity to Early-Middle Eocene floras in both North America and Europe (Su *et al.* 2020b), and an Oligocene temperate alpine ecosystem, which is older than any other alpine ecosystems worldwide (Ding *et al.* 2020). These reconstructed paleo-vegetations from Eocene to Oligocene reveal that the Tibetan Paleogene topography and climate play key roles in the origin and diversification of modern Asian plant species.

To improve the abilities in managing biodiversity and vegetation relies on how to accurate assess ecosystem functioning and services (e.g. carbon sequestration) under the enhanced emissions of greenhouse gases (CO₂, N₂O and CH₄) and global warming. Alteration in vegetation cover influenced annual soil respiration in boreal and temperate regions, thus contributing to the terrestrial carbon storage (Huang *et al.* 2020b). Though free-air CO₂ enrichment caused significant ammonium-nitrogen loss (Xu *et al.* 2020b) and continuous reduction in the positive effects of CO₂ fertilization on vegetation photosynthesis across most global terrestrial lands since 1982 (Wang *et al.* 2020g), terrestrial ecosystems in China sank ~45% of annual anthropogenic

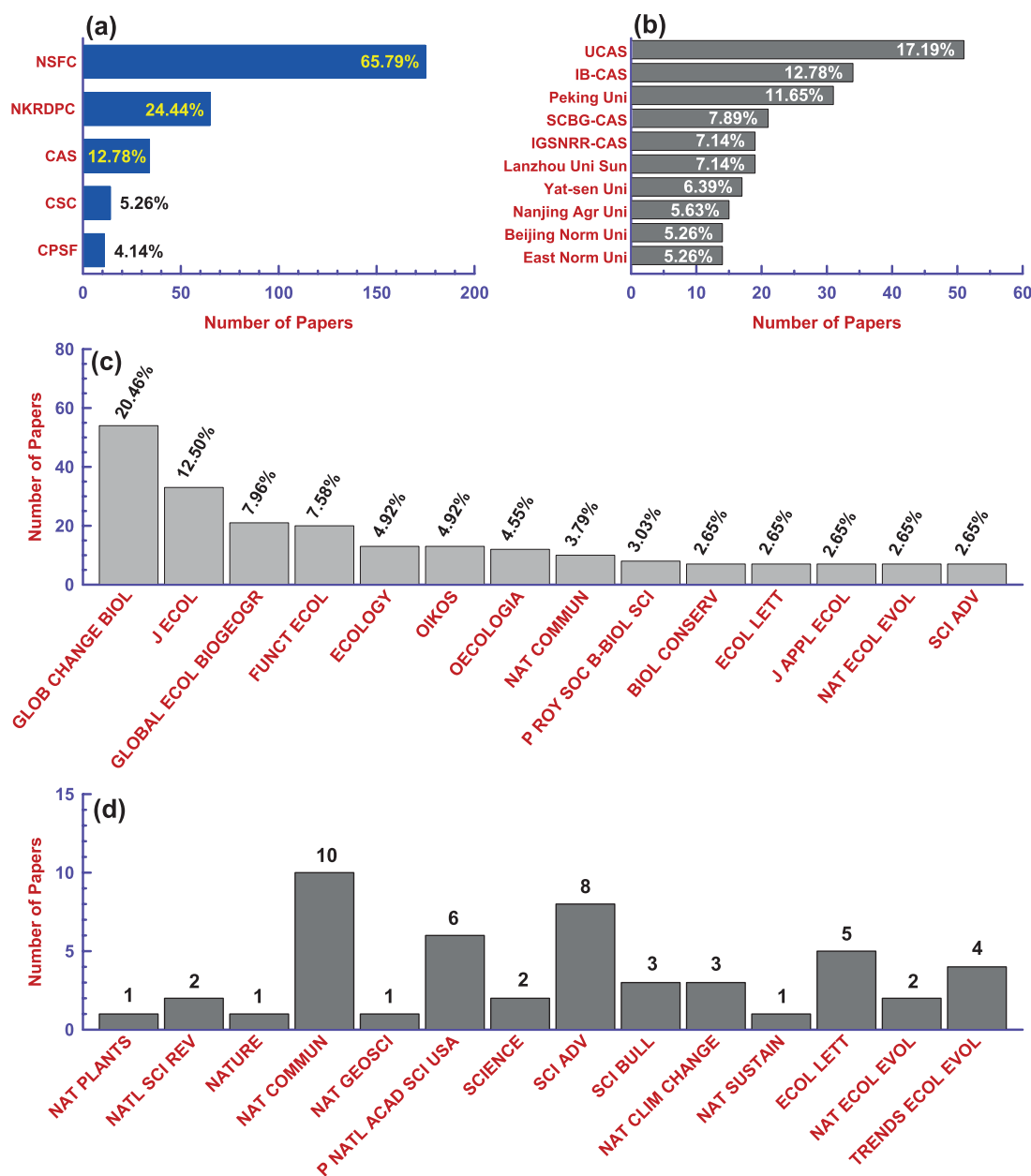


Figure 1: Information of assembled peer-reviewed articles. (a) The top-five funding agencies, National Natural Science Foundation of China (NSFC), National Key Research and Development Program of China (NKRDPC), Chinese Academy of Sciences (CAS), China Scholarship Council (CSC) and China Postdoctoral Science Foundation (CPSF); (b) the top-ten organizations, University of Chinese Academy of Sciences (UCAS), Institute of Botany CAS (IB-CAS), Peking University (Peking Uni), South China Botanical Garden CAS (SCBG-CAS), Institute of Geographic Sciences and Natural Resources Research CAS (IGSNRR-CAS), Lanzhou University (Lanzhou Uni), Sun Yat-sen University (Sun Yat-sen Uni), Nanjing Agricultural University (Nanjing Agr Uni), Beijing Normal University (Beijing Norm Uni) and East China Normal University (East Norm Uni); (c) journals in number of papers published without journal category; and (d) the number of peer-reviewed papers published in the selected top international journals by the first organization in China. See journal abbreviations in Table 1.

