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国土空间规划体系中控制性规划的生态拓展
——以北京市门头沟区为例

ECOLOGICAL EXTENSION OF REGULATORY PLANNING IN CHINA'S TERRITORIAL SPATIAL PLANNING SYSTEM: A CASE STUDY ON MENTOUGOU DISTRICT, BEIJING

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摘要

中国的国土空间规划体制改革是对整个规划体系的深刻变革。作为规划落地实施的重要环节，控制性详细规划在编制方法和指标体系的科学性、与上位和其他专项规划的协调性、规划的可操作性等方面都有待提升，尤其是国土空间用途管制与生态修复领域仍然存在诸多亟需弥补的短板。本研究提出基于生态安全格局理论的控制性规划的生态拓展方法，并以北京市门头沟区为例，重点从分区管制依据、地块用地控制管理等方面论述其实现方法与路径。本文提出采用建设－生态权衡机制对生态安全与建设活动进行冲突分析，以修正生态控制分区并建立相应导则与管控指标体系，从而形成一套基于生态拓展的完整的控制性规划编制方法，以期满足生态文明时代国土空间规划落地实施与精准管控的需求。

关键词
国土空间规划；控制性规划；生态拓展；分区用途管制；街区控制管理；生态过程回溯

ABSTRACT

The current reform of China's territorial spatial planning system is with profound expectation. Key to the implementation of spatial plans, regulatory detailed planning needs an improvement in preparation methods, indicator systems, coordination, and feasibility, etc. More work is urgently needed to make up the deficiencies of land use regulation and ecological restoration of territorial spaces. This paper devises methods for the ecological extension of regulatory planning with the theory of ecological security pattern. With Mentougou District in Beijing as a case study, this paper demonstrates the methods and roadmaps for ecological extension through land use control and community control and management. By analyzing the conflicts of ecological security and construction activities with a balancing mechanism, this study improves ecological control zoning and formulates regulatory principles and indicators. A thoughtful paradigm of preparation methods for the ecological extension of regulatory planning thus comes into being, which would offer references for the implementation and precise regulation of territorial spatial planning in China's era of Ecological Civilization.

KEYWORDS
Territorial Spatial Planning; Regulatory Planning; Ecological Extension; Land Use Control; Community Control and Management; Ecological Process Traceback

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1 引言

生态文明是后工业时代的社会文明形态[1]-[3]。中国于2018年组建了自然资源部，并赋予其履行国土空间用途管制与生态修复、负责建立空间规划体系并监督实施的职责。这一举措在顶层设计层面推动了城乡规划、土地利用规划、主体功能区规划等空间规划的融合，并逐步探索确立以生产空间、生活空间、生态空间为核心要素，以资源环境

承载力和国土空间开发适宜性评价为基本前提，以“三区三线”管控为重要手段，面向国家、省、市、县及乡镇，涵盖总体规划、详细规划、专项规划的“一张蓝图”式国土空间规划体系[4][5]，以保障生态文明建设的推进与全面落实。

然而，中国当前的国土空间规划体系与生态文明建设的整体要求仍有不相适应之处，突出表现在：1）受传统空间规划，尤其是城乡规划、土地利用规划的惯性影响[6][7]，对生态空间和生态安全格局的整体保护与建设缺乏实施保障机制；2）国家级、省级层面的国土空间规划在市县级层面的实施机制不足，虽有生态保护红线或城市开发边界的框限，却鲜有管控指标或其他依据来确保其执行力，绿地率等部分指标也存在异地转换或挤占风险[8]，以致于生态保护往往让位于城镇建设而流于口号[9]；3）作为行政执法依据的管控手段不够健全，由于缺乏足够的法理和制度依据及实施工具而出现僵化的刚性与无原则的弹性[10]，且城市建设相关行政执法片面关注城市建成区，加剧了与社会目标和公共利益的脱节[11]。

针对上述问题，本文提出一种在国土空间规划详细规划层面融合生态空间规划与建设管控的新思路，并以北京市门头沟区为例，展示该方法的实际应用策略。实践显示，这一新方法有助于更好地处理生态环境强约束下城镇发展与生态空间保护和生态修复的关系，对中国乃至同样面临着资源环境约束和人地关系紧张等问题的其他发展中国家有着广泛的借鉴价值。

1 Introduction

Ecological Civilization is the one born in the post-industrial age[1]~[3]. In 2018, China set up its new Ministry of Natural Resources, which is responsible for regulating the land use of national territory and ecological restoration, as well as establishing spatial planning systems and supervising related implementation. This overarching move not only facilitates the integration of urban-rural planning, land use planning, and core functional zone planning, but also helps build a holistic territorial spatial planning system that centers on production space, living environment, and ecosystems. Embracing the fundamental significance of the carrying capacity of resources and environment and the suitability of spatial development, this territorial spatial planning could be realized through the identification and delimitation of ecological, agricultural, and urban areas with integrated master plan, detailed plan, and special plan at national, provincial, city, county, and township levels[4][5]. This system would guarantee the full implementation of Ecological Civilization Construction.

However, China’s current territorial spatial planning system cannot perfectly meet the needs of Ecological Civilization Construction. To be specific, 1) a mechanism to guarantee the implementation of the overall protection and construction of ecological spaces and security patterns is not in place in conventional urban-rural and land use planning systems[6][7]; 2) an implementation mechanism to fulfil national- and provincial-level plans at city or county levels is lacking — there is barely any controlling criteria or regulation guidelines to enforce the ecological red lines or urban development boundaries, and, worse, planned green spaces are often diverted into other land use types[8], resulting in the fact that ecological construction has often to be secondary to urban development[9]; and 3) in terms of administrative regulations, the lack of legal and institutional basis and implementation tools leads to the failure to validate proper rigidity and elasticity[10], and administrative enforcement on urban construction focuses more on built-up areas, which undermines the coherence between societal goals and public interests[11].

To address these issues, this paper proposes a roadmap to integrate ecological spatial planning, construction, and regulation into detailed plans with a demonstrative case study on Mentougou District in Beijing. It is proved to be productive to optimize urban development under rigid demands on ecological protection and restoration in China and other developing countries that are faced with the conflicts between limited resources and increasing growth demands.

