Sustainability **2012**, *4*, 1154-1172; doi:10.3390/su4061154

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

The New Ecology of Vacancy: Rethinking Land Use in Shrinking Cities

Sean Burkholder

Department of Landscape Architecture, Pennsylvania State University, 121 Stuckeman Family Building, University Park, PA 16823, USA; E-Mail: slb59@psu.edu; Tel.: +1-814-863-8135; Fax: +1-814-865-3289

Received: 15 February 2012; in revised form: 17 May 2012 / Accepted: 18 May 2012 / Published: 5 June 2012

Abstract: Urban environments are in continual transition. Yet, as many cities continue to grow and develop in ways deemed typical or standard, these transitions can be difficult to acknowledge. Narratives of continued growth and permanence become accepted and expected while the understanding of urban dynamics becomes lost. In many parts of the world, the shrinking cities phenomenon has given rise to a new awareness of urban transition that provides a laboratory of new conditions at the intersection of urbanism and ecology. With property vacancy rates easily exceeding 50% in certain locations, cities in the American Rust Belt look more like successional woodlands than bustling metropolises, yet these cities still contain significant numbers of urban residents. A central question that arises from this phenomenon is: how can vacant land, through the provision of ecosystem services, become a resource as opposed to a liability? This paper looks to recent studies in urban ecology as a lens for understanding the land use potential of shrinking cities, while discussing unconventional solutions for sustainable development of urban land.

Keywords: shrinking cities; urban ecology; urban landscape; vacancy; off-lining; sustainable urban planning; ecosystem services

1. Introduction

The ecological potential of the urban environment is just beginning to be understood. Ecologists have begun to question long-accepted assumptions regarding the ecological condition of urban areas and are suggesting more accurate ways of studying them [1]. This newly illuminated vision of the metropolis provides not only a new way of understanding the city as we have come to know it, but also offers tremendous opportunity in the assessment and speculation of the externalities of urban trends such as suburbanization, post-industrialization and urban decline.

Within planning circles, a good deal of attention has been placed on the issue of shrinking cities, most notably at a symposium held at Berkeley, California in 2007 and the 2011 OECD symposium on the topic, held in Paris. Most of this work however, concentrates on the serious socio-economic problems the trend of urban shrinkage represents. Decreased tax bases, infrastructural abandonment and residential migration all exist as primary concerns to many post-industrial cities. Projects from planners, designers and artists around the issue of shrinking cities have run the gamut, most attempting to draw attention to the issue itself or advocate for temporary use projects [2–3]. Cities considered at the forefront of vacant land management such as Philadelphia still focus attention on the tax revenue lost though vacant land as opposed to the possible ecological benefits it could provide [4]. This position does have its benefits however as a recent study has indicated a decrease in crime in areas near vacant parcels rejuvenated by the Philadelphia Green Project [5]. In Baltimore, a city where ecological research is a significant priority by way of the Baltimore Ecosystem Study, the consideration of vacant land as a resource has still not been considered beyond the identification of species found growing on vacant parcels [6].

Recently, however, examples of planning strategies that look more broadly at the issue have begun to surface. For instance in Ohio, the Reimagining Cleveland project looked to reconsider vacant sites as they related to urban watersheds, overall green networks and development potential in a way that provided a larger framework for their city-wide incorporation [7]. Also in Ohio, the Youngstown 2010 plan looked to face the reality of its smaller size and focus on quality of life issues above urban growth [8].

As these larger scale projects are being considered, it is becoming clear that one of the true potentials of vacant land appears to be in its ability to provide ecosystem services to urban residents and the urban region. Ecosystem services can be defined broadly as the benefits people obtain from ecosystems and are broken down into supporting, regulating, provisioning and cultural services [9]. The provision of ecosystem services is becoming more important because many of these services, such as clean water, food and biodiversity are currently being utilized at unsustainable rates. Could vacant land become a valuable asset in supplying and supplementing these decreasing essential resources? This paper addresses the relationship between the growing areas of urban vacant land—something that is typically beyond the control of the metropolitan resident or administration—and the achievable quality of life benefits that these lands could provide. Through looking at ecosystem services and the defining characteristics of vacant land, significant gains in urban air, water and biologic quality could be planned for and achieved. The success of these service provisions is also tied to conditions of as aesthetics, perception and administration. If these aesthetic and administrative concerns can be addressed effectively, enhanced levels of ecosystem service, some of which are still unknown, can provide the opportunity for large-scale reconsideration of the city, and the systems in which it is integrally enmeshed, offering the possibility of new forms of sustainable urbanization.

