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Creating Restorative Nearby Green Spaces for Knowledge Workers: Theoretical Mechanisms, Site Evaluation Criteria, and Design Guidelines

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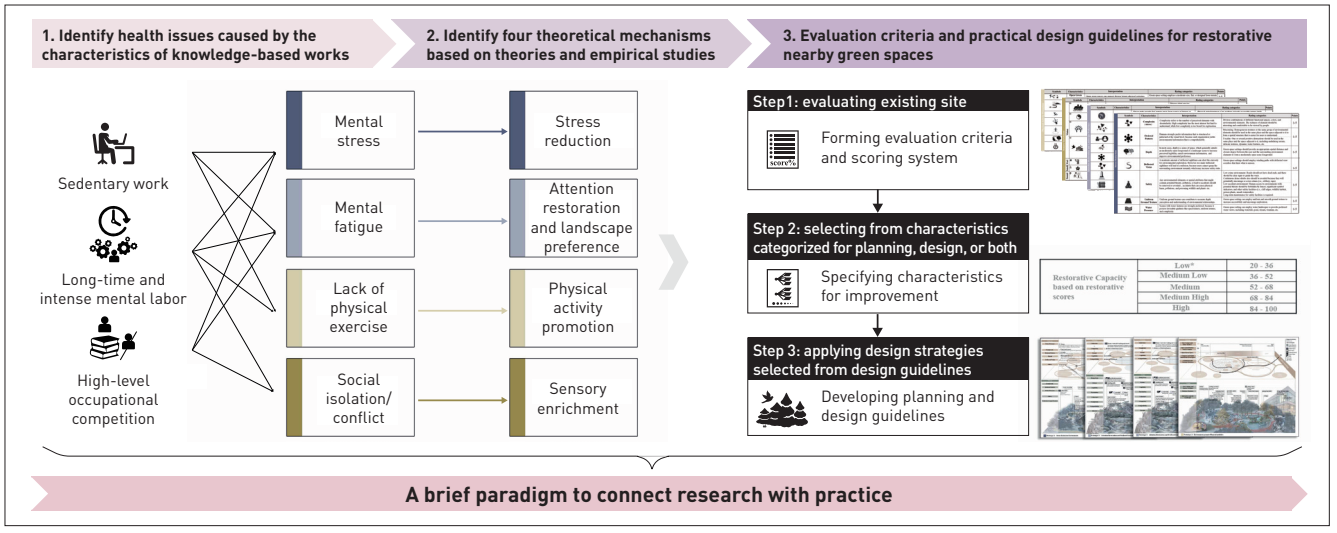
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GRAPHICAL ABSTRACT



HIGHLIGHTS

- Identified four theoretical mechanisms of restorative environment
- Identified 29 environmental characteristics of restorative green space
- Developed evaluation criteria and design guidelines
- Presented four prototypes of restorative nearby green spaces
- A brief paradigm is proposed for interdisciplinary research and design practice

ABSTRACT

Knowledge workers drive social and economic development in contemporary cities but often exhibit poor psychological and physical health because of sedentary work, long-term and intense mental labor, and high-level occupational competition. Thus, providing high-quality restorative green spaces in knowledge workers' proximity to promote their health and well-being has become an important and pressing need. Although the multiple health benefits of proximity to green spaces have been highlighted, the existing planning and design practices are not well supported by scientific theories and evidence. This study interprets the health benefits of proximity to green spaces in work environments considering four theoretical mechanisms: stress reduction, attention restoration and landscape preference, physical activity promotion, and sensory enrichment through an integrative literature review. Next, the paper identifies the key environmental characteristics of green spaces that can enhance the health and well-being of knowledge workers. In addition, it develops a set of criteria for evaluating the restorative capacity of existing sites and a set of guidelines to design restorative nearby green spaces, and proposes a simple paradigm to connect interdisciplinary research and practice.

KEYWORDS

Knowledge Workers;
Restorative Nearby Green Spaces;
Mental Health;
Physical Health;
Restorative Landscape;
Performance Evaluation

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1 Introduction: Health Crisis of Knowledge Workers

1.1 Health Problems That Knowledge Workers Suffering From

Knowledge is transforming global economies and labor markets during the information age[1]. Knowledge workers have become the fundamental driving force of productivity and competitiveness for countries worldwide[2][3]. In particular, knowledge workers play a critical role in addressing problems associated with geopolitical rivalry, cultural and social conflicts, aging populations, and the ongoing COVID-19 pandemic by developing digital tools for e-commerce, artificial intelligence, automation, and online communication and cooperation[4].

However, a growing body of evidence shows that many knowledge workers are suffering from physical and mental health problems caused by the inherent characteristics of knowledge-based occupations[5], such as sedentary work, long-time and intense mental labor, and high-level occupational competition[6]~[8] (Table 1). According to the World Health Organization (WHO), the global decline in productivity caused by health problems results in annual losses of more than one trillion USD[9]. The four health problems that are prevalent among knowledge workers are mental stress, mental fatigue, lack of physical activities, and social isolation/conflict[6][10], as described in the following text.

1) Sedentary work: knowledge-based work is mostly carried out on computers, so knowledge workers spend most of their working hours sitting in front of the screens. Such sedentary work may lead to an inactive lifestyle that impairs mental health in the form of mental stress, mental fatigue, and social isolation[11]~[13]. Moreover, sedentary work limits the time and intent of the workers for engaging in physical activities, which puts them at a higher risk of suffering from obesity, cardiovascular diseases, Type II diabetes, cancers, and other severe physical diseases[14][15].

2) Long-time and intense mental labor: knowledge-based work generally requires extended periods of concentration, which rapidly depletes the workers' attention and leads to mental fatigue[16][17]. In addition, multiple tasks or fast-paced work with tight deadlines can further lead to serious mental stress and anxiety[18][19]. Long-time and intense mental labor also causes adverse mood states and poor control of impulsiveness and aggressiveness, resulting in a higher risk of social conflicts[20][21]. Lastly, this type of heavy work can largely reduce workers' free time and energy for leisure physical activities[14].

And 3) high-level occupational competition: knowledge workers face fierce peer pressure due to the rapid development of knowledge and technological changes in the market. Lack of skill upgradation may lead to reduced income or unemployment[22][23]. The pressure to remain up-to-date with the market may lead to significant mental health problems. Fierce occupational competition prevents the workers from engaging in trust building or collaboration and may lead to long-term mental/behavioral disorders or social and mental problems such as work bullying, workplace violence, and workplace suicide[24]~[26].

Table 1: Inherent characteristics of knowledge-based work and their negative impacts on mental and physical health

Inherent characteristics of knowledge-based work	Health problems generated by the nature of knowledge-based work	
Sedentary work	Mental stress	Long working time, intense mental labor, and occupational competitions create stress for knowledge workers, which can lead to depression, anxiety, and harmful behaviors that influence their physical health
Long-time and intense mental labor	Mental fatigue	Inactive lifestyle might aggregate the mental fatigue; multitasking and prolonged periods of focusing on tasks can deplete attentional resources; competitive environments also require continuous learning, which also use attentional resources
	Lack of physical exercise	Sedentary, long-time, and intense mental works can potentially lead to obesity, stroke, cardiovascular diseases, diabetes, cancers, and other chronic diseases; however, physical activities are important in promoting both mental and physical health
High-level occupational competition	Social isolation/conflict	Competition impairs workers' relationships with their colleagues; mental fatigue lowers people's impulse control, resulting in more aggressive behaviors; long work hours also decrease workers' opportunities to socialize with others

1.2 Access to Green Spaces Can Help Restore the Health of Knowledge Workers

In recent years, academic and practical explorations have committed to addressing the significant health problems of knowledge workers. Knowledge workers with limited break times may only access green spaces that they can reach within 10 to 15 minutes.[27] Therefore, the establishment of green spaces within 15-min walking distance from the workplaces of knowledge workers can encourage them to access these spaces to restore their health. Several prominent high-technology companies have attempted to provide easily accessible green spaces to promote the health and well-being of their employees (i.e., Apple park, Googleplex, Huawei village, Tencent headquarter)[28]~[31]. However, most of these spaces are shaped by the intuitive decisions of designers, instead of scientific evidence derived from theories and empirical studies[32]. Moreover, such extravagant office parks are not affordable for small- and medium-sized enterprises with limited financial and human resources. Notably, although many empirical studies have demonstrated the health benefits of natural environments, the scientific evidence has not been systematically translated to site evaluation criteria and design guidelines to support the planning and design of spaces[33]. In summary, certain gaps remain between research and practice, which lead to significant losses for both practitioners and researchers and impede the development of healthy work environments.

1.3 Research Objectives

This research aims at bridging the gaps between academic theory, empirical research, and practical exploration with the following three objectives.

1) To identify the key theoretical mechanisms for interpreting the influence of nearby green spaces on the mental and physical health of knowledge workers.

2) To identify the key environmental characteristics that explain each theoretical mechanism.

And 3) to develop a set of criteria and design guidelines to conserve and/or create restorative nearby green spaces to enhance the mental and physical health of knowledge workers.

2 Integrative Literature Review to Provide Theoretical and Empirical Evidence for Creating Restorative Nearby Green Spaces

We conducted an integrative literature review to identify theoretical mechanisms and key environmental characteristics to provide theoretical and empirical evidence for developing the evaluation criteria and design guidelines for creating restorative nearby green spaces[34]. The literature review was based on the workflow described by Robin Whittemore in 2005[35] (Table 2), involving both theoretical or review articles and empirical articles.

