景观规划视角下的生态系统服务研究动态
——第十届生态系统服务伙伴全球会议综述

Research Trends of Ecosystem Services From the Perspective of Landscape Planning
—Summary on the 10th Ecosystem Services Partnership World Conference

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摘要

生态系统服务伙伴全球会议是生态系统服务领域最高水平的学术会议之一，聚焦世界范围内生态系统服务的研究与实践，是掌握研究前沿动态的重要途径。基于部分学者已将生态系统服务评价指标及评价方法等融入景观规划设计的理论与实践之中这一现状，本文筛选出第十届会议中与景观规划相关的分论坛主题，结合各分论坛中的发言进行总结，从多类型景观的生态系统服务研究、生态系统服务在规划与管理中的应用，以及生态系统服务制图与建模三个视角对研究及实践热点进行分析和归纳。总结而言，今后将生态系统服务研究应用于景观规划领域的热点在于：1）探索面向多种景观类型的态系统服务评价；2）探索将生态系统服务融入各类景观规划的理论与实践框架；3）探索适用于景观规划与管理的生态系统服务综合建模与制图工具。

关键词

生态系统服务；景观规划；研究议题；生态系统服务伙伴全球会议；会议综述；基于自然的解决方案；生态基础设施

ABSTRACT

The Ecosystem Services Partnership (ESP) Conference is one of the highest-level global academic conferences on ecosystem service (ES) research. Focusing on the research and practice of ES worldwide, ESP Conference offers an important way to grasp the cutting-edge knowledge for scholars and professionals. Currently, ES evaluation indicators and evaluation methods have been integrated into the research and practice of landscape planning and design. This paper sorted out the break-out session themes at the 10th ESP Conference related to landscape planning and summarized the research presented in each session. It analyzed and summarized the research and practice hot spots from 3 perspectives: multiple landscape types, the application of ES in planning and management, and ES mapping and modeling. Finally, the paper offers insights on future interests of the application of ES research into landscape planning, including 1) exploring ES evaluation for multiple landscape types; 2) exploring the theoretical and practical frameworks for integrating ES Science into landscape planning; and 3) exploring integrated ES modeling and mapping tools for landscape planning and management.

KEYWORDS

Ecosystem Services; Landscape Planning; Research Interests; Ecosystem Service Partnership World Conference; Conference Summary; Nature-Based Solutions; Ecological Infrastructure

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1 引言

生态系统服务（Ecosystem Service，简称ES）是衔接城市居民生活福祉和生境斑块自然生态过程的核心概念[1]。中国的相关研究源起于生态学[2]及地理学[3][4]领域，近些年逐渐受到城市规划[5]、景观设计[6]~[10]等领域学者的关注。部分学者已经开始尝试将ES评价指标及评价方法等融入景观规划设计的理论与实践之中。景观规划是指基于对自然和人文过程的认识，协调人与自然关系的过程；具体而言就是为某些使用目的安排最合适的地方和在特定地方安排最恰当的土地利用[11]，是融国土规划、城乡建设规划、生态保护规划和人居环境建设工程设计于一体的学科[12]。景观规划能够通过改变土地利用方式、土地覆被类型，调整景观格局结构与功能，影响ES的类型、分布及产生过程[13]。ES研究方法能够将ES的结构与功能、需求与供给等信息落到具体的环境空间之中，协调多个利益相关方，评价结果易理解，为解决空间规划问题提供了有力工具[13]。已有研究从景观规划与ES的关系入手，探讨ES研究方法如何应用于景观规划[8]~[10][14]。然而，目前景观规划领域中以会议为研究对象，对ES前沿热点进行梳理及分析的研究尚不多见。本文拟以全球ES领域最高水平的学术会议之一的“生态系统服务伙伴”全球会议（简称ESP会议）为例，通过梳理第十届会议内容，为景观规划视角下的ES研究与整合ES的景观规划实践提供借鉴。尽管会议综述具有一定时效性，但也可以从一定程度上弥补景观规划领域对ES研究与实践前沿动态关注的不足。

2 ESP全球会议对ES研究与实践的推动

ESP全球会议于2008年首次举办，现已召开了10次会议（表1）。从对ES概念的反思，到关注研究方法、解决方案，ESP全球会议一直致力于加强ES相关前沿成果的交流，呼吁研究与实践融合，推动了与生态系统保护和可持续发展相关的科学—政策—实践界面上的研究与实践发展（图1）。

第十届会议以“ES科学研究、政策与实践不断进步的十年：面向可持续未来”为主题，围绕自然保护、景观修复、可持续生态系统管理等方向展开讨论。此次会议的参会者来自65个国家和地区，参会人数超过750人。尽管ES研究已经积淀了丰富的研究成果，但是将这些科研成果融入到当前世界各地的政策与在地实践之中依然是一个巨大的挑战。

1 Introduction

Ecosystem Services (ES) is the key intermediating concept between urban residents' well-beings and the natural / ecological processes of habitat patches[1]. The associated research in China originates from the fields of Ecology[2] and Geography[3][4], and sees an increase in Urban Planning[5], Landscape Architecture[6]~[10], and other disciplines in recent years. Many scholars have integrated ES evaluation indicators and methods into the theoretical and practice exploration in landscape planning and design. Landscape planning refers to the process of coordinating the human–nature relationship through the understanding of natural evolution and socio-economic and cultural activities of the human society. Specifically, the discipline is about the appropriate organization of spatial functions and the best arrangement of land uses[11]; it covers national land planning, urban and rural construction planning, ecological protection planning, and engineering design of human settlement construction[12]. Landscape planning can impact the types, distribution, and production process of ES by altering the structure and function of landscape patterns, land use, and land-cover typologies[13]. ES research methods offer an efficient tool to address spatial planning issues by matching with and mapping the data of ES structure and function, demand and supply onto physical environments to meet the needs of various stakeholders and to develop easily-understood evaluation outcomes[13]. Existing studies focus on the relationship between landscape planning and ES and explore how ES research methods can be applied in landscape planning[8]~[10][14]. However, there are few research from the field of landscape planning systematically reviewing the ES research interests widely discussed at academic conferences. Focusing on the Ecosystem Services Partnership World Conference (hereafter ESP Conference), one of the world's highest-level academic conferences on ES, this paper, though might be deficient in timeliness, reviews and sorts out the cutting-edge ES research interests that will be beneficial for the research and practice of landscape planning.

2 ESP Conference to Promote the Research and Practice of ES Globally

The ESP Conference has held 10 conferences since 2008 (Table 1). By encouraging reflection on ES concepts and by presenting cutting-edge research methods and solutions, ESP Conference is committed to the integration of research and application, and to facilitate the development of ecosystem protection and sustainability in dimensions of scientific study, policy making, and practice (Fig. 1).