2. Background: Population Fluctuation, Vacancy and Shrinking Cities

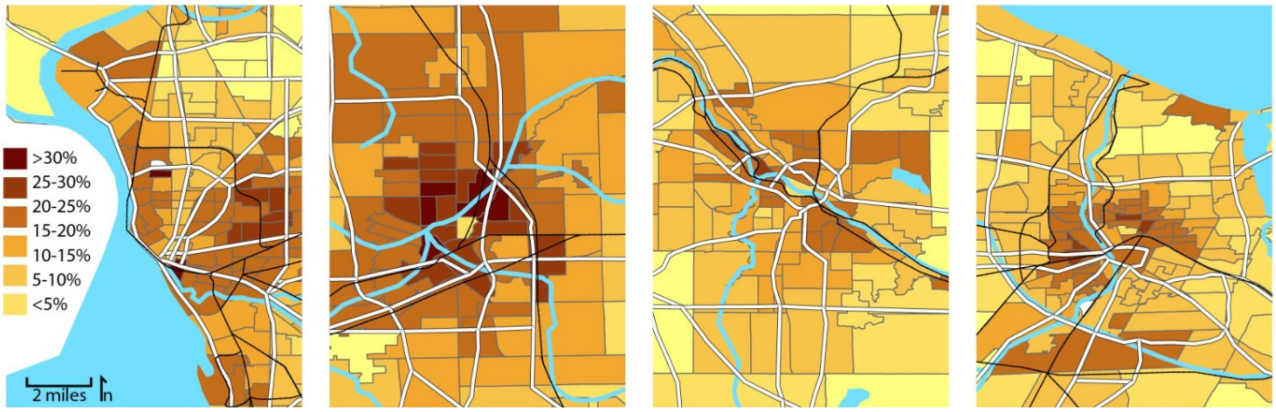
Like the populations of organisms in other ecological systems, the human populations in urban ecosystems tend to fluctuate. These fluctuations or pulses occur at a series of scales and with various levels of impact. Recently it has been observed by Berry that urban populations tend to pulsate on a time scale of about 55 years [10]. The nature of all pulses is dependent upon the availability of outside resources and their efficient use [11]. The 55 year cycle observed by Berry came at a time of heavy short-term population growth and fossil fuel extraction relating directly to the "industrial" period of urbanization [12]. Due to the changing nature of resource use and urbanization, Berry's cyclic pulses of growth at 55 year intervals are unlikely to be a continual phenomenon. Rather, Whitmore's results suggest a significant increase in the frequency of fluctuation, occurring more frequently and with larger impacts. As a result, there is less time for reconstruction between fluctuations, higher likelihood of erosion loops that can perpetuate loss, greater possibility of overshooting our resource carrying capacity, and the potential for societal collapse [13]. The central idea here is that the world is changing more rapidly, and response time is decreasing. Urban development does not abide by a rule of continuous growth. Recent population shifts within cities could be seen as an indicator of these increased frequency trends. As such, laboratories and research agendas should be established to understand the urban environmental implications of these shifts.

One of the externalities of population shift is the abandonment of previously occupied land. Nowhere is this phenomenon more evident than in cities. Abandoned land is typically results from migration, environmental disaster, decreased birth rates, or contamination, and occurs at various concentrations. While all cities have some vacant land, particular cities stand out as exceptional cases. For example one third of Detroit, Michigan is vacant. This vacant land constitutes well over 40 square miles, an area larger than the entire city of Miami, Florida. While Detroit is an extreme example, staggering levels of vacancy are not uncommon among post-industrial cities in America and Europe, as industrial jobs have moved or closed and residents migrate to the suburbs. These varying causes of urban vacancy are compounded by variations in density and urban form, result in a wide range of vacant land distribution patterns between cities.

Historically, the discipline of urban ecology focused on the ecology "within" the city, while more recent work has been done to understand the ecology "of" the city. Vacant spaces provide new possibilities for understanding urban ecology as a holistic study in spatial and temporal dynamics. Looking at vacancy maps (see Figure 1) in conjunction with work done on the relationships between urban patterns and urban ecology [14–15], areas of high vacancy begin to represent new emergent ecosystems at a scale that defines the city as an ecology instead of simply an entity containing ecology.

In Figure 1, information gathered from the USPS provides insight into this distribution disparity. While this information focuses upon address (unit) vacancy, as opposed to land vacancy, it does provide a consistent metric that illuminates the varied distribution of abandonment within different cities. It suggests that vacancy is not a ubiquitous condition. This variation is further supported by Wiechmann and Pallagst in their assessment different types of shrinking cities in the USA and Germany [16]. Because many of these city-specific vacant aggregations contain large quantities of biomass, surface area, infrastructural integration, biodiversity and nutrient cycling, these areas could be seen as an unprecedented opportunity to harness ecosystem services within the urban environment.