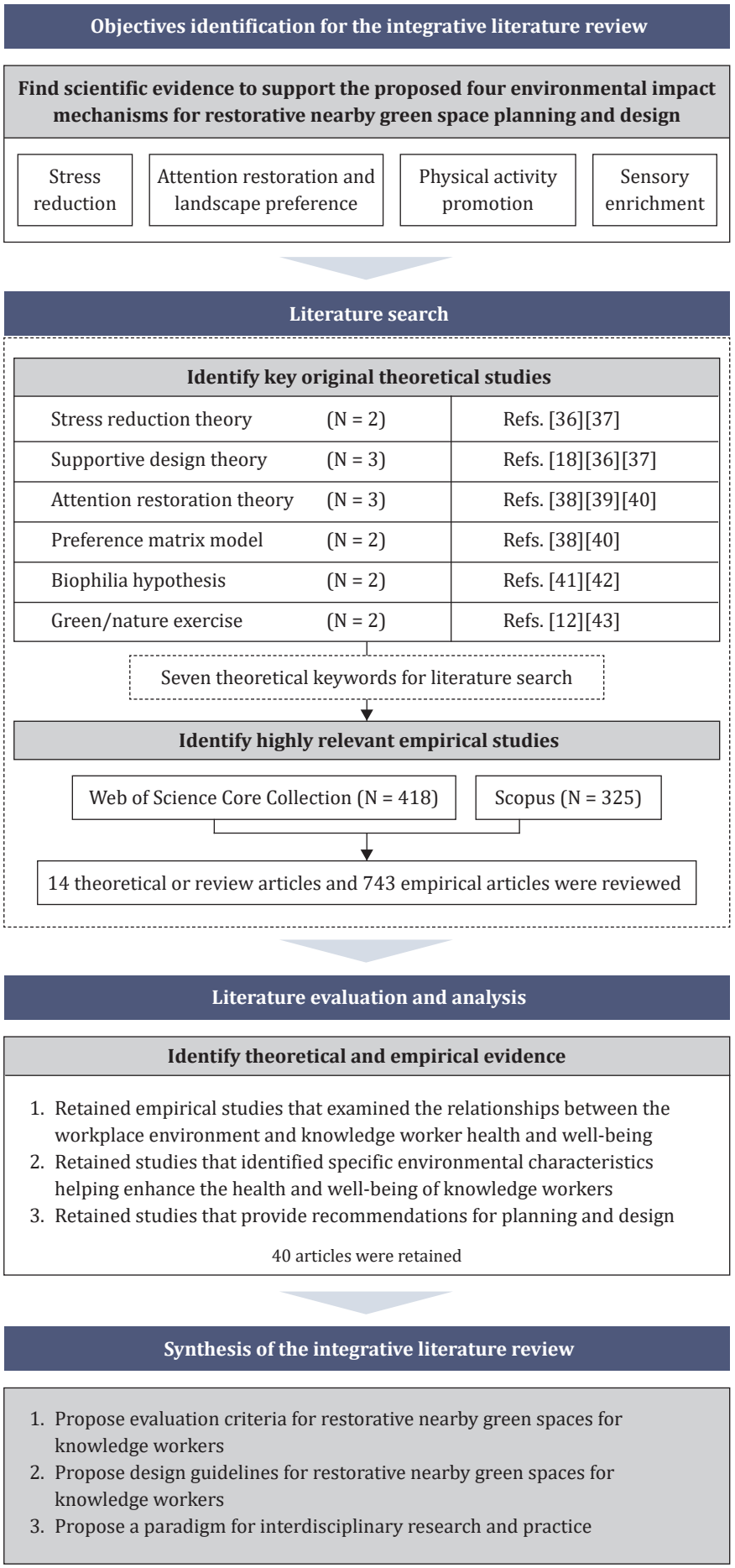
First, we specified four theoretical mechanisms that can potentially clarify the effects of appropriately designed green spaces on the health and well-being of knowledge workers: stress reduction, attention restoration and landscape preference, physical activity promotion, and sensory enrichment.

Second, we performed a two-phase literature search to select the theoretical and empirical articles. We identified six groups of key original theoretical studies related to the four proposed mechanisms[12][18][36]~[43] (Table 2). Theoretical or review articles on the interpretation of the effects of the work environment on human health and well-being, authored by researchers who proposed the relevant theories, were selected. Then, we created seven search keywords according to the key original theoretical studies to filter journal articles of empirical studies published in the last decade (from January 2010 to December 2021) by title and abstract: stress reduction theory, supportive design theory, attention restoration theory, preference matrix model, biophilia hypothesis, green exercise, and nature exercise. The search was performed in two major databases: Elsevier's Scopus and Web of Science Core Collection.

In total 14 theoretical or review articles and 743 empirical articles were selected. To develop guidelines for planning and designing restorative nearby green spaces in working environments, we retained only those studies that 1) examined the relationships between the work environment and health and well-being of knowledge workers, and 2) identified specific environmental characteristics that can enhance the health and well-being of knowledge workers, and 3) presented suggestions or recommendations for planning and design (Table 2).

Based on this integrative literature review, we identified the studies relevant to the four theoretical mechanisms through which health interventions can address the four prevalent health issues of knowledge workers[44]~[46]. Evaluation criteria and design guidelines were established based on the identified key theories and environmental characteristics. We also observed that most of the research outputs regarding the environment and human health are difficult to apply in environmental planning and design practice, and thus proposed a simple paradigm to connect interdisciplinary research and practice.

Table 2: Integrative literature review flowchart



2.1 Stress Reduction

Knowledge-based work may lead to serious mental stress, which can potentially be alleviated through contact with nature. Stress reduction theory (SRT) was proposed by Roger Ulrich in the field of evolutionary psychology[36]. During millions of years of evolution, human beings have developed inherent and positive emotional reactions to natural landscapes with certain characteristics because these landscapes have supported human survival and allowed them to thrive as a species. According to SRT, the following seven environmental characteristics of green spaces can promote stress reduction (Table 3): 1) complexity (stress) [37][47]; 2) ordered patterns[37][47]; 3) depth[37]; 4) deflected vista[37][47]; 5) safety[44]; 6) uniform ground texture[32][47]; and 7) presence of water[37][41]. We rated these characteristics using a five-point Likert scale. The points for a characteristic represent the extent to which a green space satisfies the statements of the rating categories. Notably, stress reduction is not an isolated effect but can influence other health benefits such as restoration of attentional resources, enhancement of social relationships, and promotion of physical activities[45][46].

2.2 Attention Restoration and Landscape Preference

Attention restoration theory (ART), as a key theory in the field of evolutionary psychology, emphasizes the mental benefits, especially cognitive function benefits, of contacting with nature. Directed attention is a major cognitive resource for knowledge workers to successfully complete daily tasks and accomplish career goals[20][38]. Green spaces can stimulate spatial exploration by providing compatible functions, extensive but wandering views, and diverse soft fascinations, which mainly consume involuntary attention and can thus facilitate the restoration of directed attention[39]. In addition, ART argues that an individual's landscape preference is significantly associated with the attention restoration capacity of the landscape. Preferred environments, especially preferred natural environments, can enhance directed attention[48][49]. Green spaces with the following eight environmental characteristics can contribute to attention restoration and landscape preference (Table 4): 1) being away[38]; 2) extent[38]; 3) compatibility[40]; 4) fascination[38]; 5) coherence[38]; 6) complexity (attention)[40]; 7) legibility[40]; and 8) mystery[40]. We rated these characteristics using a five-point Likert scale. The points for a characteristic represent the extent to which a green space satisfies the statements of the rating categories. This mechanism of attention restoration also facilitates stress reduction, social relationship enhancement, and physical activity promotion[38].

Table 3: Checklist for evaluating the capacity of a green space for stress reduction

Symbols	Characteristics	Interpretation	Rating categories	Points
	**Complexity**	Complexity refers to the number of perceived elements with dissimilarity; high complexity corresponds to considerable interest but low understanding; in contrast, low complexity is associated with a low interest in exploration	Diverse combinations of different functional spaces, colors, and environmental elements; the element richness is interesting and comfortable to be viewed by people	1 ~ 5
	**Ordered pattern**	Humans strongly prefer information that is structured or patterned at the visual level, because such organization yields environmental information that is comprehensible	Structuring: homogeneous textures or the same group of environmental elements are used in the same place and the space adjacent to it to form a spatial structure that is easy for users to understand Focality: one or several positive distractions are used in the same place and the space adjacent to it, such as undulating terrain, delicate structures, and dynamic water features	1 ~ 5
	**Depth**	In most cases, depth is a sense of space, which generally entails a moderately open foreground of a landscape scene to increase perceived legibility, enrich environment information, and improve landscape preference	Green space settings provide an appropriate spatial distance and closure degree between the user and the surrounding environment elements to form a moderately open scene foreground	1 ~ 5
	**Deflected vistas**	A moderate amount of deflected sightlines can elicit curiosity for environmental exploration; however, too many deflected sightlines may lead to confusion, because users would not be able to grasp the surrounding environment instantly, which may increase safety risks	Green space settings employ winding paths with deflected view corridors that provides hints for what cannot be seen yet	1 ~ 5
	**Safety**	Any environmental elements or spatial attributes that might contain potential threats, pollution, or lead to accidents that can cause physical harm, such as those involving wildlife and plant poisoning, should be removed or avoided	Low crime environment: roads do not have dead ends, and clear signs are provided to guide the paths Continuous dense shrubs are avoided because they potentially encourage or cover crimes (i.e., robbery, rape) Low accident environment: human access to environments with potential threats are forbidden by fences, significant symbol indicators, and other safety facilities (i.e., cliff edges, wildlife habitat, poison plants, unsafe watersides) Long-term maintenance for safety facilities is required	1 ~ 5
	**Uniform ground texture**	Uniform ground texture can contribute to accurate depth perception and understanding of environmental relationships	Green space employs uniform and smooth ground texture to increase accessibility and encourage exploration	1 ~ 5
	**Presence of water**	Scenes with water features are strongly preferred, because they exhibit favorable qualities such as spaciousness, uniform texture, and complexity	Green space employs water landscapes to provide preferred water views, such as waterfalls, ponds, streams, and fountains	1 ~ 5

NOTES

1. Points are assigned based on the extent to which a green space meets the rating category statements: 1 for poorly met; 2 for slightly met; 3 for somewhat met; 4 for fairly met; and 5 for highly met.
2. Each subcategory has the same weight as the other subcategories within one category.

Table 4: Checklist for evaluating the capacity of a green space for attention restoration and landscape preference

Symbols	Characteristics	Interpretation	Rating categories	Points
	**Being Away**	Places make people feel getting away from source of fatigue or mental activities that require the directed attention; it includes conceptual and physical transformation to distant places	Physical transformation: city workers visit the accessible nature/built environments away from the source of fatigue Conceptual transformation: things that trigger mind activities to distant places or cross time such as a window, a novel scene, or historic artifacts	1 ~ 5
	**Extent**	The environment is diverse and coherent without evident boundaries; it provides users with sufficient information to engage the mind to wander around, feel a whole different world, and promote exploration	Feeling of larger world in small spaces: gardens with long winding paths and the miniaturization gardens that mimic the nature are helpful in the psychological extension of spaces Feeling of past time: settings contain historic artifacts	1 ~ 5
	**Compatibility**	Consistency between the one's inclinations and environmental circumstances which allows activities to be carried out smoothly with responsive feedback	Activity preference: it depends on personal character and culture variance; natural environments usually endow the circumstances for survival needs Selections are limited, since they demand directed attentions	1 ~ 5
	**Fascination**	Promise of information with projected changes in vantage point that creates the challenge of uncertainty or difficulty which triggers process like thinking, doing, and wondering	Soft fascination holds attention in a soft way, so attending is effortless; nature is well endowed with elements generating such fascination, including process of growth, light changes, clouds movement, sunset, snow	1 ~ 5
	**Coherence**	Specific areas are distinguishable and understandable with the order, themes, and textures from the eye-level immediately	Landscape setting is well organized with symmetric and repeating visual elements/themes, harmony, and unity such as unifying textures both from plan view and perspective view	1 ~ 5
	**Complexity**	The level of richness and high numbers of contrasting elements encourage the exploration from the eye-level immediately	Spaces include visual richness or contrast like different elements, different functions, or a single function including diverse elements, which triggers interest and leads people to explore	1 ~ 5
	**Legibility**	People are able to read an environment with high level of distinctiveness and way guiding	Memorable signs or clear paths in a setting provide people with a strong sense of orientation for navigation, so people can explore safely; functions of spaces are recognizable	1 ~ 5
	**Mystery**	People can get the hints of following views which promises the discovering of potential information and new experiences	Wandering trails and penetrable foreground are both mysterious for visitors to explore a scene behind safely with anticipation and surprise	1 ~ 5

NOTES

1. Points are assigned based on the extent to which a green space meets the rating category statements: 1 for poorly met; 2 for slightly met; 3 for somewhat met; 4 for fairly met; and 5 for highly met.
2. Each subcategory has the same weight as the other subcategories within one category.

