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Impact of Urbanization On Native Plant Populations

Dr, Akhilesh Kumar, Associate Professor of Botany,

Baijnath Chaudhary Government College for Women,

Nangal Chaudhary, Kotputly Road, E-mail-profakhileshgchr@gmail.com

Abstract

Urbanization is a major driver of ecological transformation, significantly influencing native plant populations through habitat loss, fragmentation, and environmental degradation. This study examines the impact of urban expansion on native plant diversity, composition, and regeneration across urban, peri-urban, and rural gradients. Using field surveys, quadrat sampling, and diversity indices, the research identifies a marked decline in species richness and abundance in highly urbanized areas, accompanied by increased dominance of invasive and disturbance-tolerant species. Anthropogenic pressures such as pollution, land-use change, and infrastructure development further exacerbate the reduction of native flora. The findings highlight a strong negative correlation between urban intensity and native plant diversity, indicating ecological imbalance and reduced resilience of urban ecosystems. The study underscores the need for sustainable urban planning and conservation strategies to preserve native biodiversity and maintain ecosystem stability in rapidly urbanizing landscapes.

Keywords: Urbanization, Native plant diversity, Habitat fragmentation, Invasive species, Biodiversity loss

Introduction

Urbanization represents one of the most rapid and transformative forms of land-use change, fundamentally altering natural ecosystems and significantly impacting native plant populations. As cities expand to accommodate growing human populations, natural habitats are increasingly converted into built environments, leading to habitat destruction, fragmentation, and modification of ecological processes. Native plant species, which are adapted to specific local environmental conditions, often struggle to survive under such altered circumstances. The replacement of natural vegetation with infrastructure, roads, and urban landscapes disrupts soil composition, hydrological cycles, and microclimatic conditions, thereby reducing the availability of suitable habitats for indigenous flora. Moreover, urban areas are frequently characterized by elevated levels of pollution, including air contaminants, heavy metals in soil, and altered nutrient cycles, all of which adversely affect plant growth, reproduction, and survival. Another critical consequence of urbanization is the introduction and proliferation of invasive species, which tend to outcompete native plants due to their higher adaptability to disturbed environments. This leads to a decline in species richness and a shift in community composition, often resulting in biotic homogenization. Additionally, fragmentation of habitats creates isolated patches of vegetation, limiting gene flow

and reducing the resilience of native plant populations to environmental stressors. Despite these challenges, some native species may persist in urban green spaces such as parks, gardens, and remnant natural patches, although their ecological functions may be diminished. Understanding the extent and nature of urbanization's impact on native plant populations is therefore crucial for biodiversity conservation and sustainable urban planning. This study aims to analyze how varying degrees of urban development influence native plant diversity, distribution, and regeneration, providing insights into the ecological consequences of urban growth and highlighting the need for effective conservation strategies in urban ecosystems.

Background and Significance of the Study

Urbanization has emerged as a dominant global phenomenon, reshaping landscapes and exerting profound pressure on natural ecosystems, particularly native plant populations. As urban areas expand, natural habitats are increasingly replaced by built environments, resulting in habitat loss, fragmentation, and ecological imbalance. Native plants, which play a critical role in maintaining ecosystem stability, supporting local wildlife, and preserving genetic diversity, are especially vulnerable to these changes. The decline of native vegetation not only disrupts ecological interactions such as pollination and nutrient cycling but also reduces the resilience of ecosystems to environmental stressors like climate change and pollution. In rapidly developing regions, including many parts of India, unplanned urban growth has intensified these impacts, leading to a noticeable reduction in indigenous flora and an increase in invasive and non-native species. The significance of this study lies in its focus on understanding the extent to which urbanization affects native plant diversity, composition, and regeneration patterns. By examining these changes across different urban gradients, the study provides valuable insights into the mechanisms driving biodiversity loss in urban settings. Furthermore, it highlights the ecological consequences of continued urban expansion and emphasizes the urgent need for sustainable urban planning and conservation strategies. The findings of this research are expected to contribute to environmental management practices, policy formulation, and the promotion of urban biodiversity conservation, ensuring that native plant species are preserved for future generations while maintaining ecological balance in urban ecosystems.