Figure 1. Maps showing the distribution of unit vacancy intensity of census tracts: (**a**) Buffalo, New York; (**b**) Flint, Michigan; (**c**) Youngstown, Ohio; (**d**) Rochester, New York (Data from HUD and USPS 2010, maps by author).



(**a**) (**b**) (**c**) (**d**)

3. Ecosystem Services and Vacancy

Given the vast amounts of vacant land and their potential to provide ecosystem services, the question is again raised: what is the role of vacant land in the formation of more ecologically sustainable cities? Significant opportunity lies in the establishment and provision of ecosystem services through strategic design and management of large vacant sites in order to create a web of sustainable land-uses.

The Millennium Ecosystem Study [9] defines four types of Ecosystem Services: (1) provisioning services such as food, water, timber, fiber and genetic resources; (2) regulating services such as the regulation of climate, water, pest populations and waste treatment; (3) cultural services such as religious, aesthetic and recreational resources; (4) supportive services such as soil formation, photosynthesis and nutrient cycling. These supportive services are characterized by their necessity in the function of other services, and affect humans indirectly by their fostering these services.

Pushing the definition of ecosystem services beyond those established by the Millennium Ecosystem Study (MA), Fisher *et al.* [17] highlights the discrepancy between services and benefits, and proposes that ecosystem services are the resources or aspects of ecosystems utilized for human well-being. The Fisher proposal suggests that aspects of the MA that fall under the classification of cultural services are actually more complex than other more tangible services. While this view has been studied, it has been decided that, for the purposes of addressing vacant land, the MA classification provides the most well-rounded scenario and that the inclusion of cultural services is beneficial.

While the vast vacant areas of the city provide potential for ecosystem services, a key requirement in making these services possible over the long term is to assure they are planning and management priorities [18]. Therein lies the conundrum: while teeming with potential, vacant land generally receives very little management. Management that vacant urban areas do receive is generally driven by cost effectiveness (mowing), public safety (building demolition) and sanitation (barriers to block dumping and distribution of rat poison). In most cases, these methods are logical, sometimes even necessary; yet do not leverage the ecosystem services these areas could possibly provide to the city and its residents. Examples of projects in shrinking cities that are motivated by the provision of ecosystem services and funded by the city are actually quite limited. The priorities of municipal administrations tend to fall onto services more conventionally associated with quality of life issues for urban residents, such as police service and road repaving. Consequently, open space has been reduced from so called "green lungs" to "rat havens". In most shrinking cities, open land has changed from a luxury to a liability. The following sections provide detail on how ecosystem services could be delivered through the deliberate management of vacant land in terms of the various "spheres" which compose the urban ecosystem.

3.1. The Urban Ecosystem

In the realms of planning and design, few subjects have garnered more recent attention than urban ecology. As a discipline it seems poised to become one of the guiding forces of urban design and planning in the future. At its core, the breadth of urban ecology as a discipline is most clearly defined by Mark McDonnell [19]:

> "Urban ecology integrates both basic (*i.e.*, fundamental) and applied (*i.e.*, problem oriented) natural and social science research to explore the multiple dimensions of urban ecosystems".

This definition begins to illuminate the complex interactions, both physical and disciplinary, that urban ecology proposes to address. Recent research has begun to evaluate the complex relationships between natural and social systems [20–21]. This intellectual development is also exemplified in the transition from the study of ecology "within" cities to ecology "of" cities. Cities are no longer seen as vacuous sterile spaces containing various disjointed ecologies. Rather, their formal and socioeconomic characteristics are active participants within all levels of ecosystem function.

Given the inherent complexity of urban ecosystems, some process of distillation is necessary to accurately communicate particular issues and relationships. One example of this categorization is proposed by Marzluff *et al.* [22] and focuses on levels or earth spheres: hydrosphere (water), pedosphere (soil), biosphere (plant and animals), anthrosphere (people), and atmosphere (air). These spheres are understood as interrelated and codependent with an emphasis placed on the role and relationship of the anthrosphere to the entire system [23]. While understood as systemically related, this process of categorization provides a focused lens for examining the role of design and management in the provision of ecosystem services on vacant lands.

3.2. The Urban Atmosphere

Planting in the urban environment has been shown to have a positive effect on air quality by increasing deposition of particulate matter on leaf surfaces, thereby removing them from the atmosphere. This relationship is a prime example of an anthropocentrically beneficial coupling of the atmosphere and the biosphere. Modeling studies for London, England estimated that, in its current condition of tree cover, (20% of the total land area), 7% to 1.4% of the total particulate material are being removed by the canopy [24]. However, even with the remediative qualities of plants, the air-quality standards set by most cities in the developed world are seldom met [25]. As reservoirs of plant material, vacant land has the potential to help cities meet higher air quality standards.

