

# 重焕新生： 基于水文地形网络的矿场景观再生设计

## Rejuvenated Prominence: Reclaiming the Landscape of Extraction Based on Hydro-topographic Network

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### 摘要

进行中的“重焕新生”项目旨在为泰国南邦府湄墨矿场的表土景观探索一套可行的水文地形设计方案。这座占地135km<sup>2</sup>的矿场位于汪河源头的湄墨盆地内。自1969年以来，已开采了5亿多吨褐煤，而剩余的2.24亿吨储量仅可支撑接下来29年的开采。为恢复当地生态系统以及维持周边社区之后的发展，泰国国家电力局已发布2020~2049年间的后矿山开采时期的规划方案。基于此规划，本项目旨在通过复刻复杂自然地形的方式，彻底解密自然结构、功能和变化，以改造32km<sup>2</sup>已被塑造为矩形的表土堆场。依照《湄墨矿场总体规划》中的开采时序，项目团队制定了一套整合水文地形干预，并辅以土壤生物工程技术的行动方案，以激活地形景观的地质营力，从而复兴这片场地。重新设计的地貌结构可降低径流速度，从而减轻土壤侵蚀作用、分散土壤水分、补充表层土壤，这里将成为具有复杂水文地形网络的动态景观，并逐渐融入上游源头景观，最终实现湄墨盆地的韧性。

### 关键词

矿场景观；后矿山开采景观；水文地形网络；土壤生物工程；地形规划；湄墨矿场

### ABSTRACT

As an ongoing project, Rejuvenated Prominence aims to explore operative and hydro-topographic strategies for the overburdened layer landscape of Mae Moh Mine in Lampang Province, Thailand. The 135 km<sup>2</sup> mine is located inside Mae Moh Basin, the headwater of Wang River. Since 1969, over 500 million tons of lignite have been extracted, while the remaining reserve of 224 million tons will last for the next 29 years. To recover ecosystems and maintain sustainable development of surrounding communities, the Electricity Generating Authority of Thailand developed post-mining alternatives from 2020 to 2049. As a part of this research, Rejuvenated Prominence focuses on the 32 km<sup>2</sup> overburden dump, where rectangular surfaces completely replaced with complex natural terrains, to thoroughly decode the nature's structure, function and change. Time-based strategies in accordance with the Mine Master Plan deploy hydro-topographic operations combining soil-bioengineering techniques to activate topographic agents and reclaim the land. Re-engineered geomorphic structures would be initiated to moderate rapid runoff, mitigate mass wasting, disperse soil moisture and replenish the topsoil. This dump would be transformed into an operative landscape with complex hydro-topographic networks and reconnected as a part of the projected headwater landscape over time—to realize the resilience of Mae Moh Basin.

### KEYWORDS

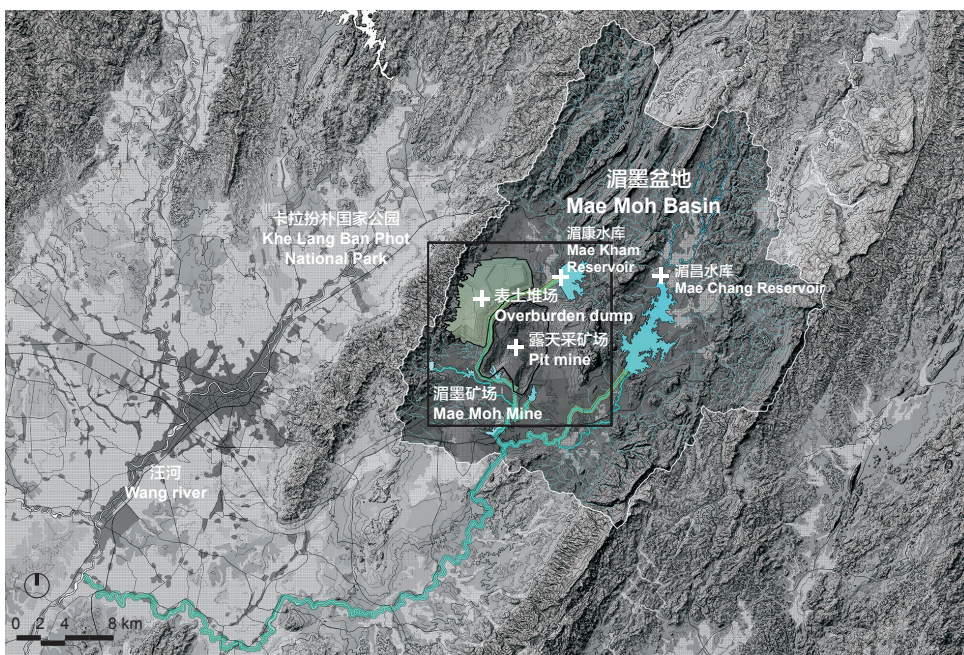
Mining Landscape; Post-Mining landscapes; Hydro-topographic Network; Soil-Bioengineering; Topography Planning; Mae Moh Mine

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1. 汪河、涓墨盆地水系，以及设计场地（包括表土堆场和露天采矿场）
2. 涓墨矿场内的表土堆场景观

1. Wang River, Mae Moh Basin water network, and the site (i.e. Mae Moh Mine) constituting of overburden dump and pit mine.
2. The overburden dump landscape of Mae Moh Mine