Table 5: Checklist for evaluating the capacity of a green space for physical activity promotion

Symbols	Characteristics	Interpretation	Rating categories	Points
	**Open**	Open green spaces can support diverse leisure physical activities	Green space setting employs a moderate size, flat, or designed lawn terrain to meet the needs of multiple age groups and leisure physical activities	1 ~ 5
	**Open and deflected vista of nature**	Penetrable and deflected sightlines of nature landscape are intently organized to continuously grasp the user's attention and curiosity, and then facilitate leisure physical activities in both indoor and outdoor environments	Multiple sight corridors are provided from indoor and outdoor environments to the original or artificial nature landscape; each sight corridor can provide different degrees of natural scenery	1 ~ 5
	**Compatible facilities**	Compatible facilities for outdoor physical activities and working can guide and encourage people to engage in outdoor activities	Fitness equipment or outdoor meeting tables are provided according to the needs of employees and employers	1 ~ 5
	**Interactive and AI landscape**	Landscape includes facilities that welcome active physical activities by providing interesting interactive opportunities that can be recognized immediately	Interactive facilities include slide, swings, and fixed bicycles; through artificial intelligence, physical movement can be responded on screens, which also triggers more movements	1 ~ 5
	**Compact and multifunctional paved space**	Compact and multifunctional paved space for diverse outdoor physical activities can support and promote people to engage in outdoor activities	Open and continuous hard surface should be smooth enough for the safety consideration of certain physical activities (i.e., basketball, badminton, dances, rope skipping)	1 ~ 5
	**Tree canopy and shelter facilities**	Intense tree canopy and other shelter facilities provide comfortable space without disturbing by heavy sunshine and rain	Shelter facilities are employed to provide outdoor space for outdoor activities without the restrictions of weather	1 ~ 5
	**Continuous and circular pathways**	Safe circular pathway can support multiple outdoor activities; suitable pavement and symbol indications can be used to support and encourage walking, jogging, and cycling	At least one safe non-vehicle walking pathway separated from vehicle road is employed to support outdoor activities	1 ~ 5

NOTES

1. Points are assigned based on the extent to which a green space meets the rating category statements: 1 for poorly met; 2 for slightly met; 3 for somewhat met; 4 for fairly met; and 5 for highly met.
2. Each subcategory has the same weight as the other subcategories within one category.

2.3 Physical Activity Promotion

Increasing opportunities for physical activities can provide multiple health benefits through physiological, psychological, and behavioral pathways[50][51]. Across different environments, physical activities can positively influence mental health, have anti-depressive and anxiolytic influences, and decrease the sensitivity to stressors in daily lives[52].

For knowledge workers, a 10 ~ 15-minute break may be adequate for leisure physical activities in easily accessed green spaces. Exposure to nature during working hours and breaks can help knowledge workers promptly recover from fatigue and stress and build strong social ties[14][53]~[55]. Working outdoors surrounded by natural environments can promote stress reduction, executive function, and social relation[55]~[57]. Physical activities during work breaks in workplace can also aid attention restoration, sleep quality, immune function, and prevention of chronic diseases such as diabetes, hypertension, depression, and certain types of cancer[27][58]~[60].

Physical activities in green spaces mainly include leisure physical activities and outdoor working. Outdoor working represents a mixed behavioral mode with minor or moderate physical activities, such as standing, walking, biking, and jogging, when people work as individuals or groups. The following seven key environmental characteristics of green spaces can facilitate physical activities (Table 5): 1) open[58][60]~[62]; 2) penetrable and

deflected vista of nature[60]~[62]; 3) compatible facilities[59][60]; 4) interactive and artificial intelligence landscape[59][60]; 5) compact and multifunctional paved space[61]; 6) tree canopy and shelter facilities[57][60][61]; and 7) continuous and circular pathways[60][62][63]. We rated these characteristics using a five-point Likert scale. The points for a characteristic represent the extent to which a green space satisfies the statements of the rating categories.

2.4 Sensory Enrichment

Sensory enrichment is a complementary mechanism for the three mechanisms above. The sensory enrichment mechanism, based on the biophilia hypothesis and relevant empirical studies, suggests additional key characteristics of restorative green spaces[41][42][64][65]. In the context of this study, as knowledge workers spend most of their working time indoors, they lack exposure to outdoor green or blue spaces, which possess rich sensory stimulations that can promote stress reduction and mental restoration, with other cognitive and emotional benefits[66]~[68].

This mechanism suggests that certain environmental characteristics can encourage people to increase their contact with nature to gain multiple health benefits[69]~[71]. Green spaces can provide four major types of sensory experiences—vision, feel, smell, and sound—that can promote mental and physical health and social interactions[70]~[72]. The following seven environmental characteristics of green spaces can facilitate these experiences (Table 6): 1) biodiversity[41][42][64][65]; 2) complementary

Table 6: Checklist for evaluating the capacity of a green space for sensory enrichment

	Symbols	Characteristics	Interpretation			Rating categories	Points
Vision		**Biodiversity**	Biodiversity of plant and animal species which create diverse layers of landscape forms			Diverse plant species Multiple layers: from canopy trees to understory, shrub, and groundcovers Diversity of plant forms: different sizes and profiles Diverse animal species	1 ~ 5
		Complementary contrast	Contrasting spatial diversity helps complement the space to enhance the unity and order			Binary contrasts of the spatial elements are used for the design, which include closure/open, shadow/light, interior/exterior, artificial/nature	1 ~ 5
		Memorable symbol	Place identity	Distinctiveness		Recognizable characteristics such as vernacularity	1 ~ 5
				Self-esteem		Symbolic features that help people improve the quality of life	
				Continuity		Consistent features that help the environmental elements in order	
				Self-efficacy		People have confidence to complete a task efficiently in a space	
		Vitality	Vitality refers all living creatures include human beings, animals and vegetation, as well as natural phenomenon	Animals	Wild animals or pets	Plants provide shelter and food for wild animals or space for pet walking	1 ~ 5
				Plants	Seasonal change of colors	The dynamic growing process of plants add the diversity and vitality	
					Natural growth	Natural shapes, geomorphology, and biomimicry (i.e., mimic natural processes and patterns)	
				Light	Natural/ artificial lightning	Changing natural light, or artificial light like colorful light shows, interactive light features	

Continued

Table 6: Checklist for evaluating the capacity of a green space for sensory enrichment

	Symbols	Characteristics	Interpretation	Rating categories	Points
Feel		**Thermal comfort**	Proper thermal environment is positively related to the productivity and performance of workers	20 ~ 26 ℃ with some amount of humidity and healthy air flow (moderate wind); people feel comfortable in such environments	1 ~ 5
Smell		**Pleasant smell**	Landscape contains smells that have therapeutic effect, and these smells encourage physical activities and duration of the stay	Elements like the blooming plants in different seasons, fragrant wood, and flowing water could enhance the pleasant smell	1 ~ 5
Sound		**Soundscape accordance**	Social activity	Positive: natural sound, conversation, laugh Negative: noise (traffic), cry	1 ~ 5
			Solitary activity	Positive: natural sound Negative: noise, conversation	
			Stress reduction	Positive: natural sound, light music Negative: noise	

NOTES

1. Points are assigned based on the extent to which a green space meets the rating category statements: 1 for poorly met; 2 for slightly met; 3 for somewhat met; 4 for fairly met; and 5 for highly met.
2. each subcategory has the same weight as the other subcategories within one category.

contrast[68][71]; 3) memorable symbols[66][67][72]~[74] ; 4) vitality[70][71]; 5) thermal comfort[65][69][75]; 6) pleasant smells[76]; and 7) soundscape accordance[77]~[79]. We rated these characteristics using a five-point Likert scale. The points for a characteristic represent the extent to which a green space satisfies the statements of the rating categories.

3 Evaluation Criteria and Design Guidelines for Creating Restorative Nearby Green Spaces

In this study, 29 environmental characteristics extracted from the four theoretical mechanisms and relevant empirical studies are translated into practical and referable site evaluation criteria and design guidelines.

3.1 Evaluation Criteria of Restorative Capacities of Nearby Green Spaces

3.1.1 Rating Checklists and Evaluation Tables

Using the checklists provided (Tables 3 ~ 6), the restorative capacity of an existing green space can be scored considering the ratings of all the listed environmental characteristics. The total score can be calculated according to the final rating chart (Table 7) to quantify the restorative capacity of the site, which can be further divided into five levels.

Table 7: Rating chart for restorative capacity of a green space

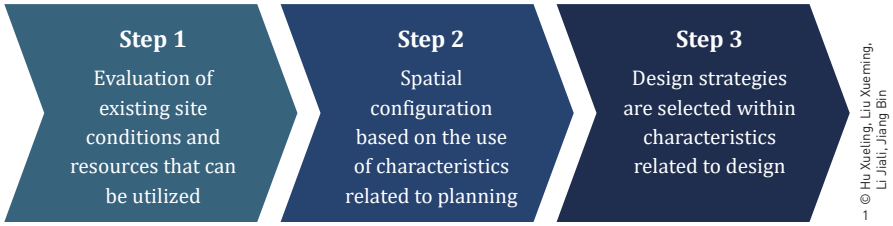
Theoretical mechanisms	Point range	Weighting coefficient	Weighted score on the scale of 5 ~ 25
Stress reduction	E1 = 7 ~ 35	C1 = 25/35	C1 × E1
Attention restoration and landscape preference	E2 = 8 ~ 40	C2 = 25/40	C2 × E2
Physical activity promotion	E3 = 7 ~ 35	C3 = 25/35	C3 × E3
Sensory enrichment	E4 = 7 ~ 35	C4 = 25/35	C4 × E4
Sum	29 ~ 145		
Restorative capacity based on the restorative score		Low	20 ~ 36
		Medium low	37 ~ 52
		Medium	53 ~ 68
		Medium high	69 ~ 84
		High	85 ~ 100

NOTE

One or more of the four categories of theoretical mechanisms get a subscore that is equal to or less than 9 will be marked with *.