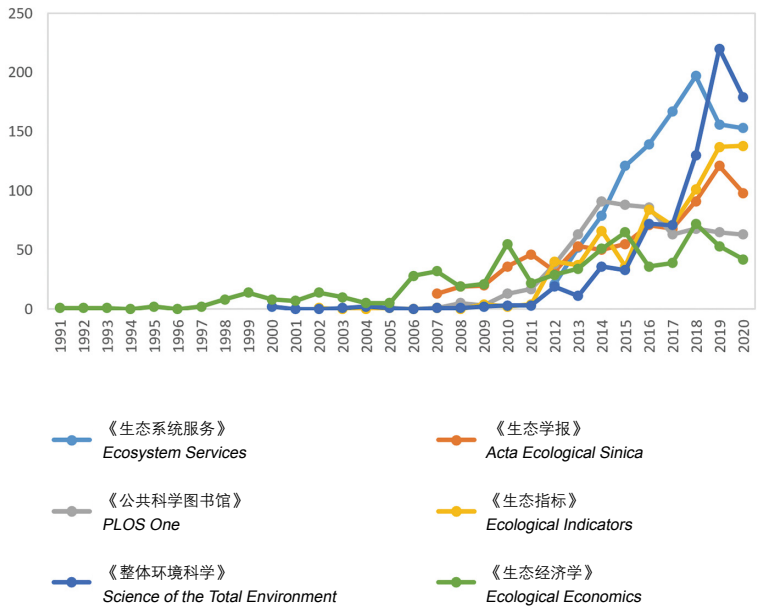
With the theme being “10 years advancing ES science, policy, and practice for a sustainable future,” the 10th ESP Conference focused on the interests of nature protection, landscape restoration, and sustainable ecosystem management. The conference gathered more than 750 attendees from 65 countries and regions. Although existing ES research outcomes are fruitful, it is still challenging to apply these research results into the current policy making and local practice around the world.

表1：历届ESP全球会议主题
Table 1: Themes of ESP Conferences

会议年份 Year	会议主题 Theme	会议城市 Host city
第一届 The 1st ESP Conference (2008)	ES：关注问题的解决方案还是需要解决的问题? ES: Solution for problems or a problem that needs solution?	德国基尔 Kiel, Germany
第二届 The 2nd ESP Conference (2009)	ES建模 Modeling ES	意大利莱切 Lecce, Italy
第三届 The 3rd ESP Conference (2010)	维持自然资本和ES解决方案 Solutions for sustaining natural capital and ES	德国基尔 Kiel, Germany
第四届 The 4th ESP Conference (2011)	ES：科学研究与实践的融合 ES: Integrating science and practice	荷兰瓦赫宁根 Wageningen, the Netherlands
第五届 The 5th ESP Conference (2012)	ES时代的来临：融合人类福祉可持续性的科学研究、政策与参与 ES come of age: Linking science, policy, and participation for sustainable human well-being	美国波特兰 Portland, USA
第六届 The 6th ESP Conference (2013)	ES价值评估 Making ES count!	印度尼西亚巴厘岛 Bali, Indonesia
第七届 The 7th ESP Conference (2014)	提升公共利益的地方行动 Local action for the common good	哥斯达黎加圣何塞 San José, Costa Rica
第八届 The 8th ESP Conference (2015)	为了自然、人类与繁荣的ES ES for nature, people, and prosperity	南非斯泰伦博斯 Stellenbosch, South Africa
第九届 The 9th ESP Conference (2017)	增强ES，促进生态文明建设：借助基于自然的解决方案修复人与景观的联系 ES for eco-civilization: Restoring connections between people and landscapes through nature-based solutions	中国深圳 Shenzhen, China
第十届 The 10th ESP Conference (2019)	ES科学研究、政策与实践不断进步的十年：面向可持续未来 10 years advancing ES science, policy, and practice for a sustainable future	德国汉诺威 Hannover, Germany

注
更多会议主题信息请访问EPS全球会议官方网站。

NOTE
Please visit the official website of EPS Conference for more information about the conference themes.



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1. 自2008年以来ES相关研究呈增长趋势（数据来源：Scopus数据库）

1. ES-related research has witnessed an increase in number since 2008 (Source: Scopus database)

3 Research Hotspots Related to Landscape Planning

The 10th ESP Conference consisted of biome working group sessions, thematic working group sessions, general sessions, and sectoral working group sessions, inviting 7 keynote speakers, organizing 51 break-out sessions and nearly 600 lectures, and presenting 160 posters. This paper selects 17 session topics related to landscape planning according to the official conference manual (Tables 2 ~ 4), and reviews the literature abstracts, reports, and other documents under each topic, and then sorts out the topics into 3 categories respectively focusing on 1) research object, 2) planning type, and 3) modeling and mapping method.

3.1 ES Research Among Multiple Landscape Types

ES research involves multiple landscape types such as urban landscape, ocean, river, wetland, forest, alpine area, and polar regions. In this paper, the research hotspots, difficulties, and practice applications on representative research objects, including urban landscapes, river, lake, and wetland landscapes, and forest landscapes are expanded in this paper (Table 2).

3.1.1 Urban Landscapes

By the year 2020, urban population has accounted for 56.2% of the total global population[①]. As one of the most important terrestrial habitat types for

表2：多类型景观的ES研究相关分会场主题
Table 2: Break-out session topics related to ES research among multiple landscape types

研究对象 Research object	研究主题 Research topic	分会场编号 Break-out session code	分会场主题 Break-out session theme
城市景观 Urban landscape	城市ES Urban ES	B10a	城市ES动态、复杂性及可持续城市发展的挑战 Urban ES: Dynamics, complexities, and challenges for sustainable urban development
	城市ES评估 Urban ES assessment	B10c	推进城市ES评估，创建更具包容性和公正性的城市 Advancing urban ES assessment for more inclusive and just cities
	城市绿色基础设施 Urban green infrastructure	B10d	影响城市生态系统正负服务的城市绿色基础设施因素 Urban green infrastructure: Factors shaping urban ES and disservices
	城市开放空间 Urban open spaces	B10e	城市和城市周边开放空间ES的治理途径 Governance approaches for ES in urban and peri-urban open spaces
	城市文化ES Urban cultural ES	T9	城市区域中的文化ES与公众健康 Cultural ES and public health in urban areas
海洋景观 Ocean landscape	珊瑚礁 Coral reef	B1b	从热带到两极：海洋文化ES评估 From the tropics to the poles: Assessing marine cultural ES
	海洋 Ocean	T6a	人类世时代海洋ES评估 Valuing marine ES in the age of Anthropocene
河湖湿地景观 River, lake, and wetland landscape	河流与湿地 Riverine and wetland	B2a	河流与湿地ES评价方法 ES assessment methods for riverine and wetland ecosystems
森林景观 Forest landscape	森林与林地 Forest and woodland	B3	半天然林和人工林：面向土地利用和气候变化的ES与权衡 Semi-natural forests and forest plantations: ES and trade-offs in the face of land use and climate change

表3：ES在景观规划与管理中的应用相关分会场主题
Table 3: Break-out session topics related to the application of ES research in landscape planning and management types

