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The Next Green Revolution: Rebuilding Urban Abundance Through Plant Community-Based Design

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摘要：气候变化、大规模物种灭绝、快速城市化以及工业土地利用极大影响了人们的生活品质，并削弱了地球上所有生命所依赖的核心生态系统服务功能。保护城市外围的自然土地已不足以确保人类自身的生存。为减少负面的环境影响，修复必不可少的生态系统服务，重塑人与自然元素的联系，并创造更健康、更具韧性的城市景观，有必要在城市和工业景观中采用具有超高生态功能并能引起公众强烈共鸣的种植方式，从根本上转变城市景观规划设计方法。介绍了美国 Phyto 景观设计工作室应用的基于植物群落的种植设计方法，解释创新的种植系统如何重建城市多样而丰裕的生境。阐述了植物之间、植物与人、植物与更大的环境如何联系的 3 个核心原则，通过案例说明该种植模式的应用，并讨论使其适应中国城市独特环境和社会政治背景的策略。

关键词：风景园林；景观种植设计；生态种植；功能性种植；基于植物群落的设计；城市生境丰度；中国城市

Abstract: Climate change, mass extinction, rapid urbanization, and industrial land use dramatically impact our life quality and reduce core ecosystem services all life on Earth depends on. Preserving natural lands outside of our cities is no longer enough to ensure our own survival. A fundamental shift in the way we plan and design urban landscapes—toward hyper-functional and highly evocative plantings in our cities and industrial landscapes—is necessary to reduce negative environmental effects, repair essential ecosystem services, reconnect people with elements of nature, and create healthier and more resilient cityscapes. This paper describes the planting design methods applied by U.S.-based Phyto Studio and explains how innovative planting systems can rebuild abundant life in our cities. We elaborate on the three core principles of how plants relate to one another, to people, and to the larger environment, illustrate the application of this planting model with case studies, and discuss strategies to adapt the model to the unique environmental and socio-political context of Chinese cities.

Keywords: landscape architecture; landscape planting design; ecological planting; functional planting; plant community-based design; urban abundance; Chinese cities

1 种植设计在后荒野世界的重要性

人类正处于两个严重的全球危机之中：气候变化和大规模物种灭绝。世界各国正经历更加频繁极端的暴雨和干旱，毁灭性的大火正吞噬大片受保护的森林。到 2100 年地球气温可能上升 2~5 ℃，预计将有 2 亿人因海平面上升而流离失所 [1]。在全球范围内，人类和其他物种赖以生存的生态系统的健康状况正以人类历史上前所未有的速度退化。目前约有 100 万种动植物濒临灭绝。自 1970 年以来，北美鸟类数量减少了 29%（近 30 亿只）[2]，而中国已有 27% 的主要陆生脊椎动物物种灭绝 [3]。人类正处于一场全球性的灾难之中，这从根本上影响了人们的生活质量、社会经济发展、国际关系以及我们所熟知的地球上的其他生命。

通过保护日益减少的自然土地来维持生物多样性和重要的生态系统功能比以往任何时候都更为重要。然而，在被工业用地和城市化极大改变的现代社会，这已远远不够。在所有可能的土地上恢复核心生态功能，已成为关乎人类自身生存的要务，生态保护以及负责的土地管理体系必须延伸至人们的生活和工作之所 [4]。我们不仅要在城市外部，更要在城市内部重塑生境丰度、生态丰富性和物种多样性。只有提升城市、郊区以及工业景观的生态功能，我们的孩子才能像我们今天一样享受这个赐予生命的美丽星球 [5-9]。

1

1 中国城市常见的景观种植设计：道路（1-1），公园（1-2）及各展会（如 2019 年北京世界园艺博览会，1-3）上的资源消耗型观赏植物

Landscape plantings commonly seen in Chinese cities along roadways (1-1) and in parks (1-2), in contrast with resource-intensive ornamental planting at exhibitions such as the International Horticultural Exhibition 2019, Beijing (1-3)

功能性城市生态系统同时具有社会和文化的重要性。人类对自然有着深层次的生理和心理需求，有力的证据表明：即使在自然中停留片刻都对人们的健康有着积极的影响 [10-11]。由城市自然创造的平和与宁静不仅能激发人们沉思与冥想，还能使人产生与周围环境和谐共处的感受 [12]。与城市自然的强烈情感联系能培养更强的环境意识，最终促进当前亟须的更广泛的公众环境管理 [13]。保护或恢复本土生态系统在保护文化完整性和国家认同感方面也起着重要的作用 [14]。

城市绿地尽管面积小、孤立且碎片化，但其可提供重要的生态系统服务，包括生物多样性保护 [15]，这已成为学术界共识。许多研究指出城市公园和花园的物种丰富度和种群丰度甚至可以高于郊区 [16-17]。具有高度生境异质性的大型连通绿地尤为重要 [18]，而优质的小型绿色斑块则为各类群野生生物提供重要的踏脚石生境 [19]，后者往往是高度发达地区唯一的野生生物避难所 [20]。然而，全球化以及文化与环境的同质化导致了城市景观设计风格和植物选择忽视背景、趋同一致 [21]，大面积草坪配以五颜六色的花坛和散植的树木成为世界各地最流行的景观风格之一。主流种植设计和土地管理策略无法提供基本的生态系统服务，如净化空气和水、固碳、缓解城市热岛效应、支持传粉动物种群以及恢复野生生物栖息地。事实上，许多通行的做法严重危害环境和人类健康。其中，轻率使用灌溉、石油基肥料、杀虫剂和不具生态功能的观赏植物等只会使问题更为严重。从根本上改进城市景观的设计方式并重建功能性的城市生态系统刻不容缓。

生态的种植设计和土地管理策略为应对当前气候和物种灭绝危机提供了新的思路。世界各国一直在探索各种方法并制定创新、循证的解决方案。例如，德国种植设计师成功地将由周边地区自播而来的野生植物（即自生植物，参见 2.3）融入公共园艺，启发性案例包括柏林的格莱斯德莱艾克（德语：Gleisdreieck）公园和素德格兰德（德语：Südgelände）公园 [22]。如今许多德国城市都拥有这种精致且易于维护的混合多年生植物组合。在英国，许多城市展示了兼具生物多样性和公众吸引力的人工自然群落案例。詹姆斯·希契莫夫（James Hitchmough）和奈杰尔·邓尼特（Nigel Dunnett）的种植理念展现了复杂生态种植给人带来的深厚情感和沉浸感 [23]。在美国，生态种植策略被应用于城市雨洪管理设施、屋顶绿化、用以替代草坪的草甸景观以及耐旱景观（xeriscapes，常见于加利福尼亚州等干旱地区）。

中国的城市迫切需要更好的种植设计和土地管理实践。空气污染、洪水、水污染和生物多样性丧失等环境问题正对国家的自然生态和人民健康产生深远影响。利用生态功能性植物重建城市生境丰度的做法仍处于起步阶段，目前仅体现在少数学者的实践尝试中 [24-28]，距离成为景观标准还有一定距离。成功的生态种植设计实例很少，而街道、公园、企业园区和大学校园普遍使用草坪或大规模的片植。另外，大型公共展览或庆祝活动仍偏爱华丽的、供人消遣的观赏植物（图 1）。本质上，中国的城市需要一场绿色革命。

2 当前的景观实践

2.1 观赏性种植

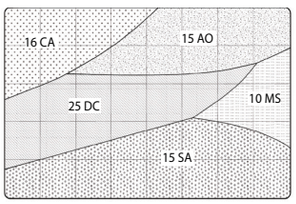
为装饰建筑、美化基础设施或庆祝大型体育和政治活动而使用的华丽观赏性植栽在世界各地十分流行。对许多国家而言，这类种植深深扎根于当地文化。例如，德国人喜欢一年一度丰富多彩的园艺展，而在美国，生机勃勃的室内花展在早春非常受欢迎。纯粹的观赏性种植可能显得俗气造作，但它们能给人带来巨大的乐趣，并提高了人们对观赏园艺所创造的艺术和娱乐的认识。

尽管奢华的装饰性种植仍有一席之地，但毫无疑问，它们高度消耗资源，需要定期灌溉、施肥、改良土壤、除草、重复覆根、重新替换并使用杀虫剂。这类种植失去人们的持续养护便无法存活，虽然对人们很有吸引力，但对昆虫几乎没有价值，改善环境的作用也微乎其微。因此，这种类型的种植方式不能也不应该用作未来景观的种植标准。

2.2 单一物种片植

片植是指使用单一植物品种构成的片区来覆盖种植区的方法（图 2）。片植尺寸灵活、结构清晰而易于被公众理解。事实上，在单一物种片区中杂草非常凸显，使片区相对容易维护。使用寿命较长的多年生植物和灌木（如萱草属、富贵草属植物和玫瑰）可以进一步减少维护需求。由于这些优点，成功使用片植的历史由来已久，它们在商业及其他机构，如办公园区、商务中心、大学校园、购物中心和道路等的植物景观中仍十分流行。

通过选择合适的、资源依赖度低的物种，



Typical plan for block planting
典型片植种植图

Traditional Planting:
- Gallons of soil disturbed
- Mulch filler
- Single plants leave room for weeds
- Vulnerable to wash out

传统种植：
- 大量土壤被干扰
- 护根填料
- 相互分立的单物种植物为杂草提供了生长空间
- 易被冲刷

CA/AO/DC/SA/MS 为植物物种简码，前缀数字为各物种总数

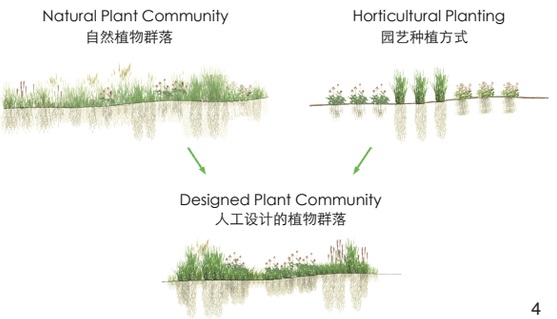
CA/AO/DC/SA/MS are abbreviations of plant species, the prefix is the total number of species.