The urban heat island effect is another significant ecological implication that arises with urban development. With increased surface area, high levels of energy exchange, and high levels of thermal capacity, cities generally remain at a higher temperature than the environment around them. It has even been considered that the urban heat island effect could be beneficial as a way to understand the impacts of global climate change within cities prior to the event [26]. However, unlike air pollution, the positive or negative evaluation of urban temperature fluctuation is more debatable, and on the surface, could have seemingly beneficial outcomes to urban life such as more comfortable winters, lower heating bills or increased habitat and growing seasons [27]. On the negative side, heat-related stresses and increased cooling costs pose problems to urban residents.

Air, or more specifically its components, is necessary for many ecological processes. Therefore, the urban atmosphere has clear ties to a range of provisional ecosystem services, such as the increasing of air quality or heating/cooling efficiency. Air quality and temperature can also be regulated by other ecosystem services providers such vegetation. For example, the recent competition brief for the Tempelhof Airfield in Berlin stressed the importance of the airfield's role in climate mitigation as a "cold air producing area" [28]. This air conditioning effect comes from its open, flat, highly-vegetated format, a format shared with many other vacant landscapes.

3.3. The Urban Pedosphere

There are several general assumptions to be made about urban soil. First, it has been clearly indicated that soils in urban environments differ significantly from those of the surrounding landscapes. Secondly, within this classification of urban soil, soils possess a wide range of characteristics, thus urban soils vary considerably from location to location [29]. The general characteristics of urban soil that differentiate them from native, undisturbed soils can be broken down in 6 attributes: harsh boundaries between layers, high levels of compaction, low water drainage, crusting and water repellency, high pH levels and high soil temperatures and moisture regimes [30].

In addition to these disturbances, urban soils are also more likely to contain contaminants than their native counterparts, due to their exposure to a wide range of urban elements that include industrial and transport processes. One of the most significant concerns is the accumulation of heavy metals in soil because they are toxic to humans and most plants. Road salt pollution is also a factor in urban areas where salt is used to de-ice roadways. Soil composition and contamination—both significantly altered by urbanization—have implications for how nutrients and chemicals flow through soil, thus directly connecting to its productivity and overall function. In many ways, soils are the universal substrate of most ecological process and have the potential to provide significant ecological services and restoration benefits if correctly managed [31].

Unlike air, soil is not a directly consumable provisional resource. Rather, is valuable as a regulating service. In many cases, urban soils are less contaminated and disturbed than one might assume in the context of the urban environment [1]. Soil has the capacity to manage the quality and function of many other provisional services such as water and vegetation thus making its role in maintaining the ecological processes within the urban environment essential. Interventions that increase soil permeability, reduce compaction, manage nutrient processing and increase subsurface biomass for carbon sequestration are all examples of possible management scenarios involving soil on vacant urban land.

3.4. The Urban Hydrosphere

Urban hydrologic processes are significantly different than the processes located outside of the city [32]. One of the key differences between the hydrology of urban environments and that of the surrounding landscape is the degree of surface perviousness. In the United States, paved areas constitute twice the area of buildings [33]. Pavement significant inhibits soil permeability and subsequent infiltration, as infiltration performance is highly determined by pavement structure [32]. Without infiltration, rainwater in urban areas moves quickly across sealed surfaces and into a water-catchment system or a nearby watercourse. This rapid transport of large quantities of water limits natural infiltration and water recharge, while mobilizing sediment and other pollutants.

These special urban conditions have made stormwater management one of the most significant ecosystem services necessary to the sustainable development of cities, particularly those with combined sewer systems. Water itself is a provisional service, as it is needed by almost every living organism, yet it also requires regulating services in order to maintain its quality and usefulness. Federally-funded green infrastructure projects are becoming commonplace within many cities, with stormwater management being the overwhelming majority of these projects. The well-distributed nature of most vacant land, particularly residential parcels, is located within many urban sub-watersheds. Larger vacant industrial parcels are located along watercourses and provide opportunities to manage large quantities of stormwater prior to entering the adjacent waterbody. In addition to these regulating services, water is also an element that provides cultural ecosystem services as it is has strong cultural, recreational and aesthetic implications.