规划类型 Planning type	分会场编号 Break-out session code	分会场主题 Break-out session theme
城乡景观规划 Urban and rural landscape planning	B9-T18c	城乡协同ES治理：搭建科学研究与决策的桥梁 Governance of ES for rural-urban synergies: Bridging science and decision-making
	B10b	通过基于自然的解决方案提升城市可持续性与ES Nature-based solutions for enhancing urban sustainability and ES
	T14b	基于景观规划和管理评估景观结构对ES的影响：平衡细节和可行性 Assessing effects of landscape structure on ES for landscape planning and management: Striking a balance between level of detail and feasibility
流域景观规划 Watershed landscape planning	B2b	河流景观自然解决方案规划与实践前沿 Frontiers in planning and implementing nature-based solutions in river landscapes
	T14b	基于景观规划和管理评估景观结构对ES的影响：平衡细节和可行性 Assessing effects of landscape structure on ES for landscape planning and management: Striking a balance between level of detail and feasibility
自然保护区景观规划 Landscape planning of nature reserves	S8a	自然保护区和保护地的ES ES for nature conservation and protected areas
	T14b	为景观规划和管理评估景观结构对ES的影响：平衡细节和可行性 Assessing effects of landscape structure on ES for landscape planning and management: Striking a balance between level of detail and feasibility

3 与景观规划相关的研究热点

第十届ESP全球会议下设生物群落工作组、主题工作组、综合主题工作组及部门主题工作组，共设置7场特邀报告和51个主题分会场，包括近600场学术报告和160份墙报。本文首先根据官方会议手册中的介绍筛选出17个与景观规划相关的分会场主题（表2～4），随后采用文献研究法逐一研读各主题下的研究摘要和汇报文件，按照研究对象、规划类型和建模与制图方法分为三类。

3.1 多类型景观的ES研究

ES研究涉及城市景观、海洋、河流、湿地、森林及极地与高山区域等多种景观类型。笔者对其中较有代表性的城市景观、河湖湿地景观、森林景观的研究热点、难点及实践应用进行了详述（表2）。

3.1.1 城市景观

截至2020年，城市人口已占全球总人口的56.2%[①]。作为人类重要

① 全球城市人口数据引自世界数据图谱分析平台KnoeMa网站。

① The data of world's urban population was sourced from KnoeMa DataFinder.

表4：ES建模与制图相关研究议题
Table 4: Research topics on ES modeling and mapping

分会场编号 Break-out session code	分会场主题 Break-out session theme
T4a	时间演变：动态ES的时间维度制图 Times are changing: Temporal mapping of dynamic ES
T4b	利用社交媒体数据制图及评价文化ES Mapping cultural ES: Use of social media to assess cultural ES
T5	整合ES模型——推进建模科学与应用 Integrated ES models—Advancing modeling science and application

的陆域栖息地类型之一，城市景观也因此备受与会研究者关注，研究热点包括：

1）对城市ES动态性、复杂性的跨学科研究。如克里斯蒂安·I·伊奥亚等人评价了罗马尼亚城市蓝色基础设施的动态分布及可用性，研究了蓝色基础设施份额与城市社会经济、地理特征之间的相关性[15]。

2）环境正义视角下的城市ES评估。如弗朗西斯科·巴罗等人研究了巴塞罗那城市ES流动与需求之间潜在的不均衡对环境正义的影响[16]。

3）影响城市生态系统正负服务的城市绿色基础设施（GI）因素（如可达性、规模、设计等）。如朱莉娅·帕利沃达等人研究了德国莱比锡城市公园与棕地的植被覆盖度、物种丰富度等绿色参数对ES使用的影响[17]。

4）综合实施蓝绿基础设施以提升城市及城郊开放空间ES的治理方法。如萨布丽娜·莱等人以意大利卡利亚里三个城镇为例，通过将区域GI适宜性地图与城市总体规划叠加并进行相关性分析，识别促进区域GI提升的规划政策[18]。

5）通过文化ES研究城市自然环境对公共健康的影响。如陈先文（音译）等人总结了研究城市及郊区环境下文化ES与公众健康之间关系所面临的挑战，指出需加强文化ES在健康促进方面的研究[19]。

城市生态系统的高度复杂性和时空异质性给城市ES的测度带来了挑战。目前大部分城市ES的研究多聚焦于城市中的自然要素，因此，理解、分析和测量城市ES，特别是将ES融入城市景观规划与城市治理，是未来需要突破的研究难点[15]~[19]。就会议内容总结而言，城市景观规划与设计实践可以通过提升某一类型的服务（如文化服务或调节服务），正负服务调节，或是ES供需平衡的角度，明确GI的规模大小、形态布局、可达性等规划设计指标，进行城市GI的规划设计研究与实践。

3.1.2 河湖湿地景观

河流及河漫滩、湿地、湖泊是最复杂也最具活力的生态系统之一，它们在供应淡水、水质净化、洪水调节、生物多样性保护、粮食供应等方面发挥着关键的ES[20]。论坛的研究热点主要集中在河流、湖泊、湿地等的ES量化，以及ES研究对于跨部门、跨学科流域景观规划与管理的支持。后者的尺度从流域尺度横跨至全球，涉及的研究方法包括协同和权衡分析、情景模拟等。分论坛B2a介绍了三个重点关注的研究项

human beings, urban landscape attracted a broad attention of participants with the following interests:

1) Interdisciplinary research on the dynamics and complexity of urban ES. For example, Cristian I. Iojă et al. evaluated the dynamic distribution and availability of blue infrastructure in Romanian cities by studying the correlation between the share of blue infrastructure and urban socio-economic and geographic characteristics[15].

2) Urban ES assessment from the perspective of environmental justice. For example, Francesc Baró et al. have studied the impact of the potential imbalance between urban ES flows and demands in Barcelona on environmental justice[16].

3) Urban green infrastructure (GI) factors (e.g., accessibility, scale, design) that affect the positive and negative ES in urban settings. For example, Julia Palliwoda et al. studied the influence of green parameters such as vegetation coverage and species richness in urban parks and brownfields in Leipzig, Germany on the use of ES[17].

4) Integrated design of blue and green infrastructure to improve ES governance of urban and suburban open spaces. For example, Sabrina Lai et al. identified the planning policies that promote the improvement of regional GI by superimposing regional GI suitability maps with urban master plans of three towns in Cagliari, Italy and making correlation analysis[18].

And 5) research on the impact of urban natural environment on public health by analyzing cultural ES. For example, Chen Xianwen et al. summarized the challenges in the research of the relations between cultural ES and public health in urban and suburban environments and emphasized the research on the role of cultural ES in promoting public health[19].

The high complexity and temporal–spatial heterogeneity of urban ecosystems pose challenges to the measurement of urban ES. While most existing urban ES research concentrates on natural elements in cities, understanding, analyzing, and measuring urban ES, especially integrating ES into urban landscape planning and urban governance, are the research difficulties that need to be addressed in the future[15]~[19]. The 10th ESP Conference highlighted that urban landscape planning and design practice can be improved by enhancing a certain type of ES (such as cultural ES and regulation ES), adjusting positive and negative services or ES supply–demand equilibrium, and specifying GI planning and design indicators, such as scale, shape, layout, and accessibility.