2-1

2-2

2

3



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2 典型片植使用单一物种片区来覆盖种植区(2-1)；这一方法非常整洁清晰，但常形成大量易杂草丛生的开放空间，如植物之间及沿着混凝土边石的裸露地块（2-2），增加维护需求
Typical block planting configures plants in single-species blocks to cover a planting area (2-1). It can be very neat and legible, but often creates open spaces, e.g., the bare spots between plants and along the concrete street curb (2-2), where weeds thrive, increasing the need for skilled maintenance

3 茂盛的自生植被生长在特意放置的铁路砾石上（德国柏林格莱斯德莱艾克公园）
Thriving spontaneous vegetation on intentionally placed railroad gravel in Berlin's Gleisdreieck park, Germany

4 人工设计的植物群落将自然植物群落与传统园艺种植的元素融合在一起
Designed plant communities meld elements of natural plant communities with those of traditional horticultural planting

片植可以有效覆盖城市地面，并提供生态价值和功能价值。大多数功能性种植（如美国的雨洪管理种植和栖息地种植）都遵循该方法。尽管如此，片植仍面临严峻挑战。1）大多数植被长期覆盖率低，单株植物间存在太多隙地。这些开放空间或是裸露的土壤，或覆盖着不同类型用以抑制杂草的护根物（mulch，如树叶、松针、木屑、碎石）。护根物除保护土壤外，生态系统功能非常有限，而且必须定期补充才能有效抑制杂草。在重覆护根物时若抑制敏感植株冠部呼吸，或使用除草剂控制杂草时，也容易使理想的、需保留的植物受到伤害甚至死亡。2）片植仅能提供有限的生物多样性和生态系统功能。由于各片区物种单一，整个种植区通常仅含少数物种。具有生态价值的植物种类越少，野生动物的食物多样性和栖息地就越少，对病虫害的抵抗力也越弱。3）片植未尊重植物在野外的实际生长方式，这一点尤为重要。大多数植物是在多样且高度复杂的植物群落中进化的群体性生物。除了被引进植物（即入侵性杂草）战胜并取代的生态丰富的植物群落，野生植物不会自然地构成单一物种的生长片区，它们也不会自然地生长在木块或细碎硬木屑等覆盖物的包围中。

在历史悠久的花园、精心设计的园林展示区和非常正式的环境中，片植方式肯定有一席之地。然而，大多数片植的密度和层次不足，难以为未来的城市提供重要的生态系统服务。

2.3 自生植被

在城市绿地中，除种植理想却耗费资源的植物之外还有一种选择——培育自生植被（spontaneous vegetation），即鼓励周边区域的野生植物自播进入场地并建立生机勃勃的植物群落[29-30]。由此产生的新生态系统备受争议，因为它们不仅包含本地物种，还包含外来甚至入侵物种。此外，由于只有在周边区域已经蓬勃生长的植物才能在此繁衍，该方法并不一定会增加城市物种的多样性，因而设计师和植被管理者常使用额外的城市适应物种来作为自生植物的补充。

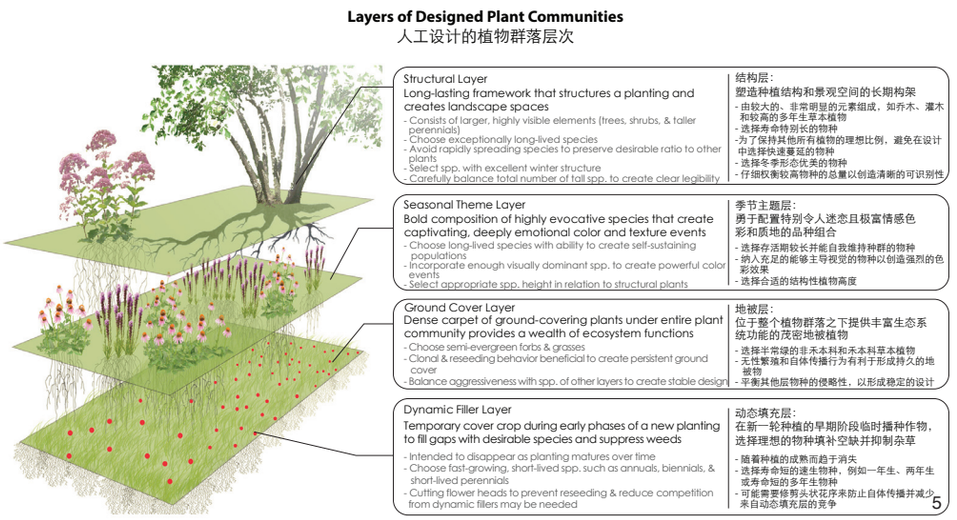
由于仅需很少的资源便能茂盛生长，自生植被是高度可持续的。自播而来的物种已预先适应了恶劣的城市环境，因而可形成极具韧性的植物群落。娴熟的种植管理对于形成更清晰美观的自生植物群落至关重要，只有高技能的管理人员才能恰当地“编辑”这样的群落。由于管理需求和种植美学方面的挑战，在公共景观中融入自生植物远未成为一种标准方法，在世界各地的成功应用案例也非常少（图3）。

3 更好的种植设计和景观管理方案

上述与传统种植和自生植被策略相关的挑战表明，需要其他种植技术来构建亟须的高性能景观，而好消息是众多种植设计专家正在寻求解决方案。笔者介绍的是专注于研发创新型种植方案的美国Phyto景观设计工作室（以下简称Phyto工作室）的方法和种植模式[31]。

解决方案的灵感来自自然植物群落及其核心原则。过去100年间，有关植物之间及植物与环境之间相互作用方式的科学见解赋予种植行业一种激动人心的创新设计方法：人工设计的植物群落（designed plant communities）。该方法源于20世纪00年代初期，20世纪70年代由德国维森的理查德·汉森（Richard Hansen）和赫尔曼·摩泽尔（Hermann Müssel）进一步改进[27]17, [32]。一方面，该方法将自然植物群落的原则和传统观赏性种植融为一体（图4），通过植物分层和有计划的冗余来创造功能多样性和韧性。另一方面，通过鲜明对比和效果强烈的季节性花卉景观来创造清晰的可识别性和惊人的情感反应，给人们带来欢乐的同时重塑人与大自然的联系。本质上，人工设计的植物群落是利用文化语言对野生植物群落的转译。

过去几十年间人们对植物群落设计的理解有了显著加深，这得益于全球范围内大量有关植物行为、寿命和相互作用的种植试验和其他科学研究[33-36]。新知识使我们能将植物搭配形成相对稳定、更易预测的组合，从而降低种植设计失败的风险。由此产生的植被



5 人工设计的植物群落将垂直兼容的物种组合在一个分层且多样的种植系统中
Designed plant communities combine vertically compatible species in a layered and diverse planting system

6 地被植物交织于较高的多年生植物之间，形成一个功能类似于高效护根物的致密的绿色层
Ground covers weave between taller perennials and form a dense green layer that functions as highly effective mulch

更能抵御干扰、更易管理，其美学特征也更易获得公众的共鸣。

Phyto 工作室在各种类型和不同规模的项目中都使用基于植物群落的设计方法，并力图持续改进这项技术。遵循这种方法并不意味着陷入自然主义的设计风格，恰恰相反：该方法适用于各种各样的风格，并依文化背景和项目目标的差异为每个项目生成不同的视觉效果。经设计的植物群落可以完全由本土物种组成，也可以是多国物种的组合，决定使用本土还是外来物种的组合取决于各物种为环境贡献的生态功能，而不仅仅是它们的地理起源。

基于植物之间、植物与人以及植物与更大的环境之间的联系这 3 个原则，设计过程通常遵循以下步骤（但毫无疑问其本质上是个迭代过程）：观察和分析场地（即理解植物与大环境间的关系），确定场地的原型景观①；制定设计框架以塑造植物与人的关系；最后，通过精心安排植物层次建立植物之间的合理关系，使之形成一个真正意义上的功能性群落②。

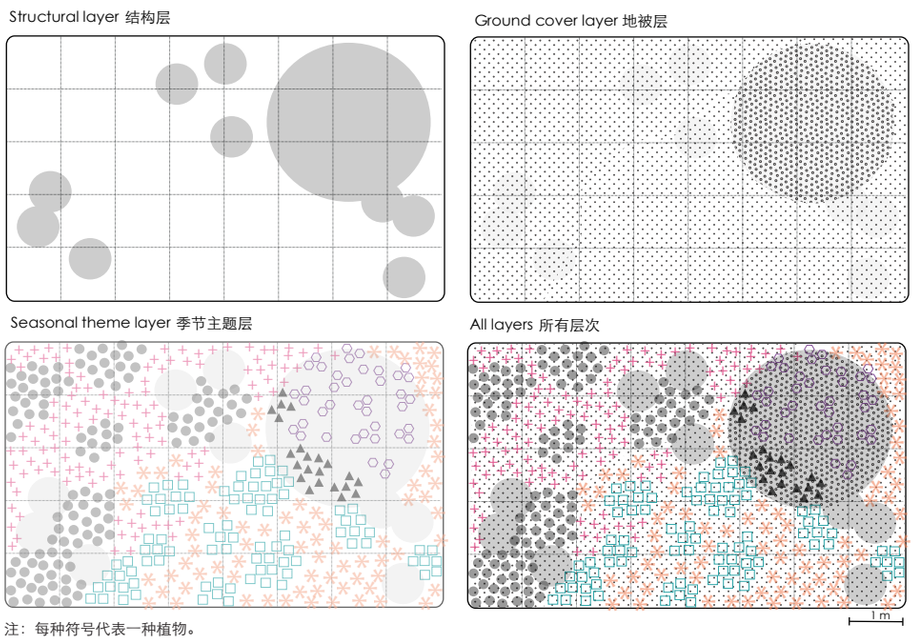
3.1 建立植物之间的联系

人工设计的植物群落是空间上垂直分层，并可在不同时间的同一垂直层中叠加不同物种的种植系统。该理念受到荒野和文化景观中多层次的植物群落（如物种丰富的林地或多彩的牧场）的启发。有些自然群落异常复杂，各植物占据不同的生态位以避免直接竞争，或在植物与其环境（包括与其他生物）之间建立互惠关系。虽然有关植物间相互作用的知识仍需完善，但最近的研究表明，在种植设计中可将植被系统的复杂性提炼成简化的分层模型，使我们能够模仿植物群落结构并确保所选物种在垂直空间和时间上和谐共存。已存在一些用以辅助种植设计师成功进行植物组合的分层模型，如詹姆斯·希契莫夫在其广受赞誉的著作 *Sowing Beauty: Designing Flowering Meadows from Seed* 中讨论的利用地面、中间冠层和上部露生层来建立植物群落的框架[37]。基于德国相似的分层模型[38]，Phyto 工作室提出的框架（图 5）将植物的行为和寿命与它们在各层中的作用联系起来，例如，具有有性繁殖行为且寿命长的物种在种植中可用作可靠的结构性元素，而具有匍枝或地下茎蔓延行为且更具活力的物种可用作高效的地被植物。

