

Integrating Ecosystem Services into Planning Practice: Situation, Challenges and Inspirations

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Abstract: Ecosystem services (ES)-related decision-making is important to promote sustainable conservation and urban development. However, there is limited information regarding the use of ES research in a planning context. We explored this gap between ES research and planning practice by evaluating whether and to what extent the ES concept is explicitly used in planning and decision-making processes. This paper selected 101 pieces of target literature, reviewed their research status and characteristics, discussed the motivation and interests, and summarized the research content. In particular, we discussed the contributions that demonstrated the significance of incorporating ES into planning and achieved beneficial results. A series of abstract strategic methods and quantitative methodological approaches were used for subsequent reference research. The ES concept existed earlier than the perception in early-stage planning documents, while its practical application was superficial, with insufficient depth, which was a challenge worthy of attention. To identify the research paradigm in previous planning related to ES, we found that ES analyses for planning were largely theory-inspired, rather than practice-inspired, and used the Schön–Stokes model of the wicked and tame to theorize problems in socio-ecological systems. Our study highlighted that Pasteur’s paradigm may be an essential and useful research style for maintaining and improving ES in socio-ecological practice.

Keywords: ecosystem services; planning; socio-ecological practice; ES methods; decision-making; Pasteur’s paradigm



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1. Introduction

Ecosystem services (ES), which are defined as the benefits that people obtain from the ecosystem, play an essential role for human beings around the world [1,2]. ES research has extended its influence to planning and landscape ecology, becoming an essential focus of the sustainability movement. This integration provides an opportunity to enhance the usability, usefulness, effectiveness, and legitimacy of ES in planning by creating ES that are fundamental to human well-being. ES are widely known to have become increasingly important; thus, they should be applied practically and become a powerful tool for environmental and land-use planning to assist decision-makers [3,4]. Appropriate policies are crucial for integrating ES in spatial planning [5]. In real-world studies, ES have been shown to facilitate decision-making processes to various ends [6]. ES knowledge is achieved at a conceptual level by reframing dialogues and raising stakeholders’ awareness, at a strategic level by supporting planning and policy, and at an instrumental level by guiding specific decisions [7].

As early as 2011, scientists proposed that ES play a pedagogic role in contemporary planning [8]. The ES concept can complement existing policy instruments that focus solely on a specific task or sectoral interest [9]. Some have stated that ‘The clock is ticking to

integrate ecosystem services into their planning and decision-making' [10]. ES have the potential to strengthen urban nature and consideration of planning benefits [11], enhance quality of life and resilience in cities, and identify a range of socio-cultural impacts and economic costs [12]. The development of ES approaches can contribute to the mitigation of environmental effects and improve urban resilience [11]. Planners are conscious of this and so try to integrate ES into their plans [13]. From comparative paradigms, ES are a powerful tool for planning, which can help achieve sustainable development goals and a better understanding of trade-offs [4]. Integrating ES into planning and decision-making may achieve diverse community goals, lead to better outcomes for people, protect natural resources [4,14], and help decision-makers facilitate communication from sectors such as planning, agriculture, and water management [9]. Using ES research to identify and protect priority areas for biodiversity can benefit people as well as animals [15]. Researchers particularly focus on cultural ES, arguing that it has incentivized the multifunctionality of landscapes [16]. Some studies point out the controversy that cultural ES can either encourage the maintenance of valuable landscapes or become an obstacle to innovation and transformation depending on the environment and analytical perspective [17].

Prior review articles on the integration of ES into planning have particularly emphasized, for example, the planning of multiple cities in a certain country, compared the planning of different cities to explore how it relates to ES, concentrated on a certain ES category, or examined methods for integrating ES into planning. The literature thus lacks a general overview integrating different pieces of ES research into a global perspective on planning. Cortinovis and Geneletti (2018) analyzed 22 samples of urban plans for Italian cities, investigating the extent to which ES are currently included in planning; they found numerous actions and tools for implementing urban ES to promote urban development. Woodruff and BenDor (2016) used criteria from the American Planning Association's Sustaining Places guidance to analyze the extent to which ES are incorporated into goal-setting, policies, and public participation processes. They found that Damascus, Oregon, which organizes the ES framework in land-use planning achieves more sustainability objectives compared with Cincinnati, Ohio, which receives recognition for advancing the art and science of planning [4]. Although previous research has found that cultural ES solves some planning and management problems, this topic still receives little attention. Cultural ES should be consistently integrated into conservation planning by maintaining and sustaining supply dependence on increasing biodiversity [16]. By reviewing 238 scientific articles, Cimon-Morin et al. (2013) determined that using quantifiable biophysical indicators and scale measuring their spatiotemporal flow is the best approach for identifying ES priority areas for conservation. They also identified a lack of spatial congruence between ES and biodiversity and suggested that incorporating ES into planning could be a new tool for protecting biodiversity.

Overall, there remains a knowledge gap between theory and practice, which restricts insight on how we can integrate ES research into planning. Therefore, this paper will explore the state-of-the-art of ES research for planning, aiming to provide a general perspective on how theoretical study and practical implementation are connected. We will focus on the research motivation, interests, contents, approaches, and data used in the sample literature. The rest of the article will discuss the achievement of ES research for planning, the gap, and challenges during the practice, as well as the inspirations and suggestions from our study.

2. Materials and Methods

This literature review focuses on articles that conducted ES (provisioning, regulating, supporting, and cultural services) research and used ES concepts for planning study or practice. This paper addresses the following four aspects: the research motivation, interests, contents, and approaches and data. A keyword search utilizing the Web of Science was used to identify relevant articles from 1986 to 2018. The following keywords were used for the search located in one of the following fields: topic, title, abstract, or keywords: ecosystem services (ES), ecological services, OR ecological systematic services, AND planning, plan,

OR programme. Figure 1. demonstrates the literature search and selection process used to obtain a unique new set of papers for this piece of research.