Concept of Urbanization

Urbanization refers to the process by which an increasing proportion of a population shifts from rural to urban areas, resulting in the growth and expansion of cities and towns. It is a multifaceted phenomenon involving demographic, economic, social, and spatial transformations that significantly alter land use and environmental conditions. At its core, urbanization is driven by factors such as industrialization, employment opportunities, improved infrastructure, and better access to education, healthcare, and other services, which attract people to urban centers. This process leads to the conversion of natural landscapes, including forests, grasslands, and agricultural lands, into built environments characterized by residential, commercial, and industrial developments. As urban areas expand, they create distinct ecological conditions, including

increased surface temperatures (urban heat island effect), altered hydrological cycles, and higher levels of pollution. These changes have profound implications for biodiversity, particularly for native plant populations that are adapted to specific environmental conditions. Urbanization also introduces significant disturbances such as soil compaction, habitat fragmentation, and the replacement of native vegetation with ornamental or non-native species. Furthermore, the process often results in increased resource consumption and waste generation, placing additional stress on surrounding ecosystems. From an ecological perspective, urbanization is not merely the physical expansion of cities but also the transformation of ecological processes and interactions within those spaces. It leads to a simplification of ecosystems, reduced species diversity, and the dominance of species that can tolerate disturbed conditions. In developing countries, rapid and often unplanned urbanization exacerbates these impacts, making it a critical environmental concern. Therefore, understanding the concept of urbanization is essential for analyzing its effects on natural systems, particularly native plant populations, and for developing strategies that balance urban development with ecological sustainability.

Definition of Native Plant Populations

Native plant populations refer to groups of plant species that occur naturally within a specific geographic region, having evolved and adapted over long periods to the local environmental conditions such as climate, soil type, topography, and interactions with other organisms. These plants are indigenous to a particular area and exist without direct or intentional human introduction, distinguishing them from exotic or non-native species that are brought from other regions. Native plant populations are integral components of their ecosystems, forming complex ecological relationships with local fauna, including pollinators, herbivores, and microorganisms. They contribute significantly to ecosystem functions such as nutrient cycling, soil stabilization, water regulation, and maintenance of biodiversity. The concept of native plant populations extends beyond individual species to include their genetic diversity, spatial distribution, and population dynamics within natural habitats. These populations are often well-adapted to local stressors, such as seasonal variations, pests, and diseases, making them more resilient compared to non-native species. However, native plant populations are highly sensitive to environmental disturbances, particularly those caused by human activities such as urbanization, deforestation, and land-use change. The disruption of their natural habitats can lead to reduced population sizes, fragmentation, and even local extinction. Additionally, the introduction of invasive species can outcompete native plants for resources, further threatening their survival. Understanding native plant populations is essential for ecological research, conservation planning, and sustainable land management, as their presence indicates the health and stability of ecosystems. Protecting these populations is crucial for preserving ecological balance, supporting wildlife, and maintaining the natural heritage of a region.

Effects on Plant Diversity and Composition

Urbanization exerts a profound influence on plant diversity and community composition, primarily through habitat alteration, environmental stress, and biotic interactions. As natural landscapes are converted into urban infrastructure, the availability of suitable habitats for native plant species declines significantly, leading to a reduction in species richness and evenness. This loss of diversity is often accompanied by a shift in species composition, where sensitive and specialist native species are replaced by a limited number of generalists, disturbance-tolerant, or invasive species. Such changes result in biotic homogenization, where urban plant communities across different regions begin to resemble one another, losing their unique ecological identity. Additionally, urban environments introduce altered microclimatic conditions, including increased temperatures, reduced soil moisture, and elevated pollution levels, which further influence plant survival and growth patterns. Soil compaction, nutrient imbalances, and contamination from heavy metals also negatively affect native plant regeneration and seedling establishment. In contrast, non-native and ornamental species, often introduced intentionally for landscaping, tend to thrive in these modified conditions, outcompeting indigenous flora. Fragmentation of habitats into smaller, isolated patches disrupts ecological connectivity, limiting gene flow and reducing the resilience of native plant populations. Moreover, changes in species composition can disrupt ecological interactions such as pollination and seed dispersal, further impacting plant community dynamics. urbanization leads to a simplified plant community structure characterized by reduced diversity, altered species dominance, and weakened ecological functioning, highlighting the urgent need for conservation and sustainable urban management practices.