2 文献综述

2.1 生态安全格局理论

俞孔坚于1998年首次提出生态安全格局理论并将其运用于生物保护领域[12]，其理论基础是景观生态学，通过对生态过程的分析与模拟，来判别对这些过程的健康与安全具有关键意义的生态格局[13]；根据生态过程的特征与动态趋势，可以判别不同安全水平的安全格局。

生态安全格局理论已有近20年的研究与实践基础，其应用方法也较为成熟。一般来说，格局分析内容包括地质灾害与水土流失过程、水生态过程、生物过程、游憩过程等[14]。基于不同生态过程得到相应的子生态安全格局（地质灾害与水土流失安全格局、水生态安全格局、生物安全格局、游憩安全格局等），并采用最大保护原则叠加可得到最终的综合生态安全格局。需要注意的是，综合安全格局不是生态规划的一种静态空间形式，而是包含了不同生态过程及其安全水平的海量信息库。

2.2 控制性规划及生态控制性规划的理论和实践进展

德国和美国等欧美发达国家多以区划作为其控制性规划手段[15]。在德国，区划又称为建造规划（bebauungsplan），以建造窗口（baufenster）和管控指标集（kontrollleuchte gesetzt）为基本手段，其特征在于对建筑物区域、开放区域和公共区域的全覆盖，以及融合土壤、气候、生物、水域、文化景观等要素的较为完善的生态管控指标体系[16]；在美国，区划是指在警察权的保护下对私人土地开发进行的控制管理，主要面向城市建成区[17]，其特征在于多样化的利益调节手段，包括开发权转移、规划单元开发、激励区划、绩效区划等，以调和保护与发展的矛盾，促进社会利益最大化[18]。

中国的控制性规划体系发端于20世纪80年代[19]，在美国、日本等国家经验的影响下，逐渐形成以控制性详细规划和法定图则为代表的控制性规划体系[20][21]。为有效应对传统空间规划体系的生态短板以及多尺度规划传导机制失衡问题，多在参考欧美发达国家空间规划体系的基础上，从非建设用地或低碳城市视角提出相应的生态环境与建设

2 Literature Review

2.1 The Theory of Ecological Security Pattern

The theory of ecological security pattern was first proposed by Yu Kongjian in 1998 and initially applied in biological conservation[12]. Stemming from concepts of Landscape Ecology, this theory analyzes and simulates ecological processes in order to diagnose and identify key ecological patterns that impact the health and security of these processes[13]. Patterns at varied security levels can be identified in relation to the characteristics and dynamic changes of the ecological processes.

Based on two decades of research and practice, the ecological security pattern theory has developed mature methods. Mostly, ecological pattern analysis is built on diagnoses on geological disaster and soil erosion process, water-cycle process, biological process, and recreational process[14]. These corresponding sub-ecological security patterns then are overlapped under the maximum conservation principle to deduce an overall ecological security pattern, which is not a final ecological planning result but a huge database that includes different ecological processes and their security levels.

2.2 Regulatory Planning and Ecologically Regulatory Planning

Developed countries such as Germany and the U.S. take zoning as the means in regulatory planning[15]. In Germany, zoning, also known as construction planning (bebauungsplan), takes place in the forms of building window (baufenster) and regulation indicator set (kontrollleuchte gesetzt), which not only covers urban built-up areas and open and public spaces, but also employs a relatively complete ecological indicator system on soil, climate, organisms, water areas, cultural elements, etc.[16] In the U.S., zoning refers to the control and management of private land development activities mainly in urban built-up areas[17] under the police power, the means of which range from transfer of development rights, planned unit development to incentive zoning and bonus zoning, aiming at reconciling conservation and development and maximizing benefits of the society[18].

China's regulatory planning originated in the 1980s[19] and grows into a system with its representative outcomes of regulatory detailed plans and statutory plans[20][21], after learning from experienced countries such as the U.S. and Japan. To make up the neglect on ecology in the conventional spatial planning system and to overcome the disequilibrium during the passing-down process of multi-scale planning, China proposes new regulation approaches on ecological conservation and urban construction by focusing on non-construction lands and

1. 控制性规划生态拓展整体框架

1. Framework of the ecological extension of regulatory planning

活动管控措施。典型案例包括南京市江北新区生态廊道控制性详细规划[22]、西安市西咸国际文化教育园区控制性详细规划[23]、淮安市生态新城[23]及无锡太湖新城生态城[24]等，它们丰富了中国生态要素规划指标体系，并在一定程度上为管理平台建设、指标审批与实施等提供了有益借鉴[24]。然而，当前实践并未从根本上解决规划内容之间传导机制缺失的问题，指标体系的制定也多停留在上位规划拆解与经验判断层面，未发挥控制性规划的应有效力。

3 研究策略

本文以北京市门头沟区为研究区域，基于文献研究与实地调研，综合运用生态过程回溯、冲突分析等手段，对区域内的发展与保护及相关空间分布进行了分析，在动态的规划年限内明确国土空间用途并采取相应管制措施，从而落实国土空间规划体系变革背景下生态涵养区的建设与维护，推进控制性规划的生态拓展（图1）。

the development of low-carbon cities. Examples include the regulatory detailed plan for the Ecological Corridor in Jiangbei New District of Nanjing[22], the regulatory detailed plan for Xixian International Cultural and Educational Park of Xi'an[23], and the Eco-New City projects in Huai'an[24] and Wuxi[24]. These cases contribute to the enrichment of China's planning indicator system on ecological elements, the establishment of management platforms, the consent and fulfillment of indicators, etc.[24] Nonetheless, such efforts do not completely address the absence of the fulfillment mechanism in the system, the poor guidance of indicators designed by decomposing higher-level plans and empirical determination. The role of regulatory planning has not been given full play to.

3 Research Strategies

Through literature review and field investigation on Mentougou District, Beijing, this paper analyzes the development and conservation strategies and spatial patterns of the study area with methods such as ecological process traceback and conflict analysis, plans the land use within staged time periods, and devises regulation measures accordingly, thus to facilitate the construction of ecological conservation areas and the ecological extension of regulatory planning under the reform of territorial spatial planning system (Fig. 1).

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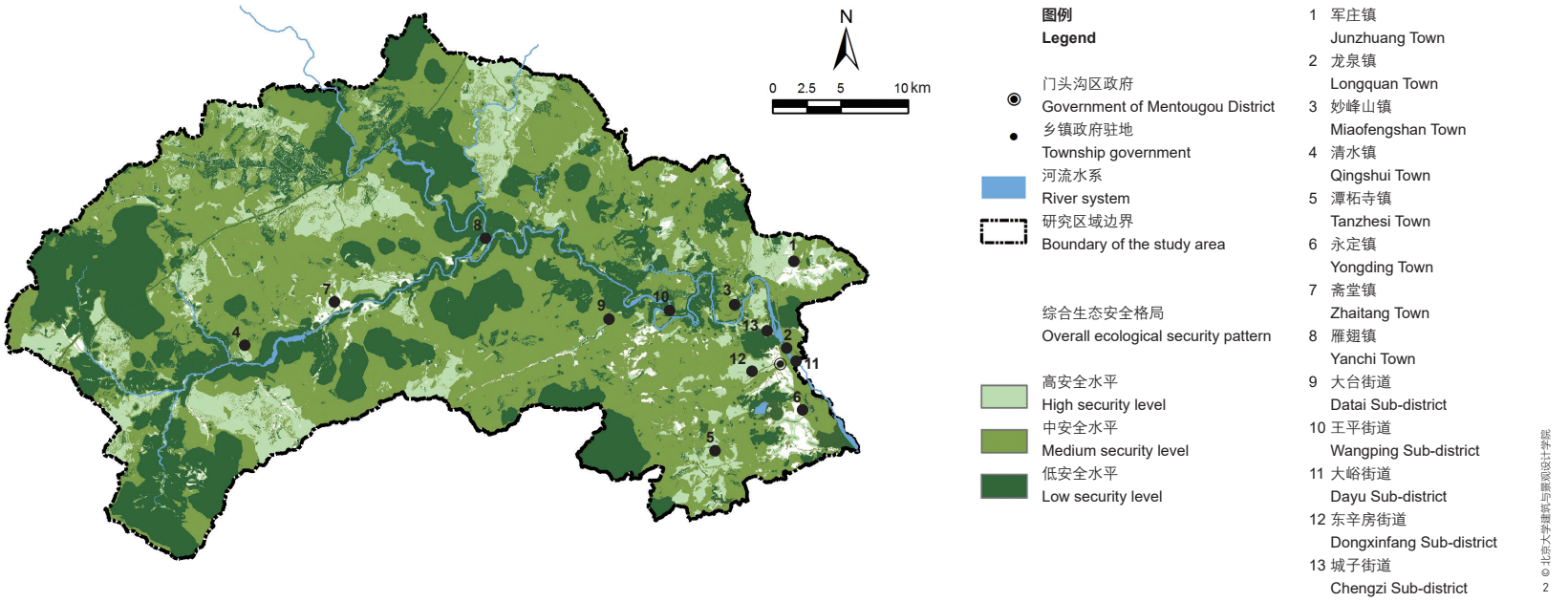