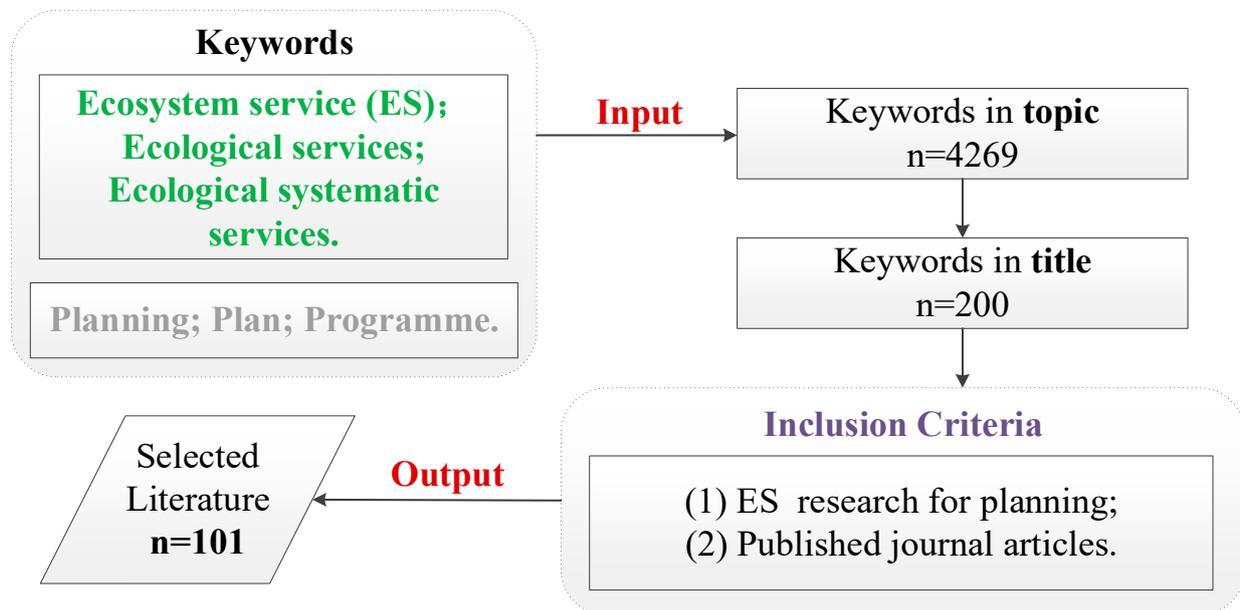


Figure 1. Simplified literature search utilizing the Web of Science and samples selection flow process for the review. Inclusion criteria focus on the published journal articles and ES research that serves to guide the planning practice.

The initial step returned 4269 published articles. Due to the large quantity, the research was refined by using only keywords in article titles, rather than topics. This reduced the total number of articles to 200. Although some articles have keywords ES and planning in their titles, they do not focus on ES-related research or do ES research that does not serve to guide the planning practice, and so these articles were excluded. As this study was concerned with published articles, presentations, conference papers, extended abstracts, grey literature, and books were excluded.

Keyword co-occurrence analysis was performed on the selected literature to determine the main focus and structure of the ES research for planning and to identify the relationship between the critical points represented by the keywords. A time-zone map of the keywords was created to demonstrate the evolution of research topics. Keywords with vigorous citation bursts indicating high strength and representing research fronts and hotspots were also identified. Study area, particularly country and continent, was noted and distribution statistics were used to identify regional patterns. Research scales were examined by the categories of regional, city, state/province, and national. Articles were also categorized based on the type of planning they focused on.

3. Results

We explored the development of research topics using trends in publications with the keywords ES AND planning based on the Web of Science (Figure 2). It revealed that since the first article appeared in 1997, the annual number of articles remained below 20 until 2003. From 2003 to 2012, it increased steadily, from 19 in 2003 to 185 in 2012. This growth became more rapid from 2012 to 2018, with average annual growth of over 100 articles, reaching 857 publications in 2018. This indicates that ES and planning have received increasing focus and have become hot topics in the 21st century. After exclusion, the final sample consisted of 101 articles, including 84 empirical studies, 12 review articles, 4 theoretical articles, and 1 leading article (Figure 3).

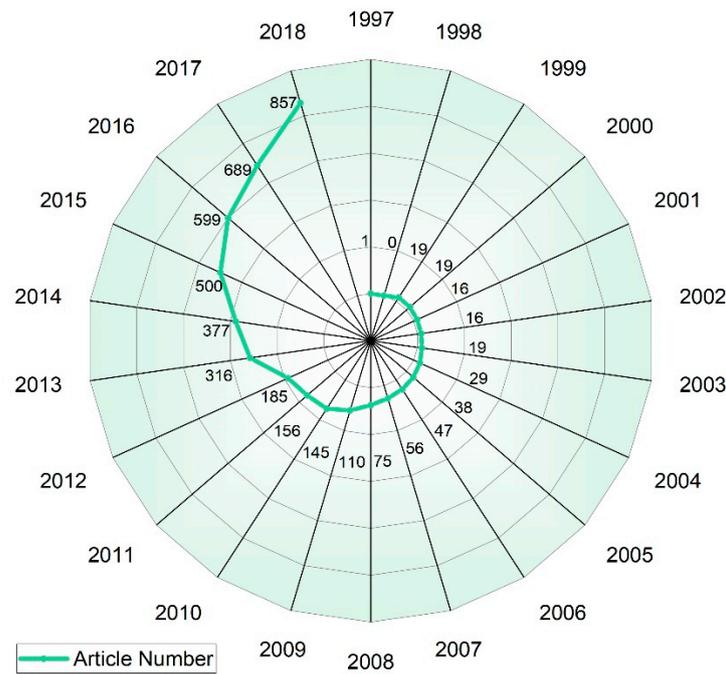


Figure 2. The number of published articles per year with keywords in the topic.

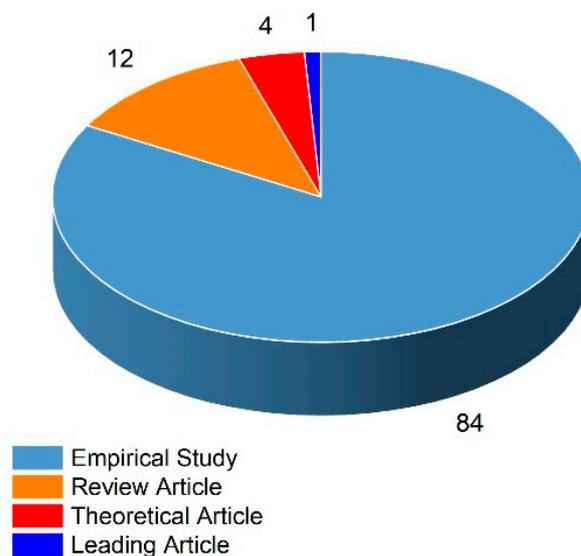


Figure 3. Composition of the sample articles. The numbers in the figure indicate the article number in each category.