emissions over 2010–16 due largely to China's aggressive policy of tree planting (afforestation) (Wang *et al.* 2020b). These findings highlight that the ground-based measurements in combination with satellite observations can better characterize terrestrial carbon budget. The afforestation project has increased vegetation cover (Li *et al.* 2020a) and

carbon sink in both northern (Hong *et al.* 2020) and southern China (Tong *et al.* 2020). Short-term fencing (4–8 years) enhanced aboveground primary productivity in the Tibetan grasslands (Sun *et al.* 2020). By contrast, mangrove deforestation led to a global carbon stock reduction in tidal wetlands after 2000 (Ouyang and Lee 2020). Moreover, Du *et al.*

(2020) discovered that one fifth of the global natural terrestrial lands was limited by nitrogen, 43% by phosphorus limited and 39% by both nitrogen and phosphorus. Progressive vegetation limitation by nitrogen was demonstrated in the Tibetan alpine permafrost region (Kou *et al.* 2020), while increases in nitrogen fixation rates were detected in successional forests in southern China even under conditions of elevated atmospheric nitrogen deposition (Zheng *et al.* 2020). Nitrogen addition relieved nitrogen limitation and enhanced both woody biomass production and emissions of CO₂, N₂O and CH₄, while the Moso bamboo forest remained a carbon sink (Song *et al.* 2020b). Phosphorous addition alleviated the negative effects of nitrogen addition in CH₄ uptake in grasslands globally (Zhang *et al.* 2020), and stimulated aboveground plant biomass production by 34.9% in the global natural terrestrial ecosystems (Hou *et al.* 2020). In addition, hydropower dams increased bioavailability of nitrogen and phosphorus, thus stimulating phytoplankton growth in Lancang River, southwest China (Chen *et al.* 2020b). Therefore, adding nitrogen together with phosphorus has likely a positive impact on carbon sequestration in natural ecosystems.