3.1.2 River, Lake, and Wetland Landscapes

Rivers, floodplains, wetlands, and lakes are some of the most complex and dynamic ecosystems, and play key roles to freshwater water supply, water purification, flood control, biodiversity protection, and food supply[20]. Related sessions focused on the quantification of ES provided by rivers, lakes, wetlands, and the contribution of ES research to intersectoral and interdisciplinary watershed landscape planning and management. The scale of watershed landscape planning and management varies from the basin to global, and the research methods include

目：德国“河流ES指数”项目提出了针对供给、调节、文化三类ES的河流ES指数，并应用于德国多瑙河、内贝尔河等案例中，协助制定综合性的规划决策[21]；欧盟HyMoCARES项目梳理了河流修复及一般管理行动、水文形态与河流ES之间的关系，利用水文、水力及栖息地模型与现有数据量化水文形态变化对河流ES的影响，指导阿尔卑斯河流域的规划和管理[22]；简·H·詹森等人探讨了如何将气候模型和水文模型与全球湿地ES模型相整合，以探讨全球气候及土地利用变化对湿地ES的影响[23]。

研究难点包括多尺度下的数据获取、定量评价方法的选择、不同ES受益方的识别，以及相关研究方法与研究结论的跨学科应用。河流及湿地景观规划与设计一方面可借鉴上述研究的评价方法展开更加科学、有效的ES评估，另一方面可利用已有的水文形态对ES影响的研究结论，从物质空间形态入手提升河流与湿地的ES功能。

3.1.3 森林景观

森林景观的分布及其ES对全球可持续发展具有重要作用，森林的植物特性、物种与群落分布、生物量、碳储存量等均对ES具有影响[24]。分会场B3关注在土地利用和气候变化背景下，半天然林和人工林的正负ES评估及调节。研究热点聚焦在：

1）评估森林的多种ES（如气候调节、固碳、休闲娱乐及审美服务等）。如埃德加·尤尔马里斯等人绘制并评估了拉脱维亚森林中多种潜在的娱乐ES[25]。

2）土地利用、气候变化及景观管理对森林ES的影响。如克瓦德沃·K·库西等人利用InVEST模型评估了三种不同的土地利用变化情境对ES的前瞻性影响[26]；米格尔·努诺·布加略研究了可持续森林管理对于保护生物多样性和维持ES的作用[27]。

3）森林ES之间、正负服务之间，以及与其他土地利用类型之间的服务权衡。如卡拉·洛克尔克劳斯等人以智利南部外来森林种植园为例识别、绘制并量化评估了ES与生态系统负面服务[28]。其中，各种服务之间的权衡是研究的难点。例如，鉴于森林所发挥的重要ES，应增加森林面积，但森林的供给服务只有在被砍伐后才能获取，增加人工林（如种植园）的面积也会带来物种入侵等环境问题。因此，未来森林景观管

synergy and trade-off analysis, scenario simulation, etc. Session B2a introduced 3 research projects: The German River Ecosystem Service Index project proposed the “River ES Index” for the measurement of provisioning, regulatory, and cultural ES, and applied it to the cases of Danube and Nebel Rivers in Germany to assist the decision-making of overall planning[21]; the EU HyMoCARES project reviewed the relations between river restoration and general management actions, hydrological morphology with river ES, and quantified the impact of hydrological changes on river ES through hydrological, hydraulic, and habitat modeling, as well as data collection, to guide the planning and management of the Alps River Basin[22]; Jan H. Janse et al. explored how to integrate climate and hydrological models with global wetland ES models to study the impact of global climate and land-use changes on the ES provided by wetlands[23].

Difficulties in associated research include data acquisition at multiple scales, the selection of quantitative evaluation methods, the identification of different ES stakeholders, and the interdisciplinary application of related research methods and findings. The application in the planning and design of river and wetland landscapes can not only adopt ES evaluation methods to improve the scientism and effectiveness, but also learn from the existing research findings (e.g., the impact of hydrological patterns on ES) to improve the ES of rivers and wetlands through spatial forming.

3.1.3 Forest Landscapes

The distribution of forest landscapes and the ES provided plays an important role in global sustainability. The plant characteristics, species, and community distribution, biomass, carbon storage of forest greatly define its ES[24]. At the conference, Session B3 focuses on ES assessment and adjustment of semi-natural forests and plantations responding to land use and climate change. Research hotspots include:

1) Evaluation of various ES provided by forests (e.g., climate regulation, carbon sequestration, recreational and aesthetic services). For example, Edgars Jūrmalis et al. mapped and evaluated a variety of potential recreational ES of forests in Latvian[25].

2) The impact of land use, climate change, and landscape management on forest ES. For example, Kwadwo K. Kusi et al. evaluated the potential impact on ES in three land use scenarios with the InVEST model[26]; Miguel Nuno Bugalho studied the role of sustainable forest management in protecting biodiversity and maintaining ES[27].

And 3) the trade-offs among forest ES, between positive and negative services, and with other land use types. For instance, Karla Locher-Krause et al. identified, mapped, and quantified the ES and negative services of the exotic forest plantations in southern Chile[28]. Among them, the trade-off between various services poses a difficulty to such research. For example, the increase in forest area would enhance the ES by forests, but the provision service of forests can only be obtained after woodcutting, and artificial forests (such as plantations) would also

理与政策需要在多种服务间进行权衡[29]。在气候变化和土地利用变化等不同预景下，可以通过预测森林ES的变化调整景观格局，并制定针对性的森林景观管理政策。

3.2 ES研究在景观规划与管理中的应用

景观规划可以通过调控土地覆被类型和空间格局来影响ES的类型和水平，也可以根据人类的需求通过调整服务功能特性指标促进或抑制不同ES的发挥[14]。会议上介绍的研究可应用于多种景观规划类型，包括城乡景观规划、流域景观规划、自然保护区规划等（表3）。区别于传统的工程解决方案，基于自然的解决方案（Nature-Based Solutions，简称NBS）受自然启发与支撑，是保护、恢复或可持续管理ES，同时提升生物多样性和人类福祉的行动[30]。NBS是景观规划与管理中促进ES的重要手段。

3.2.1 城乡景观规划

ES研究在城乡景观规划中的应用凸显了城乡环境中GI的关键作用及重要价值，基于ES制图，能够将城郊及乡村地区大面积的GI向城市化地区提供ES的趋势空间化。城乡景观规划中重点关注：

1）将ES纳入政策和规划，以增强ES在促进城乡协同方面的战略作用。如甘丹·萨瓦西等人识别了ES在规划过程和治理结构中的角色和作用，探究了ES连接不同规划过程和建立新的城乡协同的潜力[31]。

2）研究多种尺度下城乡景观结构对一种或多种ES功能及其供给的影响，以及政策对景观服务的影响。如安德莉亚·斯塔克裘尼等人研究了城市生态基础设施结构对洪水调节服务的影响，以及如何通过增加、保留和扩大廊道来改善网络连通性[32]；迪特尔·莫特尔曼斯等人研究了关键政策工具对城乡景观的地理要素、ES及社会生态功能的影响，为城市GI管理提供依据[33]。

3）NBS在解决城市可持续性方面发挥的作用，主要涵盖城市气候变化、人类健康及生物多样性三大主题。如托马斯·巴杜拉等人利用选择实验评估了城市居民对使用NBS适应气候变化的政策偏好[34]；大卫·杰内莱蒂等人通过评估不同受益群体的预期ES，以及在不同的时间范围内实施不同NBS的成本，实证分析了意大利北部城市空地实施NBS的潜在影响[35]。

cause environmental problems such as exotic species invasion. Therefore, future management and policy making of forest landscapes needs overall consideration on ES trade-offs[29]. Different ES scenarios on climate change and land-use change can inform the adjustment of forest landscape pattern and the formulation of specific management policies.