3.1. Research Motivation

Our analysis indicated that the motivation for the research followed two patterns: the need to protect the environment, people, and animals and the need to balance the relationship among people, socio-economy, and the environment (Table 1). Environmental concerns included the protection of the microclimate [18], water [19], soil [20,21], and biodiversity [22,23], while concern for people and animals included the demand for cultural ES [17,24] and the conservation of habitat [15] and landscape corridors [25]. Regarding how to integrate ES into planning in order to research the balance, studies exploring frameworks and methods for incorporating ES into planning included ecological restoration methods [26,27], ES mapping [28–36], and environmental management [19,37–42]. Some studies compared research cases, analyzing which ES types have been included in planning [43], studying urban design schemes [44], and setting scenarios for case analysis [3,45,46]. Other

studies considered issues such as knowledge gaps between ES and planning [12,35,47–49], opportunities for integrating ES into planning [31,49–54], challenges, requirements, and the impact of incorporating ES into planning management [21,39,47,54–57], focusing on solving a series of existing problems [12,39,40,58,59] for the ecological environment and planning.

Table 1. Motivation for the research of sample articles.

Category (Numbers)	Motivation	Motivation Category	Cited Articles
The protection need (10)	Protection of environment	Microclimate	[18]
		Water	[19]
		Soil	[20,21]
		Biodiversity	[22,23]
The balance need (18)	Protection of people and animals	Demand for cultural ES	[17,24]
		Conservation of habitat	[15]
		Conservation of landscape corridors	[25]
The balance need (18)	Balance the relationship among people, socio-economy, and the environment	Ecological restoration methods	[31,32]
		ES mapping	[33–41]
		Environmental management	[19,37–42]

We can understand that motivation was the basis of the research in our sample studies deserving consideration, particularly if the studies are theory-inspired or inspired by practical needs. To determine the research basis, we looked at three aspects of critical thinking: whether acknowledgements in the article mention its research motivation, whether practical requirements are put forward by a second party who supports the finance, material, data, and human resources of the research, particularly in case studies, and whether the researcher completed the research for another party's practical goals. The results showed that most of the research was theory-inspired, with a total of 82 articles, while the remaining 19 pieces (about 20%) were practice-inspired. It can be concluded that, at present, the prevailing research pattern of ES is carried out and developed based on Bohr's paradigm in the Schön–Stokes model of research [60] in socio-ecological systems.

3.2. Research Interest

Researchers' backgrounds were analyzed using statistics based on the research unit of the first author. The results showed that they were mostly in the environmental sciences (25 articles, or roughly 25%). Authors from the fields of ecology and planning produced 13 and 12 papers, respectively. Other authors were from the fields of engineering, geography, agriculture science, biology, and management science (Figure 4).

Results from the visualization co-occurrence analysis using VOSviewer [61] are presented in Figure 5. The keywords ES and management, decision-making, conservation, biodiversity, and framework were relatively frequent with a strong total link strength. In the middle of the occurrence list are green infrastructure, spatial planning, landscape planning, and land-use planning, while resilience, challenges, and sustainability are behind based on the frequency and link strength. It can be inferred that ES for planning was a popular research interest and that most articles focused on the combination of ES (theory) and practical applications, whereas policy received less attention. Most research focuses on exploring existing problems and challenges and on what has been achieved.

In the first half of the timeline, there are fewer prominent research keywords, whereas the second half contains more research keywords, closely interrelated with one another. In particular, a large number of new keywords emerged between 2014 and 2015. The keyword that first appeared centrally was management. It can be seen that the first topic regarding ES research for planning began to focus on management for services in 2006, and it remained significant until 2012 (Figure 6). The essential research content, ES, appeared in 2010. It is worth noting that ES first appeared in 2006 as a vital research topic, although in

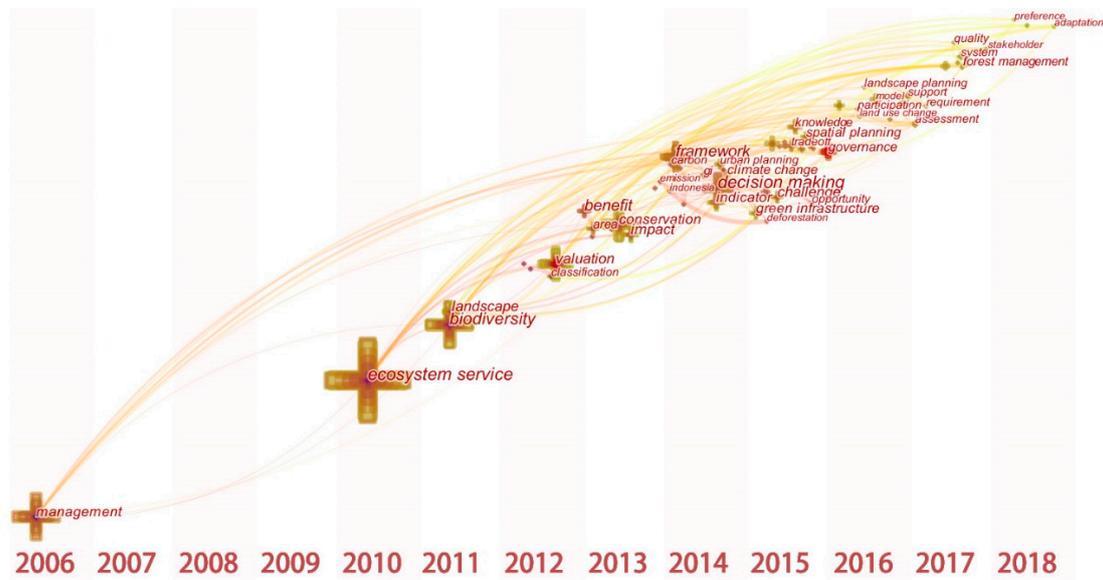


Figure 6. Burst terms of keywords based on time-zone in the research. The size of the plus symbol represents the frequency of keywords appearing in the sample articles.