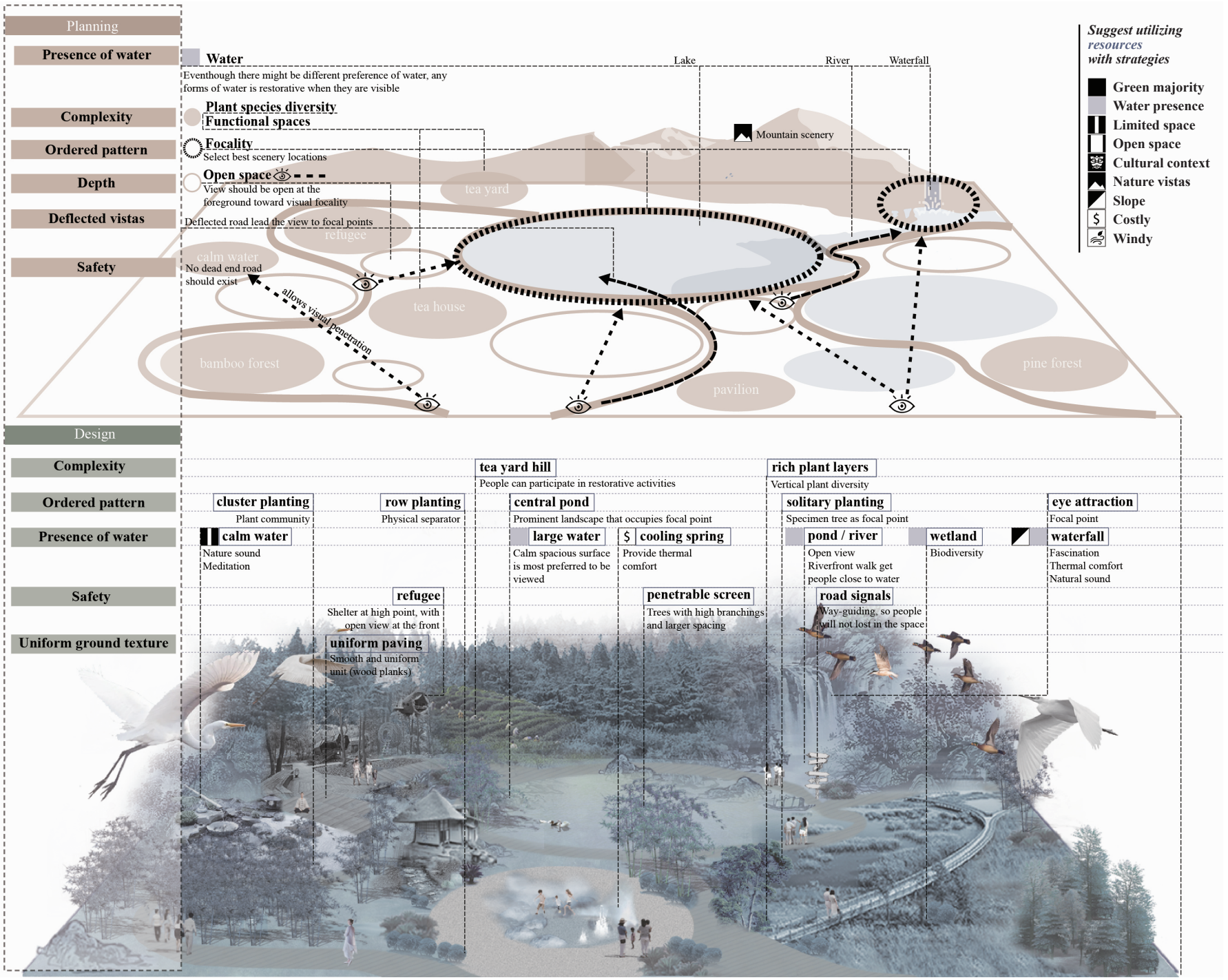
3.1.2 Procedure for Using the Evaluation Criteria

The four mechanisms are considered equally important in the evaluation criteria, with each mechanism accounting for 25 points among the 100-point evaluation criteria. The characteristics corresponding to each mechanism will be weighted because the number of environmental characteristics corresponding to each mechanism is different. Weight coefficients (C1 ~ C4) are used to adjust the four original subscores (E1 ~ E4) to the range from 5 to 25 points in the rating system (Table 7). The weighted subscores



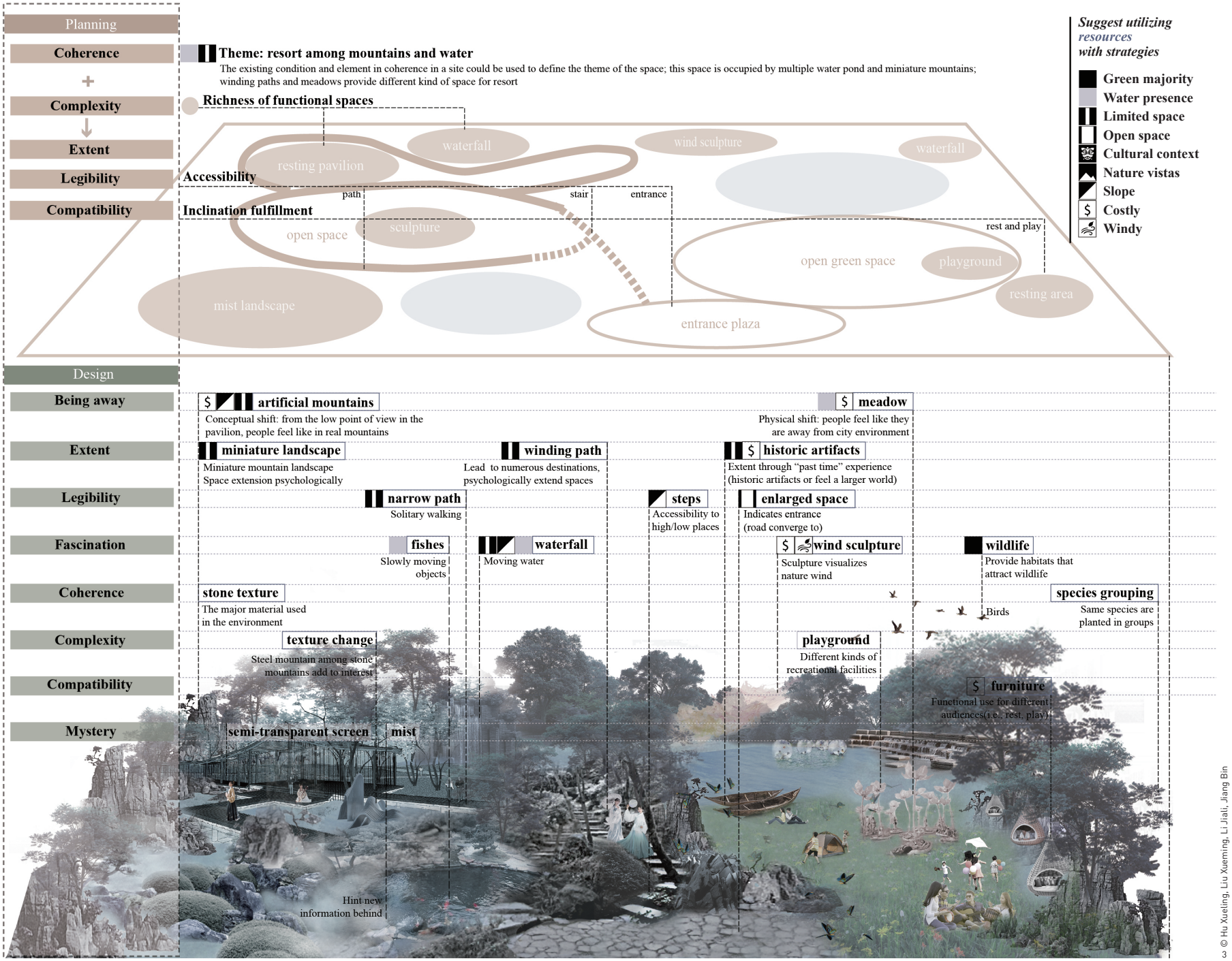
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1. Three-step workflow for creating a restorative nearby green space
2. Prototype 1: Stress reduction



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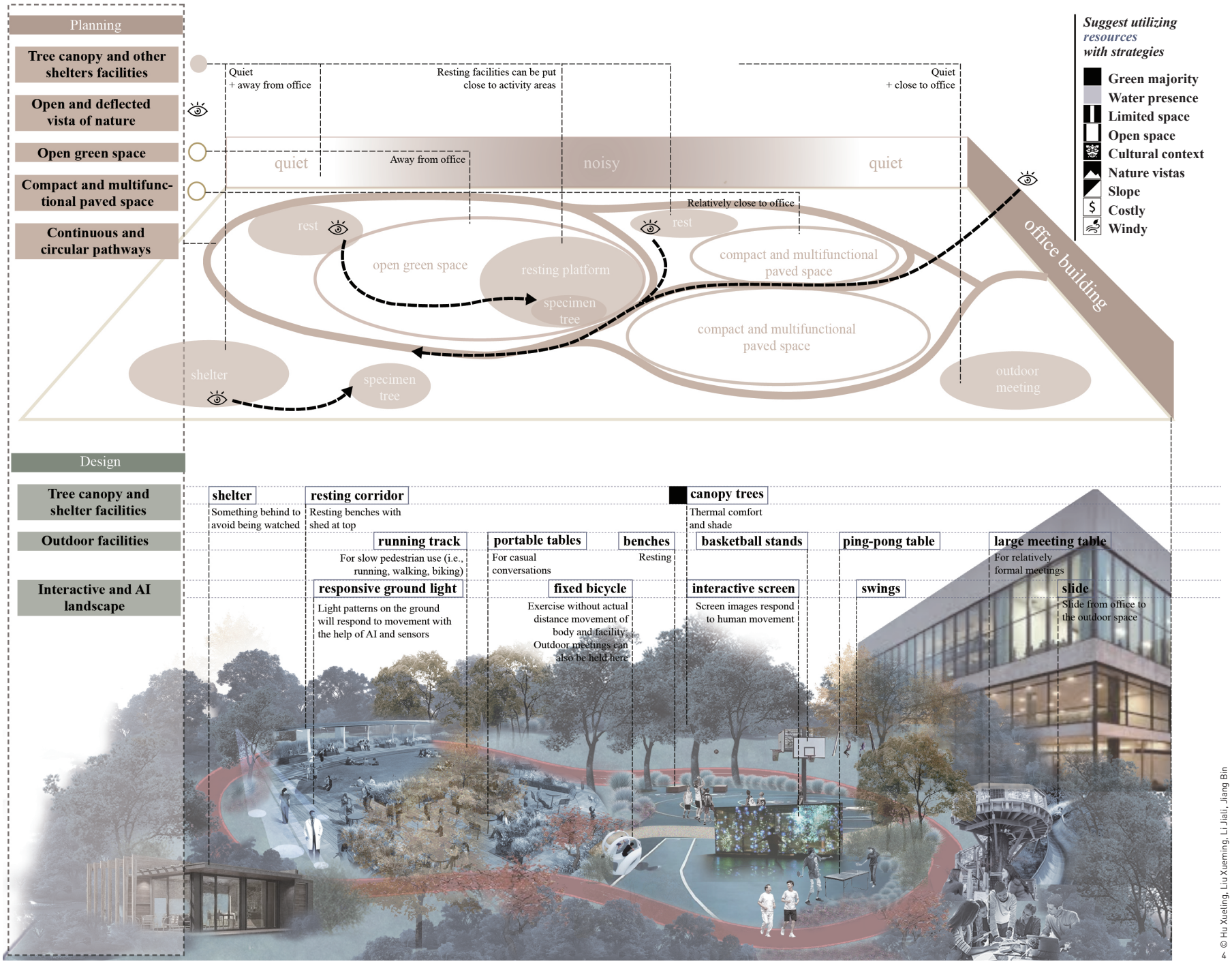
3. Prototype 2: Attention restoration and landscape preference

are then summed to rate the restorative capacity of the site.

The total score and four subscores must be considered when rating the restorative capacity. Five equal intervals are specified: low, medium-low, medium, medium-high, and high, corresponding to total scores ranging from 20 to 36, 37 to 52, 53 to 68, 69 to 84, and 85 to 100, respectively. A lower subscore of an evaluation criterion indicates a greater scope for improvement in the subcategory, whereas a higher subscore indicates the potential for conservation and utilization for the subcategory. If any subscore is equal to or less than 9, i.e. less than the sum of 5 points (the base subscore) and 20% of 20 points (the obtainable subscore), in one or more categories of theoretical mechanisms, the final rating is marked with "*", which indicates that the site has prominent shortages in certain restorative environment characteristics that must be improved with high priority.