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2

门头沟作为北京的生态涵养区之一，发挥着重要的生态功能。其生态保护红线面积454.71km^2，占全区总面积的31.38%；集中建设区（即城镇开发范围）面积52.74km^2，占全区总面积的3.64%；限制建设区面积941.45km^2，占全区总面积的64.98%①。门头沟曾是中国无烟煤的重要生产基地[25]，长期的矿业开采及其他资源型产业的无序发展对自然环境，尤其是山体造成了严重的破坏和污染；近年来，受气候变化和上游水库兴修的影响，区内永定河段出现了连续的断流与水面、河道被侵占的现象[26]，为生态涵养区的建设带来严峻挑战。

基于以上分析，门头沟区控制性规划的生态拓展通过以下途径展开：1）土地用途管制：基于生态安全格局理论与冲突分析判别市域空间的生态控制分区，构成国土空间用途管制与生态修复的空间底图，同时通过过程回溯建立分区管控导则与指标体系，切实指导分区用途管制；2）街区控制管理：构建街区层面的控制图则，为规划落实提供切实保障，并加强对于自然生态系统的保护与恢复。

As a major ecological conservation area of the city, the study area consists of ecological conservation areas (454.71 km^2), intensive built-up areas (52.74 km^2), and limited construction areas (941.45 km^2), accounting for 31.38%, 3.64%, and 64.98% of the total territory, respectively①. Mentougou was once one of the important mines of smokeless coal in China. Excessive exploitation and disordered growth of other resource-intensive industries caused severe ecological damage and environmental pollution, particularly to the mountains. Climate change and the construction of reservoirs in the upper stream of the Yongding River resulted in discontinuous flows and the encroachment on water bodies, posing grave challenges to the construction of ecological conservation areas.

With respect to such a case background, the ecological extension of regulatory planning could be realized through two means: One is land use control, i.e., to identify the ecological control zones within the city's jurisdiction in the study area supported by the ecological security pattern theory and conflict analyses; to consider the identified ecological control zones a basis for land use control and ecological restoration; and, to prepare zoning regulation guidelines and indicator systems via process traceback. The other is community control and management, i.e., to formulate community-scale control plans and strengthen the protection and restoration of natural ecosystems.

① 数据由北京市门头沟区规划和自然资源委员会提供。

① The data is sourced from the Mentougou Planning and Natural Resource Committee of Beijing.

2. 研究区域综合生态安全格局

2. The overall ecological security pattern of the study area

4 实现途径

4.1 分区管控框架的技术路线

门头沟区现拥有自然保护区、森林公园、风景名胜区、河流、水源保护区、湿地、地质公园及其他生态敏感区要素。而生态控制分区是从过程出发的、由关键空间元素构成的区域格局，虽然与生态保护红线划定存在一定的逻辑差异，但作为相互印证与补充的重要参考，其可为集中建设区、限制建设区及生态保护红线区提供管控依据。

4.1.1 生态控制分区

生态控制分区划定步骤包括：1）建立初始生态控制分区；2）冲突识别与分析，并划分生态敏感区、生态缓冲区、生态协调区及可建区。

（1）初始生态控制分区建立

研究区域内存在水生态系统结构性受损、山体破坏严重、生物栖息地破碎化、地质灾害与水土流失严重、游憩资源收缩等问题。初始生态控制分区的建立涵盖水生态安全格局、生物安全格局、地质灾害与水土流失安全格局、游憩安全格局及视觉安全格局，并采用最大保护原则叠加得到综合生态安全格局[27]（图2）。

以综合生态安全格局为基础，根据安全水平差异将生态控制分区分为生态敏感区（低安全水平）、生态缓冲区（中安全水平）、生态协调区（高安全水平）及可建区。其中，生态敏感区476.70km^2，占比32.90%；生态缓冲区面积740.25km^2，占比51.09%；生态协调区面积203.14km^2，占比14.02%；可建区面积28.81km^2，占比1.99%。

（2）冲突识别与解决

生态控制分区通过与正向规划（即城乡发展规划）的权衡达到动态均衡：一方面，生态控制分区是城乡发展规划的约束性框架；另一方面，它以生态兼容分析与白名单制度为城乡发展规划的可辩护性提供决策支持。其中，冲突区识别通过在ArcMap中将生态控制分区与城

4 Fulfillment of Regulatory Plans

4.1 Roadmap of Zoning Regulation Framework

The study area includes nature reserves, forest parks, scenic areas, rivers, water source conservation areas, wetlands, geoparks, and other ecological sensitive areas. Focusing on ecological processes, ecological control zoning is to identify regional patterns that are composed of key spatial elements. Despite of the theoretical differences, ecological control zoning validates and complements the planning of ecological red lines, providing bases for the regulation over intensive built-up areas, limited built-up areas, and ecological conservation areas.

4.1.1 Ecological Control Zoning

Ecological control zoning is conducted by steps of 1) identifying primary ecological control zones; and 2) identifying ecological sensitive areas, ecological buffer areas, ecological coordination areas, and construction areas through conflict analyses.

(1) Identification of Primary Ecological Control Zones

The study area is faced with problems like structural damage of water ecosystems, serious environmental damages of mountains, fragmented habitats, grave geological disasters and water-soil loss, and diminishing recreational resources. The planning of primary ecological control zones covers the security patterns on water ecosystem and biology; against geological disaster and water-soil loss; and on recreation and viewshed, which then, in accordance with the maximum conservation principle, could be overlapped to deduce the overall ecological security pattern for the study area[27] (Fig. 2).

In the overall security pattern, ecological control zones are classified into ecological sensitive area (of low security level, 476.70 km^2), ecological buffer area (of medium security level, 740.25 km^2), ecological coordination area (of high security level, 203.14 km^2), and construction area (28.81 km^2), which account for 32.90%, 51.09%, 14.02%, and 1.99% of the study area, respectively.