The keyword burst results (Figure 7) indicate that the highest strength was for valuation (3.634). It can be seen that the valuation of ES is a research hotspot with a high degree of attention between 2012 and 2013, followed by government (from 2015 to 2016) and biodiversity (from 2011 to 2012). The keyword model had a high strength from 2016 to 2018. It can be inferred that model research was a study frontier of ES research for planning. The time chart also indicates that new research interests in preference and adaptation appeared in 2018, which reveals that some incipient tendencies developed in research branches.

Keywords	Strength	Begin	End	2006–2018
management	1.6178	2006	2012	
biodiversity	2.084	2011	2012	
valuation	3.634	2012	2013	
governance	3.5346	2015	2016	
model	1.6577	2016	2018	

Figure 7. Top-five keywords with the strongest citation bursts. The blue represents the timeline, the red represents the time period in which the keyword appears, and thickness refers to highlighting.

From the perspective of link strength, the integration between ES research and planning is not very close, and there is a dislocation between them. From the timeline, research interest in management appeared earlier than the concept of ES, indicating that interest comes from practice and sublimates into theory, which also has dislocation. Future research should pay attention to cutting-edge research in models while continuing to focus on new directions regarding stakeholders, preferences, etc.

3.3. Research Contents

Most papers had a centrally distributed focus in Central Europe, North America, South Europe, and East Asia (Figure 8). Few studies focused on Africa, Oceania, and other Asian regions, except for East Asia. Global research was also relatively rare.

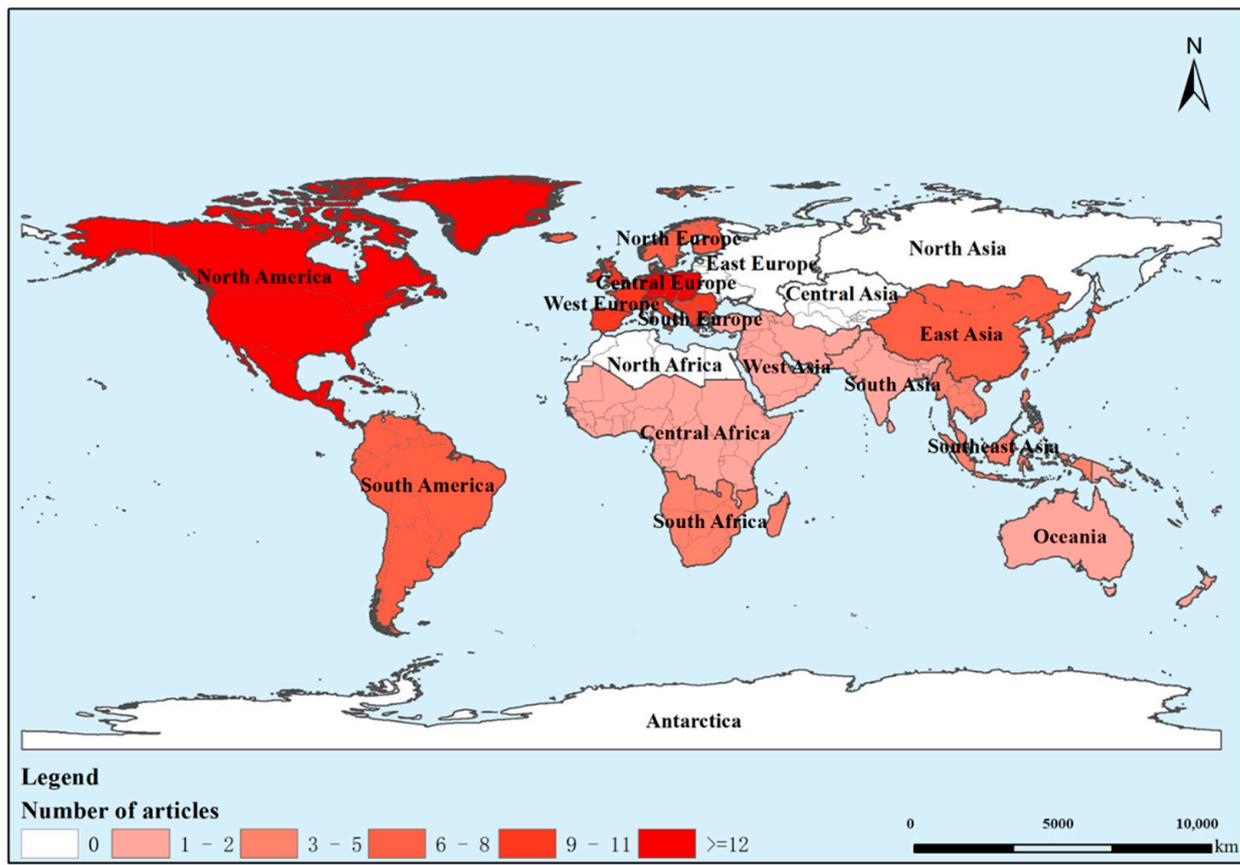


Figure 8. Regional distribution of case studies in the selected articles.

Approximately half of the research articles were on a regional scale (Figure 9). One-third of the articles focused on a city scale, while national- and state/province-scale articles accounted for about 8 and 5%, respectively.

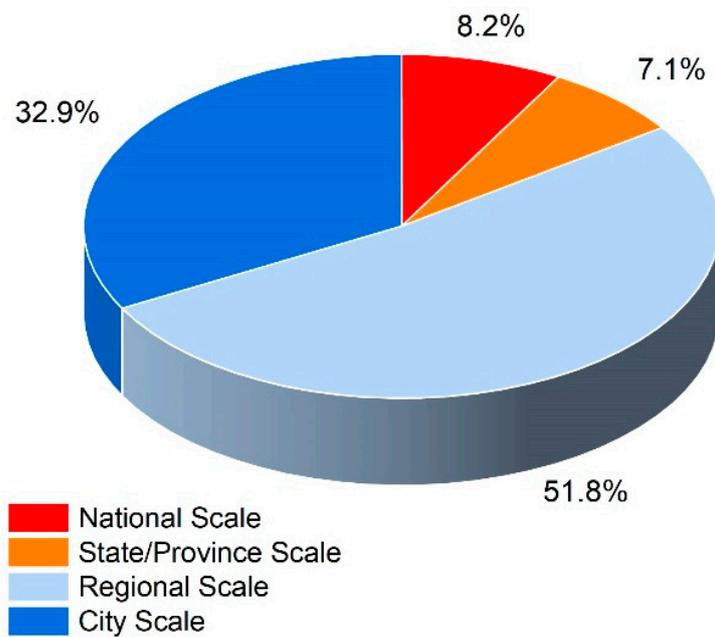


Figure 9. Research scale in the selected articles. The numbers in the figure indicate the percentage of different research scales.