结构性植物是最高的种植元素，用以塑造整个组合的骨架。它们包括在冬季具有优美形态的植物，如乔木、灌木和较高的多年生草本植物。它们的垂直形态可用来架构空间或屏蔽周围的基础设施。季节性主题植物为群落添加令人震撼、激发情感的色彩。想象大量艳丽的多年生植物绽放的盛景或是寒冷冬季中满铺的金色草叶，植物的魔力和深层感召力大多来自季节主题层。地被植物是群落中“绿色”或“有生命的”覆盖层（图 6），它们防止土壤侵蚀、保持土壤凉爽湿润、抑制杂草，并为有益的野生动物提供栖息地。冬季仍能存活的半常绿植物在地被层尤为有用。在传统的片植中，这一层经常缺失或被砾石或硬木覆盖层所取代，留出许多缺乏植物覆盖的地面。动态填充植物是由速生的一年生植物、两年生植物和寿命短的多年生植物组成的临时元素。施工结束初期，它们的基生叶能迅速填满慢生植物之间的大量空地，有效抑制杂草。随着植被成熟及植物间竞争的加剧，这些寿命短的填充植物往往完全消失。各层的视觉形态和层内的物种选择可能会有所不同，这取决于为设计提供灵感的原型景观（如开放的草地或林地、灌木地或开放的森林群落，图 7）。

除了对植物垂直分层，人工设计的植物群落在全季对植物进行时间上的分层（图 8）。自然植被系统再次成为灵感来源，在野生植物群落中几个物种经常共享完全相同的空间，它们通过在一年中不同时间占据相同空间来平衡竞争。例如，春季转瞬即逝的延龄草（trillium）可能与晚季的蕨类植物生长在完全相同的地方。球茎植物是另一个经典的例子，它们非常适合用作早春的种植元素并与晚季出现的物种在完全相同的空间完美共存。

植物随着时间推移演化并改变。树木生长并投下更多阴影，寿命短的物种可能在生命结束时消失，无性繁殖的物种逐渐扩大其种群数量。植物选择和管理导则力求提高群落进化的可预测性和可控性，以确保其长期的生



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8

7 人工设计的植物群落通常采用至少两层种植设计图，而不是片植中惯用的单一图层（见图 2–1）③

The design of plant communities is usually executed with a minimum of two planting plans instead of the single layer typically used in block planting (see Fig. 2-1)③

8 晚春（8-1）和夏季（8-2）生态植草沟种植。数种植物共享完全相同的空间，并填补各种时间生态位

Bioswale planting in late spring (8-1) and summer (8-2). Several species share the exact same space and fill various temporal niches

态功能和美学吸引力。理想情况下应使群落达到适度的长期稳定，由此减少对资源密集型管理的需求。群落进化越可预测，所需的调整便越少，失败的风险也越低。如果将具有适当行为、寿命和形态的物种分配到上述垂直层和时间层，就可以实现一定程度的可控性和可预测性。以下一些循证的植物分类系统可辅助预测植物在群落中的相容性和持久性，为植物选择提供科学严谨的设计依据。

德国慕尼黑工业大学的赫尔曼·摩泽尔（Hermann Müssel）、理查德·汉森（Richard Hansen）和弗里德里希·斯塔尔（Friedrich Stahl）创立的社会性水平模型④使设计师可以根据各物种之间的相容性对植物进行分组[39]。英国谢菲尔德大学菲利普·格里姆（Philip Grime）团队开发的竞争者—耐压力者—耐干扰者（Competitor-Stress tolerator-Ruderal，简称C-S-R）⑤策略模型解释，如果场地条件、植物配置和管理策略符合其三角模型，那么种植设计就是成功的[40]。德国柏林技术大学的诺伯特·库恩（Norbert Kühn）最近开发的植物策略类型⑥依植物行为将其适应性策略分为 8 个主要类别，且这些类别为城市和郊区环境中的人工种植量身定制[41]。

使用上述工具实现群落发展中的相对可预见性并不意味着人们能够或应该在时间和空间上冻结群落。所有植物的预期寿命都是有限的，而那些生长在条件恶劣的城市场地中的植物则会受到各种不可避免的损害，如未拴住的宠物或行人的踩踏。为了存活，群落必须有内在自愈轻微损伤的能力。这一基本功能可以通过理念的根本转变来实现，即从将植物视为传统种植空间中的个体艺术对象，转变为将其视作人工设计的植物群落中的动态种群。允许一定程度的植物动态性，群落才能自我修复。如果理想种群的动态演变发生在设定的美学框架内，种植设计就是长期稳定和成功的。事实上，只要植被的整体外观仍然符合最初的设计意图，物种组合的微小变化几乎无法辨别。

如果植物不能自我繁殖，就需要人类的干预来补充种群并确保达到长期的审美和功能目标。例如，不育的植株没有自我繁殖能力，在它们生命结束后必须重新种植。即使选择了动态物种，如果其遗传多样性和种群规模有限，也常会影响它们补充种群的能力。城市种植区面积小且孤立，往往带来物种多样性的逐渐下降。环境干扰如极端天气事件和害虫等可以导致一个物种完全消失，如果没有从周围种群播种的能力，这类植物就会从该地消失。

宾夕法尼亚州兰卡斯特市梅树街和核桃街路口的雨水花园种植设计获得了巨大成功（图 9），证明了分层的植物群落适合被用作极端都市环境下的功能性种植。所选的品种均预先适应了艰苦的城市条件，如高 pH 值土壤、夏季高温、冬季路上撒盐、狗的排泄物以及用于过滤雨水的干性沙质土壤介质。在这个非常繁忙的十字路口使用了少量较高的结构种以保持视线开阔、确保交通安全。由于城市系统所受干扰程度较高，所以种植设计的耐干扰和动态物种［如丽色画眉（*Eragrostis spectabilis*）⑦］的数量高于正常水平。在交通事故、狗、垃圾清理和严重的暴雨等造成的偶

9

9 能够自我维持的人工设计的植物群落吸收和清洁被污染的雨水径流（宾夕法尼亚州兰卡斯特市）；2014 年 5 月雨水花园施工（9-1），8 月即形成层次分明的致密群落（9-2）
Self-sustained designed plant community soaking up and cleaning polluted stormwater runoff in Lancaster City, Pennsylvania; Rain garden under installation in May 2014 (9-1), dense and layered planting three months later in August (9-2)

10

10 在马里兰州的巴尔的摩市，茂盛的植物群落充满了令人印象深刻并具有生态价值的物种，为高密度的城市环境带来了生机。多姿多彩的春季花期（10-1）之后，紧随着是更为安静、绿意尤浓的夏天（10-2）
Lush plant community filled with evocative and ecologically valuable species brings life to dense urban environments in Baltimore, Maryland. The colorful spring blooms (10-1) are followed by a quieter, greener summer (10-2)

发干扰之后，这些物种赋予植被自我修复的能力。虽然外表上几乎不可见，但地被植物［包括半常绿的美东窄叶莎草（*Carex amphibola*）[8]、金色狗舌草（*Packera aurea*）］大量存在于植株较高的物种之下。它们发挥的重要功能包括控制侵蚀、净化雨水、支持授粉，其中一些还为设计增添了美丽的花色。大部分植物以根系宽约 5 cm、深约 13 cm 的穴盘苗（landscape plugs）形式栽种，苗中心平均间距约 30 cm。施工后 3 个月内，近 90% 的地面被理想的物种覆盖。迅速形成的致密地被层保护土壤不受侵蚀并阻止原土中遗留下的大量杂草种子发芽。随着植被成熟，各物种填补更多的生态位，杂草带来的压力继续下降，免去了任何补植或重新播种的必要。建成 6 年后，土壤上茂盛的地被植物抑制了不良物种的滋生并可靠地执行雨洪管理功能。植物的种类组成趋于稳定，并从春季到冬末呈现出多种季节性色彩。

3.2 构建植物与人的关系

人工设计的植物群落美丽、令人震撼并深刻触动情感，它们能带来欢乐，还能唤起人们对更广阔、更迷人的景观的联想。越来越多的人生活在城市中而不再被自然景观环绕，然而，人们渴望过去五彩缤纷的草地和雄伟的森林。即使是从未体验过繁花似锦的草场的城市居民，似乎对优美的自然植物群落也记忆深刻，对那些令人联想到壮美自然景观的种植设计产生强烈的共鸣。人们感知的美深深植根于其进化史，且往往以人类过去创造并悉心维护的文化景观为基础。这些至今仍引起人们共鸣的原型景观能为植物群落设计提供灵感。例如，从自然森林中提取的原型森林景观常具有分布广泛的高大树冠层，树冠下少有灌木遮挡视线，而地面覆满了茂盛的蕨类、莎草类植物和五颜六色的野花。这种类型的森林层次分明、易于理解，让人感到舒适放松。

然而结构清晰分明、易于被公众理解（legibility，即易读性）并不意味着物种多样性低。德国景观设计师海纳·鲁兹（Heiner Luz）提倡“大尺度的易读性，小尺度的多样性”原则[42]。若将其应用于林地种植，这意味着物种多样性将由树冠下的复杂草本层来实现。只要群落具有清晰、典型的上层结构，草本植物的高度多样性并不会降低其易读性和情感吸引力。这一强有力的原则适用于包括草甸在内的各种原型景观，如果草甸的整体群落高度很吸引人，人们就会接受地被层更高的物种多样性。

除了以内在优美的原型景观为基础来组织种植，视觉复杂度高的群落还可采用各种方式进行架构，以增加秩序感、体现关怀从而获取更高的公众接受度。琼·纳索尔（Joan Nassauer）关于“有序框架”（orderly frames）的论述为在高度可视的空间中成功构建复杂种植做出了重要贡献[43]。该框架可以是简单的围栏、修剪过的树篱、硬质景观元素（如低矮的挡土墙）或室外家具（如条形长凳），框架设计具有无尽可能性，但效果却很强大。

使用强烈的季节性色彩主题可能是赋予人工设计的植物群落深刻情感吸引力的最有效的方式。大量具有强烈视觉冲击力的植物同时开花产生惊人的效果，想象一下城市公园在春季绽放出明黄色的水仙花后，又在夏季开满活力四射的粉红色天蓝绣球和紫锥花，最后以一片深紫色的紫菀花海结束这个季节。在花期与繁盛程度方面，片植完全无法与人工设计的植物群落相比拟，后者的效果和公众反应可以十分惊人。