3.5. The Urban Biosphere and Biodiversity

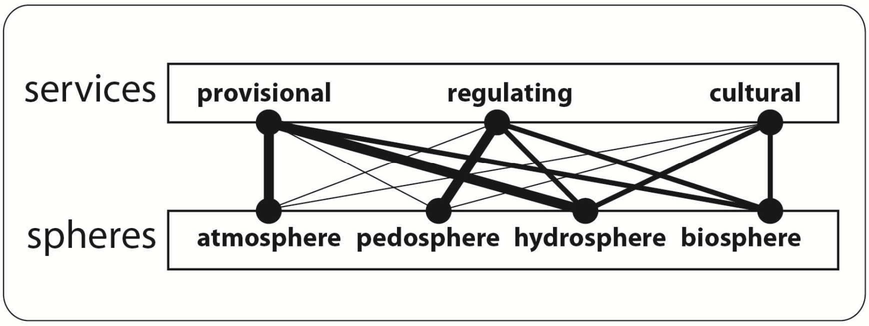
Suffice it to say that, all around the word, humans have facilitated new urban biospheres, composed of organisms that have adapted or are adapting to the unique environments present in the city. At this point, the study of plants and animals in cities has received tremendous attention, and has made up the core of early urban ecological research [34]. Only until recently has the study of the complex coupling occurring within the urban environment—of which the biosphere is an integral part—become a topic of focus [20,35]. Based on the aforementioned conditions that urbanization creates, it can be assumed that cities are warmer, drier, nutrient-laden and floristically-enriched by human activity [22]. These altered environments provide both opportunities and challenges for organisms and tend to favor anthrophilic species capable of adapting to urban environments [36]. Furthermore, human influence alters producer and consumer species composition through native species elimination, non-native introduction, pollution, exploitation and other disturbance regimes [37]. For example, human-introduced animals such as cats have been shown to considerably alter the trophic dynamics of urban ecosystems [38].

Above all else, the study of biodiversity in urban environments has become the key topic within the urban biosphere, because genetic diversity provides resilience to the environments on which we depend [39]. Given the globalized transport linkages between cities and the deposition of biologic material that occurs because of these connections, urban environments are quickly becoming homogenized [40]. While it has been shown that there is a positive correlation between biodiversity and urban development within a particular region [41] this increased biodiversity could globally register as a decrease. Fluctuations in urban biodiversity can be attributed to disturbance regimes placed on the environment within cities that do not exist in the surrounding areas. These conditions make it difficult for some species to thrive while others are lost to either altered physical conditions or are overtaken by more adventitious species. While biodiversity sounds like a clearly-defined motivator for improving planning and design in the urban environment, implications must be understood at the local, regional and global levels before true claims regarding biodiversity can be made.

The ecosystems services provided by the urban biosphere, fall into all three types: provisioning, regulating and cultural. Examples of these ecosystem services include the provision of food in urban farms, regulation of air and water quality and also include high levels of cultural purpose as they relate to recreational, symbolic and horticultural landscapes.

The role vacant land does or could possibly play in the provision of ecosystem services is vast and highly interconnected. Many of the ecosystem services listed are as interdependent as the ecological spheres themselves. However, this attempt has been made to isolate each in order to more clearly illustrate the range of possibilities these vacant landscapes could afford and the impacts they have upon one another (Figure 2).

Figure 2. Diagram showing the intensity of relationships between urban spheres and ecosystem services.



4. Characteristics of Vacant Land

A significant thread of urban ecology history can be traced back the study of ecological conditions on ruderal sites in periods following catastrophic disturbance events. Take for example the ecological studies of ruderal plant growth on bomb sites in Europe. In these conditions, the rubble from destroyed buildings provided warmer and drier conditions for plants to occupy, making once-rare plants permanent urban residents, particularly those from warmer climates [26,34]. The nature of these new ruderal habitats—and the plants and animals that colonize them—is tied to a combination of factors including their existing condition, their historic and current use, and the types of available colonizers. The successful delivery of ecosystem services through vacant land requires an intimate understanding of condition, use and colonizing forces in order to effectively manage these places as collective assets.

4.1. Existing Conditions

Any given site possesses a physical and an ecological condition. This condition dictates a relationship with external factors such as sunlight and rainfall, in addition to anthropogenic influences like polluted air or soil. Existing conditions also indicate the general structure of the site including elements such as size and composition. There are many examples of how physical conditions affect the environmental conditions of a site. For instance, some sites still contain walls and ruins for plants or animals to occupy. Cracks and crevices provide moist locations for plant growth [42]. The range of ecological conditions broadens considerably as site characteristics transform from large to small, wooded to paved, wet to dry.

The type of existing vegetation located in these areas can vary considerably. One way to differentiate botanic variation is proposed by Ingo Kowarik [41] who separates urban botanic conditions into various "natures" as a way of understanding their development.

"First nature" is defined as remnants of pristine ecosystems, providing strong habit connectivity and ecological function. These areas are defined in other texts as simply "remnant" or "native"; possessing large percentages of native vegetation and undisturbed soil [26]. The extent of this type of vegetation is generally limited in urban areas with the exception of special urban preserves such as the stand of oak-hemlocks at the New York City Botanical Garden.