3.2 Application of ES Research in Landscape Planning and Management

Landscape planning can impact the types and levels of ES by adjusting land cover types and spatial patterns, and can also promote or confine the performance of certain ES types by adjusting ES functional indicators according to human needs[14]. The studies presented at the conference can be applied into a variety of landscape planning practice types, including urban and rural landscape planning, watershed landscape planning, nature reserve planning, etc. (Table 3). Different from traditional engineering solutions, Nature-Based Solutions (NBS) refers to the actions that inspired and supported by Nature to protect, restore or sustainably manage ES and enhance biodiversity and human well-beings[30]. NBS is an important means to facilitate ES performance in landscape planning and management.

3.2.1 Urban and Rural Landscape Planning

The introduction of ES science into urban and rural landscape planning highlights the key role and important value of GI to urban and rural environments. Based on ES mapping, large-scale GI in suburban and rural areas can provide ES to urban areas through spatial formation. Related research interests include:

1) Integrating ES into policy making and planning to enhance the strategic role of ES in promoting urban-rural synergy. For example, Günden Savaşçı et al. identified the roles and functions of ES in the planning process and governance structure, and explored the potential of ES to connecting different planning processes and establishing new urban-rural synergy[31].

2) The impact of urban and rural landscape structure on one or several ES functions and their delivery at multiple scales, as well as the impact of policies on landscape services. For example, Andrea Staccione et al. studied the impact of urban ecological infrastructure structure on flood regulation, and how to improve network connectivity by adding, retaining, and expanding corridors[32]. Dieter Mortelmans et al. studied the impact of key policy instruments on geographical elements, ES, and socio-ecological functions of urban and rural landscapes, so as to guide urban GI management[33].

And 3) the contribution of NBS to addressing urban sustainability, ranging urban climate change, human health to biodiversity. For example, Tomas Badura et al. evaluated urban residents' policy preference for NBS to adapt to climate change through a choice experiment[34]. By evaluating the expected ES of different beneficiary groups and the cost-effectiveness of a series of NBS in different periods of time, Davide Geneletti et al. empirically analyzed the potential impact of implementing a range of different NBS in vacant lots of a city in northern Italy[35].

3.2.2 流域景观规划

为提升流域景观的ES，会议重点关注：

1）将NBS融入流域景观规划的不同途径和范式。如克里斯蒂安·艾伯特等人提出了一个基于NBS的景观规划框架（包括确定环境和挑战、制定共同愿景、探索NBS预景、制定解决方案战略、实施方案和监测NBS效果），并将其应用于德国拉恩河景观规划中[36]；王志芳将NBS分为自然范式、本土范式、过程范式、文化范式、实验范式和绿色范式6个概念范式，提出了一个基于理论范式的NBS规划框架，并将其应用于中国山区城市河流景观规划中[37]。

2）流域景观格局或土地利用对洪水调节服务的影响。如凯尔西·麦克唐纳等人研究了美国堪萨斯城南部流域土地覆被变化对防洪ES的时空影响[38]。

3）NBS对生态、社会和经济的有效性，基于NBS的规划和设计方法及案例，以及实施NBS的治理和商业模式。如莎拉·戈特瓦尔德等人开发并测试了基于NBS的地理设计过程，并评价了其对河流景观边界管理的贡献[12]；马里奥·布里林格等人利用文献分析法对德国三个联邦州的洪水风险管理计划及其中采用的“基于自然的措施方法”（nature-based measures）进行了内容评估，并探讨了在政策准备和决策制定中采用基于自然的措施方法的潜在影响因素[39]。

3.2.3 自然保护区景观规划

1）关注自然保护区与生物多样性景观规划，同时也涉及国家公园、生物圈保护区及风景名胜区规划等。马修·米契尔等人以加拿大为例，将生态系统容量和人类需求纳入ES评估，评估了ES热点区与保护区网络的一致性，探讨了将ES纳入保护规划的途径[40]。

2）关注城市森林政策对区域ES的影响。如马蒂亚斯·里德尔等人依托“阿尔卑斯山ES的制图、维护和管理”项目，通过收集正式或非正式文书及公众对ES和人类福祉的认识资料，根据实施过程中的机会、限制以及通过ES产生的附加值，对已经实施或适合实施ES的政策工具进行评估[41]。

3）关注保护区利益相关者偏好与参与式规划。如马诺吉·巴塔利用焦点小组讨论、关键线人访谈、非正式互动及参与者观察等方法研究了尼泊尔西部保护区附近的村民从小熊猫栖息地获得的各种ES[42]；里扎·卡伦·瓦力迪阿诺等人研究了菲律宾巴拉望山脉土著居民在森林保护项目中如何理解ES的概念，并根据科学评估与地方决策者一同采取

3.2.2 Watershed Landscape Planning

In order to improve ES of watershed landscapes, the conference highlighted:

1) A series of approaches and paradigms to integrate NBS into watershed landscape planning. For example, Christian Albert et al. proposed a landscape planning framework based on NBS (including identifying context and challenges, developing a shared vision, exploring NBS scenarios, crafting solution strategies, implementing NBS, and monitoring NBS effect), and applied it to the landscape planning of the Lahn River in Germany[36]; Wang Zhifang proposed 6 paradigms of NBS, namely natural, native, progressive, cultural, experimental, and green, as well as a NBS planning framework based on these paradigms, illustrating with a case study of river landscape planning of mountainous areas in China[37].

2) The impact of watershed landscape pattern or land use on flood regulation services. For example, Kelsey McDonough et al. studied the temporal–spatial impact of land cover change on flood regulation ES in the southern basin of Kansas City, USA[38].

And 3) ecological, social, and economic effectiveness of NBS, NBS-based planning and design methods and case studies, and the governance and business models for implementing NBS. For example, Sarah Gottwald et al. developed and tested the NBS-based geodesign process and evaluated its contribution to the boundary management of river landscapes[12]. Mario Brillinger et al. used literature analysis to evaluate the flood risk management plans of three German federal states and the nature-based measures adopted, and analyzed the potential influencing factors for the adoption of NBS in policy preparation and decision making[39].

3.2.3 Landscape Planning of Nature Reserves

1) The landscape planning of nature reserves and biodiversity, as well as the planning of national parks, biosphere reserves, and scenic areas. With case studies in Canada, Matthew Mitchell et al. integrated ecosystem capacity and human needs into ES assessment, evaluated the consistency between ES hotspots and protected areas, and discussed the ways to combine ES into conservation planning[40].