## 1 涓墨矿场

露天采矿属于挖土作业的大型工程<sup>[1]</sup>。位于泰国南邦府的涓墨矿场占地135km<sup>2</sup>，包括一个大型褐煤矿和数个燃煤发电厂，年生产量为2 400兆瓦，足以供泰国10%的居民使用。该矿场位于汪河上游源头的涓墨盆地内（图1）。为确保泰国国内建设开发有充足的能源供给，自1969年以来，泰国国家电力局（EGAT）已开采5亿多吨褐煤，目前剩余的2.24亿吨储量仅够支撑未来二十几年使用。目前，涓墨矿场正处于关停过渡期内，而EGAT已在2020年发布后矿山开采时期的规划方案——《涓墨矿场总体规划》，以在矿场关闭后恢复该地区生态系统并维持周边社区发展。作为EGAT和朱拉隆功大学的学术开发中心合作的科研项目，“重焕新生”根据《涓墨矿场总体规划》中提出的开采时序改造表土堆场，并致力于探索一套可行的水文地形设计方案。这座堆积而成的巨大平顶山占地面积为32km<sup>2</sup>，南北向宽约为8km，规划方案拟定的最高海拔为600m（图2）。堆场现有的阶梯状景观由多个横平竖直的平面构成，地形变化极具规律性<sup>[2]</sup>。而与堆场相邻的卡拉扮朴国家公园内，有80km<sup>2</sup>1A级流域保护区，此处的山地上森林遍布，且山体坡度可达50%以上。不同于堆场的乏味，这里的森林生机勃勃，并且通过

地上和下的水文过程的作用，呈现出极为丰富的地质特征。图1清晰地展示出设计场地中表土堆场的西部边界——一个复杂且不规则的自然山体斜坡和矩形的人造地形之间的分界线。作为一项实验性的探索，该项目将重新定义岩土工程技术作业，通过复刻自然状态来重构水文地形景观，并利用土壤生物工程——一种将生态技术、生物技术和工程技术结合起来，用于维护场地稳定性并恢复水文廊道的方法<sup>[3]</sup>——以激活多种地质营力、削弱土壤侵蚀、分散土壤水分，和补充表层土壤。

## 2 绘制景观变化图

本项目的测绘工作结合专家学者（包括景观设计师、岩土工程师、采矿工程师和环境研究员）的跨学科分析，明确了矿场景观是如何随时间发展变化的。场地的历史积淀不仅是一种视觉展示，也是揭示堆场迄今为止的发展轨迹的依据。根据《涓墨矿场总体规划》，对未来29年的景观每三年绘制一幅变化图（为全面分析该场地内水文状况，分析范围从涓墨盆地缩小至15km×15km方形区域），以识别关键的地形变化动因并预测水文生态效应（图3）。这种变化主要源自两种采矿作业：挖掘和运输<sup>[1]</sup>。挖掘矿坑以清除大量沉积物，从而露出下层褐煤矿

（图4）。然后开采、粉碎矿石，并将其运送至发电厂，而沉积物则运送至堆场（图5）。这些成吨的材料通过场地内的传送带和分离器进行运输，最终运送至总体规划中拟定的位置进行重新布局。在矿场关停前，这些巨型机器会不断累积沉积物、重塑堆场地形（图6）。目前，堆场海拔高度为500m，只需再增加16.3亿吨沉积物，2049年，堆场将达到拟定的最终高度600m。因此，在未来几十年的时间中，这些沉积物和采矿机械将会成为重塑这片地形景观的原料与动力。

## 3 可持续的水文地形景观

作为一个仍在实验阶段的研究项目，在表土堆场的地形改造方案中，设计场地将聚焦于方形区域中的堆场和露天采矿场两个地块，而此概念设计将从以下4个方面展开（图7）：1）运用地理信息系统（ArcGIS）和MineSight（一款矿场规划软件）对堆场现有的矩形边界进行放坡模拟，以呈现其复杂的曲线边界；2）依照这些阶梯状坡面以及现状线性排水渠，设计含有径流路径的起伏地形，以减少地表侵蚀和物质坡移的发生<sup>[2]</sup>；3）表土堆场的顶部平面则参照毗邻的卡拉扮朴国家公园的自然地形，建设一系列的山脊、土丘和山谷，新的山谷将垂直于盛



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行风向，以防止造成地表侵蚀；4）新的山谷和山脊将丰富场地地形，提升其生态系统多样性，为各类生物群落的生长提供了必要环境<sup>[4]</sup>——场地内径流通道的最大坡度仅为3%，可以维持较低的径流流速，同时促进土壤的水分吸收；将先锋物种成片种植于山谷中，以增强表层土壤的稳定性，而其他生长迅速且需水较少的地被和固氮植物则种植在更加干燥、海拔更高的土丘上，以防止坡面的地表侵蚀<sup>[2]</sup>。

表土堆场的设计改造方案将随时间发展不断融合场地变化并适应外界干扰<sup>[5]</sup>。根据矿场关停过渡期的场地规划，该方案将分为5个实施阶段（图8）——每个阶段，传送带和分离器的特定空间位置将决定水文地形景观再设计的建设顺序。在第一阶段，借助沉积物堆积形成多个高脊，从而构建出山谷；这些人工建造的水文廊道将模拟自然地形，连接现有的卡拉扮朴国家公园内的排水通道。在第二阶段，通过分离器增高山脊和土丘，使堆场的地形结构更为多样化。这种坚固的地形可以创造出不同的背风区和阴凉区，以减轻地表侵蚀影响，并为多元生态提供环境基础<sup>[2]</sup>。工程从南向北推进，重新设计的山丘将在表土堆场上逐步建造。按《湄墨矿场总体规划》制定的开采计划，这些山丘最高海拔将被控制在600m以下。第三阶段，在地形准备工作完成后，将着手准备植被修复。选择多种本地植物作为抑制侵蚀作用和补充表层土壤的生物机制；并种植固氮植被，以增加土壤养分和有机物；混种各种深根物种以增加地表糙度，进而拦截地表雨水径流、加固土壤<sup>[2]</sup>（图9）。在第四阶段，当地形施工与原生演替完成后，新的生态系统将逐步建立，且随着时间推移，土壤中养分和水分也会逐渐

增加。作为环境恢复和再生林的领导性组织，EGAT的知识与经验可以帮助建立连续的森林斑块，以作为上游源头保护区的缓冲区<sup>[5]</sup>。在这一阶段，表土堆场将完全转变为可自我维护和演替的景观，而自然和人工生态系统将在此重新统一。在第五阶段，随着矿场持续作业，多余的沉积物将会被运输和储存至指定的堆场中。至此，完成水文地形改造的堆场和矿场将会组成一个跨越多个高程的相互关联的景观网络。最终，矿坑将演变为存蓄有多余径流和沉积物的容器，进而逐步形成新的湿地生态系统（图10）。从土壤生物工程的微观策略到表土景观的重建，此再生设计过程中的水文地形网络将逐渐把后矿山开采场地与周边的大型水源景观重新连接起来。