Literature Review

Urbanization has been widely recognized as a major driver of ecological change, significantly influencing ecosystem structure and function. Marina Alberti (2005) emphasized that urban patterns, including land-use change and spatial configuration, directly affect ecosystem processes such as nutrient cycling, energy flow, and biodiversity distribution. Her work highlights that increasing impervious surfaces and fragmented landscapes reduce ecological efficiency and disrupt natural interactions among species. Similarly, Nancy B. Grimm et al. (2000) proposed an integrated approach to studying urban ecosystems, arguing that cities should be viewed as complex socio-ecological systems where human and natural components interact dynamically. This perspective has been fundamental in understanding how urban expansion modifies ecological resilience and long-term sustainability. Mark Antrop (2004) further contributed by examining landscape transformations in Europe, demonstrating that urbanization leads to the fragmentation and simplification of natural landscapes, which in turn affects native vegetation patterns and ecological continuity. These foundational studies collectively establish that urbanization is not merely a physical transformation but a process that alters fundamental ecological functions,

thereby creating new environmental conditions that challenge the persistence of native plant populations.

The impact of urbanization on biodiversity, particularly plant diversity, has been extensively documented in ecological literature. Michael L. McKinney (2002, 2006) highlighted urbanization as a primary cause of biodiversity loss and biotic homogenization, where native species decline and are replaced by a limited number of widespread, disturbance-tolerant species. This process reduces regional uniqueness and leads to ecological uniformity across urban landscapes. Amy A. Alvey (2006) focused specifically on urban forests, emphasizing the importance of maintaining native biodiversity within cities through conservation and management strategies. Her findings suggest that urban green spaces can serve as refuges for native plant species if properly managed. Additionally, Stefan Siebert Cilliers (2010) explored the social dimensions of urban biodiversity, arguing that human preferences, cultural practices, and management decisions play a crucial role in shaping plant communities in urban environments. These studies collectively indicate that while urbanization generally leads to biodiversity decline, targeted interventions and sustainable planning can mitigate its negative effects and support native plant conservation within urban ecosystems.

Another critical dimension of the literature focuses on habitat fragmentation and its ecological consequences. Fragmentation, as described by Richard T. T. Forman (2014), involves the breaking up of continuous habitats into smaller, isolated patches, which significantly affects species distribution, population dynamics, and ecological interactions. Smaller and isolated patches often experience edge effects, altered microclimatic conditions, and reduced resource availability, all of which negatively impact native plant survival. Robert B. Blair (2001) provided evidence of homogenization in urban bird communities, which parallels similar patterns observed in plant communities, where only a few adaptable species dominate fragmented habitats. Furthermore, Jennifer F. Chace and John J. Walsh (2006) demonstrated that urbanization alters habitat structure and resource availability, leading to declines in native species and changes in community composition. Although their work focuses on avifauna, the underlying ecological principles apply equally to plant populations, as both are affected by habitat loss and fragmentation. These studies reinforce the understanding that fragmentation is a key mechanism through which urbanization reduces biodiversity and disrupts ecological stability.

In addition to physical habitat changes, the literature also highlights the role of socio-ecological interactions and restoration potential in urban ecosystems. Stefan Siebert Cilliers (2010) emphasized that urban biodiversity is shaped not only by environmental factors but also by human values, planning policies, and management practices. This perspective aligns with the concept of urban ecosystems as hybrid systems where ecological and social processes are deeply interconnected. Richard T. T. Forman (2014) further argued that effective urban planning must integrate ecological principles to maintain biodiversity and ecosystem services. The literature also suggests that despite the negative impacts of urbanization, opportunities exist for ecological

restoration and conservation within cities, particularly through the development of green infrastructure and the protection of remnant natural habitats. Nancy B. Grimm et al. (2000) highlighted the importance of long-term ecological research in understanding urban dynamics and informing sustainable management strategies. Overall, the reviewed studies collectively demonstrate that urbanization poses significant challenges to native plant populations, but also provide insights into potential solutions through integrated planning, conservation efforts, and increased awareness of the ecological value of native biodiversity.