In a warming world, primary succession of vegetation in regions experiencing glacier retreat was accelerated and significantly reduced atmospheric mercury concentrations (Wang *et al.* 2020d). Based on millions leaf unfolding and flowering records across Europe, more than half (7 of 12) models were found to overestimate the advance in spring phenology, while warming indeed advanced spring leaf-out, flowering (Wang *et al.* 2020f) and autumn leaf senescence for perennials (Chen *et al.* 2020a). In addition, photoperiod and mean annual temperature positively interacted to trigger the onset of wood formation in Northern Hemisphere conifers (Huang *et al.* 2020a). The advanced leaf-out in spring enhanced annual surface warming in the Northern Hemisphere (Xu *et al.* 2020a), exacerbated soil moisture deficit in summer (Lian *et al.* 2020), but it did not alter annual biomass production in an alpine steppe in the Tibetan Plateau (Wang *et al.* 2020c). Even though vegetation feedbacks may shorten water scarcity period in most monsoon regions (Cui *et al.* 2020a), a larger-than-normal carbon sink in lands was detected in a wetter year (Yue *et al.* 2020).

In summary, human activities including land use change (e.g. afforestation/deforestation), greenhouse gases emission, warming, atmospheric nitrogen deposition and artificial substances (e.g. micro-/

nano-plastics, nano-materials and antibiotics) dominate global changes, understanding how plants perform, adapt and form natural communities and ecosystems to fulfill ecosystem functions and services are either uncertain and/or unresolved. Answering the following questions would advance our knowledge on contemporary plant ecology. We expect that Chinese ecologists will make greater achievements on these topics in the coming years.

1. What is the balance of plants within a community and an ecosystem to maintain biodiversity and to provide ecosystem functioning?
2. How do plants, communities and ecosystems react and the underlying mechanisms by which they acquire resources?
3. How does the land use change restore and improve biodiversity/vegetation and ecosystem functions?
4. What and how do plants affect the cycles of energy and information at both local and global scales?

REFERENCES

- Agathokleous E, Feng Z, Oksanen E, *et al.* (2020) Ozone affects plant, insect, and soil microbial communities: a threat to terrestrial ecosystems and biodiversity. *Sci Adv* **6**:eabc1176.
- Chen L, Hänninen H, Rossi S, *et al.* (2020a) Leaf senescence exhibits stronger climatic responses during warm than during cold autumns. *Nat Clim Change* **10**:777–780.
- Chen Q, Shi W, Huisman J, *et al.* (2020b) Hydropower reservoirs on the upper Mekong River modify nutrient bioavailability downstream. *Natl Sci Rev* **7**:1449–1457.
- Chen N, Yu K, Jia R, *et al.* (2020c) Biocrust as one of multiple stable states in global drylands. *Sci Adv* **6**:eaay3763.
- Corlett RT, Tomlinson KW (2020) Climate change and edaphic specialists: irresistible force meets immovable object? *Trends Ecol Evol* **35**:367–376.
- Cui J, Piao S, Huntingford C, *et al.* (2020a) Vegetation forcing modulates global land monsoon and water resources in a CO₂-enriched climate. *Nat Commun* **11**:5184.
- Cui E, Weng E, Yan E, *et al.* (2020b) Robust leaf trait relationships across species under global environmental changes. *Nat Commun* **11**:2999.
- Ding W-N, Ree RH, Spicer RA, *et al.* (2020) Ancient orogenic and monsoon-driven assembly of the world's richest temperate alpine flora. *Science* **369**:578–581.
- Du E, Terrer C, Pellegrini AFA, *et al.* (2020) Global patterns of terrestrial nitrogen and phosphorus limitation. *Nat Geosci* **13**:221–226.
- He N, Li Y, Liu C, *et al.* (2020) Plant trait networks: improved resolution of the dimensionality of adaptation. *Trends Ecol Evol* **35**:908–918.