#### 4 泰国的矿场再生设计

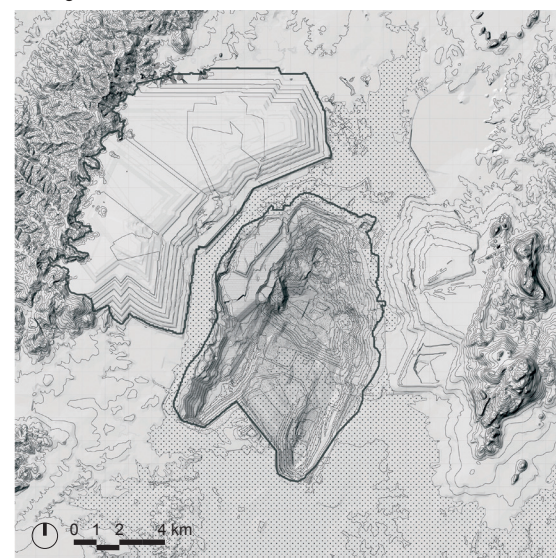
由EGAT发起的这项研究仍在进行中，并有望成为泰国最大的矿场景观再生项目。毫无疑问，湄墨矿场是一个自然与文化复杂关联的景观综合体。项目采用了协同测绘的方法，整合了相关学科的研究成果，并制定出能实现更高质量的空间设计方案。设计过程分析了现有条件和投影地形的变化，以预测景观未来的动态变化。景观随时间变化是常态，但其可持续性需要依赖适应能力。“重焕新生”只是一次对后矿山开采时期场地设计的初探——设计不再只是停留于单纯的空间布局，而是为不可预见的动态变化制定水文地形策略。与《湄墨矿场总体规划》的开采时序协调一致，设计方案仍在动态调整中。当然，场地的未来发展方向仍需深入探讨——实现湄墨矿场和水源盆地的长期韧性，不能仅依靠优化生态过程，还需综合考虑多方因素，尤其是时空维度上的文化因素和社会经济因素。**LAF**

#### 致谢

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#### 地层分析 Stratigraphy analysis

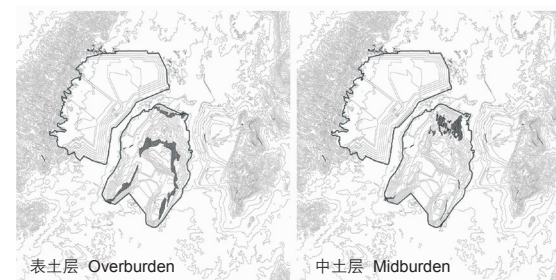
湄墨矿场2020年的地质影响因素  
Geological features of Mae Moh Mine in 2020



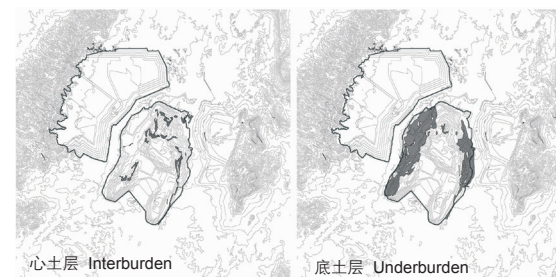
#### 地层划分 Strata

	表土层 Overburden		底土层 Underburden
	中土层 Midburden		红层 Red beds
	心土层 Interburden		冲积层 Alluvium

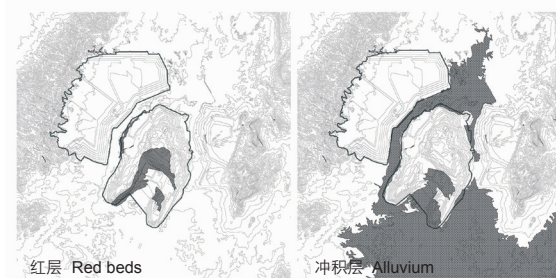
#### 沉积物清除次序：第1步 Burden extraction sequence 1