2) The impact of urban forest policies on regional ES. Based on the project of “Alpine Ecosystem Services—Mapping, Maintenance, and Management,” Matthias Riedel et al. evaluated the policy tools which are implemented or suitable for implementing ES, by collecting formal or informal documents of public awareness about ES and human well-beings, according to the changes and limitations in ES implementation, and added value generated by ES[41].

And 3) stakeholders’ preferences and participatory planning of protected areas. For example, Manoj Bhatta studied various ES acquired from red panda habitats by villagers near the protected area in western Nepal through focus group discussions, key informant interviews, informal interactions, and participant observation[42]. Rizza Karen Veridiano et al. studied how indigenous people in the Palawan Mountains of the Philippines understand the concept of ES in forest conservation projects, take actions with local decision-makers based on scientific assessments, and inform the local forest management and conservation

行动，将其转化为森林管理和养护政策，为参与式规划影响规划政策提供了案例借鉴[43]。

3.2.4 小结

除了上述规划类型之外，在国土空间规划方面，费尔南多·桑托斯马丁等人以西班牙为例，通过绘制14个ES指标的空间分布图和热力图，解释了与土地利用强度梯度相关的ES协同效应和权衡，提出需要建立一个国土尺度下的新的景观规划模型[44]。

景观规划以协调人与自然关系为目标，注重规划客体的多重价值属性及空间分异，是景观管理的基本手段[45]。然而，多重价值之间在同一时空下往往相互冲突，如何把握规划客体的空间分异规律，寻求能够最大化景观多重价值、功能及潜力的空间途径，以缓解、协调价值冲突区域，是景观规划要解决的主要问题[45]。总体而言，该议题下的研究热点可总结为：

1）ES融入各类空间规划（如国土空间规划、城乡GI规划、流域景观规划、土地利用规划等）的框架、方法和途径；

2）景观结构特征及变化对ES供应及效益的影响；

3）规划或管理政策对ES的影响；

4）在景观规划设计实践中应用NBS提升各类型景观的ES。

ES将自然资源与人类福祉关联在一起，定量化的评估和可视化的表达可以使利益相关方明确价值冲突区域，从服务流动、供需、权衡等多个角度深入剖析空间潜力，借鉴景观特征影响ES的相关研究成果，可进一步优化景观格局，为多尺度、多类型的景观规划设计和管理提供科学依据。

3.3 ES建模与制图

ES建模与制图是历届ESP全球会议讨论的热点议题。第十届会议集中讨论了其在动态ES（包括价值变化、情景探索、动态可视化、实时应用、现场监测、临界点建模）②，非物质性ES评估，以及综合ES模型等方面的研究（表4）。会议上介绍的定性、定量模型可以借助机器学习等技术，构建面向用户的景观决策支持系统，提供了从理论研究向实践转化的有效途径。ES建模由通过整合物质空间数据的传统模式向满足多尺度、多用户、多需求转变；在方法上由允许数据共享与集成向鼓

② 引自第十届ESP全球会议官方网站上对T4a分会场的会议描述。

policy making, which provides a case study for how participatory planning informs planning policies[43].

3.2.4 Summary

In addition to the above types of planning, in terms of national spatial planning, Fernando Santos–Martín et al. concentrated on the case studies in Spain to illustrate ES synergies and trade-offs related to land-use intensity gradient by mapping the spatial distribution and heat spots of 14 ES indicators, and put forward the need to establish a new national-scale landscape planning model[44].

Landscape planning, as a basic means to landscape management, aims at coordinating the human–nature relationship and pays attention to the multiple value attributes and spatial differentiation of planning objects[45]. However, due to the temporal–spatial conflicts among multiple values, how to understand the spatial differentiation laws of planning objects, seek spatial approaches that maximize the values, functions, and potentials of landscapes, so as to alleviate and coordinate value-conflicting areas, is a main problem to be addressed in landscape planning[45]. In general, the research hotspots in landscape planning and management can be summarized as follows:

1) The framework, methods, and approaches to the integration of ES into various spatial planning (e.g., territorial spatial planning, urban-rural GI planning, watershed landscape planning, and land use planning);

2) The impact of landscape structural characteristics and changes on ES delivery and benefits;

3) The impact of planning or management policies on ES;

And 4) applying NBS into landscape planning and design practice to improve ES of various landscape types.

ES matters and connects natural resources with human well-beings, and quantitative evaluation and visualized expression help stakeholders identify value-conflicting zones. By analyzing the spatial potentials in service flows, supply and demand, and trade-offs, and learning from the relevant research findings of the impact of landscape characteristics on ES, landscape patterns can be optimized to provide scientific bases for multi-scale and multi-type landscape planning, design, and management.

3.3 ES Modeling and Mapping

ES modeling and mapping has been a hot topic discussed at previous ESP global conferences. The 10th ESP Conference focused on the research on dynamic ES (including value change, scenario exploration, dynamic visualization, real-time application, on-site monitoring, and threshold modeling)②, immaterial ES evaluation, and integrated ES models (Table 4). The qualitative and quantitative models introduced at the conference can be used to build user-oriented landscape decision-making systems, with aid of machine learning and other technologies, facilitating associated application and practice. ES modeling is shifting from the traditional models that integrate spatial data towards the ones that respond to

② Sourced from the "Session Description" of T4a on the official website of the 10th ESP World Conference.

励开源和机器学习改变。以“改善大西洋景观管理项目”介绍的综合建模技术为例，通过整合社会经济和气候变化情景建立生物监测空间数据库，利用模拟平台整合多个模型，可用于分析河流景观单元内自然过程及人类活动间的相互作用及多种ES评估[46]。模型还嵌入了利益相关者的参与框架，使参与性评估与模型相互补充[46]。此外，会议重点推出的ES人工智能建模平台可以实现线上快速ES评估，融合了可查找、可访问、互操作性、可重用、可定制等功能，不但可以分析ES的时空变化及受惠者流动路径，还可以使用模块化模型组件和根据上下文选择的数据自动推荐查询结果，为景观规划和政策决议提供更用户友好、更有针对性的服务[47][48]。

纵观会议研究成果，为克服ES的空间流动性和非地理定位性带来的景观规划和管理障碍，利用建模整合地理空间数据与社交媒体数据进行交互分析已经成为识别非物质ES（如文化服务、支持服务）的主流途径。T4b分论坛集中讨论了非物质性ES量化方法和制图工具进展。例如，通过识别Flickr、Twitter及Instagram等常用社交媒体中的关键词（社交媒体图片标签），以及图片中的景观特征来研究文化服务的空间分布[49][50]。除此之外，会议还指出了参与式方法对调查社会、经济、制度等影响ES服务权衡的因素的重要性[51]。

4 会议对景观规划研究与实践的启示

多尺度、多领域的景观规划可通过构建GI或生态安全格局来建立生态系统空间网络。在中国生态文明建设与国土空间规划变革的背景下，亟需通过景观规划与设计保障自然的ES，构建人与土地、人与自然的和谐关系[53][54]。本文基于第十届ESP全球会议所呈现的最新研究及应用成果，对景观规划设计专业人员提出以下建议。