美国马里兰州巴尔的摩市的金莺体育场花园（图 10）是构建植物与人密切关系的杰出实例，设计灵感来自最具视觉吸引力的区域森林植物群落。物种配置力求增强自然色彩效果，例如，以本土植物加拿大耧斗菜（*Aquilegia canadensis*）、斑点老鹳草（*Geranium maculatum*）和布氏美东薄荷（*Monarda bradburiana*）[8]的花景在整个生长季创造数次强烈的、触动人心的色彩迸发场景。种植的整体结构简单明了，高大的乔木提供上方遮蔽的树冠，葱郁的地被形成下方绿得闪耀的地毯，而中间层仅以少量的灌木来屏蔽体育场的基础设施。清晰易读的种植结构优美地勾勒出视觉上更为复杂的地被层。附近办公楼的员工经常来公园内散落的长椅休息放松，将自己沉浸于植物之中，他们洋溢的微笑和放松的面部表情似乎表明美丽的植物能重塑游客与自然的联系，并让人从紧张的工作中获得恢复活力和快乐的机会。垃圾无迹可寻，也鲜见破坏公物的行为，这或许是人们喜欢和尊重这片城市绿洲的标志。

人工设计的植物群落不仅应与享受植物的人相联系，还必须与其管理者紧密相连。设计得再好的植被若管理不当也将无法长期生存。事实上，如果放任不管，即使是最优雅、最深思熟虑的设计也会变得面目全非。尽管如此，与中国类似，美国和欧洲的大多数设计

师和承建商仍在销售即时景观产品，很少有设计师会在项目完成几年后坚持追踪其发展。然而，营造人工设计的植物群落是一个长期的过程，需要从静态的配方式维护转变为符合植物动态生长规律的适应性管理（adaptive management）。对于大多数种植而言，适应性管理着重于养护期结束后应用于整个群落的粗放式操作。例如，对草地群落可能有必要进行年度修剪或火烧，以防止木本物种抢占优势；对某些灌丛和林地群落而言，不同形式的疏伐可起到保持理想乔灌组合的重要作用。定期监测入侵物种并迅速彻底清除它们也是长期管理中需要着重考虑的。

了解种植管理人员的技术水平很重要，长期在公共花园工作的员工往往技术水平较高，而商业承包商的临时雇员通常仅有其几分之一的经验。人工设计的植物群落的复杂程度必须得当，且与管理团队的技能和资源相匹配。虽然推进管理技能水平是绝对必要的，但设计师对项目维护的期望值应符合实际。

3.3 构建植物与环境的关系

所有植物都与其周围环境互相影响，也与所处环境中的生物和非生物元素有着复杂的关系。毋庸置疑，植物越适应环境，其生长便越繁荣。传统种植方法旨在为植物创造理想的生长条件，而不管周围环境如何。促使植物茂盛生长的手段，如改良土壤、施肥和旱季灌溉以使植床变得完美等，在除高强度菜园之外的场地丝毫没有必要。事实上，地球上最美丽、最持久的植物群落更偏爱营养水平低、土壤干燥的艰苦立地条件。我们“完美化”场地的上述举措实际上将植物的多样性限制于只在肥沃土壤中生长、并依赖持续生命支持的物种上，既消耗不必要的资源，实际又严重限制了审美多样性。

更可持续的选择是接受尽可能多的现有条件并就场地的现实情况选择植物搭配，即使这与世界上许多大学仍在讲授的内容相反。这种更明智的方法使群落寿命更长，不易失败也更容易长期管理。看似严格的场地限制条件往往为设计提供巨大潜能，例如，具有高 pH 值和低有机质的干旱土壤可支持美丽精致、适应干旱的物种组合，而这些组合无法在肥沃的土壤上茁壮成长。茂密的湿地植物在不排水、潮湿的沟渠中长势最旺，任何灌溉系统都无法在精心准备的花园土壤上模拟这些条件。城市环境看似极端，但总能找到可在类似条件下茁壮成长的野生植物群落，我们只需要仔细寻找这些灵感。

城市环境对植物施加很大压力，它们常受到一系列危险污染物的污染，如石油基物质、农药残留和重金属，只有预先适应这些压力的物种才能茁壮成长。然而许多植物不仅能生存，它们实际还可以在细胞组织中储存甚至分解污染物，将其转化成无害的物质而净化土壤。凯特·凯南（Kate Kennen）和尼尔·柯克伍德（Niall Kirkwood）的力作 *Phyto: Principles and Resources for Site Remediation and Landscape Design* 广泛记述了利用高生态功能物种使城市土壤和水体对人类更安全的种植技术（phytotechnologies）[44]。虽然并非所有类型的污染都可以通过植物来解决，但在每个城市项目中都可以引入高生态功能物种，通过植物修复（phyto-remediation）和缓冲（phyto-buffering）来清理现有并防止未来的污染 [44]14-16。例如，雨水花园和生态植草沟接收来自附近街道和停车场的污染径流，发动机油、富含重金属的刹车片灰尘和汽油残渣逐年积累，如不加以管理，这些场地未来将成为棕地。但如果从一开始就采用正确的植物种类，污染物的积累以及向地下水或其他水体的输出就可以得到缓冲和减缓。那些生物量极大、根深、根系饱满和生长快速的物种，如灯心草类和莎草类植物，在分解有机污染物（如石油、氯化溶剂和杀虫剂）方面表现最好 [45]，而水生植物，尤其是沉水植物可以直接高效地从水中提取金属，使其在芽、根或土壤中积累并稳定下来 [46]。

清洁城市的不仅只有公园和花园中种植的植物。自播而来在城市废弃地、栅栏边甚至是路面微小缝隙中安身立命的野生植物对城市的生态系统功能同样贡献重大 [47]。最近的研究表明，受益于这些自生植物，德国柏林市内如今拥有比周围森林和农业景观更高的物种多样性 [48]。许多种植在花园和公园里的物种最终“逃脱”了人工栽培，成为新型城市生态系统的一部分。了解到这个过程的重要性，便可以利用它来有策略地规划此“自然化”（naturalization）过程，以丰富城市环境。因此，植物群落设计常精心选择有能力通过城市媒介（如雨水径流、步行交通、风或建设活动）离开种植地点的物种。那些城市适应性强并能产生大量微小种子的物种尤其成功，如坚被灯心草（*Juncus tenuis*）和千叶蓍（*Achillea millefolium*）。虽然很难预测这一策略的应用速度及成功程度，但可以预期某些物种最终将创造自我维持的种群并为通常由外来观赏植物主导的新植物群落增加功能多样性 [49]。在城市结构中重新引入的高生态价值物种越多，新生态系统对有益的野生动物（如本地蜜蜂和鸣禽）来说就越有吸引力。

随着科学不断揭示城市植物和野生动物之间的复杂关系，我们无须仅靠道听途说来为有益的野生动物创造合宜的栖息地 [50-53]。以依赖花蜜和花粉的传粉昆虫为例，研究表明，在种植设计中全年跨季节使用高覆盖率的开花植物对其非常重要 [54]。无生态功能的植物，如为培育硕大花朵和延长花期而人工繁殖的一年生和多年生植物，通常不再具有蜜腺和花粉，应该予以避免。然而仅靠花粉和花蜜尚不足以养活昆虫，例如，毛虫在变成蝴蝶之前以寄主植物的叶子为食并且通常对寄主植物种类非常挑剔。由于植物在抵御饥饿昆虫时使用毒素等防御机制，许多昆虫只能消化很少的寄主物种 [55-56]。含有较多毒素而不可口的寄主植物，如某些紫叶栽培品种 [57] 也应予以避免，因为它们对昆虫的繁殖力和种群量有潜在的长期影响。

宾夕法尼亚州立大学植物园正在建设新的传粉昆虫和鸟类花园，花园专为培育、研究和展示本地传粉昆虫和鸟类种群而设计。通过与大学传粉昆虫研究中心密切合作，Phyto 工作室发展并应用了一系列野生动物友好的设计原则。花园中设计的植物群落物种极为丰富多样，以填补大量时空生态位。植物配置由顶级的食物和寄主植物组成，其中许多是与当地鸟类和传粉昆虫有着深刻进化关系的本土植物。富含花蜜和花粉的各类花卉有着不同的形状、大小、颜色和花期，这对吸引艳丽的蝴蝶至关重要。然而也不能忘了每一只蝴蝶之前都是一只饥饿的毛毛虫，并且它通常取食于完全不同的物种，甚至包括不显眼的莎草和其他不产蜜的草。除了食物，设计还提

供了全年充足的水源和各种野生动物庇护所，包括无数越冬用的树枝和树叶。花园的管理计划建立在园内各物种的生命周期需求之上，访客将从中惊喜地学到一种围绕野生动物需求、利用种植设计及管理来支持生命的新方法。

4 实施挑战和推进步骤

在中国城市应用基于植物群落的设计和土地管理方法将面临挑战，其中某些可能是中国特有的，但更多的无疑是全球性的。Phyto 工作室及众多同行探索出战胜困难的策略，以支持更好、更激动人心的种植技术。国际合作和知识交流有助于学习如何克服初期障碍并制定出适用于中国文化背景的成功策略。

人工设计的植物群落在全球范围内面临的最大挑战或许是人们对复杂种植美学的有限接受程度。与中国一样，许多国家都有高强度农业土地利用的悠久历史，随后是大规模快速城市化。这种发展割裂了人与自然更深层次的联系，并使年轻一代难以理解和欣赏自然世界的韵律。自然植物群落早已从城镇甚至村庄消失，而中国城市的普通民众极少有日常料理私家花园的机会。此外，小学至高中环境教育的断层导致公众生态知识匮乏，受到的自然启发和情感培养十分有限。这些现实解释了公众为何对视觉上复杂的种植接受程度有限，试点项目一旦设计不佳、施工仓促或管理不当，易被感受为杂草丛生、过于混乱或乡野。负面的公众感知是一个严重的问题，这会使创新项目的建设更加困难。虽然人工设计的植物群落确实比许多传统植物群落在视觉上更复杂，但它们绝不应当使人感到凌乱或过度自然而与其场地和文化背景不合。巧妙地使用有序的框架、强有力的季节性色彩主题、适当的视觉复杂性，并为使用者创造沉浸于植物的机会通常会带来积极的公众反应。人工设计的植物群落必须经过精心规划和长期适当管理来保持其在未来多年内的高度美感。