3.2 Design Guidelines

3.2.1 Design Guidelines: Four Visualized Design Prototypes



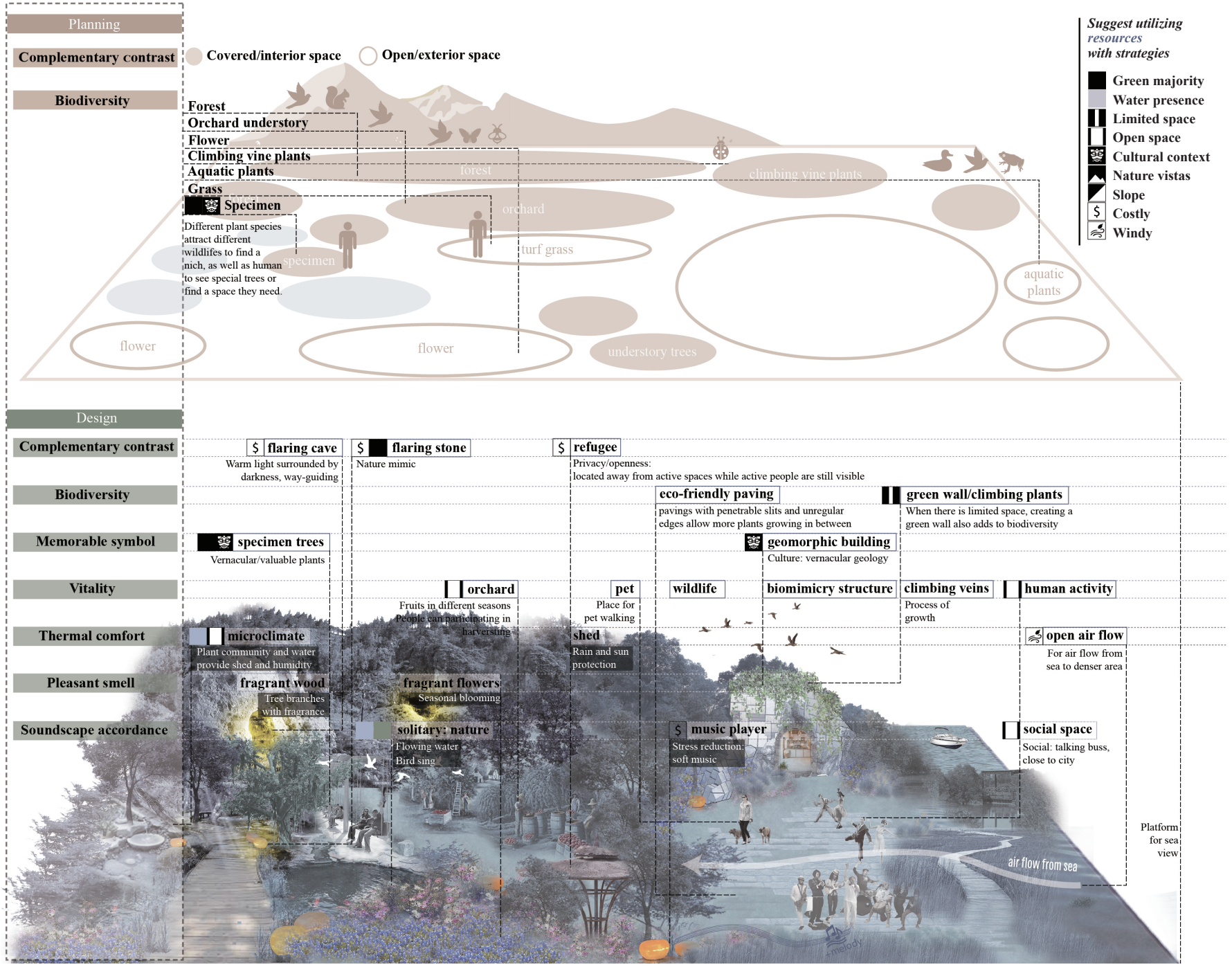
4. Prototype 3: Physical activity promotion

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The guidelines present four visualized prototypes corresponding to the four mechanisms: 1) stress reduction; 2) attention restoration and landscape preference; 3) physical activity promotion; and 4) sensory enrichment. For all prototypes, the guidelines provide only the most applicable planning and design strategies as a reference to creating restorative green spaces near workplaces.

3.2.2 Procedure for Applying the Design Guidelines

The design guidelines should preferably be implemented after site evaluation to synthesize a complete three-step design workflow (Fig. 1). Each visualized design prototype is developable and flexible, aiming at providing guidance and an initial framework for planners, designers, and policy makers (Figs. 2 ~ 5). Each prototype diagram contains two sections: planning layout (top) and design strategies (bottom). To minimize the destruction of the existing environment and maximize the values of the existing resources, valuable natural resources must be conserved and utilized. The key in the upper-right in each prototype diagram provides suggestions



5. Prototype 4: Sensory enrichment

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for selecting the most suitable strategies based on existing site conditions. Certain environmental characteristics can be applied at both the planning and design stages (Table 8).

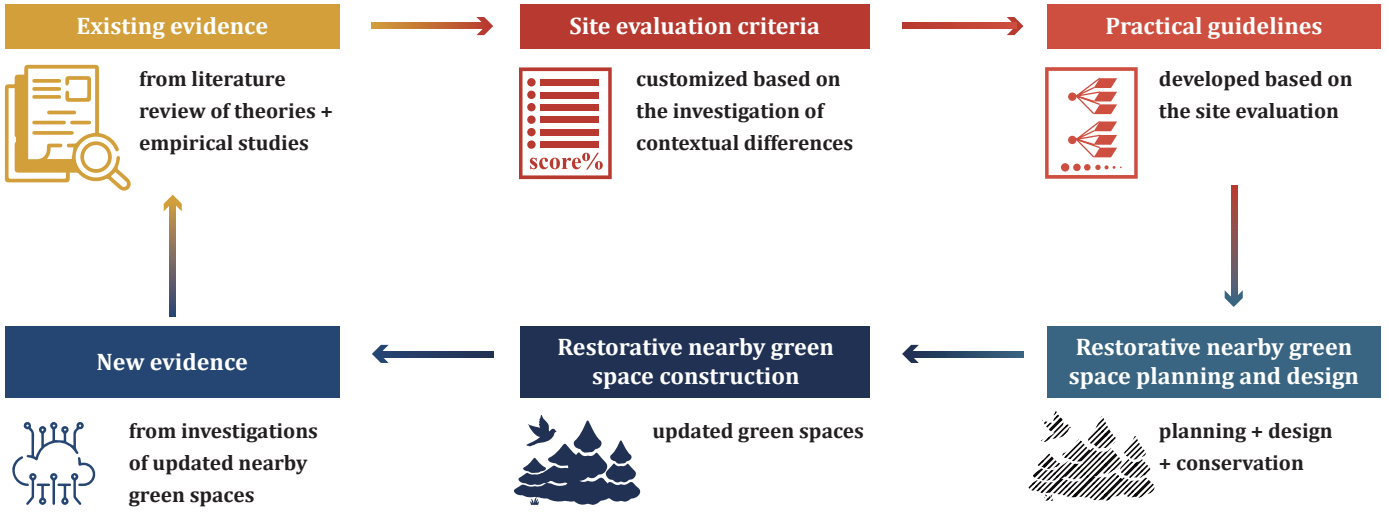
3.3 Paradigm for Interdisciplinary Research and Practice

We established a comprehensive toolkit for planning and designing restorative nearby green spaces. This toolkit includes the evaluation criteria and design guidelines that can bridge the gap between the research and design of restorative nearby green spaces for knowledge workers. In particular, the proposed guidelines interpret and translate conceptual environmental characteristics into measurable scores and practical design.

Furthermore, we established a simplified paradigm to connect interdisciplinary research and practice (Fig. 6). This framework is an open-ended system that allows for complete circulation between research and practice to promote evidence-based design. The procedure begins with an integrative review of relevant theories and empirical studies, which allows researchers to acquire the

Table 8: Environmental characteristics corresponding to four theoretical mechanisms that can be applied at planning and/or design stages

Stress reduction	Attention restoration and landscape preference	Physical activity promotion	Sensory enrichment
Planning: **Depth**	Planning + design: **Coherence**	Planning: **Open**	Planning + design: **Biodiversity**
Planning + design: **Ordered pattern**	Planning + design: **Complexity (attention)**	Planning: **Compact and multifunctional paved space**	Planning + design: **Complementary contrast**
Planning + design: **Complexity (stress)**	Planning + design: **Extent**	Planning + design: **Continuous and circular pathways**	Design: **Memorable symbol**
Planning: **Deflected vistas**	Planning + design: **Compatibility**	Planning: **Open and deflected vista of nature**	Design: **Vitality**
Planning + design: **Presence of water**	Planning + design: **Legibility**	Planning + design: **Tree canopy and shelter facilities**	Design: **Thermal comfort**
Planning + design: **Safety**	Design: **Being away**	Design: **Compatible facilities**	Design: **Pleasant smell**
Design: **Uniform ground texture**	Design: **Fascination**	Design: **Interactive and AI landscape**	Design: **Soundscape accordance**
	Design: **Mystery**		



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6. Simplified paradigm to connect interdisciplinary research with practice

latest knowledge to develop site evaluation criteria. The criteria contain the same four categories, but the items in each category are modified to fit the regional and/or local context. For example, the criteria for American cities are expected to be different from those for Chinese cities because the two regions differ in demographic and socioeconomic characteristics, transportation modes, climatic conditions, individuals' behavioral modes, social norms, etc. Based on the results of site evaluation, researchers can develop a holistic set of guidelines for evidence-based planning, design, and conservation of nearby green spaces. After environmental interventions, the green spaces are expected to become more effective in delivering health benefits. Through site investigation and data analyses, researchers can identify the interventions that may have significant individual and interactive effects on different aspects of public health and well-being. In this manner, a new set of empirical evidence can be generated and added to the literature. Iterative literature reviews can advance the relevant research and practice. Thus, a loop of the development of knowledge and practical approaches can be achieved.

4 Limitations and Future Research Opportunities

This study has four major limitations that can be considered opportunities for future research. First, this study is mainly based on the literature review of theoretical and empirical studies and lacks the collection and analysis of original data. On-site observation of behaviors and survey and interview of knowledge workers should be conducted in future studies to improve findings of this study. Second, the four mechanisms are essentially interactive thus the parallel relationship among them presented in this study might have a risk of oversimplification. Future studies can be focused on quantifying the interactions to refine the mechanisms. Third, the design guidelines are mainly proposed for landscape architects. However, the creation of restorative working environments requires interprofessional negotiation, compromise, and cooperation among the clients, government stakeholders, psychologists, landscape architects, architects, planners, interior designers, etc. Thus, similar studies must be performed for other professions to create a collective set of guidelines that can account for the complex teamwork across professions. Fourth, the development of new technologies and working modes may influence the location and design of workplaces. Several roles of current knowledge workers may be replaced by artificial intelligence. All these possibilities should be estimated and considered in future research.