(2) Conflict Identification and Elimination

Ecological control zoning achieves dynamic balance by trading off with positive planning (i.e., urban-rural development planning): on one hand, it offers a constraint framework for the urban-rural development planning; on the other hand, it supports the decision-making on the justifiability of the urban-rural development planning via ecological compatibility analysis and the white list. When identifying the conflicting areas, the plans of ecological control zones and the urban-rural land use schemes are nondestructively overlapped

表1：研究区域内冲突区分布（单位：km^2）
Table 1: The distribution of conflicting zones in the study area (km^2)

行政单位 Administrative unit	无冲突 No conflict	轻度冲突 Mild conflict	中度冲突 Moderate conflict	重度冲突 Severe conflict	总计 Total
王平街道 Wangping Sub-district	0.40	0.20	1.34	1.07	3.01
大台街道 Datai Sub-district	0.37	0.42	0.90	0.48	2.17
雁翅镇 Yanchi Town	0.38	1.38	1.79	2.21	5.76
斋堂镇 Zhaitang Town	1.73	1.44	2.39	3.63	9.19
清水镇 Qingshui Town	0.72	1.55	1.80	2.22	6.29
妙峰山镇 Miaofeng Mountain Town	0.37	2.08	2.93	1.66	7.04
永定镇 Yongding Town	6.48	2.50	9.07	6.20	24.25
军庄镇 Junzhuang Town	2.17	3.19	3.91	0.18	9.45
潭柘寺镇 Tanzhesi Town	0.39	4.25	3.08	0.91	8.63
龙泉镇 Longquan Town	3.60	5.65	10.05	3.09	22.39
总计 Total	**16.61**	**22.66**	**37.26**	**21.65**	**98.18**

乡用地规划图进行无损叠加，从而识别建设开发与多级生态保护冲突的用地构成与空间分布，并划定重度冲突、中度冲突、轻度冲突和无冲突区域。

随后的兼容性分析与白名单制定以适宜性理论为基础，结合研究区域内生态过程与建设用地特征构建生态－建设兼容性矩阵（表1），作为兼容性分析的基础[28][29]。其中，建设用地属性的具体分类方面依据现状与规划用地性质分布并参考《城市用地分类与规划建设用地标准GB 50137–2011》，将部分相近用地类型合并、简化（表2，3）；利用兼容性矩阵可以识别真正的冲突区，并将兼容性用地②划入适宜建设区。适宜建设区与可建区不同，可建区是基于生态过程健康与安全分析划定的可以进行开发建设活动的区域；而适宜建设区的划定相对

② 兼容性用地指生态过程与当前土地利用方式相适应的地区，比如水库与大部分生态过程相兼容。

in ArcMap in order to identify the conflicts in land use and spatial layout between development and multi-layered ecological conservation. Accordingly, areas of severe conflicts, moderate conflicts, mild conflicts, and no conflict are defined.

The compatibility analysis and the white list preparation are built on suitability theories. In this case, the compatibility analysis is conducted with the ecology-construction compatibility matrix (Table 1) in light of the characteristics of ecological processes and construction lands[28][29]. Specifically, the existing and planned land use types of construction lands are classified according to the Urban Land Use Classification and Planned Construction Land Standard GB 50137-2011, where land types with similar use purposes are consolidated and simplified (Table 2, 3). The compatibility matrix is employed to identify the areas of authentic conflicts. The compatible land② can be integrated into the areas suitable for construction. Areas suitable for construction and construction areas are conceptually different: the former is defined by urban-rural development plans and land use patterns in a certain time period, while the latter refers to the

② Compatible land refers to the areas where mutual-adaptation between the ecological processes and the land use patterns exists. For instance, reservoirs are compatible with most ecological processes.

表2：兼容性矩阵部分示意一
Table 2: A demonstration of compatibility matrix (I)

安全水平 Security level	生态过程 Ecological process	城市建设用地 Urban construction land					
		居住用地 Residential land	商业服务业设施用地 Commercial and service facility land	公共管理与公共服务设施用地 Land for public administration and service	公用设施用地、物流仓储及工业用地 Land for public facilities, logistics warehouse, and industrial use	道路与交通设施用地 Transportation land	绿地 Green space
低安全水平 Low security level	地质灾害与水土流失过程 Geological disaster and water-soil loss process	1	1	1	1	1	1
	水生态过程 Water-cycle process	1	1	1	1	1	0
	生物过程 Biological process	1	1	1	1	1	0
	游憩过程 Recreational process	1	1	1	1	1	0
中安全水平 Medium security level	地质灾害与水土流失过程 Geological disaster and water-soil loss process	1	1	1	1	1	1
	水生态过程 Water-cycle process	1	1	1	1	1	0
	生物过程 Biological process	0	0	0	1	1	0
	游憩过程 Recreational process	0	0	0	1	0	0
高安全水平 High security level	地质灾害与水土流失过程 Geological disaster and water-soil loss process	1	1	1	1	1	0
	水生态过程 Water-cycle process	0	0	0	1	0	0
	生物过程 Biological process	0	0	0	1	0	0
	游憩过程 Recreational process	0	0	0	0	0	0

注释
1表示二者不兼容；0表示兼容，但需要依据生态指标进行约束与管控。
NOTE
1 means incompatible; 0 means compatible, but should be controlled according to ecological indicators.

狭义，取决于特定时期的城乡发展规划与土地利用方式。需要注意的是，一旦土地利用方式发生变化，则必须重新进行生态兼容性分析。

研究确定冲突区兼容性用地面积87.66km^2，其中，重度冲突区18.72km^2，多分布在门头沟新城③东南部及清水镇镇区一带，主要由城镇建设用地与低安全水平的雨洪格局、水源保护格局构成；中度冲突区29.67km^2，集中分布于新城沿永定河两岸处，主要由城镇建设用地和中安全水平的地下水保护格局构成；轻度冲突区22.66km^2，分散于东辛

③ “新城”即门头沟新城，简称“门城”，是《北京城市总体规划》（2004-2020）确定的11个新城之一。

③ Mentougou New Town is one of the 11 new towns established by Beijing General Urban Plan 2004-2020.

lands that can accommodate development and construction activities, which are defined by evaluation and security analysis of ecological processes. Once the land use pattern changes, associated evaluation and analysis should be re-done.

The study identifies 87.66 km^2 of compatible land in the conflicting area in total. Severe conflicting area is 18.72 km^2, mostly distributed around the southeast Mentougou New Town③ and Qingshui Town, consisting of urban construction land with low-security-level flooding control pattern and water source conservation pattern. Moderate conflicting area is 29.67 km^2, mostly composed of urban construction land

表3：兼容性矩阵部分示意二
Table 3: A demonstration of compatibility matrix (II)

安全水平 Security level	生态过程 Ecological process	镇、乡、村庄建设用地 Construction land for towns and villages			其他建设用地 Other construction land		
		村庄建设用地 Construction land for village	乡建设用地 Construction land for rural town	镇建设用地 Construction land for town	水库 Reservoir	其他绿地 Other green space	其他水面 Other water area
低安全水平 Low security level	地质灾害与水土流失过程 Geological disaster and water-soil loss process	1	1	1	1	0	1
	水生态过程 Water-cycle process	1	1	1	0	1	0
	生物过程 Biological process	1	1	1	1	1	1
	游憩过程 Recreational process	1	1	1	1	1	1
中安全水平 Medium security level	地质灾害与水土流失过程 Geological disaster and water-soil loss process	1	1	1	1	0	1
	水生态过程 Water-cycle process	0	0	0	0	0	0
	生物过程 Biological process	1	1	1	0	0	0
	游憩过程 Recreational process	1	1	1	0	0	0
高安全水平 High security level	地质灾害与水土流失过程 Geological disaster and water-soil loss process	0	0	0	0	0	0
	水生态过程 Water-cycle process	0	0	0	0	0	0
	生物过程 Biological process	0	0	0	0	0	0
	游憩过程 Recreational process	0	0	0	0	0	0

注释
1表示二者不兼容；0表示兼容，但需要依据生态指标进行约束与管控。
NOTE
1 means incompatible; 0 means compatible, but should be controlled according to ecological indicators.