挑战之二与中国严峻的气候条件直接相关。某些地区的公众坚持认为除非大量灌溉并反复投入大量资源，否则什么也不能栽种。然而，研究和实践都证明中国的土壤和气候实际可支撑众多物种 [27, 58]，其挑战在于苗圃业尚不能提供多种能在艰苦场地条件下蓬勃生长的品种。中国的绿色产业迎合传统市场，苗圃业关注常见的装饰性树木、灌木和适合花坛种植的一年生植物。专注于生态性和功能性物种的种子供应商仍然很少 [58]。这与 30~50 年前北美和英国的情况相似，整个绿色产业需要几十年才能适应新的需求和不断变化的市场。种植技术的发展需要种植设计师、施工人员和土地管理者就不断变化的需求和市场机会进行持续沟通。例如，Phyto 工作室经常与本地苗木供应商和工具制造商沟通项目需求，目的是提升每个人的技能水平并建立实施群落设计方法所需的弹性专业网络。

对自然主义美学的抵触、对速成景观效果的需求以及经济优先的强烈愿望，减缓了政策制定者对人工设计的植物群落的认同和支持。改善生态系统往往列席于当地政治议程的末位，但坚持不懈地向决策者们传达人工设计的植物群落的优点及解释其建造过程可以带来积极的转变。幸运的是，这些优点可以从生态和人类健康之外的角度来衡量。有明确的证据表明人工设计的植物群落可以降低长期种植管理成本 [59]，此外，美丽的植物景观能降低犯罪率，并增加周围建筑的地产价值 [60]。本质上，人工设计的植物群落提供诸多经过实践验证的效益，可以与决策者的价值观和信念产生共鸣。

人们普遍缺乏创建和管理人工设计的植物群落的知识是广泛应用该方法的另一个关键挑战。试图改善城市生态系统的项目往往在并未充分理解该方法生态原则和技术的状况下便加以实施，导致种植设计的失败，未来的创新项目也更加难以赢得支持，这种知识上的差距也迫使设计师更易做出妥协。为此，迫切需要推广跨学科教育以培养率先尝试该方法的专业人员。高等院校的课程必须融合生态学、土壤和植物科学、设计、工程、承包和土地管理等多领域的技能。只有全面的教育和实践才能促进亟须的多学科合作并创造出综合的解决方案，推进在大尺度上成功应用这一方法，并最终实现生态系统功能效益。

早在美国园艺师发现并将美洲本土植物用于自己的花园之前，欧洲的园艺师便已经开始培育这些植物了。中国公众可能还没有意识到本土风景和植物群令人惊叹的美，而世界其他地区的人们已深有体会。一些独特的中国景观启发了世界各地的设计师，整个地球都在种植中国植物。发掘中国自然界的优美和潜力并将其有意识地用于丰富城市景观的时代已经到来。尽管德国人几十年前便进行了第一次尝试，人工设计的植物群落也只是最近才在城市和村庄里变得越来越普遍。中国正处于这一进程的开端，詹姆斯·希契莫夫在成都和北京的设计属于中国第一批人工设计的植物群落。尽管从批准到建成付出了大量努力，但精心设计和维护的试点项目极具影响力，且一旦建成就会成为变革的中心。人们相信并信任他们所亲见的，文字和迷人的照片虽能提高对创新种植的意识，但只有实施完成的设计才能展示真正的可能性。试点项目建成后可能的绩效监测将为中国城市继续改进种植方法提供宝贵借鉴。

世界各地正纷纷创建新型城市绿化项目，这一事实表明一场绿色革命已经开始并蓄势前行。在城市项目中贯穿笔者所讨论的方法将有助于形成解决当代重大危机的优化设计。上述危机的巨大规模和严重性可能令人生畏甚至麻痹，但无论尺度多小，每个优化设计项目都会带来可观影响，而所有努力的积累终将引起更加可持续的行为和结果。世界范围内各种项目传达出的最富希望的经验便是：大自然是极有韧性的，而积极的生态变化可以相对快速地发生。德国仅用了几十年时间便将其东部生态恶化的煤矿修复成了周围遍布新生森林和茂盛草原的清澈湖泊。曾目睹过对自然疯狂掠夺和破坏的一代如今在生机勃勃的大自然中尽情漫步。连野生动物都得到了快速恢复，让人出乎意料，欣喜不已。如果现在就采取行动，或许我们也能在有生之年享受到更绿色宜居的城市所带来的回报。

注释：

① 原型景观：参考植物群落，代表了最基本和最值得纪念的植被模式。

② 获取设计过程的更多细节，参见 [31]121-188 页。

③ 此处为行文简洁略去动态填充层。

④ 社会性水平模型：社会性由同种群植物之间的生长

距离决定。社会性较低的植物[如蓝花赝靛（*Baptisia australis*）]通常高大而占视觉优势，因此应单植或以3~10株为一组种植。相反，社会性高的植物[如匍匐形的栎叶黄水枝（*Tiarella cordifolia*）]因其形状和行为而成为优良的地被植物，应以10~20株甚至更多株组团进行种植。

⑤ 竞争者—耐压力者—耐干扰者策略模型：竞争者擅长在低压力和低干扰的栖息地战胜其他对手；耐压力者通过保持生物量在高压力、低干扰的地区生存；而荒地植物则经常在高干扰和低压力的区域繁殖。如将C-S-R策略模型应用到城市街道设计中，由于种植常受到交通、狗、街道清理等持续扰动，可使用耐干扰植物的组合来创造经久耐用的设计。

⑥ 8个主要植物策略类型：保护型生长、适度压力适应、压力规避、区域占领、区域覆盖、区域扩张、占据生态位以及占据空隙。举例来说，为设计一个几乎得不到任何维护的种植，应使用隶属“区域覆盖”类型的地毯式低矮植物，因为它们的生存策略是密集覆盖所有可用的栖息地空间。

⑦ 所有植物物种的英文俗名请参见文章英文部分（英文俗名可不唯一）。

⑧ 译者注：此植物物种官方中文俗名暂不可查，由译者根据英文俗名翻译。

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（编辑 / 刘玉霞）

1 The Importance of Planting in a Post-Wild World

We are in the middle of two serious global crises: climate change and mass extinction. Countries are experiencing more frequent and extreme storms and droughts. Fires of devastating intensity are consuming unimaginable expanses of protected forests. With a potential two to five-degree Celsius temperature increase by 2100, 200 million people are expected to be displaced due to rising sea levels[1]. The health of ecosystems on which we and all other species depend is declining globally at rates unprecedented in human history. Around one million animal and plant species are now threatened with extinction. North America has lost 29% (nearly three billion individuals) of its bird populations since 1970[2], and China has lost 27% of its key terrestrial vertebrate species[3]. We are in the midst of a global catastrophe that fundamentally impacts our quality of life, economic development, international relations, and life on Earth as we know it.

Protecting diminishing natural lands to preserve biodiversity and essential ecosystem services is more important than ever before—but in a world so dramatically altered by industrial land use and urbanization it is simply no longer enough. Restoring core functions anywhere we can is now a matter of our own survival. Conservation and responsible land stewardship must be extended to where we live and work[4]. We must rebuild abundance, ecological richness, and species diversity—not just outside of our cities, but within. We must facilitate ecological functions within urban and suburban areas as well as industrial landscapes if we want our children to enjoy this beautiful, life-giving planet as we enjoy it today[5-9].

Functional urban ecosystems are socially and culturally important. Humans have deep physiological and psychological needs for nature. There is undisputable prove that even a few minutes in nature have positive effects on our health[10-11]. The peace and tranquility created by urban nature inspires reflection, meditation, and a general feeling of harmony between oneself and one's surroundings[12]. Strong emotional bonds to urban nature foster greater environmental awareness, which ultimately leads to an urgently needed increase in environmental stewardship[13]. Protection or restoration of local ecosystems also plays an important role in protecting cultural integrity and national identity[14].

It has been well recognized that, despite being small, isolated, and fragmented, urban green spaces offer significant ecosystem services including biodiversity conservation[15]. Many studies documented higher species richness and abundance in urban parks and gardens than rural areas[16-17]. Whereas large, connected green spaces with high habitat heterogeneity are particularly important[18], small but high-quality green patches serve as significant steppingstone habitat for a variety of taxa[19]. The latter, often times, are the only wildlife refuges in highly developed areas[20]. Yet, globalization and the homogenization of cultures and environments have led to a unification of landscape design styles and plant choices no matter what the context[21]. Colorful flower beds on lawns with scattered trees became one of the most prevailing landscape styles worldwide. Mainstream planting design and land management strategies fall short in providing essential ecosystem services such as cleaning air and water, sequestering carbon, mitigating urban heat island effect, supporting pollinator populations, and restoring wildlife habitat. In fact, many widespread practices downright harm our environment and health. The thoughtless use of irrigation, petroleum-based fertilizers, pesticides, and ecologically non-functional ornamental plants, for example, only amplify the problem. It is high time that we fundamentally improve urban landscape design to rebuild functional urban ecosystems.

There is an alternative: ecological planting design and land management strategies offer solutions that address the current climate and extinction crises in meaningful ways. Different countries have been exploring various approaches and are developing innovative, evidence-based solutions. Planting designers in Germany, for example, successfully integrate wild plants that seed in from surrounding areas (i.e., spontaneous vegetation, see section 2.3) into public horticulture in inspiring examples such as the Gleisdreieck and Südgelände parks in Berlin[22]. Sophisticated, maintenance-friendly mixed perennial plantings now exist in many German cities. In the U.K., many cities showcase beautiful examples of anthropogenic, naturalistic communities that balance biodiversity and attractiveness. James Hitchmough's and Nigel Dunnett's evocative

plantings demonstrate the deeply emotional, immersive qualities of complex ecological planting[23]. In the U.S., ecological planting strategies are applied to urban stormwater management, green roofs, meadow-inspired turf alternatives, and xeriscapes in states such as California.

Chinese cities are in urgent need of better planting and land management practices. Alarming environmental issues, such as air pollution, flooding, water pollution, and biodiversity loss are severely affecting the country's biophysical and human health. Yet, practices that use ecologically functional plantings to rebuild urban abundance remain in their infancy. They are primarily pursued by a small group of scholars[24-28], and remain far from becoming a landscape standard. Successful ecological planting examples are rare, whereas turf or large-scale block planting are widespread in streetscapes, parks, corporate landscapes, and university campuses (Fig. 1). Exuberant ornamental plantings purely for human consumption, on the other hand, remain the governments' favorite for large public exhibitions or celebrations. In essence, Chinese cities need nothing less than a green revolution.