Second and third natures are characterized by anthropogenic vegetation established for agricultural or silvicultural purposes in the case of second nature and as urban greening in the case of third nature. In both of these conditions, intentional propagation by humans is required. These two conditions are described elsewhere as managed or constructed landscapes [26]. In areas of vacancy, these plants are at a disadvantage due to the level of maintenance and resources they require to survive. Without management, they are generally overrun, or at least co-populated with other more adventitious vegetation. Interesting conditions arise from this co-population on many once-occupied vacant lots in residential areas (see Figure 3) hinting at the possibilities of productive recombinant ecosystems.

Figure 3. Images of vacant residential landscapes in (**a**) Niagara Falls, NY and (**b**) Youngstown, OH, show emergent combinations of human-planted and ruderal vegetation (photos by author).

(**a**) (**b**)

Fourth nature is composed primarily of ruderal or adaptive vegetation. These plants have populated the site after the initial disturbance and have found ways to thrive in the harsh, low-energy environments that these sites provide. Compared to managed landscapes that are culturally prized, these emergent stands of vegetation provide more ecological function, yet they offer very little in the way of cultural meaning or value [41]. These areas of vegetation are typically associated with vacancy and abandonment. Species such as opportunistic *Ailanthus altissima* have become synonymous with vacancy, earning the name “ghetto palm” due to their long, palm-like compound leaves and prevalence in distressed urban areas. The nature and composition of this adaptive vegetation can serve as an indicator of not only of what can survive, but also what past and present site uses have occurred that contribute to ruderal emergence, and what types of ecosystem services may be possible.

4.2. Use

Equally important, but less visually obvious, are the uses of the site—both historic and current. The processes that occurred on a site have the ability to transform its ecological function. One of the most obvious examples would be the addition of heavy metals such as lead or cadmium, during a manufacturing process which negatively affects plant growth and photosynthetic activity. Other examples of altered soil chemistry arise from fertilizer use, the presence of animals, increased pH levels due to road salt exposure or compacted soil from heavy machinery. Existing use is also a factor because the temporal occupation of vacant lots has the ability to transform ecological conditions when, for example, accumulated trash provides nutrient and shade rich environments, and walking-paths trample emergent vegetation.

This layered network of conditions and uses makes vacant lots in the urban environment a menagerie of ecological situations. These conditions themselves continue to evolve due to the inevitable chronic disturbances vacant areas are subjected to [43]. These disturbances are also variable and dependent primarily upon socioeconomic conditions as opposed to the ecological disturbance regimes found outside the urban environment [26].

A clear understanding of the existing conditions of a site, in combination with its past and present uses provides significant insight into its potential to provide ecosystem services. This information can be coupled with knowledge of sphere/service relationships (Figure 2) to begin study and experimentation toward what the most effective design strategies may be and what ecosystem services could be prioritized as most viable. While the possibilities of these new urban landscapes seem rich, challenges do exist.

5. Moving Forward: Challenges

5.1. “Off-Lining”

In some cities, sections of the urban fabric have been considered for closure and natural reestablishment. While this process of “off-lining” could provide amenities such as enhanced habitat connectivity, increased stormwater management, carbon sequestration, and a reduction in both the urban heat island effect and air pollution, these are not the primary factors behind such closures. In many cities, the cost of infrastructure and other services far exceeds tax revenues. Thus ways of minimizing the cost of services are always being explored. In some cases, these areas are planned to be temporarily closed or “mothballed” and used again upon speculated population increase. In other cases, there are no plans for reoccupation. These sectors of the urban landscape, cut off from services and residents, spread throughout the city, offer significant opportunities for reconsidering new, more sustainable urban conditions. Thus special consideration should be taken as this process of off-lining occurs, in order to maximize the benefits, while minimizing the negative social impacts associated with this drastic measure. The most notable of these negative impacts is the in involuntary movement of urban residents. The only large example of the off-lining process is underway in East Germany. Translated as "urban restructuring", this federally funded program proposes the simultaneous demolition of large numbers of structures and re-investment into the buildings that remain as a way of revitalizing urbanism at a lower density. Unfortunately the process has received criticism because its funding structure has encouraged only demolition without investment in the remaining urban fabric [44].

From the point of view of the city, these areas are removed from services due to either very low or nonexistent population, or particularly excessive costs of services. In both cases, the motivating factor is monetary. This poor financial condition is expected, as the entire enterprise of off-lining is a product of low tax revenue due to low population densities. Under these tenuous circumstances, available capital to invest in ecological services as a formal project is not readily available. Therefore, shrinking cities would be wise to consider a suite of informal, low maintenance options for sustainably managing vacant land.