房街道、军庄镇及潭柘寺镇等地，主要由城镇建设用地和高安全水平的地下水保护格局、地质灾害与水土流失安全格局构成；无冲突区面积16.61km^2（表4）。

冲突区非兼容性用地（即真实冲突区）面积10.52km^2，其中，重度冲突区2.94km^2，碎片状分布于永定镇、城子街道、大峪街道、清水镇和斋堂镇等地，主要由交通设施用地与低安全水平的生物格局、水源保护格局构成；中度冲突区7.59km^2，集中分布在潭柘寺镇东部和永定镇中部等地，主要由城镇建设用地和中安全水平的地质灾害与水土流失格局构成。④

表4：生态－建设兼容性分析（km^2）
Table 4: Compatibility analysis of ecological conservation vs construction (km^2)

	兼容性用地 Compatible land	非兼容用地 Incompatible land	总计 Total
无冲突 No conflict	16.61	0.00	16.61
轻度冲突 Mild conflict	22.66	0.00	22.66
中度冲突 Moderate conflict	29.67	7.59	37.26
重度冲突 Severe conflict	18.72	2.93	21.65
总计 Total	**87.66**	**10.52**	**98.18**

④ 冲突区非兼容性用地面积统计过程中存在数据四舍五入情况。

④ All the figures in the area of non-compatible land are results of a rounded calculation.

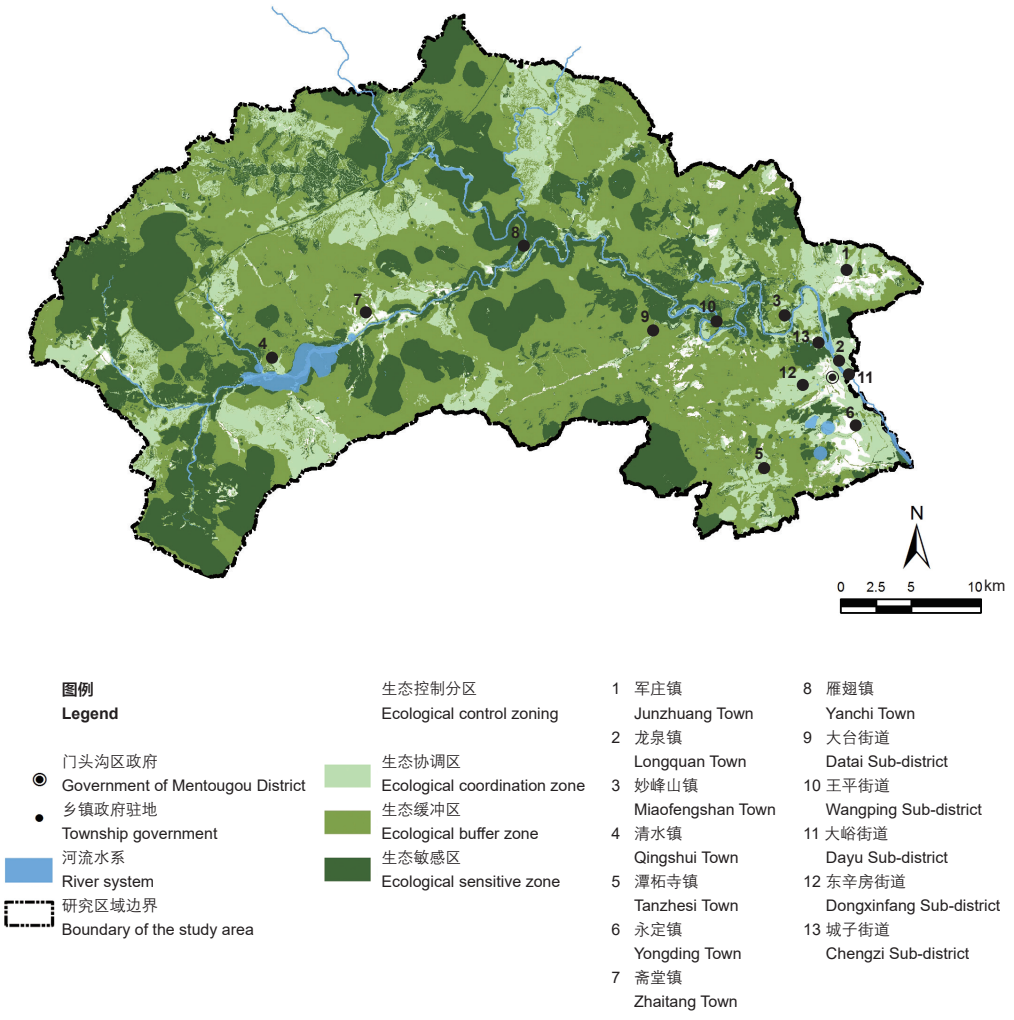
根据兼容性分析结果，将兼容性用地划入适宜建设区，非兼容性用地维持不变，最终划定生态控制分区（图3）。其中，生态敏感区面积457.92km^2，生态缓冲区面积710.58km^2，生态协调区面积180.48km^2，可建区面积99.86km^2。

4.1.2 管控分区划定与指标体系设计

划定生态控制分区是生态规划体系中监督与管理实施的基础，而管控导则与指标体系则是保障监督与管理实施的依据与手段。本研究参照国内外空间规划经验提出“导则+指标”的双重管控体系。

（1）管控分区划定

管控导则针对区域层面的生态保护与建设活动进行强制性约束，其基本单元是生态控制分区，按“生态敏感区、生态缓冲区、生态协调区、可建区”实行差异化管控。其中，生态敏感区要严格保护现有生态环境与资源利用方式，禁止任何形式的建设开发活动；生态缓冲区以生态保护与生态恢复为管控策略，鼓励现有独立工矿用地向生态用地转变，积极推进现有城乡建设用地的空间布局优化，是生态恢复与土地利用管控的重点；生态协调区允许适度的开发和城乡建设用地增量，并优



3. 研究区域生态控制分区划定

3. Ecological control zoning of the study area

along the banks of the Yongding River in the New Town with a medium-security-level underground water conservation pattern. Mild conflicting area is 22.67 km^2, distributed in Dongxinfang Sub-district, Junzhuang Town, and Tanzhesi Town and largely composed of urban construction land with high-security-level underground water conservation pattern and the pattern against geological disaster and water-soil loss. Non-conflicting area is 16.61km^2 (Table 4).