2 Current Landscape Practices

2.1 High-Intensity Ornamental Planting

Extravagant ornamental plantings that decorate architecture, beautify infrastructure, or celebrate big sporting and political events are popular all over the world. For many countries, these plantings are deeply anchored in local culture. For example, Germans enjoy their colorful annual garden shows, and exuberant indoor flower shows in the U.S. are extremely popular in early spring. Purely ornamental plantings may be kitschy, but they bring people tremendous joy and raise awareness for the art and entertainment created through ornamental horticulture.

While there is a place for extravagant, decorative plantings, it goes without saying that they are highly resource intensive and require regular irrigation, fertilizer, soil amendments, weeding, re-mulching, replacement planting, and pesticides. Such plantings do not survive without constant human support. They appeal to people but have next to no value for insects and contribute little to a better environment. For these very reasons, this type of planting cannot and should not be used as a planting standard for future landscapes.

2.2 Monocultural Block Planting

Block planting refers to the method of configuring plants in single-species blocks to cover a planting area (Fig. 2). Adaptable in size, blocks are legible and easily understood by the public. The fact that weeds clearly stand out from the rest makes the blocks relatively easy to maintain. The need for maintenance can be further reduced using long-lived perennials and shrubs, such as *Hemerocallis*, *Pachysandra*, and roses. Because of these benefits there is a long history of successful block plantings – and they are still very popular in commercial and institutional plantings in office parks, business centers, university campuses, shopping centers, and along roadsides.

With appropriate, less resource-dependent species, block plantings can be one solution to covering urban ground and providing ecological and functional values. Most functional plantings, such as stormwater management and habitat plantings in the U.S., follow this planting method. Nonetheless, block plantings have serious challenges. First, most are chronically under-vegetated with too much open space between individual plants. This open space is either bare soil or covered with different types of mulch (e.g. leaves, pine needles, wood chips, gravel) to suppress weeds. Other than protecting soil, mulch performs very limited ecosystem functions. Mulch must be replenished on a regular basis to effectively suppress weeds. Desirable plants can be damaged or killed when re-mulching smothers sensitive plant crowns or when herbicides are used to control weeds. The second challenge with block planting is the limited biodiversity and ecosystem function they provide. Massings of monocultural blocks contain relatively few species. The fewer and less ecologically valuable species there are, the less food diversity and habitat for wildlife, and the less resistance to pests and diseases. The third and perhaps most important challenge with this planting method is that it does not respect how plants actually grow in the wild. Most plants are social beings that evolved in diverse and highly complex plant communities. Excepting cases where introduced plants, i.e., invasive weeds, outcompete and displace ecologically rich plant communities, few wild plants naturally grow in monocultural arrangements. And no wild plant naturally grows surrounded by wood chips or triple-shredded hardwood mulch.

There is certainly a place for this type of planting in historic gardens, elaborate garden displays, and extremely formal settings. However, most block plantings are not dense and layered enough to provide significant ecosystem services to the cities of our future.

2.3 Spontaneous Vegetation

In urban green spaces, an alternative to planting desirable, but resource intensive vegetation is cultivating spontaneous vegetation: the practice of encouraging wild plants from surrounding areas to seed themselves into a site and establish thriving plant communities on their own[29-30]. The resulting novel ecosystems are highly debated since they contain not only native, but also exotic, even invasive species. This approach does not necessarily increase urban species diversity since only plants that already thrive in surrounding areas can seed in. Designers and planting managers therefore often supplement spontaneous vegetation with additional, urban-adapted species.

Working with spontaneous vegetation is highly sustainable as it requires few resources to create dense plantings. The species that seed in are preadapted to the tough urban conditions and create remarkably resilient plant communities. Skilled planting management is essential to massage these spontaneously formed plantings into more legible, aesthetically pleasing

ones. And only highly skilled management crews are able to edit such communities correctly. Due to these challenges in management needs and planting aesthetics, building spontaneous vegetation into public landscapes is far from being a standard approach. The number of successful applications around the world is sadly very small (Fig. 3).

3 The Solution to Better Planting Design and Landscape Management

The above-mentioned challenges associated with traditional planting and spontaneous vegetation strategies demonstrate that other planting techniques are required to create the high-performance landscapes we so urgently need. The good news is that many planting design experts are working on solutions. This text describes the approaches and planting models used by Phyto Studio, a U.S.-based landscape architecture firm with strong focus on creating innovative planting solutions[31].

It should not come as a surprise that these very solutions are inspired by natural plant communities and their core principles. Over the last century, new scientific insights into the way plants interact with one another and their environments have given us an exciting, innovative approach to planting design: designed plant communities – an approach that originated in the early 1900s, and was further improved by the work of Richard Hansen and Hermann Müssel in Weihenstephan, Germany since the 1970s[27, 32]. In this method, principles of wild plant communities and traditional ornamental planting meld together (Fig. 4). Functional diversity and resilience are created through plant layering and planned redundancies within planting. Crisp contrast and powerful seasonal flower events, on the other hand, create clear legibility and stunning emotional responses that bring people joy and reconnect us with nature. In essence, a designed plant community is a translation of a wild plant community into a cultural language.

Our understanding about designed plant communities has significantly improved over the last decades. Global scientific research and countless test plantings have taught us essential details about plant behavior, longevity, and plant interaction[33-36]. This new knowledge allows us to combine plants in relatively stable, more predictable compositions so as to reduce the risk of planting failure. The resulting plantings are more resilient to disturbances, easier to manage, and have beautiful, highly evocative aesthetics.

Phyto Studio uses the designed plant community approach in projects of any type and size and is evolving the technology further. Following this approach does not mean one is locked into a naturalistic design style. Quite the opposite: the approach can be applied to a wide variety of styles and generates different visual outcomes with every project depending on cultural context and project goals. A designed plant community can be composed of an entirely native palette or an international mix of species. Decisions about how native versus exotic a plant palette is are based on the functional contributions species bring to their environment, not simply their geographic origin.

The following section introduces the three major principles of designed plant communities: how plants relate to one another, how they relate to people, and how they relate to the larger environment. Honoring these three principles, the design process typically follows the steps below, but is undoubtedly iterative in nature: observing and analyzing the site (i.e., understanding how plants relate to the larger environment), identifying the archetypal landscape ① the site wants to become, developing the design framework that relates plants to people, and finally, relating plants to other plants by carefully layering them into a truly functional community ②.

3.1 Relating Plants to Other Plants

Designed plant communities are vertically and temporally layered planting systems. They are inspired by multi-layered plant communities found in both wild and cultural landscapes, such as species-rich woodlands or colorful pastoral meadows. Some natural communities are remarkably complex, with plants filling diverse ecological niches to avoid direct competition or create beneficial relationships between plants and their environments, including other organisms. While there remains a lot to learn about plant interaction, recent research has taught us that, for planting design purposes, the complexity of vegetation systems can be distilled into simplified layering models that allow us to mimic plant community structures and ensure selected species are vertically and temporally compatible. There are several layering models that help planting designers with creating successful plant combinations. For example, in his critically acclaimed book *Sowing Beauty*, James Hitchmough published the framework of using ground, middle canopy, and upper emergent layers to create plant communities[37]. Our framework below (Fig. 5) is based on similar layering models developed in Germany[38]. This model aligns plant behavior and longevity with the role plants play in their respective layers. Long-lived species with non-clonal behavior, for example, can be used to create reliable structural elements in planting. More dynamic species with stoloniferous or rhizomatous spreading behavior, however, can be effective ground covers.

Structural plants are the tallest elements of planting and form the framework of a composition. They include plants with excellent winter structure, such as trees, shrubs, and taller perennials. Their vertical presence can be used to frame spaces or screen surrounding infrastructure. Seasonal theme plants give a planting stunning, emotional color. Imagine large quantities of showy perennials in bloom or the golden copper foliage of grasses in winter. Much of a planting's magic and deep evocative power comes from this layer. Ground cover plants are the 'green' or 'living' mulch layer of a planting (Fig. 6). They prevent soil

erosion, keep soils cool and moist, suppress weeds, and provide habitat for beneficial wildlife. Semi-evergreen plants are especially useful here due to their winter presence. In traditional block plantings this layer is frequently missing or replaced by gravel or hardwood mulches, leaving a lot of ground bare of plants. Dynamic filler plants are temporary elements made of fast-growing annuals, biennials, and short-lived perennials. Their basal foliage quickly fills in between slower-growing plants, providing substantial weed suppression right after installation when there is a lot of open ground. As the planting matures and competition between plants increases, these short-lived gap fillers often disappear completely. Depending on the archetypal landscape from which the design takes inspiration (e.g., open grassland vs. woodlands, shrublands vs. open forest communities) the visual presence of the layers and the species selection within the layers may vary (Fig. 7).

In addition to vertically layering plants, designed plant communities layer plants temporally throughout the seasons (Fig. 8). Once again, natural vegetation systems are the inspiration. In wild plant communities, several species often share the exact same space. They balance competition by occupying this space at different times of the year. For example, a spring ephemeral trillium may grow in exactly the same spot as a late-emerging fern. Bulbs are another classic example. They are highly successful early season components of planting and perfectly coexist with late-emerging species in exactly the same place.

Plantings evolve and change over time. Trees grow and cast more shade, short-lived species may disappear as they reach the end of their lives, and clonal species gradually expand their populations. Plant choices and management recommendations try to create predictability and control as planting evolves to ensure function and aesthetic appeal over time. Reaching an appropriate level of long-term stability in planting is desirable as it reduces the need for resource-intensive management. The more predictably a planting evolves, the less editing it needs and the lower the risk that it will fail. A certain level of control and predictability can be achieved if species with appropriate behavior, longevity, and morphology are assigned to the vertical and temporal layers described above. Several evidence-based plant classification systems help predict a plant's compatibility and persistence in planting and firmly root design choices in science.

The Levels of Sociability ④ developed by Hermann Müssel, Richard Hansen, and Friedrich Stahl at the Technical University of Munich, Germany, allow designers to group plants based on how compatible they are with other species[39]. The C-S-R (Competitor-Stress tolerator-Ruderal ⑤) Strategies developed by Philip Grime's team at the University of Sheffield, UK, explain that planting is successful if site conditions, plant palette, and management strategies line up within their triangular model[40]. And Prof. Norbert Kühn at the Technical University of Berlin, Germany, recently developed the Plant Strategy Types ⑥ that group plants with similar behavior into eight major categories of adaptive strategies specifically tailored to man-made plantings in urban and suburban environments[41].