- Hong S, Yin G, Piao S, *et al.* (2020) Divergent responses of soil organic carbon to afforestation. *Nat Sustain* **3**:694–700.
- Hou E, Luo Y, Kuang Y, *et al.* (2020) Global meta-analysis shows pervasive phosphorus limitation of aboveground plant production in natural terrestrial ecosystems. *Nat Commun* **11**:637.
- Huang J-G, Ma Q, Rossi S, *et al.* (2020a) Photoperiod and temperature as dominant environmental drivers triggering secondary growth resumption in Northern Hemisphere conifers. *Proc Natl Acad Sci U S A* **117**:20645–20652.
- Huang N, Wang L, Song X-P, *et al.* (2020b) Spatial and temporal variations in global soil respiration and their relationships with climate and land cover. *Sci Adv* **6**:eabb8508.
- Hughes AC, Lechner AM, Chitov A, *et al.* (2020) Horizon scan of the belt and road initiative. *Trends Ecol Evol* **35**:583–593.
- Jia S, Wang X, Yuan Z, *et al.* (2020) Tree species traits affect which natural enemies drive the Janzen-Connell effect in a temperate forest. *Nat Commun* **11**:286.
- Kou D, Yang G, Li F, *et al.* (2020) Progressive nitrogen limitation across the Tibetan alpine permafrost region. *Nat Commun* **11**:3331.
- Li Y, Piao S, Chen A, *et al.* (2020a) Local and teleconnected temperature effects of afforestation and vegetation greening in China. *Natl Sci Rev* **7**:897–912.
- Li X, Piao S, Wang K, *et al.* (2020b) Temporal trade-off between gymnosperm resistance and resilience increases forest sensitivity to extreme drought. *Nat Ecol Evol* **4**:1075–1083.
- Li Y, Reich PB, Schmid B, *et al.* (2020c) Leaf size of woody dicots predicts ecosystem primary productivity. *Ecol Lett* **23**:1003–1013.
- Li H-D, Tang L, Jia C, *et al.* (2020d) The functional roles of species in metacommunities, as revealed by metanetwork analyses of bird–plant frugivory networks. *Ecol Lett* **23**:1252–1262.
- Li C, Yu C, Zhou S, *et al.* (2020e) Liquid harvesting and transport on multiscaled curvatures. *Proc Natl Acad Sci U S A* **117**:23436–23442.
- Lian X, Piao S, Li LZ, *et al.* (2020) Summer soil drying exacerbated by earlier spring greening of northern vegetation. *Sci Adv* **6**:eaax0255.
- Liang M, Johnson D, Burslem DFRP, *et al.* (2020) Soil fungal networks maintain local dominance of ectomycorrhizal trees. *Nat Commun* **11**:2636.
- Liao W, Liu X, Xu X, *et al.* (2020) Projections of land use changes under the plant functional type classification in different SSP-RCP scenarios in China. *Sci Bull* **65**:1935–1947.
- Liu H, Ye Q, Wiens JJ (2020a) Climatic-niche evolution follows similar rules in plants and animals. *Nat Ecol Evol* **4**:753–763.
- Liu J, Yong DL, Choi C-Y, *et al.* (2020b) Transboundary frontiers: an emerging priority for biodiversity conservation. *Trends Ecol Evol* **35**:679–690.
- Lu Y, Yang Y, Sun B, *et al.* (2020) Spatial variation in biodiversity loss across China under multiple environmental stressors. *Sci Adv* **6**:eabd0952.
- Ouyang X, Lee SY (2020) Improved estimates on global carbon stock and carbon pools in tidal wetlands. *Nat Commun* **11**:317.
- Song H, Huang S, Jia E, *et al.* (2020a) Flat latitudinal diversity gradient caused by the Permian–Triassic mass extinction. *Proc Natl Acad Sci U S A* **117**:17578–17583.
- Song X, Peng C, Ciais P, *et al.* (2020b) Nitrogen addition increased CO₂ uptake more than non-CO₂ greenhouse gases emissions in a Moso bamboo forest. *Sci Adv* **6**:eaaw5790.