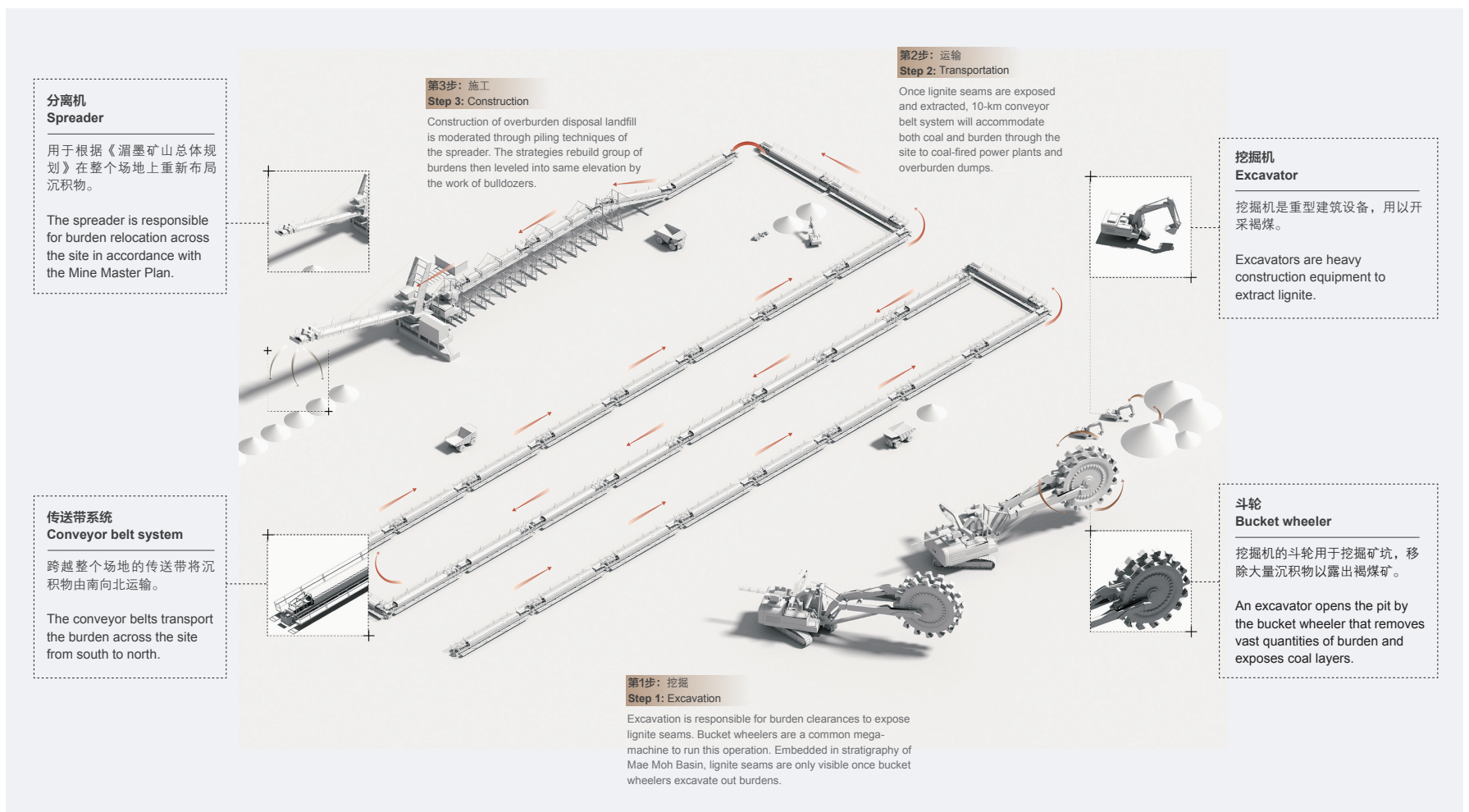
#### 沉积物清除次序：第2步 Burden extraction sequence 2



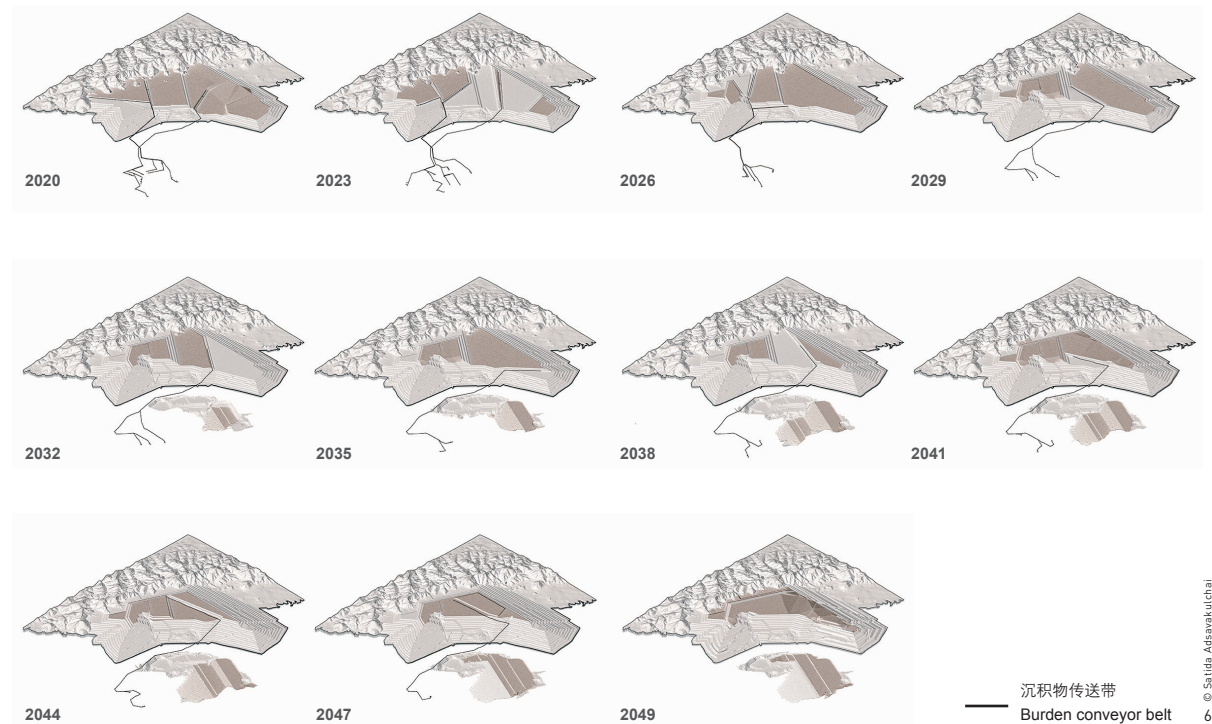
#### 沉积物清除次序：第3步 Burden extraction sequence 3