The relative predictability in the development of planting we can achieve with these tools does not mean we can or should freeze a planting in time and space. All plants have limited life expectancies, and those on tough urban sites are subject to a variety of unavoidable damages, such as by unleashed pets or foot traffic. For plantings to survive they must have the ability to self-heal minor damages from within. This essential function can be achieved through the fundamental shift from seeing plants as individual art objects in space in traditional planting, to understanding them as dynamic populations in designed plant communities. Only if a certain level of plant dynamics is allowed can plantings self-heal. Plantings are stable and successful over the long-term if the dynamic behavior of desirable populations happens within set aesthetic frames. In fact, slight changes in species composition are almost invisible as long as the overall appearance of a planting still matches the original design intent.

If plants cannot self-proliferate then human intervention is needed to replenish populations and make sure long-term aesthetic and functional goals are reached. For example, sterile plant selections do not have the ability to self-proliferate and must be replanted after they reach the end of their lifespan. Even if dynamic species are selected, limited genetic diversity and population sizes frequently affect their ability to replenish populations. The small size and isolation of urban planting areas often lead to the gradual decline of species diversity. Disturbances such as extreme weather events and pests can cause a species to completely disappear. Without the ability to seed in from surrounding populations the plant will remain absent from the site.

The hugely successful rain garden plantings at the intersection of Plum and Walnut Street in Lancaster, Pennsylvania (Fig. 9), prove that layered plant communities are suitable for functional planting in ultra-urban sites. The selected species are pre-adapted to tough urban conditions, such as high soil pH, very hot summer temperatures, road salt, dog waste, and the dry sand-based soil media used for water filtration. Taller structural species were used in small percentages to keep sightlines open and ensure traffic safety in this very busy intersection. Due to the high level of disturbance urban systems are exposed to, ruderal and dynamic species [such as *Eragrostis spectabilis* (purple lovegrass) ⑦]were used in higher than usual quantities. These species gave the plantings the ability to repair themselves after occasional disturbance created by traffic accidents, dogs, trash removal, and severe rainstorms. Ground covers, including semi-evergreen *Carex amphibola* (eastern narrowleaf sedge) and *Packera aurea* (golden ragwort), are barely visible here but present in large numbers under taller species. They perform

essential functions including erosion control, stormwater pollutant removal, pollinator support, and some of them add beautiful flower color to the design. The majority of plants was installed as landscape plugs (root systems about 5 cm wide and 13 cm deep) with an average spacing of about 30 cm on center. Within three months after installation, nearly 90% of the ground was covered with desirable species. The quick establishment of dense ground cover protected the soil from eroding and prevented the germination of abundant weed seeds that were already in the soil. Weed pressure continues to decline as the planting matures and species fill more ecological niches. No enhancement planting or seeding was required. Six years after installation, the soil is covered with lush ground covers that suppress germination of undesirable species and reliably perform stormwater management functions. The plantings now appear to be stable in species composition and radiate with several seasonal color themes from spring to late winter.

3.2 Relating Plants to People

Designed plant communities are stunningly beautiful and deeply emotional – they bring us joy and have the power to evoke much larger, captivating landscapes. More and more of us live in cities and are no longer surrounded by natural landscapes. Yet we long for the colorful hayfields and majestic forests of the past. Even urban dwellers who never experienced a blooming pasture meadow seem to have a deep memory of beautiful natural plant communities and respond with overwhelming emotion to plantings that remind of such powerful landscapes. What we find beautiful is deeply rooted in our evolutionary history and often based on the cultural landscapes we used to create and care for. These archetypal landscapes still resonate with people today and inspire designed plant communities. Archetypal forests, for example, have a tall canopy of widely spaced trees. Few shrubs obstruct the view under this canopy. The ground is covered with lush ferns, sedges, and colorful wildflowers. This type of forest is clearly layered and easily understood which in turn makes us feel comfortable and at ease.

But clear legibility does not mean low species diversity. German landscape architect Heiner Luz promotes the principle he calls 'legibility on a large scale, diversity on a small scale'[42]. Applied to woodland plantings, this means that the species diversity is found within the complex herbaceous layer far under the tree canopy. High diversity of herbaceous species does not decrease legibility and emotional appeal as long as planting has clear, archetypal super-structure. This powerful principle works for various other archetypal landscapes, including meadows – if we find the overall height of a meadow appealing, we accept much higher species diversity within the ground layer.

In addition to structuring planting based on inherently beautiful, archetypal landscapes, visually more complex planting can be framed in various ways to increase the sense of order and care for greater public acceptance. Joan Nassauer's work on orderly frames is an important contribution to making complex planting work in highly visible spaces[43]. Frames can be simple fences, clipped hedges, hardscape elements such as low retaining walls, or outdoor furniture such as linear benches. The possibilities are endless, but the effects are powerful.

Powerful seasonal color themes are perhaps the most effective way of giving designed plant communities deep emotional appeal. The effects created through large numbers of visually impactful plants blooming all at once are dramatic. Imagine an urban planting erupting with bright yellow daffodils in spring, then changing to a mix of vibrant pink phlox and echinacea in summer and ending the season with oceans of deep purple asters. Block plantings do not nearly offer the same level of flower power that designed plant communities can contribute to our cities. The results and public response can be spectacular.

One outstanding example of planting that strongly relates to people is the stunning garden at Baltimore's Orioles Stadium in Maryland (Fig. 10). The design is inspired by the most visually appealing regional forest plant communities. The species palette amplifies natural color events, such as the bloom of native *Aquilegia canadensis* (red columbine), *Geranium maculatum* (spotted geranium), and *Monarda bradburiana* (eastern beebalm), to create several strong, deeply emotional explosions of color throughout the growing season. The overall structure of the planting is simple and legible. Tall trees provide a sheltering canopy above and lush ground covers form a sparkling carpet below. Only a handful of shrubs was planted in the mid layer to screen stadium infrastructure. The clear structural legibility beautifully frames a more visually complex ground layer. Employees from nearby offices frequently immerse themselves in the plantings during breaks and relax on the benches scattered throughout the park. Abundant smiles and relaxed facial expressions seem to indicate that the beautiful plantings reconnect visitors with nature and provide a rejuvenating and joyful break from stressful jobs. The lack of trash and vandalism may be a sign of love and respect for this urban oasis.

Designed plant communities not only relate to the people enjoying a planting, they must also relate to the people managing them. No matter how well-designed a planting is, it will not survive long-term if not managed correctly. In fact, if left alone, even the most elegant and thought-through plan will evolve into something completely different. Nonetheless, like China, the majority of designers and contractors in the U.S. and Europe still sell a product of instant landscape. Too few designers stick with projects for more than a few years after installation. However, creating a designed plant community is a long-term process. It requires a shift from static maintenance recipes to adaptive planting management that matches the natural dynamics of how plants grow. For most plantings, adaptive management focuses on coarse actions applied to the overall community after the establishment phase. For example, an annual

mowing or burning of grassland communities may be necessary to keep woody species from dominating. Various kinds of thinning may be important to certain shrubland and woodland communities to preserve the desired tree and shrub combinations. Regular monitoring for invasive species and the speedy and thorough removal of them are also important long-term management considerations.

Understanding the skill level of the crews that will be managing the planting is important. Longtime employees of public gardens usually have high skill levels while seasonal employees of commercial contractors generally have a fraction of the experience. A designed plant community must have an appropriate level of complexity that lines up with the skills and resources of the management team. While pushing for higher skill levels is absolutely necessary, designers must be realistic in their expectations.

3.3 Relating Plants to the Environment

All plantings affect and are affected by their surroundings – they have complex relationships with the biotic and abiotic elements of their environment. It goes without saying that the more a planting is adapted to its surroundings, the more it will thrive. Traditional planting approaches aim to create ideal growing conditions for plants – no matter what the surroundings look like. Planting beds are made perfect by amended soils, fertilizers, and irrigation during dry weather. These resources are rarely necessary to make planting thrive outside of high-intensity vegetable gardens. In fact, the most beautiful, long-lasting plant communities on the planet prefer more stressful site conditions with low nutrient levels and dry soils. The very actions we take to make sites perfect for planting actually limit plant diversity to species that thrive on rich soils and dependent on constant life support. With more resources spent than necessary, what we achieve is in fact severely limited aesthetic diversity.

The more sustainable alternative is to accept as many of the existing conditions as possible and build plant palettes around a site's realities – even if this is contrary to what is still taught at many universities worldwide. This more sensible approach leads to longer-lived plantings that are less susceptible to failure and much easier to manage long-term. What at first glance may seem like a serious site constraint is often a huge asset. For example, dry soils with high pH and low organic matter support beautifully delicate, drought-adapted species compositions that would not thrive on richer soils. And lush wetland-inspired plantings grow best in undrained, soggy ditches. No irrigation system can quite simulate these conditions on carefully prepared garden soils. As extreme as urban conditions may seem, there is likely a wild plant community that thrives under similar conditions; we just have to carefully look for these inspirations.

Urban sites can be very stressful for plants– they are often contaminated with a range of dangerous pollutants, such as petroleum-based substances, pesticide residues, and heavy metals. Only species that are pre-adapted to these stressors can thrive. But many plants do more than just survive – they actually clean up the soils by taking up pollutants in their cell tissues and even breaking them down into harmless substances. Kate Kennen and Niall Kirkwood's well-researched book *Phyto: Principles and Resources for Site Remediation and Landscape Design* describes a wide range of phytotechnologies that use hyper-functional species to make urban soils and waterbodies safer for humans[44]. While not all types of contamination can be addressed with planting, highly functional species can be incorporated into every urban project to clean up existing and prevent future contamination through *phyto-remediation* and *phyto-buffering*[44][14-16]. For example, in rain gardens and bioswales that receive contaminated runoff from nearby streets and parking lots, engine oils, heavy metal-rich brake dust, and gasoline residues may accumulate over time, leading to future brownfields if unmanaged. However, if the right plant species are incorporated from the very beginning, pollutant accumulation and export to groundwater or other water bodies can be buffered and slowed down. Species with the greatest biomass, root depth, root mass and growth rate such as rushes and sedges performs the best at breaking down organic contaminants such as petroleum, chlorinated solvents and pesticide[45], whereas aquatic plants, especially submersed ones, have high capacity to take up metals directly from the water, accumulate and stabilize them in their shoots, roots, or soil[46].