Besides, 10.52 km^2 of non-compatible land in the conflicting area (i.e., the authentic conflicting area) is identified. Severe conflicting area is 2.94 km^2, scattered in Yongding Town, Chengzi Sub-district, Dayu Sub-district, Qingshui Town, and Zhaitang Town and mostly composed of transportation land with low-security-level biological and water source conservation patterns. Medium conflicting area is 7.59 km^2, spreading in east Tanzhesi Town and the center of Yongding Town and consisting of urban construction land with a medium-security-level pattern against geological disaster and water-soil loss.④

According to the compatibility analyses, the identified compatible land should be included in the areas suitable for construction, while the land use of the non-compatible land should remain unchanged. The final ecological control zoning plan is obtained (Fig. 3), including 457.92 km^2 of ecological sensitive area, 710.58 km^2 of ecological buffer area, 180.48 km^2 of ecological coordination area, and 99.86 km^2 of construction area.

4.1.2 Regulation Zoning and Indicator System Design

Ecological control zoning provides a basis for and guarantees the management of ecological planning by formulating regulation guidelines and establishing indicator systems. This study proposes a “Guidelines + Indicators” regulation system by adopting spatial planning experience from China and abroad.

(1) Regulation Zoning

Regulation guidelines make compulsory control on all kinds of ecological conservation and construction activities in the study area, comprised of ecological control zones as entities where the regulation over ecological sensitive areas, ecological buffer areas, ecological coordination areas, and construction areas varies correspondingly. To ecological sensitive areas, the existing ecosystems and resource use patterns must be strictly protected and any forms of construction activities should be forbidden. To ecological buffer areas, ecological protection and restoration should be prioritized, while encouraging the transformation of industrial mining land into ecological land and facilitating the optimization of spatial pattern of urban-rural construction land. To ecological coordination areas, proper development and increase in urban-rural construction land should be allowed, which would

先用于区域基础设施建设和公共服务品质建设，但以严格的生态保护为前提。

（2）指标体系设计

以生态过程回溯法为基础建立生态管控指标体系（图4），内容包括：根据社会自然与人文特征建构多种过程，并构建基于不同过程的分系统安全格局，进一步叠合形成涵盖低、中、高安全水平的综合安全格局；基于多种过程与人类社会系统的相互作用关系，分别构建相应的管控指标；在建立分区用途管制的基础上，以过程回溯判别不同生态控制分区的生态过程及其安全水平等级，并提出相应过程的管控指标，形成面向街区控制管理的指标集。

4.2 街区控制管理的实现

本研究选取门头沟区新城北部采空区作为街区控制管理的示范，其选取标准包括：1）涵盖三种等级的生态控制分区；2）涵盖尽可能多的生态过程；3）以问题为导向，有助于解决未来城乡建设问题。

在某种意义上，街区控制管理属于过程规划，其核心成果是生态－建设数据库、分区管控导则与指标集。一方面，借助地理信息系

be mainly used for infrastructure construction and public service enhancement on the prerequisite of high-level ecological protection.

(2) Indicator System Design

The ecological regulation indicator system (Fig. 4) is designed through ecological process traceback. To be specific, multiple processes and the corresponding security patterns are identified in light of the social, natural, and cultural features of the study area, so as to identify the overall security pattern with gradients in security level; specific regulation indicators are selected in line with the interactions of different processes with human society; based on land use control, the ecological processes and their security levels in different control zones are identified through process traceback and corresponding regulation indicators are set up, so as to offer indicator sets for community control and management.

4.2 Community Control and Management

This study takes the coal goaf in north of Mentougou New Town as a demonstration of community control and management for three reasons: 1) the area covers all levels of ecological control zones; 2) the variety of ecological processes included in the area is relatively rich; and 3) the issues of urban-rural development found in this area are typical to the city.

To some extent, community control and management is a sort of process planning, the core outcomes of which include ecology-construction database, zoning regulatory principles, and the indicator sets. The ecology-construction database will be updated