5 Conclusions

This study represents an initial effort to mitigate the severe health problems of knowledge workers by creating restorative nearby green spaces. A key contribution of this study is the identification of available environmental characteristics that can facilitate landscape design practice, allowing the recommendations to be effectively understood and implemented by designers. This study first proposes four theoretical mechanisms for improving knowledge workers' health: stress reduction, attention restoration and landscape preference, physical activities promotion, and sensory enrichment. Next, we extract 29 key characteristics of restorative environments that can positively influence the health and well-being of knowledge workers. In addition, we identify whether these environmental characteristics are available during landscape planning and/or design, thereby providing a basis for formulating evaluation criterion and design guidelines. In addition, the study proposes a set of criteria for evaluating the restorative capacity of existing green spaces and a set of guidelines for creating restorative nearby green spaces. In the end, an open-ended paradigm is proposed to bridge the gaps between the research and design practice of restorative green spaces.

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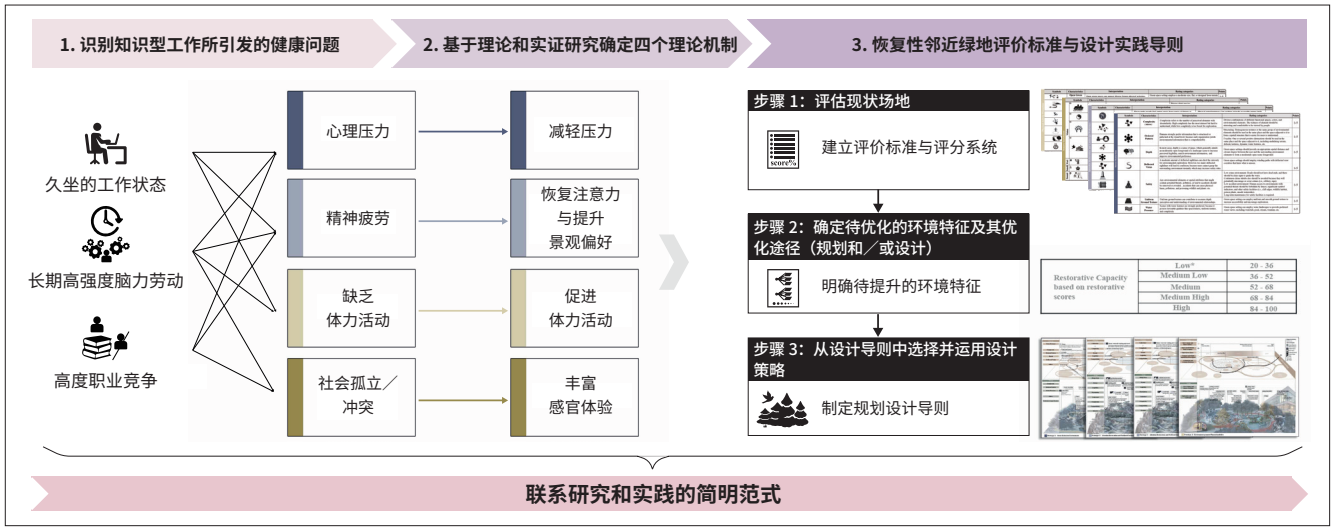
为知识工作者创造恢复性邻近绿地：理论机制、场地评价标准与设计导则

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图文摘要



文章亮点

- 确定了恢复性环境的四个理论机制
- 确定了29个恢复性环境特征
- 制定了一套包含三个步骤的场地评价标准和设计导则
- 展示了四个恢复性邻近绿地原型
- 为跨学科研究和设计实践提出了一个简明范式

摘要

知识工作者推动了当代城市的社会和经济发展，但他们往往由于久坐的工作状态、长期的高强度脑力劳动，以及高度职业竞争，而心理及生理健康状况堪忧。因此，为知识工作者提供高质量恢复性邻近绿地以促进他们的健康和福祉已成为一项紧迫的重要需求。尽管许多研究已经证明邻近绿地具有多重健康效益，但这些学术理论和研究证据并不足以有效地为相关规划和设计实践提供指导。本研究通过综合性文献研究，归纳总结出能体现工作场所邻近绿地所带来健康效益的四个理论机制：1）减轻压力；2）恢复注意力和提升景观偏好；3）促进体力活动；4）丰富感官体验。而后，本文确定了可以提高知识工作者健康和福祉的绿地关键环境特征。最后，研发了一套现状场地恢复性能力的评价标准及一系列恢复性邻近绿地设计导则，并为联系跨学科研究与实践提出了一种简明范式。

关键词

知识工作者；
恢复性邻近绿地；
心理健康；
生理健康；
恢复性景观；
绩效评估

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1 引言：知识工作者的健康危机

1.1 知识工作者面临的健康问题

信息时代，知识正在改变全球经济与劳动力市场[1]。知识工作者已成为世界各国生产力与竞争力的基本驱动因素[2][3]。通过开发用于电子商务、人工智能、自动化技术与线上交流合作的数字工具，知识工作者在地缘政治较量、文化与社会冲突、人口老龄化，以及当前新冠肺炎（COVID-19）疫情等问题上发挥了关键作用[4]。

然而，越来越多的证据表明，许多知识工作者因为知识型工作的固有特性[5]——包括久坐的工作状态、长期高强度脑力劳动与高度职业竞争[6]~[8]——正遭受着生理和心理健康问题的困扰（表1）。世界卫生组织表示，健康问题造成全球生产力下降，由此导致的经济损失每年约1万亿美元[9]。本研究总结了在知识型工作者中普遍存在的四类健康问题：心理压力、心理疲劳、缺乏体力活动，以及社会孤立／冲突[6][10]。

1）久坐的工作状态：知识型工作通常在计算机上操作，因此，知识工作者的大部分工作时间都是坐在电脑屏幕前度过的。这种久坐的工作状态可能导致静态／缺乏活动的生活方式，造成心理压力、精神疲劳和社会孤立，进而损害知识工作者的心理健康[11]~[13]。此外，久坐的工作状态还限制了知识工作者体力活动的时间和意愿，增加其患肥胖症、心血管疾病、II型糖尿病、癌症和其他严重生理疾病的风险[14][15]。

2）长期高强度脑力劳动：知识型工作通常需要长时间地保持专注，这会快速耗费工作者的注意力，导致精神疲劳[16][17]。各种期限紧迫的任务可能进一步导致严重的心理压力与焦虑[18][19]。长期高强度脑力劳动也会给知识工作者带来负面情绪，以及难以控制的冲动和攻击性行为，这增加了社会冲突的隐患[20][21]。此外，这种繁重工作可能极大压缩知识工作者进行休闲体力活动的时间和精力[14]。

3）高度职业竞争：知识和技术的快速发展与市场变化使知识工作者面临激烈的同侪压力，如果落后于人，他们可能会收入锐减，甚或失业[22][23]。这种需与市场保持同步的压力可能造成严重的心理健康问题。激烈的职业竞争也会妨碍知识工作者之间建立起信任与协作，造成长期精神或行为障碍，甚至严重的社会与心理问题，如欺凌行为、工作场所暴力或自杀行为[24]~[26]。

1.2 接触邻近绿地有助于恢复知识工作者的健康

近年来，旨在解决知识工作者严重健康问题的学术与实践探索持续涌现。通常，只有在10~15分钟步行距离范围内的绿地才便于休息时间极为有限的知识工作者使用。[27]因此，在他们的工作场所15分钟步行距离范围内建立绿地，可以鼓励他们进入这些空间以恢复健康。一方面，一些著名的技术公司已尝试为其员工提供邻近绿地，以提升他们的健康和福祉（如苹果公司总部、谷歌总部、华为松山湖小镇、腾讯前海总部）[28]~[31]。然而，这些绿地的营造大多基于设计师的直觉，而非基于理论与实证研究得出的科学成果[32]。而且，奢华的办公园区对财力与人力资源有限的中小企业来说难以负担。另一方面，虽然已有大量实证研究阐述了自然环境的健康效益，但是这些科学成果尚未被系统地转化为能够支持规划设计实践的场地评价标准与设计导则[33]。简言之，既有研究成果和实践之间仍然存在一定的差距，这对于规划设计从业者与研究者来说都是重大损失，妨碍了健康工作环境的发展。

1.3 研究目标

本研究旨在通过以下三个步骤缩小学术理论、实证研究和实践探索之间的差距：

1）确定邻近绿地影响知识工作者身心健康的关键理论机制；

表 1：知识型工作的固有特性及其对身心健康的负面影响

知识型工作的固有特性	知识型工作导致的健康问题	
久坐的工作状态	心理压力	长工作时间、高强度脑力劳动，以及职业竞争会给知识工作者带来压力，从而导致抑郁、焦虑，甚至引发危害他们身体健康的行为
长期高强度脑力劳动	精神疲劳	久坐的生活方式可能会加剧精神疲劳；多线任务和长时间的专注会消耗人的注意力；竞争激烈的职场环境要求工作者持续学习，这也需耗费大量注意力资源
	缺乏体力活动	久坐且高强度的长期脑力劳动可能导致肥胖症、脑卒中、心血管疾病、糖尿病、癌症和其他慢性病，而体力活动对于增进身心健康至关重要
高度职业竞争	社会孤立／冲突	职场竞争会损害工作者之间的同事关系；精神疲劳会降低人们的冲动控制力，导致更具攻击性的行为；同时，长时间的工作也减少了工作者人际交往的时间与机会

2）确定每个理论机制发挥效用的关键环境特征；

3）开发一套评价标准与设计导则，用以保护和／或营建恢复性邻近绿地，从而促进知识工作者的身心健康。

2 综合性文献研究：为营建恢复性邻近绿地提供理论和实证依据

本文通过综合性文献研究确定营建恢复性邻近绿地的理论机制与关键环境特征，为研发相关评价标准与设计指南提供理论与实证证据[34]。该综合性文献研究采用由罗宾·惠特莫尔于2005年提出的工作流程[35]（表2），述评对象包括理论研究或综述文章，以及实证研究。

首先，为阐释设计恰当的绿地对知识工作者健康与福祉的影响，我们总结出四个理论机制：减轻压力、恢复注意力与提升景观偏好、促进体力活动，以及丰富感官体验。

其次，分两步检索理论文献与实证研究：筛选出六组与上述四个影响机制相关的核心原始理论[12][18][36]~[43]研究（表2），选择由该理论提出者所参与撰写的、阐释了环境对人们健康与福祉影响的理论研究或综述文章。而后，根据这六组核心原始理论研究拟定了7个搜索关键词："stress reduction theory"（压力减轻理论）、"supportive design theory"（支持性设计理论）、"attention restoration theory"（注意力恢复理论）、"preference matrix model"（偏好矩阵模型）、"biophilia hypothesis"（亲生命假说）、"green exercise"（绿色运动），以及"nature exercise"（自然运动）。我们在爱思唯尔的Scopus数据库和Web of Science核心合集中进行检索并通过标题和摘要筛选了近10年（2010年1月至2021年12月）发表的实证文献。

我们总共搜索到14篇理论研究或综述文章与743篇实证研究。为制定能够指导工作环境恢复性邻近绿地的规划设计导则，最终只保留以下文献：1）研究工作场所环境与知识工作者健康与福祉之间的关系；2）发现有益于知识工作者健康与福祉的具体环境特征；3）提出规划和设计的建议（表2）。

基于该综合性文献研究，我们筛选出支持四种理论机制的文献，证明了基于影响机制的健康干预可以改善知识工作者四类普遍的健康问题[44]~[46]。在总结出这些关键理论与关键环境特征的基础上，我们进一步提出了评价标准与设计导则。此外，我们还发现，大多聚焦环境与人类健康的学术研究难以应用于环境规划设计实践。为了解决这个问题，我们提出了一种旨在联系跨学科研究与实践的简化范式。