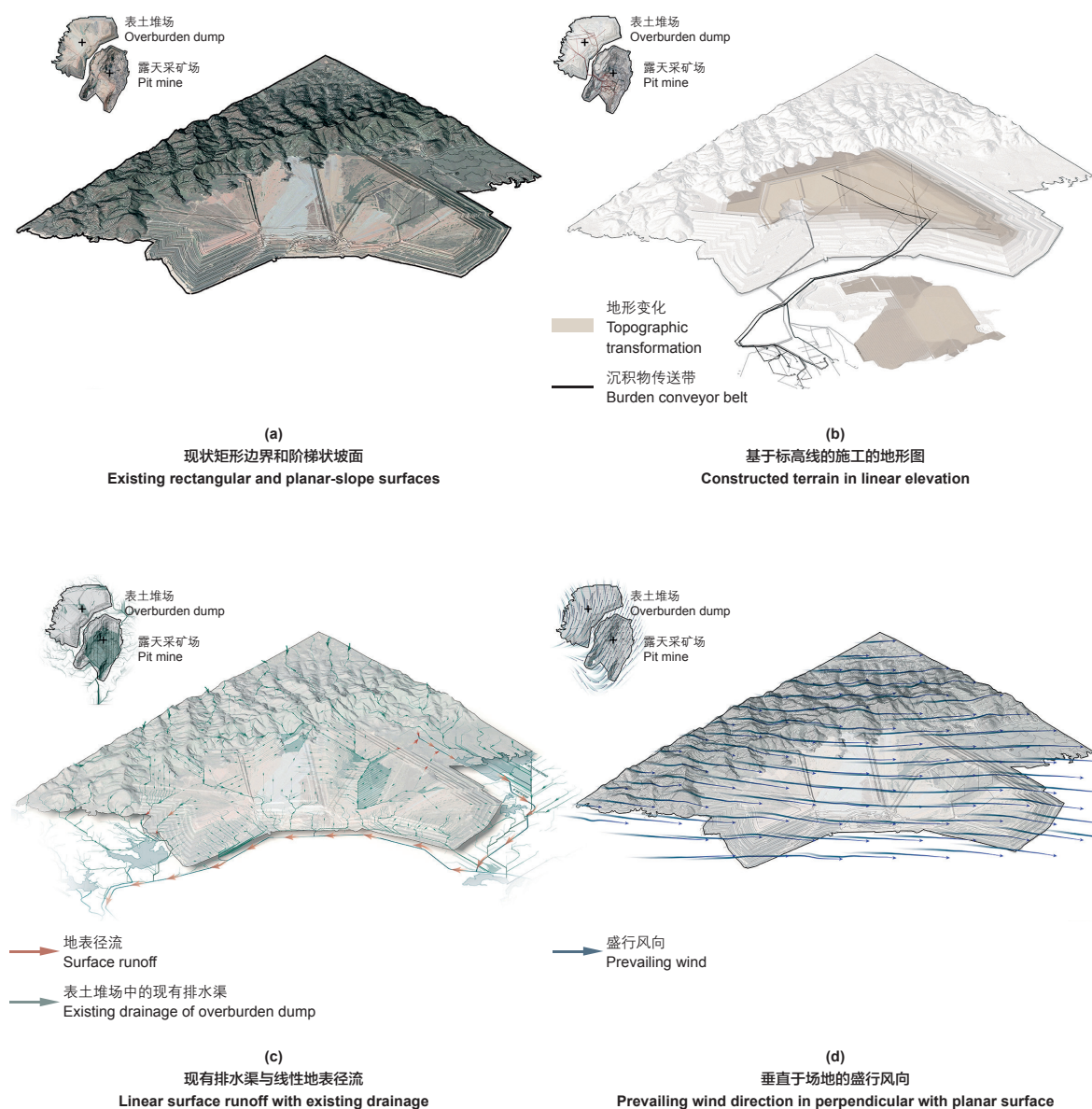


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- 按1:25 000比例缩小制作的模型展示了《涓墨矿场总体规划》所确定的11个阶段以及相应的设计场地改造过程，这个模型也被用作跨学科研究团队分析场地变化的工具。
- 涓墨矿场地层总体分析图。涓墨盆地建立于天然的向斜构造之上，具有“地垒-地堑”的地形特征，影响了沉积物和褐煤所分布的海拔高度，涓墨盆地常见的沉积物包括冲积层、红层、表土层、中土层、心土层和底土层。
- 两个主要的采矿作业（挖掘和运输）的运作过程
- 在未来29年的景观地形作业中使用的传送带网络
- The 1:25,000 model exhibits the 11 phases of the Mine Master Plan with the pit transformation, which has become one of the transdisciplinary tools for research teams to understand the mine transformation.
- The mining ground: overall stratigraphy analysis of the site. Mae Moh Basin's topographic feature naturally builds upon syncline structure with "Horst and Graben" topographic feature, which has influenced the burden and lignite to locate in diverse elevation. Burdens that are found commonly are listed: alluvium, red beds, overburden, midburden, interburden, and underburden.
- Two primary mining operation: excavation and transportation
- Topographic operations by the network of conveyor belts over the next 29 years





7. 表土堆场景观的概念设计

7. Conventional grading frameworks of the overburden dump landscape

## 1 Mae Moh Mine

Surface mining is a massive earth-removal operation<sup>[1]</sup>. The 135 km<sup>2</sup> Mae Moh Mine in Lampang Province, Thailand, is composed of a large-scale lignite mine and coal-fired power plants with an annual production capacity of 2,400 MW, supplying 10% of the electricity in Thailand. The mine is located within the Mae Moh Basin, which is the headwater of Wang River (Fig. 1). Since 1969, the Electricity

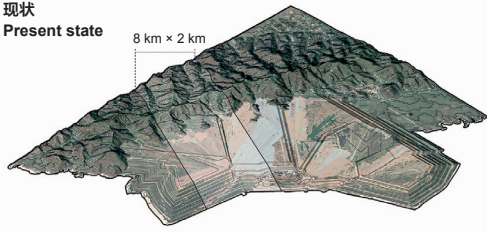
Generating Authority of Thailand (EGAT) has extracted more than 500 million tons of lignite to ensure sufficient energy for developments in the country. At present, the remaining reserves of 224 million tons will last for more than two decades. The Mae Moh Mine is currently in its transition to be decommissioned. EGAT developed post-mining alternatives—Mine Master Plan—in order to recover ecosystems and maintain surrounding communities after mining decommission in 2049. Thus, the mine