5.2. Perception of Vacancy

While vacant landscapes can provide significant improvements in urban biodiversity and environmental education, many of these areas, particularly those left unmanaged, are indicative of urban failure in the minds of most people [45]. The success of these landscapes, particularly those used for education, depends highly upon their perception by city residents [46]. Other studies indicate that the designation of these vacant landscapes as parks requires significant research and community input, as results appear to vary considerably [45–47]. One consistent finding does appear to be the positive perception of utility or function of the landscapes. While promoting order, function and legibility are all key guidelines for successfully fostering value within vacant land, the physical design of these places should be well considered with stakeholder input. It should be noted that education, aesthetics and recreation are considered ecosystem services by the MA standard and with sound planning, vacant landscapes do hold potential to provide these types of cultural services. One possible solution, illustrated below (Figure 4) demonstrates how the process of vegetation removal from large areas of ruderal, colonizing plants could provide a geometrically legible landscape while the addition of a walking trail provides some indication of the site's overall function. This design only requires the management of 1/3 of the total site area, while providing a sense of care, ownership and recreational value to the surrounding community.

Figure 4. Proposed walking park for an abandoned site in Youngstown, OH, USA. Note the large amounts of unmanaged land. (Design by author).

5.3. Scale

Transforming vacant land into environmental education and community gardens has demonstrated reasonable success in cities for decades. However neither have the ability to usefully transform large amounts of urban land on the scale that exists in many shrinking cities. Large-scale management of urban land has become necessary. Industrial farms, forestry, or wildlife conservation areas may serve as useful models for such large-scale management. An example of such an effort is Hantz Farm in Detroit, which proposes to buy ten thousand acres of vacant, city-owned and transform it into a privately managed farm. Planning must consider the larger picture of what vacancy provides as fodder for its own future development. While most of this would be completed incrementally, a larger agenda must be established to address vacancy at scale.

6. Discussion: Suggestions for Sustainable Urbanism in Shrinking Cities

Ecologically "sustainable" cities have been a topic of enthusiasm and debate across many disciplines. Efforts toward a sustainable urbanism stem from two directions: new and retrofitted. On one side, you have the conceptual development of entirely new, ecological cities. Masdar City in Abu Dhabi is likely the most well-known example of such a city. Masdar is planned at 2.3 square miles and designed to be a net-zero (no carbon, no waste) city of fifty thousand people. On the other side, ecologically retrofitted places allow sustainable principles to be incorporated piece-meal into an existing city. The small town of Dardesheim, Germany is an example of this type of sustainable urbanism. Dardesheim proposes the use of wind and solar energy as the way of removing the city from external energy reliance. While the grandiose idea of new cities running off the grid on renewable energy and completely waste-free sounds wonderful, the resources to build such places are generally unavailable. When they are possible, they require the de-structuring or exploitation of other resources. It is likely that the most fruitful place for urban sustainability research and exploration is within existing urban areas due to their prevalence and diversity. It could also be hypothesized that established cities, with their site-specific information—information being Odum's highest form of energy [11]—and long-term exposure to past energy fluctuations, provide a more resilient structure for accommodating future change. This line of thought leads back to shrinking cities, as places of site-specific knowledge, historic exposure to change and abundant land.

6.1. The Development of Novel Ecosystems for Ecosystem Servicing

On the other hand, would doing absolutely nothing and allowing urban ecosystems to evolve on their own be a tremendous failure? Even after the accident at Chernobyl, high levels of biodiversity have been discovered near the site, primarily due to the lack of human occupation [48]. Understanding that a good portion of historical urban ecology science has arisen from research on disturbed, vacant urban land, the possibilities of abandoned urban landscapes to serve as ecological laboratories seems to hold great potential.

We live in a dynamic world where doing nothing is in fact doing something. Ecological processes will move forward with or without human intervention. As these processes develop, they will continually be subjected to human-influenced disturbances that will force them to adapt and change.

New species will be introduced, while others fade. Nutrients will pulse through the landscape. All of these dynamics lead to the creation of new ecosystems [49]. While the benefits of these new ecosystems are subject to debate, given their prevalence, they have received surprisingly little consideration as subjects for ecological research and monitoring [50].

Novel ecosystem studies show promise for several reasons, including increased biodiversity and more passive ecological service provisions. The rise of naturally occurring, recombinant [51] ecosystems provide conditions that have never existed before. As completely new biologic formations, there is a great deal that can be learned from these types of ecosystems. Species find ways of co-existing and evolving within the urban environment in ways not possible elsewhere, thus vacant landscapes could be seen as centers of evolution [52]. These associative ecosystems have important ecosystem service implications and, in some cases, actually perform better than their more rural counterparts [53].

The historic human-managed relationship between corn, beans and squash or "the three sisters" is a good example of insight into the benefits of a designed, mutualistic relationship between species and their subsequent benefits to humans. It has also been shown that the larger urban areas can be, the greater the chances of establishing self-sustaining populations of rare or endangered species [54]. Larger areas of urban land facilitate a wider range of ecological conditions and possible benefits by way of increasing continuous habitat for biodiversity and creating novel ecosystems.