2.1 减轻压力

知识型工作产生的严重心理压力可以通过接触自然来缓解。"减压理论"（stress reduction theory）由进化心理学家罗杰·乌尔里希

表 2：综合性文献研究流程图

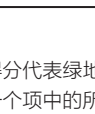


提出[36]。经过千百万年的进化，人类已发展出对具有特定特征的自然景观的正向内在情感，因为这些景观支持人类这一物种的生存与繁荣。根据该理论，能促进减轻压力的绿地具有以下七个环境特征（表3）：1）（压力）复杂性[37][47]；2）有序的形态[37][47]；3）深度[37]；4）视野转换[37][47]；5）安全感[44]；6）统一的地表肌理[32][47]；7）存在水体[37][41]。我们使用李克特量表（5分）对这些特征进行评分，每项的得分越高，表示绿地满足该评分描述的程度越高。值得注意的是，减轻压力并不是一种孤立的效应，它还会影响其他健康效益，例如恢复注意力、加强社会关系和促进体力活动[45][46]。

2.2 恢复注意力与提升景观偏好

“注意力恢复理论”（attention restoration theory）是进化心理学领域中的另一个重要理论，强调接触自然的心理效益，特别是认知功能效益。定向注意力是知识工作者成功完成日常任务与实现职业目标的一种

表 3：绿地减轻压力能力评分清单

符号	特征	内涵	评分项	得分
	**复杂性**	复杂性是指感知到的不同元素的数量；高复杂性通常更能引起人们的兴趣，但难以理解；相反，低复杂性通常不会引发人们探索的兴趣	不同功能空间、色彩、环境元素的多样化组合；丰富的元素既有趣又给人以舒适的视觉体验	1 ~ 5
	**有序的形态**	人们喜欢结构化或模式化的视觉信息，因为这样组织的环境信息易于被理解	结构化：在同一地点及其相邻的空间中使用同质肌理或同一组环境元素，以形成易于理解的空间结构 焦点：在同一个地点及其相邻的空间中包含一种或几种具有视觉吸引力的元素，如起伏的地形、巧妙的结构和动态的水景	1 ~ 5
	深度	在大多数情况下，深度是一种空间感，通常需要适度开放的景观作为前景，以增加感知易读性、丰富环境信息、提高景观偏好	绿地布局上，在使用者与周围环境元素之间保留适当的空间距离和封闭度，以形成适度开阔的前景	1 ~ 5
	视线转换	适量的视线转换可以引起人们对环境探索的好奇心，但视线转换过多可能会导致视觉感知混乱，因为使用者难以快速掌握周围环境情况，并可能增加安全隐患	绿地采用蜿蜒的路径和变换的视廊，道路前方的景观若隐若现	1 ~ 5
	安全感	任何可能存在潜在威胁、污染，或可能导致人身伤害事故的环境元素或空间（如野生动物栖息地或有毒植物生长空间）都应该从场地中移除	低犯罪环境：道路不是死胡同，并提供清晰的道路标志引导 避免形成连续茂密的灌木丛，因为这种环境可能会存在犯罪隐患（如抢劫、强奸） 低事故环境：通过设置围栏、醒目警示标识的形式禁止人类进入存在安全隐患的环境，或接近其他安全隐患（如悬崖边缘、野生动物栖息地、有毒植物、不安全的水岸） 需要对安全设施进行长期维护	1 ~ 5
	统一的地表肌理	统一的铺装形式有助于准确感知空间纵深并理解环境关系	绿地采用统一、平整的铺装来提升可达性，并鼓励探索	1 ~ 5
	存在水体	人们通常非常偏好具有水体的景观，因为这些场地通常空间开阔、具有统一的肌理又兼具复杂性	绿地利用水体营造受到人们欢迎的水景，如瀑布、池塘、溪流和喷泉	1 ~ 5

注

1. 得分代表绿地满足该评分项描述的程度：1 表示完全不符合；2 表示不太符合；3 表示部分符合；4 表示较为符合；5 表示非常符合。
2. 一个项中的所有子项的权重相同。

表 4：绿地恢复注意力和提升景观偏好能力评分清单

符号	特征	内涵	评分项	得分
	**精神远离感**	场所能够让人感受到远离了疲劳或需要专注才能完成的脑力活动；这里的“远离”是指精神或物质空间层面上的	物质空间的转换：城市中的工作者到访可达的、能够远离精神疲劳的自然／建成环境 精神远离：能够让人们在精神上远离现有环境的事物，如窗户、新奇场景或历史遗迹	1 ~ 5
	**延展性**	场所环境多样化且没有明确的边界；能够提供丰富的信息供使用者去畅想、探索，去感受浑然不同的世界	在小空间中体验大世界：花园中设置蜿蜒小径或模拟自然环境，能够提升空间的延伸感 感受过去：场所中包含历史遗迹	1 ~ 5
	**兼容性**	个体偏好与环境条件的一致性，即场地可供个体活动自然而然地发生，回应个体需求	活动偏好：取决于个体的性格和文化差异；自然环境通常会满足个人生存的需求 不提供过多的空间探索选择，因为做出选择也是消耗定向注意力的行为	1 ~ 5
	**迷人性**	在重点空间中设置一些独特的景致与信息，营造不确定感，激发使用者的思考与探索	这种变化产生的迷人性是柔和的，让使用者的体验毫不费力；散发这种柔和迷人性的自然变化包括万物的生长、光影的变化、云雾的变幻、日出日落、飘雪等	1-5
	**连贯性**	特定空间中，人视高度上直接获取的秩序、主题或材质更易于被感知和理解	景观以对称性或重复性的视觉元素／主题呈现，如无论是平面还是空间角度都运用和谐统一的材质	1 ~ 5
	**复杂性**	人视高度上直接获取的丰富性和大量具有鲜明对比的景观元素能够极大刺激使用者的探索欲	空间中的视觉丰富度包括不同的元素、不同的功能（单一功能空间中具有多样化的元素），能够激发使用者进行空间探索	1 ~ 5
	**可读性**	人们能够通过高度的独特性与空间指引来解读环境	令人记忆深刻的标识或清晰的道路系统给使用者强烈的方向感，指引人们进行安全的探索；空间功能清晰可辨	1 ~ 5
	**神秘性**	人们可以发现对后续景观的提示，激发对探索潜在的信息与体验的兴趣	蜿蜒的道路或视线可穿透的前景空间，都可让使用者满怀期待和惊喜去安全地探索空间	1 ~ 5

注
1. 得分代表绿地满足该评分项描述的程度：1 表示完全不符合；2 表示不太符合；3 表示部分符合；4 表示较为符合；5 表示非常符合。
2. 一个项中的所有子项的权重相同。

主要认知资源[20][38]。绿地能通过兼容多元的功能、广阔而富于变化的视域，以及多样化的柔性吸引力来激发人们对于空间的探索，这一过程主要消耗非定向注意力，从而促进恢复定向注意力[39]。此外，注意力恢复理论表明，人类的景观偏好与景观的注意力恢复能力紧密关联。有研究发现，人们偏好的环境——尤其是偏好的自然环境——能显著改善定向注意力[48][49]。有助于恢复注意力提升与景观偏好的绿地具有以下八个环境特征（表4）：1）精神远离感[38]；2）延展性[38]；3）兼容性[40]；4）迷人性[38]；5）连贯性[38]；6）（注意力）复杂性[40]；7）可读性[40]；8）神

秘性[40]。我们使用李克特量表（5分）对这些特征进行评分，每项的得分越高，表示绿地满足该评分描述的程度越高。这种注意力恢复机制还有助于减轻压力、加强社会关系和促进体力活动[38]。

2.3 促进体力活动

体力活动机会的提升可带来生理、心理与行为层面上的多种健康效益[50][51]。在不同环境下，体力活动都能对心理健康产生积极影响，不仅能够缓解抑郁与焦虑，还可以降低人们对日常生活中压力源的敏感度[52]。

对知识工作者来说，10~15分钟的工作休息时间已足够到访邻近绿地并进行休闲体力活动。有研究表明，在工作与休息时间置身于自然环境中，有助于知识工作者迅速从疲劳与压力中恢复，增进社交联系[14][53]~[55]；在以自然景观为主的户外环境中工作，能有效减轻压力、提升执行力、增进社会关系[55]~[57]；工作休息期间进行体力活动还能帮助恢复注意力、改善睡眠质量、增强免疫力，并有助于预防如糖尿病、高血压、抑郁症与部分癌症等慢性疾病[27][58]~[60]。

在绿地开展的体力活动主要包括休闲体力活动与户外工作，而户外工作包括多种行为——人们在单独或团队工作时，可能会涉及低至中等强度的体力活动，如站立、步行、骑行、慢跑等。有助于促进体力活动的绿地具有以下七个关键环境特征（表5）：1）开敞[58][60]~[62]；2）通透且变换的自然视野[60]~[62]；3）兼容性设施[59][60]；4）互动型人工智能景观[59][60]；5）紧凑的多功能硬质铺装场地[61]；6）树荫与遮蔽设施[57][60][61]；7）贯通的环路[60][62][63]。我们使用李克特量表（5分）对这些特征进行评分，每项的得分越高，表示绿地满足该评分描述的程度越高。

表 5：绿地促进体力活动能力评分清单

符号	特征	内涵	评分项	得分
	**开敞**	开敞的绿地可以成为多种休闲体力活动的载体	绿地规划设置中等尺度的、平整或经地形设计的草地，为不同年龄层的使用者提供休闲体力活动空间	1 ~ 5
	**通透且变换的自然视野**	通透而变换的自然景观视野可以持续地抓住人们的注意力和好奇心，并激起人们在室外／室内环境中进行休闲体力活动	由室外／室内环境为视点，设置可欣赏天然或人造自然景观，且视野各不相同的视廊	1 ~ 5
	**兼容性设施**	兼容户外体力活动和工作的设施促使人们开展户外活动	设置健身器械或者户外会议桌以满足企业成员的活动和交谈需求	1 ~ 5
	**互动型人工智能景观**	互动形式清晰且有趣的景观装置可触发人们自发进行交互活动	互动型景观设施包括滑梯、秋千、动感单车等；结合人工智能技术，使用者的肢体行为将会被反馈到屏幕上，从而激发出更多的活动	1 ~ 5
	**紧凑的多功能硬质铺装场地**	多功能的平整硬质铺装场地促使人们开展多样化的户外活动	特定的体力活动（如篮球、羽毛球、舞蹈、跳绳）需要开敞连续的平整硬质场地，方可安全地进行	1 ~ 5
	**树荫与遮蔽设施**	浓密的树荫或其他遮蔽设施可提供舒适的热环境，使人们不受烈日和暴雨的影响	遮蔽设施使户外活动无需受限于天气条件	1 ~ 5
	**贯通的环路**	安全的环路可以支持多种户外活动，合适的铺装和路面标识可以引导人们开展散步、慢跑、骑行等活动	至少有一条非机动车慢行道，将慢行活动与车行道分开	1 ~ 5

注

1. 得分代表绿地满足该评分项描述的程度：1 表示完全不符合；2 表示不太符合；3 表示部分符合；4 表示较为符合；5 表示非常符合。
2. 一个项中所有子项的权重相同。