is being redesigned and reprogrammed. As a part of the collaboration between EGAT and Chula Unisearch, Rejuvenated Prominence is a research-based project, which aims to explore operative and hydro-topographic strategies in reclaiming the overburden dump in congruence with the existing time-based Mine Master Plan. This gigantic flat-topped mountain covers an area of 32 km<sup>2</sup> with approximated longitudinal length of 8 km and the designated final elevation of 600 m above mean sea level (Fig. 2). The conventionally grading landscape is structured by rectilinear-and-planar surfaces with a minimum topographic variation<sup>[2]</sup>. Adjacent to the dump, the 80 km<sup>2</sup> protected area of Khe Lang Ban Phot National Park is classified as 1A watershed, which refers to preserved headwater with forest cover and more than 50% of slope. In contradiction to the dump, the existing forest is dynamic, and geological characteristics are highly diversified by hydrologic processes both above and below ground. Shown in figure 1, the western border of the overburden dump is an interface between the complex irregularity of natural slopes and rectangularity of the manufactured terrain. As an experimental platform, the project is to re-conceptualize geotechnical operations and restructure the hydro-topographic landscape in replicating natural states. Soil-bioengineering techniques, a method that combines ecological, biological and engineering technologies for site stabilization and hydrologic corridors restoration<sup>[3]</sup>, are applied to activate diverse topographic agents, mitigate soil erosion, disperse moisture in soil, and replenish the topsoil.

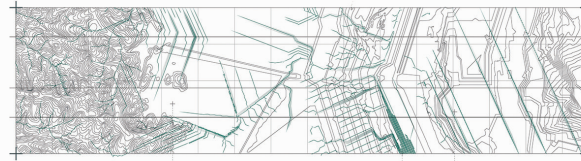
## 2 Mapping the Mining Landscape Transformations

Mappings are conducted under transdisciplinary expertise, including landscape designers, geotechnical engineers, mining engineers, and environmental researchers, to

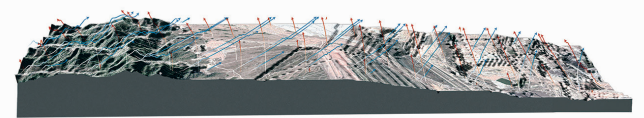
现状  
Present state



0 500 1000 2000 m

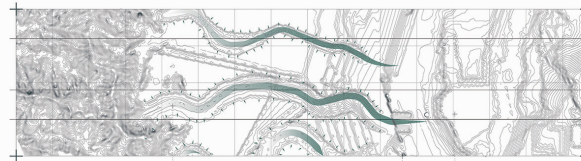
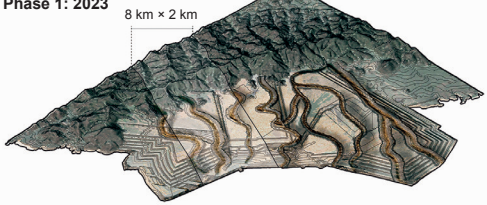


现状径流 Existing water runoffs

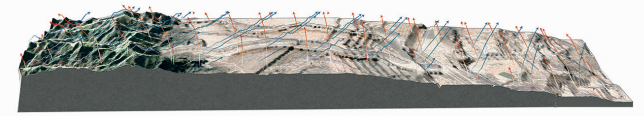


季风盛行风分析 Monsoon prevailing wind analysis  
夏季盛行风分析 Summer prevailing wind analysis

第一阶段：2023年  
Phase 1: 2023

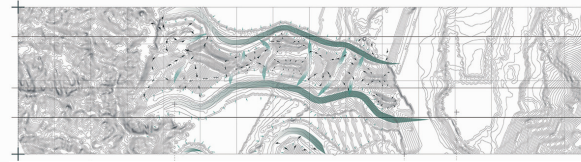
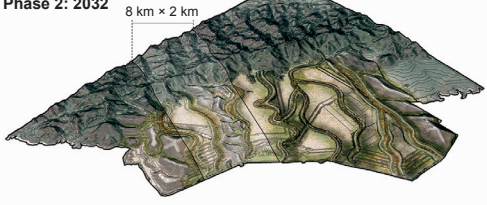


排水通道 Drainage corridors  
来自自然复杂边界的地表径流 Surface runoff from curvilinear boundaries

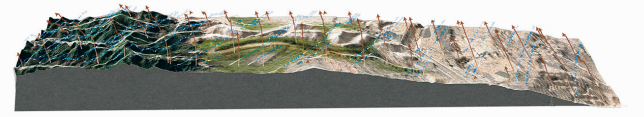


季风盛行风分析 Monsoon prevailing wind analysis  
夏季盛行风分析 Summer prevailing wind analysis

第二阶段：2032年  
Phase 2: 2032

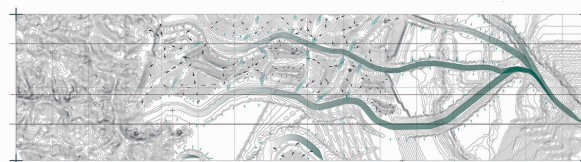
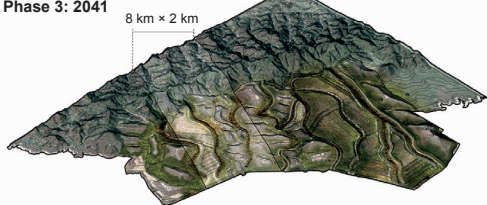


排水通道 Drainage corridors  
来自自然复杂边界的地表径流 Surface runoff from curvilinear boundaries

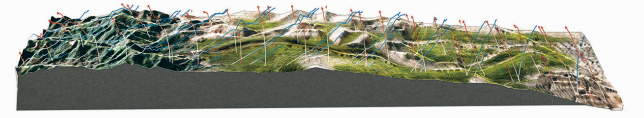


季风盛行风分析 Monsoon prevailing wind analysis  
夏季盛行风分析 Summer prevailing wind analysis

第三阶段：2041年  
Phase 3: 2041

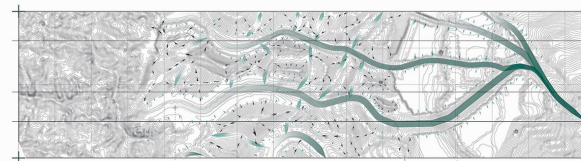
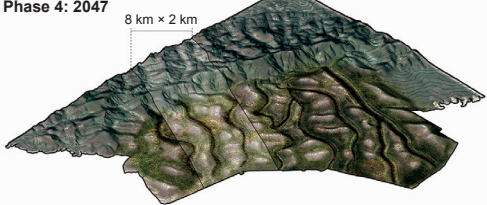