It is not only the planted vegetation in our parks and gardens that clean up our cities. Wild plants that spontaneously reseed on their own and occupy urban wastelands and fence lines down to the tiny cracks in pavement contribute significantly to urban ecosystem functions[47]. Recent studies have shown that, thanks to these spontaneous plants, the city of Berlin, Germany, now houses a higher species diversity than the surrounding forests and agricultural landscapes[48]. Many species planted in gardens and parks eventually 'escape' cultivation and become part of the novel urban ecosystem. Now that we know how important this process is, we can use it to strategically plan for naturalization to enrich urban environments. Designed plant communities include carefully chosen species that have the potential to escape a planting site via urban vectors, such as stormwater runoff, foot traffic, wind, or construction activities. Urban-adapted species that produce large quantities of tiny seeds, e.g. *Juncus tenuis* (poverty rush) and *Achillea millefolium* (common yarrow), are especially successful. While it is very hard to predict the speed and success of this strategy, it is expected that some species will eventually create self-sustaining populations and add functional diversity to novel plant communities that are often dominated by exotic ornamental plants[49]. The more ecologically valuable species we reintroduce into the urban fabric, the more attractive novel ecosystems will become to beneficial wildlife such as native bees and songbirds.

As science continues to reveal the complexities and nuances of the relationship between urban planting and wildlife, we no longer need to rely solely on anecdotal evidence to create suitable habitat for beneficial wildlife[50-53]. We now know that a high coverage of flowering plants throughout the year is very important for pollinators that depend on the nectar and pollen[54]. Ecologically dead plants, such as annuals and perennials bred for the huge flowers and extremely long bloom times, often no longer have nectaries and pollen. They should be avoided. But pollen and nectar alone are not enough to support insects. Caterpillars, for example, feed on the leaves of host plants before they can morph into stunning butterflies (Fig. 10). And caterpillars are often very selective about which host plant they eat. Many insects can only digest a small number of host species due to plant defense mechanisms and the toxins plants produce to ward of hungry insects[55-56]. Plants that include more toxins and are therefore less palatable to insects, e.g., certain purple leaf cultivars[57], should be avoided because of potential long-term impact on insect reproduction and abundance.

The new Pollinator and Bird Garden under construction at the Pennsylvania State University Arboretum in State College, Pennsylvania, is specifically designed to nurture, research, and display local pollinator and bird populations. Through close collaboration with the University's Center for Pollinator Research, Phyto Studio developed and applied a number of wildlife-friendly design principles. The garden's designed plant communities are incredibly species rich and diverse, filling numerous spatial and temporal niches. The plant palette consists of top-ranking food and host plants, many of which are native to the region and have deep evolutionary relationships with local birds and pollinators. Nectar- and pollen-rich flowers with a range of shapes, sizes, colors, and bloom times are important to attract showy butterflies, however, don't forget that, before the butterfly there is a hungry caterpillar that often eats entirely different species, even inconspicuous sedges and other grasses that produce no nectar at all. Besides food, the design also provides generous year-round water sources and all sorts of wildlife shelters, including countless branches and leaves for overwintering. The garden's management plan is built on the life cycle needs of the species occupying the garden. Visitors will learn an exciting new approach to supporting life with planting design and management strategies that work around the needs of beneficial wildlife.

4 Implementation Challenges and Steps Forward

Applying plant community-based design and land management approaches in Chinese cities will face challenges—some may be unique to China, but others are undoubtedly global. Firms like Phyto Studio develop strategies to overcome these hurdles and generate excitement and support for better planting techniques. International collaboration and knowledge exchange can help learn how to move past initial resistance and develop successful strategies within the cultural context of China.

Perhaps the biggest challenge designed plant communities face globally is the limited acceptance of more complex planting aesthetics. Like China, many nations have a long history of intense agricultural land use followed by large-scale, rapid urbanization. This development deprived people of deeper connections with nature and is making it difficult for young generations to understand and appreciate the rhythms of the natural world. Natural plant communities have been long gone around cities, towns, even villages. Access to private gardens in Chinese cities is extremely rare for the general public. Besides, the critical gaps in environmental education from primary to high school result in a lack of ecological knowledge and emotional exposure to natural inspiration. These realities explain the limited public acceptance of visually complex planting. Poorly designed, hastily installed, or incorrectly managed pilot projects can be perceived as messy, weedy, or too rural by the public. Negative public perception is a serious concern that can make it more difficult to build innovative projects. While it is true that designed plant communities are more visually complex than many traditional plantings, they should never feel messy or too naturalistic in relation to a planting's site and cultural context. The smart use of orderly frames, powerful seasonal color themes, appropriate visual complexity, and opportunities for people to immerse themselves into planting typically result in overwhelmingly positive public response. Designed plant communities must be carefully planned with proper long-term management to ensure the planting stays beautiful for many years to come.

The second challenge is directly linked to China's tough climate conditions. In certain parts of the country, there is a strong public belief that nothing can be cultivated unless it is intensely irrigated and receives repeated, high resource input. However, both research and practice demonstrate that Chinese soils and climate do indeed support a wide range of species[27, 58]. The challenge is that plant growers do not yet offer a wide variety of species that thrive under tougher site conditions. China's green industry caters to a traditional market. Plant growers focus on common ornamental trees, shrubs, and bedding annuals. Seed producers that specialize in ecological and functional species remain rare[58]. This is similar to the condition in North America and the U.K. 30 to 50 years ago. It takes decades to elevate the entire green industry to new needs and changing markets. The evolvement of planting technologies requires constant communication between planting designers, installers, and land managers regarding evolving needs and market opportunities. Phyto Studio, for example, frequently communicates their project needs to local plant growers and tool makers with the goal of elevating everyone and building the resilient networks of professions needed to implement this approach.

Resistance to naturalistic aesthetics, demands for immediately attractive results, and an overwhelming desire to prioritize economic development contribute to slow policymaker buy-in and support for designed plant communities. Often, ecosystem enhancement work sits at the bottom of the list on local political agendas. But relentless outreach to decision makers about the benefits of designed plant communities and the process of building them can make a difference. Fortunately, these benefits can be measured in more than just ecological and human health terms. There is clear evidence that designed plant communities can reduce long-term planting management costs[59]. Moreover, beautiful plantings have the potential to reduce crime and increase the property values of surrounding buildings[60]. In essence, there are many convincing benefits that resonate with policymaker's values and beliefs.

The general lack of knowledge of how to create and manage designed plant communities is another critical challenge to broad implementation of this approach. Often, where sound attempts are made to enhance urban ecosystems, projects are implemented without a full understanding of the ecological principles and techniques that the designed plant community approach is built upon, resulting in failed plantings that make it harder to win support for future innovative projects. This knowledge gap also subjects designers to being pressured into compromises. There is an urgent need for interdisciplinary training to educate and increase the number of professionals spearheading this approach. University and school curricula must integrate skills that blend the world of ecology, soil and plant sciences, design, engineering, contracting, and land management. Only wholistic education and problem solving will facilitate much needed collaboration between disciplines and create the complex solutions needed to employ this approach successfully at the broad scale required to realize ecosystem function benefits.

European gardeners cultivated American native plants long before gardeners in the U.S. discovered them for their own gardens. The Chinese public may not yet see the beauty of their own landscapes and breathtaking flora, but the rest of the world does. Some distinctive Chinese landscapes inspire designers all over the world, and Chinese plants are cultivated all over the planet. It is time for China to discover the beauty and potential of its natural world to enrich its cities through that awareness. Germans implemented their first designed plant communities decades ago, but they are just now becoming more abundant in cities and villages. China is at the beginning of this process. James Hitchmough's plantings in Chengdu and Beijing are some of the first designed plant communities the country has seen. Despite the substantial efforts to get them approved and built, well-designed and cared for pilot projects are extremely powerful. Once installed, they become the epicenter for change. People believe and trust in what they see. While words and glamorous photos raise awareness of innovative planting, only installed designs show what is actually possible. Once built, pilot projects are invaluable opportunities to monitor performance and continue improving the approach for Chinese cities.

Innovative, urban greening projects are being built all over the world and demonstrate that a green revolution has started and is gaining momentum. Incorporating the methods described in this paper into urban projects will ultimately lead to better designs that truly address the big crises of our time. The overwhelming scale and gravity of these crises can be intimidating, even paralyzing. But each project that addresses these issues makes a difference, no matter how small. All our combined efforts add up and will lead to more sustainable behaviors and outcomes. The most hopeful lesson learned from a variety of projects worldwide is that nature is resilient and positive change can happen relatively quickly. It only took a few decades of restoration to turn the ecologically dead coal mines of eastern Germany into thriving lakes with crystal clear water, surrounded by young forests and flourishing meadows. The generation that saw unimaginable exploitation of nature and destruction now enjoys long walks in thriving nature. Few could have imagined how quickly wildlife that brings us such joy can recover. If we act now we will likely enjoy the rewards of greener, more livable cities in our lifetimes.

Notes:

① Archetypal landscape: reference plant community that represents the most basic and memorable patterns of vegetation.

② Refer to citation [31] pages 121-188 for more details on the design process.

③ The dynamic filler layer was omitted for brevity.

④ The Levels of Sociability model: Sociability refers to how far plants within the same population grow from each other. Plants with lower sociability [e.g., *Baptisia australis* (blue wild indigo)] are generally tall and visually dominant, and therefore should be arranged individually or in small clumps of three to ten. Contrastingly, plants with high sociability [e.g., spreading forms of *Tiarella cordifolia* (heartleaf foamflower)] often have shapes and behaviors that make them excellent ground covers and should be arranged in masses of ten to twenty or more.

⑤ The Competitor-Stress tolerator-Ruderal model: Competitors are good at outcompeting others in habitats of low stress and disturbances. Stress tolerators maintain biomass to survive in areas of high stress intensity with low levels of disturbance. Ruderals frequently colonize areas of high levels of disturbance and low stress intensity. An example of applying the C-S-R model is to utilize a combination of ruderal species to create a long-lived design for urban street plantings that suffer from constant disturbances by traffic, dogs, street cleaning, etc.

⑥ The eight major plant strategy types: conservation growth, moderate stress adaption, stress avoidance, area occupation, area coverage, area expansion, niche occupation, and gap occupation. An example of applying this model would be to include carpet-forming, low-height plants of the "area coverage" type for a new planting that will receive little maintenance, because their survival strategy is dense cover of all available habitat space.

⑦ Please refer to the English version of the article for the English common names of all plant species. Note that each plant species can have multiple English common names.

Sources of Figures:

Fig. 1 was provided by Claudia West and Zhang Zhibin, Fig. 2, 3, 6, 8~10 were provided by Claudia West, Fig. 4, 5, 7 were drawn by Claudia West and Wu Hong.

(Editor / LIU Yuxia)