Habitat Fragmentation and Ecological Disturbance

Habitat fragmentation and ecological disturbance are among the most critical consequences of urbanization affecting native plant populations. Fragmentation occurs when large, continuous natural habitats are divided into smaller, isolated patches due to infrastructure development such as roads, buildings, and industrial zones. This spatial separation disrupts ecological connectivity, limiting the movement of species, reducing gene flow, and increasing the vulnerability of native plant populations to local extinction. Smaller habitat patches often support fewer species and are more susceptible to environmental fluctuations, leading to decreased biodiversity and altered community structure. In addition, edge effects become more pronounced in fragmented landscapes, where the boundaries between natural and urban areas experience changes in light intensity, temperature, humidity, and wind exposure. These altered conditions can negatively affect sensitive native plant species while favoring opportunistic and invasive species. Ecological disturbances associated with urbanization, including soil compaction, pollution, land clearing, and human interference, further exacerbate these impacts. Such disturbances disrupt soil structure, nutrient cycles, and microbial communities, all of which are essential for plant growth and survival. Frequent disturbances also hinder natural regeneration processes by affecting seed dispersal, germination, and establishment of seedlings. Moreover, urban environments often experience repeated anthropogenic disturbances, preventing ecosystems from reaching a stable equilibrium and maintaining them in a degraded state. The combined effects of fragmentation and disturbance lead to a decline in native plant diversity, simplification of vegetation structure, and loss of ecosystem functionality. Understanding these processes is essential for developing effective conservation strategies, such as habitat restoration, creation of ecological corridors, and sustainable urban planning, to mitigate the adverse effects of urbanization on native plant populations.

Impact of Pollution and Human Activities

Pollution and intensified human activities associated with urbanization play a significant role in shaping the structure and survival of native plant populations. Urban environments are characterized by elevated levels of air, soil, and water pollution, which directly and indirectly affect plant health and ecological functioning. Air pollutants such as sulfur dioxide, nitrogen oxides, ozone, and particulate matter can impair photosynthesis, damage leaf tissues, and reduce overall plant productivity. Soil pollution, particularly through the accumulation of heavy metals

like lead, cadmium, and mercury, alters soil chemistry and inhibits root growth, nutrient uptake, and microbial activity essential for plant development. Water contamination from urban runoff, sewage discharge, and industrial effluents further degrades habitats, affecting moisture availability and introducing toxic substances into plant systems. In addition to pollution, various human activities such as construction, deforestation, landscaping, and recreational use of green spaces contribute to the degradation of native plant habitats. These activities often lead to soil compaction, trampling, and removal of natural vegetation, thereby disrupting regeneration processes and reducing plant diversity. The intentional introduction of ornamental and exotic plant species for urban beautification also intensifies competition for resources, often resulting in the displacement of native species. Furthermore, frequent disturbances caused by maintenance practices such as mowing, pruning, and pesticide application can alter natural growth patterns and ecological interactions. Over time, these combined pressures lead to a decline in native plant abundance, changes in species composition, and reduced ecosystem resilience. The cumulative impact of pollution and human activities underscores the urgent need for environmentally responsible urban management practices, including pollution control, conservation of natural habitats, and promotion of native vegetation in urban landscapes to sustain biodiversity and ecological balance.

Research Methodology

The present study adopted a quantitative research design to assess the impact of urbanization on native plant populations across an urban–peri-urban–rural gradient. The study area was systematically divided into three zones based on the intensity of urban development. Data collection was carried out using the quadrat sampling method, with 30 quadrats randomly placed in each zone to ensure representative sampling. Within each quadrat, parameters such as species richness, plant density, and the presence of native and invasive species were recorded. Environmental variables including soil quality, signs of pollution, and habitat disturbance were observed. Plant identification was conducted using standard floristic guides. To evaluate biodiversity, the Shannon-Wiener Diversity Index was calculated, while statistical tools such as mean, standard deviation, and correlation analysis were applied to examine relationships between urbanization and plant diversity. Data on pollution levels, particularly soil heavy metal concentration, were also incorporated to understand their effects on plant health. The collected data were tabulated and analyzed using appropriate statistical techniques, enabling comparison across different zones and supporting objective interpretation of results regarding the ecological impact of urbanization.