排水通道 Drainage corridors  
来自自然复杂边界的地表径流 Surface runoff from curvilinear boundaries

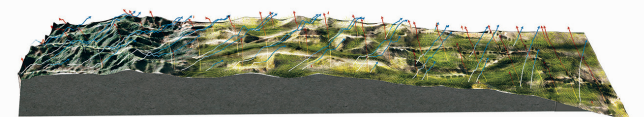


季风盛行风分析 Monsoon prevailing wind analysis  
夏季盛行风分析 Summer prevailing wind analysis

第四阶段：2047年  
Phase 4: 2047

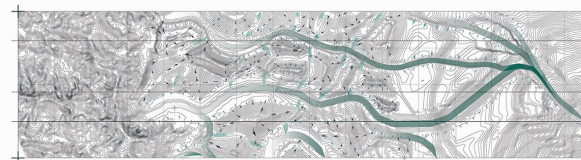
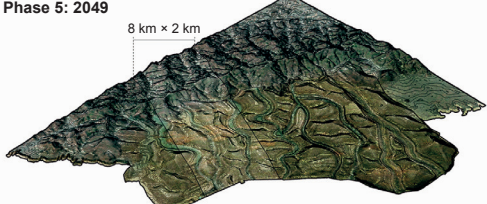


排水通道 Drainage corridors  
来自自然复杂边界的地表径流 Surface runoff from curvilinear boundaries

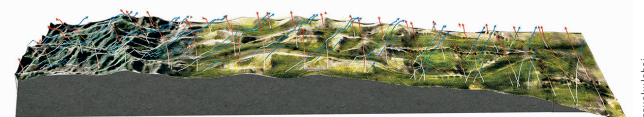


季风盛行风分析 Monsoon prevailing wind analysis  
夏季盛行风分析 Summer prevailing wind analysis

第五阶段：2049年  
Phase 5: 2049



排水通道 Drainage corridors  
来自自然复杂边界的地表径流 Surface runoff from curvilinear boundaries



季风盛行风分析 Monsoon prevailing wind analysis  
夏季盛行风分析 Summer prevailing wind analysis

understand how the landscape operated and changed over time. Accumulated history of the site is not only a visual reference but also the evidence that reveals a trajectory toward its present condition. Based on the Mine Master Plan, zoomed in to a 15 km × 15 km site from the Mae Moh Basin for comprehensive topographic analysis, mapping three-year-interval landscape transformations over the next 29 years is to identify key topographic agents and anticipate hydro-ecological consequences (Fig. 3). Change derives from two primary mining operations: excavation and transportation<sup>[1]</sup>. Excavation opens the pit, removes vast quantities of burden and exposes coal layers (Fig. 4). Then lignite is extracted, crushed, and transported to power plants, while burden is carried to the dump (Fig. 5). Tons of these materials are transported by the network of conveyor belts and spreaders across the site, which is eventually relocated in accordance with the Mine Master Plan. Not until decommission,

topography of the dump is being shaped repeatedly by these mega machines (Fig. 6). The current elevation of 500 m above mean sea level will be raised by additional 1,630 million tons of burden to reach the final elevation of 600 m in 2049. Thus, the mining machines and burden definitely become topographic agents in re-structuring the landscape over the next few decades.

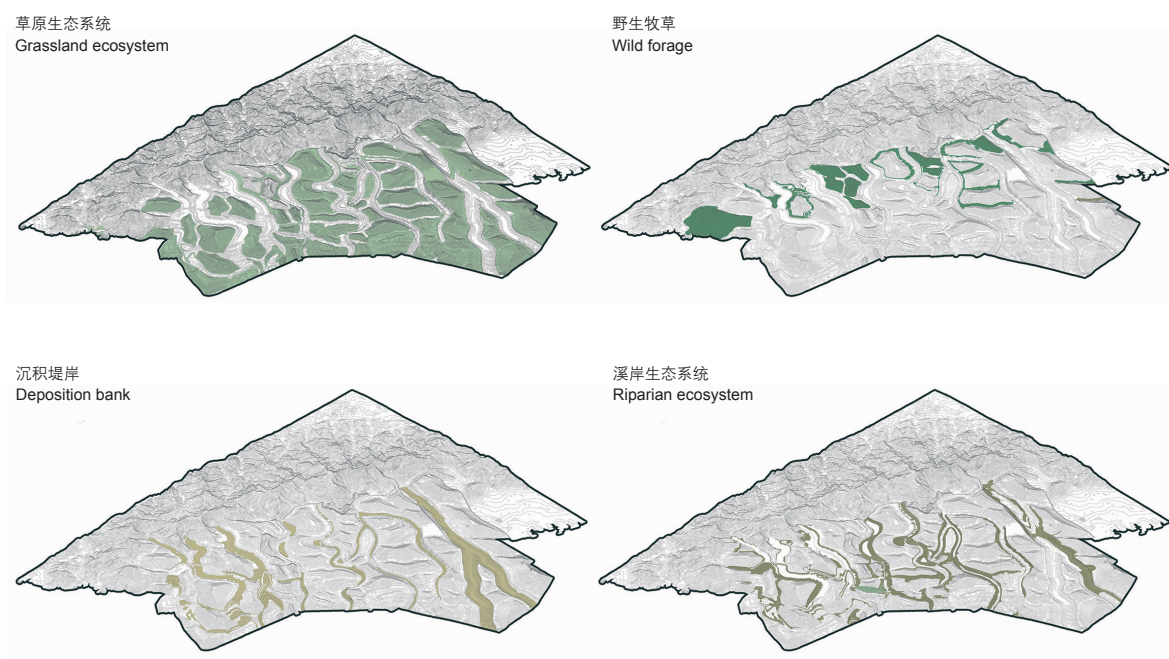
### 3 An Operative Hydro-topographic Landscape