4.1 探索面向多种景观类型的ES评价

从城市到乡村，从陆地到水域，从平原到山区，随着评价对象种类与尺度多样性的拓展，ES评价为卡尔·斯坦尼兹经典研究框架中的景观表述与景观评价提供了基础数据与科学依据，可直观地识别出能够提供重要ES的景观类型。一方面，应进一步加强对ES量化评估体系、测度方法与评价模型的研究，特别是关于服务需求和服务流动的量化评

different needs across scales for various stakeholders. Methodological focuses shift from data sharing and integration towards open source and machine learning. For example, in order to improve the management of Atlantic Landscapes, biodiversity and ES integrated modeling was used as a simulation platform that integrates multiple models, to analyze the interaction between natural processes and human activities in riparian landscapes, as well as the assessment of a variety of ES, by establishing a biological monitoring spatial database according to socio-economic and climate change scenarios[46]. The model also adopted a participation framework of stakeholders, and support the iteration between participatory assessment and modeling[46]. In addition, the Artificial Intelligence for ES modeling platform, which was introduced at the conference, can be used for quick online ES evaluation, supporting searching, access, interoperable, re-use, and customized functions; for analyzing temporal–spatial ES changes and the flow path of beneficiaries; and for targeted services for landscape planning and policy decision-making through modular modeling and automatic recommendations of query results[47][48].

In order to overcome the obstacles in landscape planning and management caused by spatial mobility and non-geolocation of ES, modeling integration of geospatial data and social media data for interactive analysis has become a mainstream approach to identify immaterial ES (such as cultural and supporting ES). The T4b session focused on the development of immaterial ES quantification methods and mapping tools. For example, the spatial distribution of cultural ES was studied by identifying keywords (social media picture tags) in popular social media (e.g., Flickr, Twitter, and Instagram), and analyzing the distribution of cultural ES by identifying the landscape characteristics in the pictures[49][50]. The conference also highlighted the participatory approaches to investigating the social, economic, institutional factors that influence the ES trade-off[51].

4 Conference Insights on Landscape Planning Research and Practice

Multi-scale and multi-domain landscape planning can promote the establishment of ecosystem network by building GI or ecological security pattern. In China’s current ecological civilization construction and the transformation of territorial spatial planning, it urgently needs to guarantee the ES of nature through landscape planning and design, and to rebuild the harmony between human and land, and between man and nature[52][53]. Upon the latest research and application results introduced at the 10th ESP Conference, this paper offers landscape planning and design professionals with the following insights.

4.1 ES Evaluation for Multiple Landscape Types

From cities to villages, from land to water, from plains to mountainous areas, the increase in types and scales of ES evaluation objects enriches data and scientific bases for landscape representation and landscape evaluation within the Carl Steinitz’s classic research framework, which helps identify the landscape types that provide critical ES. On the one hand, research on ES quantitative evaluation

估。在此基础上，深入开展对ES供需及权衡与协同关系的研究。另一方面，深入探索景观规划、景观格局与ES之间的相互作用关系，以及物质空间形态与ES评价的关联。除此之外，鉴于ES评价在表征景观空间的特征与功能方面的优势，应积极探索如何将评价结果落到具体的空间规划中，探索如何将“价值空间”转化为“空间价值”，为主体功能区划分、景观安全格局构建、生态红线划定、景观绩效评估等提供重要科学依据[54][55]，支持城市韧性与可持续发展。

4.2 探索将ES研究融入各类景观规划的理论与实践框架

正如景观设计实践与现代科研之间存在错位[56]，ES研究与规划设计实践之间也存在着较大的鸿沟。一方面，学者应加强气候变化、景观格局与特征、景观规划政策与治理措施对ES的影响机制研究，得出能够具体指导规划设计实践的格局指标和政策措施。另一方面，规划设计师应加强科学循证，充分利用ES的专业知识与科研结论转化为设计导则、空间模式和量化指标，搭建ES研究与设计实践之间的桥梁。尝试将ES理论融入各类景观的规划与设计研究框架。以景观规划设计领域较为经典的卡尔·斯坦尼兹研究框架为例：在景观表述中，对景观所提供的ES进行识别和描述；在景观过程中，理解与分析景观中的ES过程；在景观评价中，通过利用ES评价模型评估ES水平判断景观运作情况；在景观改变中，提供景观格局或结构的改变策略和预景；在景观影响中，评估景观结构或格局的变化对ES带来的影响；最终在景观决策中，基于提升ES选择最终的景观改变模型。除此之外，还需要充分考虑服务间的流动与相互关系，将ES时空格局、供需关系、权衡与协同关系纳入景观规划分析框架（图2）。

4.3 探索适用于景观规划与管理的ES综合建模与制图工具

多尺度的ES综合建模和面向用户的学习型制图技术的发展，能有效展示并预测空间格局、社会经济、保护管理等方面的变化对ES的影响。景观规划领域应积极探索ES综合建模与制图的强大功能，一方面，整合多个模型进行综合建模，搭建政府机构、大学、非政府组织和