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Result and Discussion

Table 1: Comparison of Species Richness Across Urban Gradient

Study Area	Sample Size (Quadrats)	Number of Native Species	Mean Species Richness	Standard Deviation (SD)
Urban Area	30	18	6.2	1.5
Peri-Urban Area	30	32	10.8	2.1
Rural Area	30	48	16.5	2.8

Table 1 demonstrates a clear variation in native plant species richness across the urban–rural gradient. The urban area shows the lowest number of native species (18) with a mean richness of 6.2, indicating reduced biodiversity due to intense anthropogenic pressures such as land-use change and habitat loss. In contrast, the peri-urban area exhibits moderate species richness (32 species; mean 10.8), reflecting transitional ecological conditions where some natural habitats are still preserved. The rural area records the highest species richness (48 species; mean 16.5), suggesting minimal disturbance and more favorable conditions for native plant growth. The increasing standard deviation from urban to rural areas indicates greater variability in species distribution in less disturbed ecosystems.

Table 2: Shannon-Wiener Diversity Index (H') Across Study Sites

Study Area	Total Individuals	Species Count	Shannon Index (H')
Urban Area	420	18	1.85
Peri-Urban Area	610	32	2.67
Rural Area	890	48	3.21

Table 2 highlights the variation in plant diversity using the Shannon-Wiener Index, which considers both species richness and evenness. The urban area shows the lowest diversity (H' = 1.85), reflecting a simplified plant community dominated by fewer species. The peri-urban area has a moderate diversity value (H' = 2.67), indicating a more balanced distribution of species due to reduced urban pressure. The rural area exhibits the highest diversity (H' = 3.21), suggesting a complex and stable ecosystem with well-distributed species. These results indicate that increasing urbanization negatively impacts plant diversity, while less disturbed rural environments support richer and more evenly distributed native plant communities.

Table 3: Abundance of Native vs Invasive Species

Study Area	Native Species (%)	Invasive Species (%)
Urban Area	40%	60%
Peri-Urban Area	65%	35%
Rural Area	85%	15%

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Table 3 illustrates the proportional distribution of native and invasive species across different study areas. In the urban area, invasive species dominate (60%), while native species constitute only 40%, indicating strong ecological disturbance and habitat alteration. In the peri-urban area, native species increase to 65%, suggesting partial recovery of ecological balance. The rural area shows a high dominance of native species (85%) with minimal invasive presence (15%), reflecting stable and less disturbed ecosystems. This trend highlights that urbanization promotes invasive species establishment due to disturbed habitats, while rural environments favor native species survival and ecological integrity.

Table 4: Effect of Habitat Fragmentation on Plant Density

Patch Size (m^2)	**Number of Patches**	**Mean Plant Density (plants/m^2)**
Small (<500)	15	8.5
Medium (500–1000)	10	14.2
Large (>1000)	5	21.6

Table 4 presents the relationship between habitat patch size and plant density. Smaller patches (<500 m^2) show the lowest plant density (8.5 plants/m^2), indicating that fragmentation negatively affects plant survival and regeneration. Medium-sized patches (500–1000 m^2) exhibit moderate density (14.2 plants/m^2), suggesting improved ecological conditions compared to smaller fragments. Larger patches (>1000 m^2) support the highest plant density (21.6 plants/m^2), reflecting better habitat quality, resource availability, and ecological stability. These findings emphasize that habitat fragmentation reduces plant population density, while larger, continuous habitats are crucial for maintaining healthy native plant populations.

Table 5: Impact of Pollution on Plant Health Indicators

Parameter	**Urban Area**	**Peri-Urban Area**	**Rural Area**
Leaf Chlorosis (%)	35%	20%	8%
Growth Reduction (%)	40%	22%	10%
Soil Heavy Metals (ppm)	75	45	20

Table 5 reveals the adverse effects of pollution on plant health across different areas. The urban area shows the highest levels of leaf chlorosis (35%), growth reduction (40%), and soil heavy metal concentration (75 ppm), indicating severe environmental stress on plants. The peri-urban area displays moderate levels of these indicators, reflecting partial exposure to pollution. In contrast, the rural area records minimal chlorosis (8%), lower growth reduction (10%), and the least heavy metal concentration (20 ppm), suggesting healthier plant conditions. These results demonstrate that pollution significantly impairs plant physiological functions and growth, with urban environments posing the greatest threat to native plant health.