As an experimental research-based project, the study area is regenerated from large scale to a smaller scale that particularly focuses on the overburden dump and pit mine. According to the analysis of mining landscape transformations, proposed topographic operations to the overburden dump are conceptualized under four major frameworks (Fig. 7). First, the shape of the dump is reconfigured from rectangularity to convoluted

curvilinear boundaries with multiple low points as containments from Geographic Information System (ArcGIS) and MineSight (mine planning software platform). Second, planar slope and linear drainage pattern of conventional grading is transformed to concave-and-convex terrains with tributaries of radial hydrologic pattern in order to reduce the impact of surface erosion and mass-wasting<sup>[2]</sup>. Third, the flat-topped surface of overburden dump will be substituted with series of ridges, mounds, and valleys in replicating the adjacent natural terrain of the Khe Lang Ban Phot National Park. New valleys will be oriented perpendicular to the prevailing wind in order to create wind shadow, which aids in the prevention of surface erosion. Finally, established valleys and ridges will create more variations in landform, which promotes ecosystem diversity to support ranges of living communities<sup>[4]</sup>. The maximum waterway slope of 3% reduces runoff velocity and increases moisture absorption in soil. In these valleys, pioneer species will be clustered to aid stability of topsoil while fast-growing groundcovers and nitrogen-fixing species which require less moisture are planted on drier high mounds to prevent surface erosion<sup>[2]</sup>.

These landscape operations are time-based. The overburden dump becomes an operative surface to reconcile temporal changes and adapt to disturbances<sup>[5]</sup>. The development strategies would be implemented over 5 phases in parallel with Mae Moh Mine Closure Plan<sup>[2]</sup> (Fig. 8). Designated locations of conveyor belts and spreaders in each mining stage determine the spatial sequence of reclamation processes. In Phase 1, valleys would be constructed by adding multiple high ridges with the burden layers. These new hydrologic corridors replicate natural landforms and connect to the existing drainage corridors of the adjacent Khe Lang Ban Phot national park. In Phase 2, ridges and mounds would be added by spreaders to diversify topographic structures of the dump.

9. 利用土壤生物工程生态技术构建微生态，以增强土壤稳定性。  
9. Soil-bioengineering ecological technology: the selection of micro-ecology to enhance soil stability.



This indurated terrain is to create variation of wind shadow and shaded areas to mitigate surface erosion and initiate multi-ecological conditions<sup>[2]</sup>. From south to north, the re-engineered mounds would be constructed towards the overburden dump. The top elevation is controlled at the maximum of 600 m above mean sea level as the original mining plans. In Phase 3, revegetation would begin after the topographic preparations. Diverse native plants are selected as living mechanisms of erosion control and topsoil replenishment. Nitrogen-fixing species would be sowed to add nutrient and organic matters. Variations of species with different root depths are mixed to increase surface roughness, intercept raindrops, and reinforce the topsoil<sup>[2]</sup> (Fig. 9). In Phase 4, after landform manipulation and primary succession, a new ecosystem starts to establish with additional nutrients and moisture over time. Since EGAT is one of the leading organizations in environmental restoration and reforestation, their empirical knowledge and experiences can be applied to establish successive forest patches as buffer areas for the protected headwater<sup>[5]</sup>. In this phase, the overburden dump is completely transformed into a self-maintaining and functioning landscape where natural and manmade ecosystems reunified. In the final phase, the pit would continuously being excavated, while extra burden would be transported and stored at the designated in-pit dump. Operations and reclamation strategies of the upper dump can be applied to create a connective landscape network across multiple elevations. With accumulating excessive runoff and sedimentation in the pit as a containment, new wetland ecosystems can be established over time (Fig. 10). Throughout the rejuvenating processes, from the micro-strategies of soil-bioengineering to the reconstruction of the overburden landscape, this hydro-topographic network would gradually reconnect the post-mining site into the greater headwater landscape.



10. 2049年将会形成新的湿地生态景观。  
10. The new wetland ecosystem will be established in 2049.

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#### 4 Mine Reclamation in Thailand

Initiated by EGAT, this ongoing research will lead to the largest mine reclamation in Thailand. Undoubtedly, Mae Moh Mine is an interconnected landscape of natural and cultural complexities. A synergistic mapping process is applied in order to integrate coherent disciplines and build design strategies that move beyond achieving spatial qualities. The process analyzes both existing conditions and projective topographic transformations in order to anticipate performances of the landscape over time. Time-based change is the norm, and a key characteristic of sustainability is adaptability. As a part of the project, Rejuvenated Prominence serves as an initial experimentation towards post-mining reclamation in which design departs from merely spatial arrangements to operational hydro-topographic strategies in tackling unforeseen dynamics. Reconciling with the Mine Master Plan, these operations are time-based, and still being developed. Definitely, additional research is required to determine the future of the site. The resilience that allows Mae Moh Mine and the headwater basin

to persist over time cannot be achieved by merely optimizing ecological processes, but by synthesizing coherent factors, especially cultural and socioeconomic aspects in place and time. **LAF**

#### ACKNOWLEDGEMENTS

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#### REFERENCES

- [1] Hayes, B. (2006). *Infrastructure: The Book of Everything for the Industrial Landscape*. New York, NY: W. W. Norton & Company, Inc.
- [2] Schor, H. J., & Gray, D. H. (2007). *Landforming: An Environmental Approach to Hillside Development, Mine Reclamation and Watershed Restoration*. Hoboken, NJ: John Wiley & Sons, Inc.
- [3] Kangas, P. C. (2004). *Ecological Engineering: Principles and Practice*. Boca Raton, FL: CRC Press.
- [4] Forman, R. T. T. (1995). *Land Mosaics: The Ecology of Landscape and Regions*. Cambridge, England: Cambridge University Press.
- [5] Dramstad, W. E., Olson, J. D., & Forman, R. T. T. (1996). *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning*. Washington, DC: Island Press.