Most articles (59 or about 60%) concentrated on land-use planning, urban planning, spatial planning, and landscape planning (Figure 10). This was followed by conservation planning, regional planning, and green infrastructure planning.

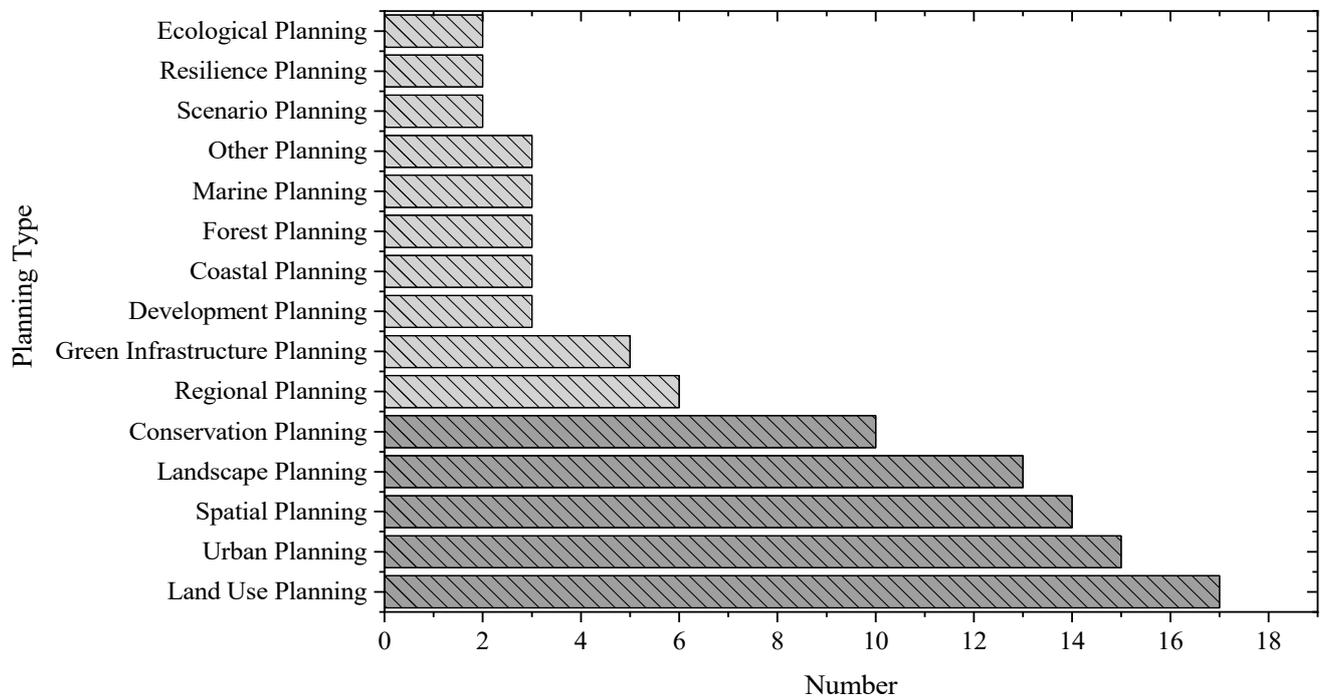


Figure 10. Planning types examined in the selected articles. The *x*-axis represents the number of different planning types.

3.4. Research Approaches and Data

The most common research method was GIS-based, accounting for about one-fifth of the articles, followed by empirical case studies, interviews or surveys, and literature reviews. Interviews or surveys included questionnaires, expert-based, stakeholder workshops, and meetings. About 60% of the papers used these four standard research methods. A small number of research articles used theoretical research methods, document analysis methods, mathematical or statistical methods, and biophysical evaluation models. In addition, approximately 11% of the studies used a combination of two or three types of research methods.

Nearly one-third of the articles used land-use/land-cover change data, ecological data, or literature data (Figure 11). Ecological indicators included understory diversity, soil chemistry, water supply, and carbon capture. About 25% of the papers used survey data or document data, particularly planning documents. A small number of papers (less than 10%) used topographic data, socioeconomic data, remote sensing data, meteorological data (including climate data and weather), or biophysical data. Some papers also combined different types of research data.

Approaches for integrating ES can be subdivided into two types: (1) abstract strategic methods from a macro qualitative perspective and (2) a specific methodological approach from a quantitative perspective. Methods related to decision-making tools and frameworks can be regarded as abstract strategic methods from a macro qualitative perspective (Table 2). In addition to abstract strategic methods, there are specific methodological approaches from a quantitative perspective, which can be summarized into two types of specific evaluation methods (Table 3): ES benefit assessment methods and GIS-based ES evaluation. ES evaluation methods include ES benefits or value assessment and the potential to provide ES. GIS-based ES evaluation methods include practical requirements and stakeholder requirements.

Early studies on the integration of ES into planning were mainly based on LUCC, ecological and other geographical data using the GIS method, and also focus on a literature review. After 2013, empirical case studies, interviews or surveys, theoretical research, and analysis of planning documents gradually increased, and were more closely combined with the application of GIS tools. The improvement and development of research approaches and data mean that the planning practice incorporating ES is gradually improving in actual attempts. The research styles are gradually attracting people’s attention from the perspective of GIS quantification. Researchers constantly summarized study experience and made some progress in practice. They gradually theorized and preliminarily formed a framework system, thus developing the topic into a hot research topic. In the future, we can continue to deepen the construction of the planning framework integrating ES, improve the theoretical system, and make the practical activities useful, useable, and effective under the guidance of scientific theory.