Conclusion

The present study clearly demonstrates that urbanization has a significant and largely negative impact on native plant populations, affecting their diversity, composition, density, and overall ecological stability. The findings reveal a consistent decline in species richness and diversity from rural to urban areas, indicating that increased urban intensity leads to habitat degradation and loss of native flora. Urban environments, characterized by high levels of pollution, habitat fragmentation, and anthropogenic disturbances, create unfavorable conditions for the survival and regeneration of native plant species. As a result, these areas tend to be dominated by invasive and disturbance-tolerant species, contributing to biotic homogenization and reduced ecological resilience. In contrast, rural areas, with minimal human interference, support higher species diversity and healthier plant communities, emphasizing the importance of intact natural habitats. The study also highlights the critical role of habitat size and connectivity, as larger and less fragmented patches were found to sustain higher plant densities and biodiversity. Furthermore, pollution indicators such as soil heavy metal concentration and plant health parameters like chlorosis and growth reduction underscore the physiological stress experienced by plants in urban settings. Overall, the results emphasize that unchecked urban expansion poses a serious threat to native plant populations and ecosystem functioning. Therefore, it is essential to adopt sustainable urban planning practices that incorporate green spaces, promote the use of native species in landscaping, and implement effective pollution control measures. Conservation strategies such as habitat restoration, creation of ecological corridors, and protection of remnant vegetation patches are crucial for maintaining biodiversity. This study underscores the urgent need for integrated approaches that balance urban development with ecological preservation to ensure long-term environmental sustainability.

References

1. Alberti, M. (2005). The effects of urban patterns on ecosystem function. *International Regional Science Review*, *28*(2), 168–192. https://doi.org/10.1177/0160017605275160
2. Alvey, A. A. (2006). Promoting and preserving biodiversity in the urban forest. *Urban Forestry & Urban Greening*, *5*(4), 195–201. https://doi.org/10.1016/j.ufug.2006.09.003
3. Antrop, M. (2004). Landscape change and the urbanization process in Europe. *Landscape and Urban Planning*, *67*(1–4), 9–26. https://doi.org/10.1016/S0169-2046(03)00026-4
4. Blair, R. B. (2001). Creating a homogeneous avifauna. *Ecological Applications*, *11*(6), 1646–1661. https://doi.org/10.1890/1051-0761(2001)011[1646:CAHA]2.0.CO;2
5. Chace, J. F., & Walsh, J. J. (2006). Urban effects on native avifauna. *Landscape and Urban Planning*, *74*(1), 46–69. https://doi.org/10.1016/j.landurbplan.2004.08.007
6. Cilliers, S. S. (2010). Social aspects of urban biodiversity. *Urban Ecosystems*, *13*(2), 139–149. https://doi.org/10.1007/s11252-009-0103-1
7. Forman, R. T. T. (2014). *Urban ecology: Science of cities*. Cambridge University Press.
8. Grimm, N. B., Grove, J. M., Pickett, S. T. A., & Redman, C. L. (2000). Integrated approaches to long-term studies of urban ecological systems. *BioScience*, *50*(7), 571–584.
9. Kowarik, I. (2011). Novel urban ecosystems. *Environmental Pollution*, *159*(8–9), 1974–1983. https://doi.org/10.1016/j.envpol.2011.02.022

10. McKinney, M. L. (2002). Urbanization, biodiversity, and conservation. *BioScience, 52*(10), 883–890. https://doi.org/10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2
11. McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological Conservation, 127*(3), 247–260. https://doi.org/10.1016/j.biocon.2005.09.005
12. Pickett, S. T. A., Cadenasso, M. L., & Grove, J. M. (2001). Urban ecological systems. *Annual Review of Ecology and Systematics, 32*, 127–157.
13. Shochat, E., Warren, P. S., Faeth, S. H., McIntyre, N. E., & Hope, D. (2006). From patterns to emerging processes in mechanistic urban ecology. *Trends in Ecology & Evolution, 21*(4), 186–191.
14. Suding, K. N., Gross, K. L., & Houseman, G. R. (2004). Alternative states and positive feedbacks in restoration ecology. *Trends in Ecology & Evolution, 19*(1), 46–53.
15. Turner, B. L., II, Lambin, E. F., & Reenberg, A. (2007). The emergence of land change science. *Proceedings of the National Academy of Sciences, 104*(52), 20666–20671.