2.4 丰富感官体验

丰富感官体验是对上述三个机制的补充。基于亲生命假说与相关实证研究，丰富感官体验机制指出了恢复性绿地的其他关键特征[41][42][64][65]。在本研究中，知识工作者大多工作时间都身处室内，很少接触户外蓝绿空间，而户外蓝绿空间可提供丰富的感官刺激，促进减轻压力、恢复注意力，并提供其他认知与情感效益[66]~[68]。

该机制表明，特定环境特征能鼓励人们更加亲近自然，以获得多种健康效益[69]~[71]。绿地能提供四种主要的感官体验（即视觉、触觉、嗅觉与听觉），这些体验能促进人们的身心健康与社交互动[70]~[72]。能促进感官体验的绿地具有以下七个环境特征（表6）：1）生物多样性[41][42][64][65]；2）互补性对比元素[68][71]；3）记忆标志[66][67][72]~[74]；4）活力[70][71]；5）热舒适性[65][69][75]；6）气味宜人[76]；7）声景和谐[77]~[79]。我们使用李克特量表（5分）对这些特征进行评分，每项的得分越高，表示绿地满足该评分项描述的程度越高。

3 营建恢复性邻近绿地的评价标准与设计导则

本文将29个从上述四个理论机制与相关实证研究中提炼出来的环境特征，转化为实践中可参考的场地评价标准与设计导则。

3.1 邻近绿地恢复性能力评价标准

3.1.1 评分清单和评估表格

某一绿地的恢复性能力可通过对评分清单（表3~6）中列出的所有环境特征评分项描述的满足程度进行打分的方式来评估；然后，依据评

表 6：绿地丰富感官体验能力评分清单

符号	特征	内涵	评分项			得分
视觉	生物多样性	植物和动物种类的多样性营造出丰富的景观层次	丰富多样的植物种类 丰富的植物层次：上、中、下层乔木、灌木和地被 多样的植被形态：不同的尺寸和形态 丰富多样的动物种类			1 ~ 5
	互补性对比元素	形成鲜明对比的空间平衡了空间的单调，并增强了整体和秩序性	绿地中设有对比鲜明的空间元素，包括封闭／开放空间、影／光、室内／室外、人工／自然			1 ~ 5
	记忆标志	场所认同	独特性		可辨识的记忆点，如本土性元素	1 ~ 5
			自尊感		可以提升生活品质的象征性元素	
			连续性		连续出现的相似元素增强了环境的整体性	
			自我效能		人们有在场地中有效完成工作或任务的信心	
	活力	活力是指一切有生命力的事物，包括人类、动物、植物，以及不断变换的自然现象	动物	野生动物或宠物	植物为野生动物提供了遮蔽和食物，也为人们提供了溜宠物的场所	1 ~ 5
			植物	季相变化	植物动态的生长过程为场地增添了多样性和活力	
				自然生长	植物的自然形态，以及地形学和仿生学特征（包括模仿自然过程和肌理）	
			光照	自然／人工光照	变化的自然光照，或者灯光秀、交互式灯光等人工光景观	

续表见下页

表 6：绿地丰富感官体验能力评分清单

	符号	特征	内涵	评分项	得分
触觉		**热舒适性**	合适的热环境可以提高工作效率和表现	当温度在 20~26℃之间，并伴随适宜的湿度和清新的空气流通（适度的风）时，人们感觉舒适	1 ~ 5
嗅觉		**气味宜人**	景观散发出具有疗愈效果的宜人气味，促使人们在场地中开展体力活动并延长停留时间	不同季节开放的花卉、芳香的木本植物，以及流动的水都可以带来令人愉悦的气味	1 ~ 5
听觉		**声景和谐**	社交活动	积极的：自然的声音、谈话声、笑声 消极的：噪音（交通噪音）、哭声	1 ~ 5
			独处活动	积极的：自然的声音 消极的：噪音、谈话声	
			减轻压力	积极的：自然的声音，轻音乐 消极的：噪音	

注

1. 得分代表绿地满足该评分项描述的程度：1 表示完全不符合；2 表示不太符合；3 表示部分符合；4 表示较为符合；5 表示非常符合。
2. 一个项中的所有子项的权重相同。

估表格（表7）计算总分，量化场地的恢复性能力（恢复性能力分为五个等级）。

3.1.2 评价标准使用步骤

四个机制在该评价标准中同等重要，因此每个机制在总分为100分的评价标准中各占25分。由于每个机制对应的环境特征数量不同，所以加权相加每个机制的得分来评价场地的恢复性能力。我们采用权重系数（C1~C4）将四个机制的原始评价分数（E1~E4）分别调整至评级系统中5~25分的范围内（表7）。

总分与各项机制得分在评价恢复性能力时都会被考虑。评价标准将总分平均划分为五个区间：20~36、37~52、53~68、69~84和85~100，分别对应低、较低、中、较高与高五个恢复性能力等级。若某项理论机制得分较低，表明该项机制对应的环境特征具有较大的提升空间，得分较高则表明场地具有保护与利用该类型环境特征的潜力。如某项机制的得分等于或小于9——即小于单项基础分5分加上可获得分20分中的20%——最终评分将用“*”标记，表示该场地在特定恢复性环境特征方面存在明显短板，亟待改善。

表 7：绿地恢复性能力评估表

理论机制	得分范围	权重系数	加权得分（范围：5~25 分）
减轻压力	E1=7 ~ 35	C1=25/35	C1×E1
恢复注意力与提升景观偏好	E2=8 ~ 40	C2=25/40	C2×E2
促进体力活动	E3=7 ~ 35	C3=25/35	C3×E3
丰富感官体验	E4=7 ~ 35	C4=25/35	C4×E4
合计	29 ~ 145		
基于恢复力得分的环境恢复性能力评级		低	20 ~ 36
		较低	37 ~ 52
		中等	53 ~ 68
		较高	69 ~ 84
		高	85 ~ 100

注

四项机制中，若一项或多项机制的得分等于小于 9，将会被标记为“*”。

3.2 设计导则

3.2.1 设计导则：四个设计原型

设计导则包含四个原型，分别对应四个影响机制：1）减轻压力；

表 8：可在规划和／或设计阶段考量的四种理论机制所对应的环境特征

减轻压力	恢复注意力与提升景观偏好	促进体力活动	丰富感官体验
规划 深度	规划 + 设计 连贯性	规划 开敞	规划 + 设计 生物多样性
规划 + 设计 有序的形态	规划 + 设计 （注意力）复杂性	规划 紧凑的 多功能硬质铺装场地	规划 + 设计 互补性对比元素
规划 + 设计 （压力）复杂性	规划 + 设计 延展性	规划 + 设计 贯通的环路	设计 记忆标志
规划 视线转换	规划 + 设计 兼容性	规划 通透且变换的自然视野	设计 活力
规划 + 设计 存在水体	规划 + 设计 可读性	规划 + 设计 树荫与遮蔽设施	设计 热舒适性
规划 + 设计 安全感	设计 精神远离感	设计 兼容性设施	设计 气味宜人
设计 统一的地表肌理	设计 迷人性	设计 互动型人工智能景观	设计 声景和谐
	设计 神秘性		

2）恢复注意力与提升景观偏好；3）促进体力活动；4）丰富感官体验。在这些原型中，设计导则仅提供最实用的规划设计策略，为在工作场所附近营建恢复性绿地提供参考。

3.2.2 设计导则运用步骤

本设计导则推荐在对场地现状进行评价后使用，共分为三步（图1）。每个设计原型都可以灵活调整，图示旨在为规划设计人员及政策制定者提供指导与初步框架（图2~5）。每项理论机制的设计原型图示都包含两部分：规划布局（上部）与设计策略（下部）。为了尽量减少对现有环境的破坏并最大限度地提高现有资源的价值，场地中现有的宝贵自然资源须得到妥善保护和利用。每个设计原型图示右上角的“场地利用建议”部分列出了根据现有场地条件选择最合适策略的建议；某些环境特征在规划和设计阶段都需要加以考量（表8）。

3.3 跨学科研究与实践范式

本研究为规划设计恢复性邻近绿地研发了一套综合工具包。该工具包包括评价标准与设计导则，有助于桥接服务于知识工作者的恢复性邻近绿地的相关研究与设计实践，并尝试将概念性环境特征转化为可度量的分数与切实可行的设计策略。

此外，我们提出一种简化的研究范式，旨在联系起跨学科研究与实践（图6）。该框架是一个开放系统，便于形成研究与实践的完整循环，能极大地促进循证设计流程。该流程起始于对理论与实证研究的综合性文献综述，即要求研究人员运用最新的科学依据来制定场地评价标准。标准包含四个类别，但每个类别中的评价项目需要根据区域和／或场地

环境条件进行调整。例如，美国城市的标准应与中国城市的标准不同，因为二者在人口与社会经济特征、交通方式、气候条件、居民行为模式与社会规范等方面都存在显著差异。

这些环境干预措施可使绿地更加有效地提供健康效益。通过场地调查与数据分析，研究人员有机会发现可能对公众健康与福祉的不同方面具有显著独立与共同影响的干预措施，为相关研究贡献新的实证证据，而新的文献综述也将会进一步推进实践与研究。由此，可实现理论和实践方法发展的连续循环。

4 局限性与未来研究机遇

本研究的局限性主要体现在四个方面，以供参考。第一，本研究主要基于对理论和实证研究的文献综述得出成果，缺乏对原始数据的收集和分析。未来应进行现场行为观察，以及对知识工作者的调查和访谈，以改进本研究的结果。第二，本研究提出的四种机制在本质上是相互关联的，因此研究中采用的平行的分析方式可能存在过于简化的风险。未来可量化机制间的相互作用，以细化机制。第三，本文中的设计导则主要针对景观设计师，而营建恢复性工作环境需要设计委托方、政府利益相关者、心理学家、景观设计师、建筑师、规划师和室内设计师等各方之间的跨专业协商、妥协和配合。因此，我们建议未来应考虑在其他专业进行类似研究，以最终形成适合跨专业复杂团队工作的一整套导则。第四，新技术与工作模式的快速迭代可能对工作场所的选址与设计产生重大影响。当前知识工作者的部分岗位在未来可能会被人工智能所替代。上述这些可能性都应在未来的研究中进行估计和考量。

5 结论

本文呈现了一项通过营建恢复性邻近绿地来缓解知识工作者严重健康问题的初步研究。研究的主要贡献之一是确定了可应用于景观设计实践的环境特征，从而使设计师能够更有效地理解和实施干预建议。本文提出了四项改善知识工作者健康的理论机制——减轻压力、恢复注意力与提升景观偏好、促进体力活动与丰富感官体验——进而总结出能够对知识工作者的健康与福祉产生积极影响的29个恢复性绿地的关键环境特征。此外，我们判断这些环境特征在景观规划和 / 或设计阶段是否可用，为制定评价标准与设计导则提供了依据。最后，本文提出了一套评估现有场地恢复性能力的标准，以及一套营建恢复性邻近绿地的设计导则，旨在以一种开放的范式来弥合恢复性绿地相关研究和规划设计实践之间的差距。

图 1. 恢复性邻近绿地设计工作流程
图 2. 原型一：减轻压力
图 3. 原型二：恢复注意力与提升景观偏好
图 4. 原型三：促进体力活动
图 5. 原型四：丰富感官体验
图 6. 联系跨学科研究和实践的简明范式