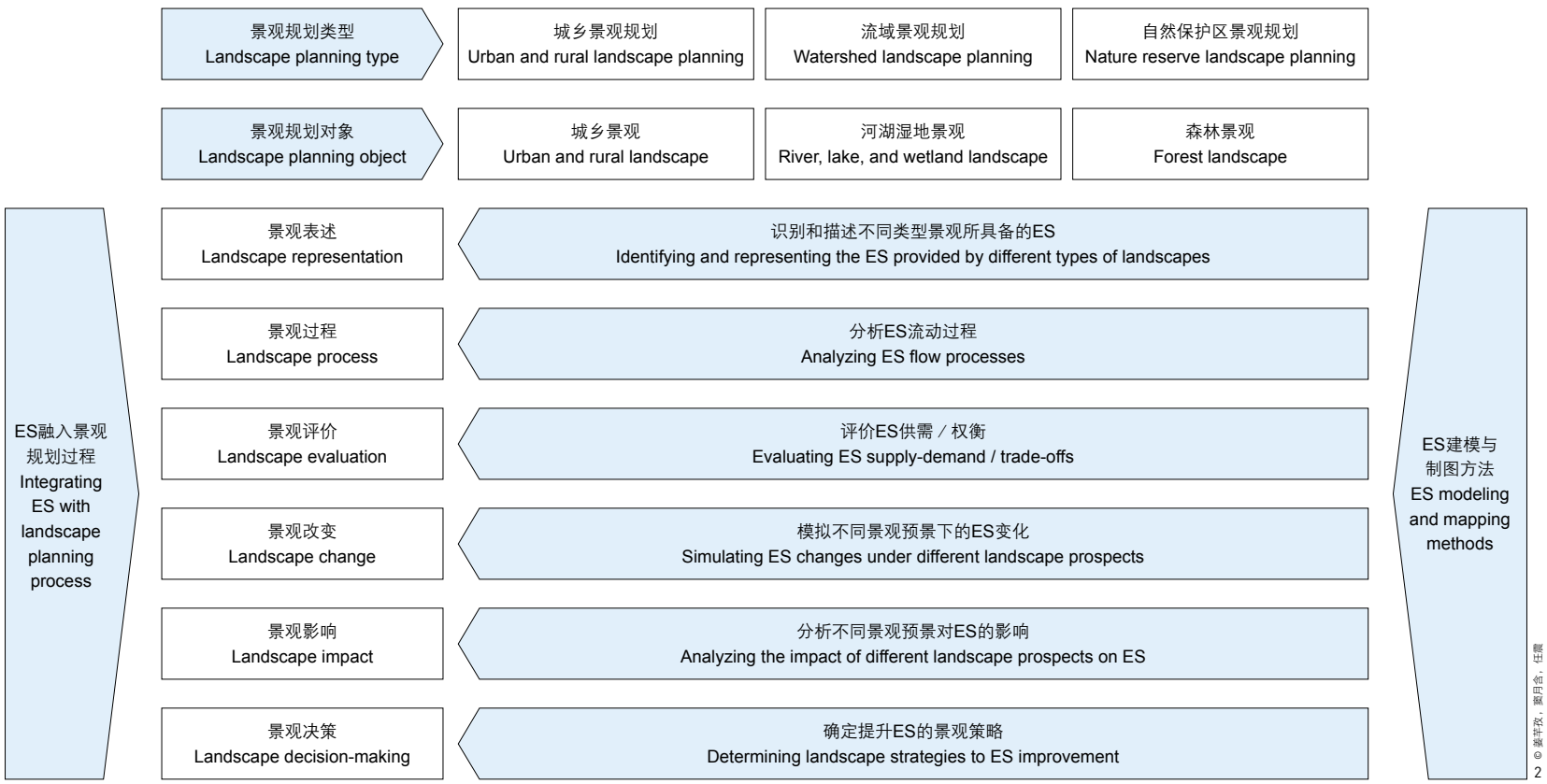
system, measurement methods, and evaluation models—especially the quantitative evaluation on service demands and service flows—the supply and demand, and the trade-off and synergy of ES should be enhanced. On the other hand, in-depth exploration of the interaction between landscape planning, landscape pattern, and ES, as well as the relations between spatial forms and ES evaluation. In addition, in view of the advantages of ES evaluation in identifying the characteristics and functions of landscapes, future research interests might include the application of evaluation results into specific planning practices, and the promotion of the space value of sites. This will provide scientific bases for the identification of core-function areas, the construction of landscape security patterns, the delineation of ecological protection boundaries, and the evaluation of landscape performance[54][55], propelling urban resilience and sustainable development.

4.2 The Theoretical and Practical Frameworks for Integrating ES Science Into Landscape Planning

Just as there is a dislocation between research and practice in landscape design[56], there is also a big gap between ES research and associated planning and design practice. On the one hand, scholars should strengthen the research on the impact mechanism of climate change, landscape patterns and characteristics, landscape planning policies and governance measures on ES, so as to inform the development of pattern indicators and policy measures that can specifically guide planning and design practices. On the other hand, urban planners should strengthen scientific evidence-based, make full use of ES professional knowledge and scientific research conclusions into design guidelines, spatial models and quantitative indicators, and build a bridge between ES research and design practice. Meanwhile, it is necessary to try to integrate ES theory into the planning and design research framework of various landscapes. Taking the classic Carl Steinitz's research framework in the field of landscape planning and design as an example: in the landscape representation, identifying and describing the ES provided by the landscape; in the landscape process, understanding and analyzing the ES process in the landscape; In landscape evaluation, the operation of landscape is judged by using ES evaluation model to evaluate ES level; in landscape change, the strategy and prospect of landscape pattern or structure change are provided; in landscape impact, the impact of landscape structure or pattern changes on ES zone is evaluated. In the final landscape decision-making, the final landscape change model is selected based on the promotion of ES. In addition, it is also necessary to fully consider the flow and interrelationship between services, and incorporate ES spatiotemporal patterns, supply-demand relationships, trade-offs and synergy into analysis frameworks of landscape planning (Fig. 2).

4.3 Integrated ES Modeling and Mapping Tools for Landscape Planning and Management

The development of multi-scale integrated ES modeling and user-oriented learning mapping technology can effectively display and predict the impact of



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2. 融入ES的景观规划与设计研究框架

2. Landscape planning and design research framework integrated with ES

其他利益相关方的合作平台，不断纳入和学习用户上传数据，对不可见的ES进行可视化的直观展现，动态分析不同社会经济环境中多种类型ES的权衡与协同、供给与需求关系；另一方面，探索整合气候条件、地理空间、社交媒体及社会经济等多源数据融合的ES制图方法，并将其转化为适用于不同尺度景观规划的图示语言，以辅助景观分析、公众参与及多情景模拟下的景观规划方案比选。

5 结语

与生态学、地理学视角下的ES研究有所不同，景观规划视角下的ES研究以景观为载体，围绕规划设计—景观格局与功能—ES—人类福祉这一主线，将基于分析与评价的人地关系空间营建技术作为研究核心。将ES的概念和科学研究框架融入景观规划、设计和管理行动，将

changes in spatial pattern, social economy, and protection management on ES. Scholars in landscape planning field are expected to enhance the functions of integrated ES modeling and mapping. On the one hand, multiple models can be integrated for comprehensive modeling by building a cooperative platform among government agencies, universities, NGOs, and all kinds of stakeholders and continuously incorporating user-uploaded data. This can visualize the intangible benefits of ES, and support the analysis of dynamic trade-offs and synergy / supply and demand relations of multiple ES types in different social-economic contexts. On the other hand, scholars also need to explore ES mapping methods that integrate multi-source data such as climate conditions, geospatial, social media, and social economy, and improve associated graphic application in landscape planning at different scales. This method can assist landscape analysis, public participation, and decision-making of landscape planning schemes through multi-scenario simulation.

5 Conclusion

Different from the perspective of Ecology and Geography, the ES research in the field of landscape planning focuses on the interests from planning and design, landscape patterns and functions, ES, and human well-being, among which the

为以“人地关系空间营建”为核心的景观规划与设计专业带来机遇和挑战。它能加强景观规划中基于科学实证的分析技术，扩展景观规划的认知维度与技术方法，帮助分析与评价多类型景观的功能与服务，并面向不同利益相关方权衡多种规划预景和政策措施。当然，在ES融入景观规划的过程中也将面临诸多问题。例如，景观规划如何运用ES的科学认知优势克服景观规划中的数据缺失、不确定性以及利益相关方的价值冲突等[57]。**LAF**

man-land spatial construction technology based on analysis and evaluation is key. Integrating ES concepts and associated scientific research frameworks into landscape planning, design, and management actions will pose both opportunities and challenges to landscape planning and design profession that is missioned to improve human-land spatial construction. Such research can also strengthen the scientific analysis technology in landscape planning, enrich related cognitive dimensions and techniques, help analyze and evaluate the functions and services of multiple landscape types, and weigh multiple planning scenarios and policies for different stakeholders. The integration of ES research and landscape planning also faces other challenges. For example, researchers need to pay attention to how to use the scientific cognitive advantages of ES to overcome the existing landscape planning problems, such as lack of data, uncertainties, and value conflicts of stakeholders[57]. **LAF**

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