4. 生态过程回溯流程

4. Steps of ecological process traceback

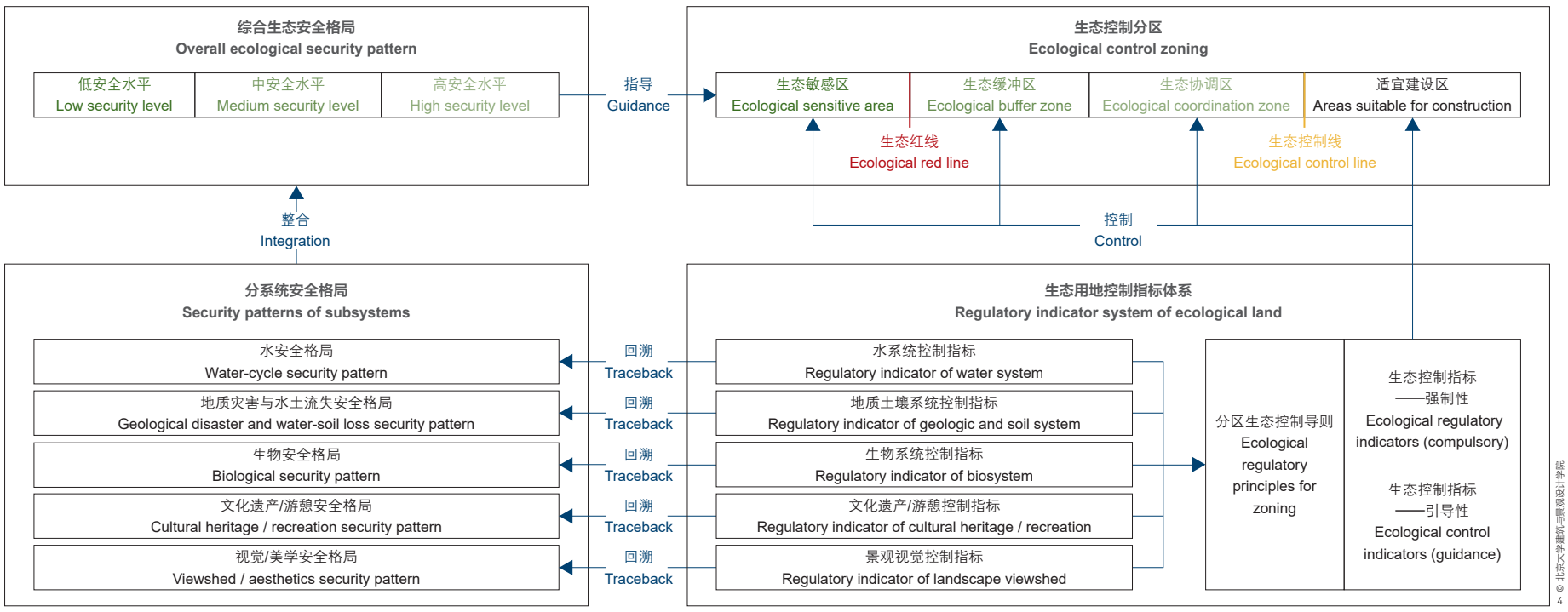


表5：管控指标体系示意

Table 5: A demonstration of regulation indicator system

管控内容 Control objects	管控指标 Control indicators	指标类型 Indicators types		生态敏感区 Ecological sensitive zone	生态缓冲区 Ecological buffer zone	生态协调区 Ecological coordination zone	指标来源 Sources of indicator
		约束性 Compulsory	引导性 Guidance				
水生态过程 Water-cycle process	地表水环境质量标准 Environmental quality standard of surface water areas	△▲		Ⅱ类 Type Ⅱ	Ⅲ类 Type Ⅲ	Ⅲ类 Type Ⅲ	《地面水环境质量标准》（GB 3838-2002） Environmental Quality Standards of Surface Water Areas (GB 3838-2002)
	水体岸线自然化率 Ratio of natural bank of water body	△▲		≥ 90%	≥ 70%	≥ 50%	《城市园林绿化评价标准》（GB/T 50563-2010） Evaluation Criterion of Urban Landscapes (GB/T 50563-2010)
	河道绿化普及率 Ratio of green space along river		△	≥ 90%	≥ 70%	≥ 50%	《国家园林城市系列标准》 Standard Series of National Garden Cities of China
	暴雨洪水临时设防标准 Flood control standard		△	50年 50 years	100年 100 years	200年 200 years	《防洪标准》（GB 50201-94） Flood Control Standards (GB 50201-94)
农业活动 Agricultural activity	化肥施用强度 Fertilization use intensity		▲	≤150 kg/ha	≤200 kg/ha	≤250 kg/ha	《生态县、生态市、生态省建设指标》 Indicators of Ecological Construction at Town, City, and Province Levels
	灌溉用水有效利用系数 Effectiveness coefficient of water use for irrigation		▲	≥ 0.65	≥ 0.6	≥ 0.55	《生态县、生态市、生态省建设指标》 Indicators of Ecological Construction at Town, City, and Province Levels

注释

▲代表生态修复类控制指标，△代表建设开发类控制指标。

NOTE

▲ represents control indicators of ecological restoration; △represents control indicators of urban construction.

统进行生态－建设数据库的更新与再分析，以对城乡建设发展实施动态监测与精细化管控；另一方面，参照国内外区划或法定图则相关研究，以街区为单位建立国土空间规划管控体系，以保障有关国土空间生态保护、修复及建设的宏观区域规划的精准实施。

4.2.1 管控指标制定

管控指标的制定应针对生态过程与建设开发特征，注重定量与定性、刚性与弹性相结合，以“分区+分类”的方式对不同生态控制分区中的不同生态过程进行管控。指标分为约束性指标与引导性指标，其中约束性指标包括建设活动管控指标和生态修复管控指标（表5）。

4.2.2 街区控制图则编制

本研究依据城乡用地规划数据确定新城北部采空区的范围，选取9个地块作为街区控制管理示范，以英文字母与阿拉伯数字对用地进行

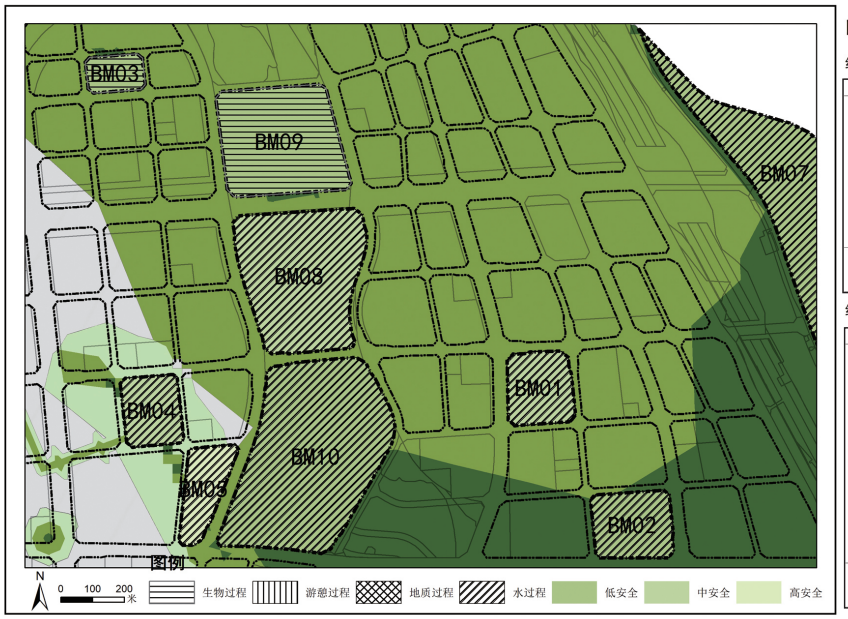
and iterated with dynamic ArcGIS data so as to monitor and refine the regulation over urban-rural development. At the same time, based on studies on precedents of zoning or statutory plans, taking community entities as planning units would help improve the accuracy of implementation of larger-scaled plans of ecological protection, restoration, and construction.

4.2.1 Development of Regulation Indicators

The development of regulation indicators should be in line with the local characteristics of ecological processes and construction activities, and emphasize both quantitative and qualitative research and balance rigidity and elasticity. Different ecological processes in different ecological control zones should be regulated with varied methods, including compulsory indicators and guiding indicators, while the former including the ones on construction activities and ecological restoration (Table 5).

4.2.2 Preparation of Community Control Plans

This study defines the territory of the coal goaf based on relevant urban-rural land planning data, chooses nine plots as the demonstrative sites of community control and regulation, and names them with unique codes in letters and numbers. Such control plans include 1) construction and ecological protection



门头沟分区规划-生态安全与空间管控分图则

约束性管控指标——城乡建设用地

地块编号			BM01	BM02	BM03	BM04	BM05	BM06
生态过程	地质水土	建筑抗震等级	-	-	-	-	-	
		水土保持-植被覆盖率	-	-	-	-	-	
	水	地表水环境质量标准	Ⅱ类	Ⅰ类	Ⅱ类	Ⅱ类	Ⅲ类	
		道路广场透水面积比重	100%	-	100%	100%	≥80%	
	生物	本地木本植物指数	≥0.65	≥0.65	-	≥0.65	≥0.65	
		噪声达标区覆盖率	≥85%	≥85%	-	≥85%	≥85%	
	游憩	文保单位缓冲区达标率	≥85%	≥85%	≥85%	≥86%	≥85%	
		古树名木保护率	100%	100%	100%	200%	100%	
	视觉	建筑高度	按控规	按控规	按控规	按控规	按控规	
用地属性		规划用途	城镇建设用地					
		权属性质	村集体	混合	村集体	混合	混合	

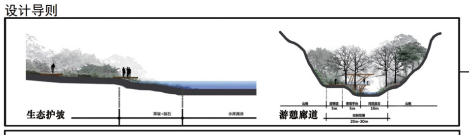
约束性管控指标——城乡建设用地
Compulsory indicator of urban-rural construction