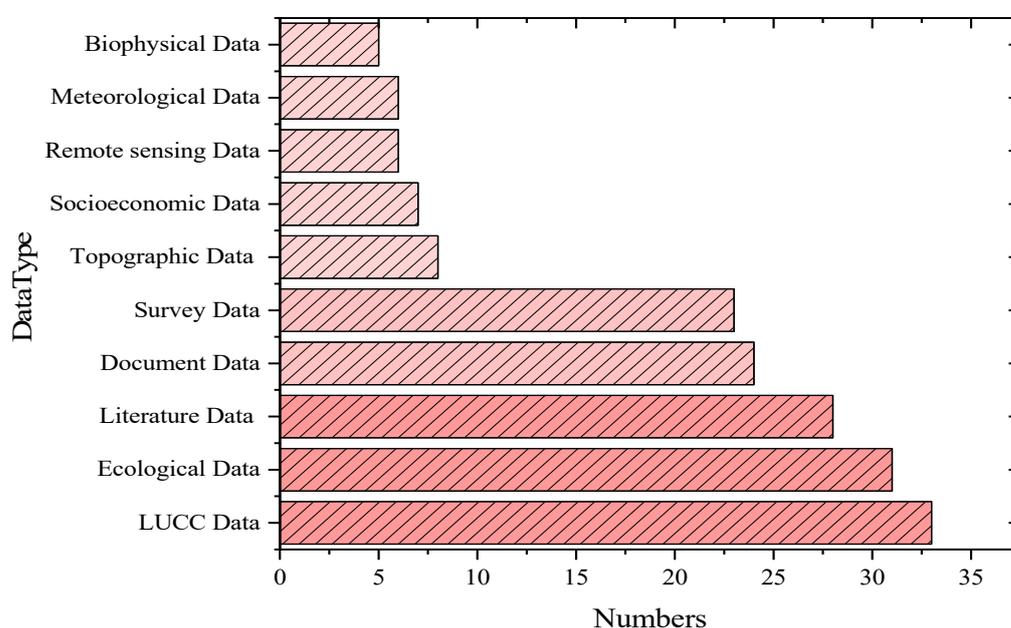


Figure 11. Data types used in the selected articles. The x-axis represents the number of different data types.

Table 2. Abstract strategic methods from a macro qualitative perspective.

Category (Numbers)	Method	Brief Introduction	Application
Decision-making tools and their methods (6)	Structured decision making	Evaluating potential benefits of ecological restoration	Three pilot areas in Italy [62]
	Toolkit analysis in the form	Exploring trade-offs between various land-use alternatives	Livestock farming in Flanders [3]
	Spatial decision support the tool PALM	Supporting the allocation of the urban development zone	Switzerland [5]
	Multi-Criteria Decision Analysis	Developing ‘ES policy circle’	Tempelhof Airport in Berlin [48]
	Participatory approach with ES knowledge	Stakeholder assessment to provide decision-making guidelines	The county of Biscay [63]
	Practice-oriented ES evaluation model	Providing a structure for assessment and distinguishing	No case study [41]

Table 2. Cont.

Category (Numbers)	Method	Brief Introduction	Application
Frameworks and their methods (17)	Conceptual framework	Conceptual spatial planning framework	Not yet [64]
		Sensitive conceptualization of UGLs (urban green lands)	Not yet [18]
		Framework for modular landscape planning	Dresden (Germany) [65]
		Linkages between GI and ES research	Not yet [66]
	Practical framework	Proposes a reclamation strategy	Liaoning, China [67]
		Using web-based visualization platform for integrating ES into everyday decision-making	Canton of Zurich, Switzerland [68]
		Linking the ES approach with social preferences and needs	Krummhörn, northwestern Germany [69]
	ES framework	Combining social-multicriteria evaluation approach with the ES framework and future scenario analysis	Sierra Morena mountain range (Jaén, Spain) [70]
		Assessing contributions of urban gardens	Barcelona, Spain [71]
		Distinguishes three frames of ES: socio-cultural; economic; sustainability frame	Not yet [72]
Planning framework	Assessment and communication of planning trade-offs and outcomes	New Hanover County, NC; Baltimore County, MD; Philadelphia, PA; Damascus, OR [73]	
	Participatory scenario planning framework	Andalusia, southwestern coast of Spain [40]	
	Systematic planning framework for individual trade-off	Central Coast ecoregion of California, US [51]	
Response framework	Driving Forces, Pressures, State, Impacts, and Responses (DPSIR) model.	Steinhuder Meer Lake, Germany [38]	
		Narail district of Bangladesh [74]	
Others	Trade-offs and synergies framework	Changsha, China [75]	
	Flexible methodological framework	North-eastern Iberian Peninsula [19]	

Table 3. Specific methodological approaches from a quantitative perspective.

Category (Numbers)	Method	Brief Introduction	Application
ES assessment methods (10)	ES benefit or value assessment	Linking the benefit of ES to the planning of future ecological conservation strategies	Tibet Plateau [26]
		Estimating the benefits of ES for prioritization	Taiwan island [36]
		Comparing the spatial configuration of ES supply value	Tampere region in Southwest Finland [34]
		PANDORA 3.0 model: Bio-physical evaluation models	Metropolitan area of Bari, Italy [23]
		Integrating ESVs to balance future ES benefit and risk	Changsha, Middle China [70]

Table 3. Cont.

Category (Numbers)	Method	Brief Introduction	Application
ES assessment methods (10)	Potential to provide ES	Evaluating the potential provision of ES under future land-use scenarios	Central Kalimantan, Indonesia [76]
		An expert-based estimation of land-use potential in providing ES	Italy [77]
		Qualitative estimation of regional potentials to provide ES	Saxony, Eastern Germany [78]
		Realistic appraisal of the potential for landscapes to provide ES	Saxony, North-Eastern Germany [79]
	Others	Methodological protocol of strategic environmental assessment	Southeast Pampas of Argentina [80]
GIS-based methods (11)	Practical requirement	Mapping air filtering to predict particulate matter concentration	Metropolitan area of Milan (north-west of Italy) [32]
		Optimizing hotspot areas	Chongqing, China [44]
		Identification of expansion of palm oil production	Central Kalimantan [33]
		Identifying the multifunctional key areas of GI	Southern Finland [81]
	Stakeholder requirement	Assessing the impact of future growth in rural regions	East Coast of the U.S. [82]
		Designing landscape corridors that maximize the value of ES	Gwacheon, South Korea [25]
		Spatial conservation prioritization (SCP) framework	Uruguay, South America [83]
Other	Other	Assessing accessibility to water-related cultural ES via stakeholders	Stockholm region in Sweden [24]
		Participatory stakeholder workshop	Germany [84]
		Verbal articulation, spatial identification, and quantified marine-related values and threats	Seascape of northern Vancouver Island, Canada [30]
		Mapping tool selection: InVEST and EcoServ-GIS and SENCE	New York and Berlin [85]

4. Discussion

4.1. Inspirations

The need for practice-inspired ES: Where is it? What is missing?