- Su Y, Guo Q, Hu T, *et al.* (2020a) An updated Vegetation Map of China (1:1000000). *Sci Bull* **65**:1125–1136.
- Su T, Spicer R A, Wu F-X, *et al.* (2020b) A Middle Eocene lowland humid subtropical “Shangri-La” ecosystem in central Tibet. *Proc Natl Acad Sci U S A* **117**:32989–32995.
- Sun J, Liu M, Fu B, *et al.* (2020) Reconsidering the efficiency of grazing exclusion using fences on the Tibetan Plateau. *Sci Bull* **65**:1405–1414.
- Tong X, Brandt M, Yue Y, *et al.* (2020) Forest management in southern China generates short term extensive carbon sequestration. *Nat Commun* **11**:129.
- Wan N-F, Zheng X-R, Fu L-W, *et al.* (2020) Global synthesis of effects of plant species diversity on trophic groups and interactions. *Nat Plants* **6**:503–510.
- Wang Y, Fan X, Gao G, *et al.* (2020a) Decreased motility of flagellated microalgae long-term acclimated to CO₂-induced acidified waters. *Nat Clim Change* **10**:561–567.
- Wang J, Feng L, Palmer PI, *et al.* (2020b) Large Chinese land carbon sink estimated from atmospheric carbon dioxide data. *Nature* **586**:720–723.
- Wang H, Liu H, Cao G, *et al.* (2020c) Alpine grassland plants grow earlier and faster but biomass remains unchanged over 35 years of climate change. *Ecol Lett* **23**:701–710.
- Wang X, Luo J, Yuan W, *et al.* (2020d) Global warming accelerates uptake of atmospheric mercury in regions experiencing glacier retreat. *Proc Natl Acad Sci U S A* **117**:2049–2055.
- Wang T, Si Y, Dai H, *et al.* (2020e) Apex structures enhance water drainage on leaves. *Proc Natl Acad Sci U S A* **117**:1890–1894.
- Wang H, Wu C, Ciais P, *et al.* (2020f) Overestimation of the effect of climatic warming on spring phenology due to misrepresentation of chilling. *Nat Commun* **11**:4945.
- Wang S, Zhang Y, Ju W, *et al.* (2020g) Recent global decline of CO₂ fertilization effects on vegetation photosynthesis. *Science* **370**:1295–1300.
- Xu X, Riley WJ, Koven CD, *et al.* (2020a) Earlier leaf-out warms air in the north. *Nat Clim Change* **10**:370–375.
- Xu C, Zhang K, Zhu W, *et al.* (2020b) Large losses of ammonium-nitrogen from a rice ecosystem under elevated CO₂. *Sci Adv* **6**:eabb7433.
- Yang R, Cao Y, Hou S, *et al.* (2020) Cost-effective priorities for the expansion of global terrestrial protected areas: setting post-2020 global and national targets. *Sci Adv* **6**:eabc3436.
- Yue C, Ciais P, Houghton RA, *et al.* (2020) Contribution of land use to the interannual variability of the land carbon cycle. *Nat Commun* **11**:3170.
- Zhang L, Yuan F, Bai J, *et al.* (2020) Phosphorus alleviation of nitrogen-suppressed methane sink in global grasslands. *Ecol Lett* **23**:821–830.
- Zheng M, Chen H, Li D, *et al.* (2020) Substrate stoichiometry determines nitrogen fixation throughout succession in southern Chinese forests. *Ecol Lett* **23**:336–347.

2020年中国植物生态学研究主要进展概要

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2020年, 中国植物生态学研究取得了重要进展: 通过对已发表研究论文的梳理, 我们筛选到35个国际主流科技期刊(Zhang *et al.*, 2021)中研究论文266篇, 如*Nature* (1篇)、*Science* (2篇)和*Trends in Ecology & Evolution* (4篇)。这些科技论文的前3位资助单位分别是: 国家自然科学基金委员会(65.8%), 国家重点研发计划(24.4%)和中国科学院(12.8%); 论文发表数量前五位机构分别是: 中国科学院大学, 中国科学院植物研究所, 北京大学, 中国科学院华南植物园, 中国科学院地理科学与资源研究所和兰州大学; 论文发表数量最多的前3种期刊分别是: *Global Change Biology*, *Journal of Ecology*和*Global Ecology and Biogeography*。我们进一步筛选到以中国机构为第一单位的重要研究进展论文49篇, 并进行了从植物功能性状到生态系统功能方面的系统性归纳陈述(Zhang *et al.*, 2021)。同时, 结合当代植物生态学研究热点、难点和特点, 建议了4个相对重要的研究方向, 我们坚信中国植物生态学研究将会取得更加辉煌的科技成果。