约束性管控指标——生态用地修复

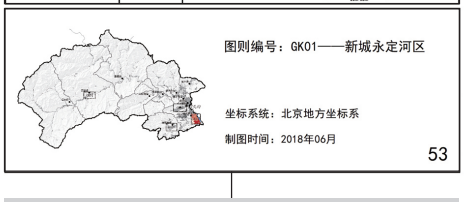
地块编号			BM07	BM08	BM09	BM10	BM11	BM12
生态过程	地质水土	受损弃置地生态恢复率	-	-	-	-		
		危险地带村庄搬迁率	-	-	-	-		
		水土保持-植被覆盖率	-	-	-	-		
	水	地面水环境质量标准	Ⅰ类	Ⅱ类	Ⅱ类	Ⅰ类		
		水体岸线自然化率	100%	100%	200%	100%		
	生物	综合物种指数	≥0.3	-	100%	≥0.3		
		本地木本植物指数	≥0.65	-	-	≥0.65		
		shannon多样性指数	0.1	-	1.04	0.1		
		景观边界密度指数	5.48	-	17.8	5.48		
		shannon均匀性指数	0.14	-	0.94	0.14		
		景观聚集度指数	90.31	-	47.58	90.31		
	游憩	文保单位缓冲区达标率	100%	-	-	-		
		古树名木保护率	-	-	-	-		
用地属性		规划用途	河流	混合	其他绿地	混合		
		权属性质	-	村集体	村集体	村集体		

约束性管控指标——生态用地修复
Compulsory indicator of ecological restoration

设计导则



典型地区生态修复示例
Ecological restoration examples



制图基本信息
Planning and cartographic information

引导性管控指标

控制内容		控制指标	生态核心区/禁止建设	生态缓冲区/限制建设	生态协调区/有条件建设
生态过程	水生态	河道绿化普及率	100%	100%	≥60%
		暴雨洪水临时设防标准	50年一遇	100年一遇	200年一遇
	生物	本地植物指数	-	-	≥0.6
		森林覆盖率	≥65%	≥35%	≥12%
		珍稀濒危物种保护率	100%	100%	-
	游憩	文保单位缓冲区达标率	100%	100%	≥85%
	视觉	建筑立面视觉形象	禁止进行城乡建设	参照景观背景严格控制	参照景观背景和控规要求严格控制
		建筑体量	禁止进行城乡建设	参照景观背景严格控制	参照景观背景和控规要求严格控制
农业活动		新增农用地面积	-	-	-
		化肥施用强度	≤150kg/ha	≤200 kg/ha	≤250 kg/ha
		灌溉用水有效利用系数	≥0.65	≥0.6	≥0.55

引导性管控指标——生态与农业空间
Guidance indicator of ecological and agricultural space

规划管控导则

	规划导则
生态核心区/禁止建设区	生态核心区是保障人类生存发展的生态安全底线，保障核心生态系统服务功能持续稳定发挥；实行严格管控，原则上按禁止开发区域进行管理。
生态缓冲区/限制建设区	生态缓冲区是生态核心区的延展，提供更高水平的生命安全及生态安全的保护。区内的城乡、工矿及基础设施建设应严格管控，原则上不再新增城乡建设用地和独立工矿用地，并鼓励现有城乡建设用地和独立工矿用地逐步搬迁退出，区域性基础设施及旅游游憩基础设施的建设，如有必要，应在认真论证其生态安全影响的前提下，履行必要的报批手续再行开展，并按照相关规划及法律法规的标准进行建设管理。
生态协调区/有条件建设区	生态协调区是生态核心区和缓冲区更大范围的延展，是区域生态系统在结构和功能上完整的坚实屏障。在满足生态过程兼容性的前提下，根据各村发展需求，结合各村土地利用总体规划有序进行新增建设用地布局安排，鼓励现有独立工矿用地的搬迁退出，或转化为城乡建设用地。

不同生态控制分区规划管控导则
Regulatory principles for the planning of different ecological control zones

5. 街区控制管理示意

5. A demonstrative plan of community control and management

唯一编码。图则内容主要包括：1）与生态控制分区对应的规划导则，以明确分区构成及建设与保护原则；2）生态管控指标体系，以约束性指标和引导性指标对城乡建设用地和非建设用地分别作出空间管控要求（图5）。

随后，以街区控制图为空间参照，利用ArcMap进行生态过程回溯来确定街区内生态与建设属性，包括生态过程及其安全水平、建设用地类型及其开发强度等，并从管控指标库中选取相应的指标与取值，从而对生态保护、修复及建设活动进行有效控制管理。

5 结论与展望

生态文明不是唯生态论，而是人类追求社会福利不断增长及社会永续发展而对自身行为做出的约束和管理。生态文明建设时代要求城

guidelines for the corresponding ecological control zones, and 2) an ecological regulation indicator system, including compulsory and guiding ones, which list spatial regulation requirements for urban-rural construction land and non-construction land (Fig. 5).

Subsequently, the community control plans are used as basis maps for the ecological process traceback in ArcMap to learn the ecological and construction characteristics of each plot, covering ecological processes and their security levels, construction land types, and development intensity evaluation. Corresponding indicators and values are selected from the regulation indicator database to regulate local ecological protection, restoration, and construction activities.

5 Conclusions and Prospects

Ecological Civilization does not equal to environmentalism. Instead, it stresses a moderate growth to ensure long-term social

市治理的现代化体现包括规划的精准实施与精细管控，尤其是在生态环境面临建设开发压力与管控缺位的双重压力的当下。

在多数城市已经步入存量发展时代，微尺度的生态修复与城市修补已成为城市建设常态的背景下，本研究立足于国土空间规划体系重构的契机，提出控制性规划的生态拓展思路，并以北京市门头沟区为例论述分区用途管制、街区控制管理与地块建设维护的方法与途径，希望能为国土空间规划体系的完善提供有益探索。值得注意的是，在整个研究推进过程中也暴露出一些生态控制分区划定与管理方面的问题，未来应重点加强生态控制单元的理性划定以适应其城乡规划与生态属性，并引入成本－收益分析丰富多元利益主体博弈下的生态－建设权衡体系，以提高生态控制性规划落地实施的可操作性。**LAF**

benefits and a sustainable development of the society. Ecological Civilization Construction requires a modern urban governance system which performs precise implementation and refined regulation of planning outcomes. This is particularly crucial when the ecological environment is faced with mounting development pressure and inadequate regulation.

While most cities are witnessing a development reflection and reform, where micro-scale ecological restoration and urban renewals are mainstreaming practices in urban construction. By seizing the opportunity of re-structuring China's territorial spatial planning system, this paper comes up with the idea of promoting the ecological extension of regulatory planning and explores the methods and approaches to realize land use control, community control and management, and plot construction and maintenance in the demonstrative case study on Mentougou District in Beijing, attempting to offer a reference for the improvement of the entire planning system. It is noteworthy that this study also sees shortcomings in the delimitation and management methods of ecological control zoning. Future research should spend more efforts on improving the scientism in the identification of ecological control zones so as to better adapt to the planning contexts. Moreover, the cost-benefit analysis should be introduced to expand the ecology-construction interest balancing system among multiple stakeholders, eventually facilitating the implementation of ecological control plans. **LAF**

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