Based on the research motivation, we can derive a reflection on the practice-inspired ES paradigm. In order to clarify the current status, the motivation, and knowledge gap of planning research incorporating ES, we can explore and understand it by means of the Schön–Stokes model of research [60] in socio-ecological systems through the paradigm of thinking (Figure 12). The Schön–Stokes model for ecological practice and research and the paradigms of Bohr or Pasteur provide a better understanding and consideration of the viewpoint, method, and inspiration while conducting ES research. The commonly conducted research paradigm of Bohr’s quadrant refers to purely theoretical or applied basic research, where scholars mainly pursue a fundamental understanding and basic knowledge building as the main purpose [86,87]. While an alternative to the prevalent Bohr’s quadrant in ES research could be Pasteur’s quadrant, which is use-inspired basic research for practice, could be an appealing paradigm for the scholarly community and ecological practitioners. Pasteur’s paradigm emphasizes mission-oriented research inspired by social needs and human concern [86], as well as interest in both producing new knowledge and practice, capable of skillfully fusing theory and practice into a cohesive research whole [60,87,88]. The American ecological planner Ian Lennox McHarg, author of *Design with Nature* (1969), is a significant and representative researcher of Pasteur’s paradigm. People acquire ecophronesis (ecological phronesis) from McHarg’s ecological practice. His activities pursue the goals of expanding basic knowledge and achieving practical application, thus embodying a valuable research style. Two paradigms that are purely applied research seeking the use of the practical application are Edison’s quadrant and Johnson’s quadrant, which neither pursue basic knowledge nor application value.

principle. Though closely related, perception and concept are distinguished by whether they are carried out in a methodical and organized manner toward the object ES. Some practical applications already integrate relevant ES perceptions, not limiting themselves to a systematic concept. We need to examine how the ES concept supports practical projects, particularly in planning, and test it using specific case studies.

The ES concept is largely absent in urban planning-oriented literature, although it is frequently used in ecology and, increasingly, in economic assessment. There are few ecological studies devoted to urban systems [8]. Explicit ES integration is generally low, while some notions associated with ES are present in policy and guidance documents, although indirectly [93]. Research on the uptake of the ES concept in planning discourses found explicit references to the concept of ES in documents [11]. Planners familiar with the concept of ES consider it essential to integrate ES in spatial planning [13]. Some pieces of research found that some planning documents mentioned the ES concept explicitly, while others mentioned it only implicitly, and that comprehensive and green planning referred to the concept of ES more explicitly than plans focused on a single issue [94].

There is a research gap between the ES concept and urban policy, and ES remains poorly implemented in urban policy and governance, although the ES approach has attracted policy attention from its demonstrated benefits [48]. The ES concept is expected to become a more comprehensive urban planning framework; however, its application and practice, including relevant challenges, remain an area for future investigation [85]. Nonetheless, particularly at the operational level, awareness and understanding of ES have increased in recent years. However, to have a better impact on decision-making, ES must expand from academia into practice [11]. Perceptions of ES, which are integrated into planning applications, must be systematic with the concept. The adoption of the ES concept in planning practice requires high-level policies to be involved in the application.

The concept of ES developed from the ES perception is expected to become a more comprehensive urban planning framework; however, its application and challenges in planning practice remain an area of investigation. Adopting the ES concept in strategic planning, the views of stakeholders in urban green space planning, management of the ES concept, and the needs and challenges of stakeholders in planning and management must be examined in order to address the above-mentioned knowledge gap [85].

Europe received the most attention in our sample. For instance, the ES concept was adopted in a comparative case study of New York and Berlin [85], as well as comparative studies of municipalities of southern Sweden [94] and of Italian cities [6] using urban planning documents about ES integration and application. There are a large number of actions and a variety of tools for urban ES implementation. Actions such as recreation and regulating services are frequently addressed, whereas others are rarely considered [6,85,94]. Against the background of the European policy and guideline framework, [13,93] drew a profile of ES integration into strategic environmental assessment and spatial planning and investigated its potential application.

Although the concept of ES has been integrated into planning and plays a useful role, knowledge gaps and challenges in linking ES research to planning persist. Some papers identified a gap between ES research and management based on a gap between science and practice in many scientific disciplines. Future ES studies should focus on identifying key opportunities and challenges for bridging this gap [49]. In addition, there is a gap between ES science and ES policy. Urban ES promotion adds complexity to the workloads of planners, urban managers, and policy-makers, as well as increasing political demands for it in urban areas lead to a growing need for urban ES [47]. Some research has identified challenges in urban green governance, which include financial constraints from the municipal budget, expertise losses, and low awareness of different actors toward green benefits [57]. The implementation context, challenges, and opportunities for ES must be understood in order for decision-makers to operationalize it for local development. This is largely because the method to explore the possibilities of integrating scientific information in management, planning, and implementation and the complexity of that

information are absent [54]. When we discuss challenges regarding ES in integrating landscape planning and decision-making, discussions about public policy areas, such as nature conservation and natural resource management, have changed based on ES valuation efforts and approaches, while a trade-off between development and environment should be avoided [39]. In addition, the impact of changes in land use, land cover, and climate poses severe challenges to maintaining ES in urban areas [95].

4.3. Achievements

Regarding research status, different motivations, dislocation of research interests, and diversification of research content all reflect that the ES research for planning has gradually attracted the attention of researchers and has become a hot topic in the past 15 years. In particular, from the research approaches and data, the positive contributions are reflected in revealing the multi-faceted significance of incorporating ES research into planning, as well as various scientific explorations and practical attempts to integrate ES into planning, including abstract strategic methods from a macro qualitative perspective and specific methodological approaches from a quantitative perspective.

Some new approaches have been developed to integrate the ES concept into planning practice and to test it in particular research areas. These methods can be used as decision-making tools, to build related framework systems to solve planning problems, to evaluate ES, and to perform ES mapping or geographical analysis, which achieve the scientific combination of ES concepts and planning practices. The approach is general and can be used to investigate other planning studies that perform ES assessments and fit into a decision-making process [27]. It has been noted that policy with approaches related to conducting decision-relevant, scale-specific ES assessments and plans for effective monitoring and evaluation may be useful when integrated into the decision-making framework [96]. The achievement of research approaches and development may contribute to the inclusion of more than one method category.

ES should be integrated into the decision-making process in the real world to benefit people, maintain human health and a sustainable environment, protect and conserve wildlife, and assist in the recovery of degraded or damaged ecosystems. Some articles propose a variety of ES integration methods that offer decision-making based on their planning needs and research purposes, applying them in case analyses to achieve usability, usefulness, and efficiency. The construction of the conceptual framework, practical framework, ES framework, planning framework, or response framework, which could be termed agenda or guideline from ES research, is a kind of strategic research approach. This may be a framework containing multiple specific research methods, a purely theoretical research concept, or a research attempt combining conceptual analysis and practice. The purpose is to build a general universal framework to utilize the benefits of incorporating the ES concept into planning practice.

Integrating the ES concept into planning facilitates the consideration of trade-offs and decision-making (or decision-support) multifunctionality and helps people recognize how ES affect individuals or societies. Furthermore, this improves the preconditions for public participation and serves as a cross-reference for the assessment and monitoring systems of different environmental disciplines [44,56]. The collaboration of diverse actors and the co-production of relevant knowledge will be effectively supported when ES are integrated into planning [37]. Bottom-up demand will be an essential driver for improving ES integration in plans and policies [93]. Scoping the context, objectives, and capacities carefully are required to achieve effective integration. To identify priority areas for ES for conservation, the most effective approach is based on quantifiable biophysical indicators and their spatiotemporal flow scale [97].

The multifunctionality of urban green infrastructure must be considered and urban ES must be assessed using effective methods [6]. Considering ES within infrastructure planning suggests that we can increase the relevance of ES for infrastructure development and lower the barriers to its inclusion in decision-making processes [52]. The large and

contiguous natural core areas, smaller green areas, and their ecological connections can be the essence of the regional ecological network. These are also the necessary conditions for maintaining the intercommunication of biodiversity and species habitats [95]. Therefore, it is essential to maintain ES in urban areas that build ecological networks at the local and regional levels.

Topics that have been addressed in our sample include urban expansion and population growth pressure on natural environmental sustainability [98], achieving sustainable use of ecological resources, and economic, social, and ecological benefits during rapid urbanization [99], and exploiting the potential for further development of ES approaches, which is closely linked to the mitigation of environmental impacts and improvement of urban resilience [11].

4.4. Suggestions

ES research in planning: to be useful, usable, and effective.

The main factor for measuring whether research has practical significance for humans and potential for further development is whether it is useful, usable, and effective. Case studies illustrating the effects of applying ES in planning processes demonstrated that, as a boundary object, the usefulness of the ES concept was derived from scientists and practitioners by their focus group [56]. Many practitioners consider ES information useful, while its type, production, and communication need to be adjusted according to the specific context [37]. The usefulness of the ES concept, information, and tools are the three levels of ES research potential for planning that are worth exploring and fundamental for the development of practical exploration in the direction of effectiveness. It is also necessary to explore the feasibility of using ES recommendations for planning purposes and to classify the different purposes of ES assigned to support the planning process [100].

While it is generally recommended that ES be integrated into the planning process, this step is still critical but far from complete [100]. The lack of inclusion of the ES concept in urban planning could be related to differences in scientific and disciplinary fields and the absence of mandatory inclusion in planning processes [101]. To realize the potential of ES to improve spatial planning, new and innovative regional planning laws and standards are required that explicitly recognize and highlight the relationship between ecosystems and well-being [4]. Further integration for a higher level of spatial governance and planning and strengthening planning decisions should lead to ES being included in strategic objectives and the identification of demands and beneficiaries [6,102]. More practical experiments about the planning process are needed in order to apply the ES concept for planning purposes while strengthening the role of the marginal Strategic Environmental Assessment [100].

ES for planning is a new research field, presenting a critical evaluation of studies applying ES in different practice fields in real-world cases [37]. It requires a focus on the various effects of ES in planning practice, including evaluating, weighing, and selecting, in order to achieve the requirements of usability for planning aims to guide practice. Future urban planning will benefit from the use of ES methods by practitioners and decision-makers. Recognizing the full range of urban ES and identifying the strategic objectives related to their provision can increase awareness of the value involved, ensure long-term commitment during the implementation phase, and strengthen planning for conflicts of interest.

5. Conclusions

In the last 15 years, the current situation of research has been that ES-related research for planning has gradually attracted the attention of researchers and become a hot topic. They would like to achieve better integration of useful ES knowledge into planning in an available paradigm and conduct effective practice toward decision-making. Our review of 101 articles focuses on ES research for planning, while supporting decision-making, including not only the explicit uptake of the concept of ES, but other ES-related research,

including biodiversity and green infrastructure. The starting point of this research is mainly to explore the essence and use of the ES concept, the influence and relationship of ES types, and the interaction between people and ES. The motivation is to protect the environment, meet the needs of the biosphere, and balance the relationship between natural and social-ecological systems. There is a misalignment of research interests between theory and practice. The study frontier of ES research for planning could be inferred as the relevance of model research, while the hotspot was the valuation of ES. Most of the research areas were concentrated in Central Europe, North America, and East Asia. Most studies focused on the regional scale, and the planning types mainly included land-use planning and urban planning. The main research methods were GIS-based models and empirical research methods with multiple data types. It can be summed up into two categories: abstract strategic methods from a macro qualitative perspective and specific methodological methods from a quantitative perspective. The research data mainly include land-use data, ecological data, and literature data.

The positive contributions are mainly reflected in the diversification of research content, and the improvement of research methods and data, which reveals the significance of incorporating ES into planning and achieving a certain success in practical guidance. Although the concept of ES has not yet prevailed in planning, ES perceptions can be traced back to early existing planning policies. The knowledge gaps and challenges in linking ES research to planning also remain. Our findings revealed that research on ES for planning and relevant case studies are largely theory-inspired, with few practice-inspired studies, which raises the question of wicked and tame problems in socio-ecological systems. The scholarly community faces the dilemma of whether to stand on theory's high ground or focus on practice. According to the Schön–Stokes model, the ES research paradigm of Pasteur's quadrant, both pursue the objective of fundamental understanding and high interest for consideration in practice. This paradigm could be appealing and ecophonetic for the scholarly community and ecological practitioners in urban planning. In socio-ecological practice research, Pasteur's paradigm may be useful for scholarly practitioners, focusing more on the needs of planners and people's well-being and providing a more favorable policy background for ecological planning. It is the researchers' ultimate aim to make the planning practice research-integrated ES useful, usable, and effective.

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