6.2. The Vacant Land Laboratory

Urban ecological research is necessary, and vacant landscapes could provide a key resource for data collection and observations. Yet challenges exist. The politics of existing cities play a large role in regulating what can be done with land and resources. The idea of relocating residents in the process of off-lining could be seen by many as political suicide, because it typically affects low income, minority populations. The Hantz farm project is currently stalled due to a state law restricting commercial farming on urban land. Even accepting a lower urban population is a subject most shrinking cities tend to avoid because many are still operating under the assumption that growth will still occur.

Nevertheless, baring these challenges, there are still important implications for environmental education within urban landscapes. The level of biodiversity encountered in urban areas does provide significant opportunities for environmental education, particularly for urban residents with little access to other forms of complex ecosystems [52]. Residents are also more likely to appreciate areas of successional, emergent vegetation as a valuable ecosystem if benefits can be communicated to them [45].

An understanding of the site specific potentials of these isolated landscapes may help inform the process of prioritizing certain sites over others for off-lining. Even doing nothing in terms of management and studying what happens may yield insights to ecological function and sustainability.

Urban ecology laboratories could provide vacancy solutions if managed correctly. Biodiversity, ecological services, jobs, education and land management provide a strong argument for funding. Two urban sites, Baltimore, MD and Phoenix, AZ are funded by the National Science Foundation's Long Term Ecology Research (LTER) program, attesting to the importance of urban landscapes as ecological laboratories at the federal level. The physical locations of these studies are not tied to land but to the entire municipal area. Could vacant urban land serve as the next LTER typology? By locating these programs in specific areas, the management and study of the sites could provide the site occupation and function necessary to mitigate the negative perception of these areas as vacant, dangerous landscapes. Table 1 below describes the possible secondary benefits of locating urban ecology laboratories on off-lined urban land. The primary, long-term benefit would be the accumulation of information and research on ecological processes taking place in these transitional landscapes, leading toward a growing body of knowledge to create more ecologically functioning cities in their likeness.

An example of such a research landscape has been developed in association with Duisburg Nord Landscape Park in Germany. Here the Ruhr Region Biological Station collects information regarding the wide range of ecosystems within the post-industrial park while also serving as an educational resource to visitors. What sets this type of station apart from existing LTER typologies in the United States is the emphasis on the development of strategies that can be implemented on other urban land.

Table 1. Possible benefits of productive urban laboratories in shrinking cities.

	resident	**city**	**region**
ecological	(1) environmental education (2) access to "nature"	ecosystem services	biodiversity
social	(1) neighborhood identity (2) blight reduction	opportunity to create more dense, livable communities	regional solidarity
economic	job creation	(1) lower infrastructural management costs (2) access to federal research funding.	ties to the larger regional economy

Ecosystems tend to abide by the rule of maximum power. Odum [55] rephrases Alfred Lotka's definition of the maximum power concept as:

> "In self organizational processes, systems develop those parts, processes, and relationships that capture the most energy and use it with the best efficiency possible without reducing power"

Put another way, successful systems use energy efficiently. Anthropogenic constructs such as information provide us with tremendous opportunities for promoting efficient energy use since data driven information has a strong potential to control energy at lower levels [55]. For example, information derived from research provides us with methods for reducing our energy use. However, human decision-making is seldom based on ideas of long-term efficiency. With more than half of the world population living in and moving to cities, we have only a small window of opportunity to take advantage of vacant urban land. Shrinking cities will not always be shrinking. The discovery of ways to develop the urban environment in more sustainable ways is absolutely necessary, yet our window of intervention is consistently nearsighted. At this moment in time, cities with large amounts of available land, access to water, and developed infrastructure should not go to waste or be removed from the discussions of contemporary sustainable urbanism. These shrinking cities have the potential to become role-models for the future of urban life rather than being reconciled to rusty, abandoned relics of failure. It's time we began treating them that way.

Acknowledgments

I would like the thank everyone who has shown me around their city and for the incredibly constructive feedback from three anonymous reviewers.

Conflict of Interest

The author declares no conflict of interest.

References and Notes

1. Pickett, S.T.A.; Cadenasso, M.L.; Grove, J.M.; Groffman, P.M.; Band, L.E.; Boone, C.G.; Burch, W.R., Jr.; Grimmond, C.S.B.; Hom, J.; Jenkins, J.C.; Law, N.L.; Nilon, C.H. *et al.* Beyond urban legends: An emerging framework of urban ecology, as illustrated by the Baltimore Ecosystem Study. *BioScience* **2008**, *58*, 139–150.
2. Denton, J.; Senatsverwaltung für Stadtentwicklung. *Urban Pioneers: Berlin: Stadtentwicklung Durch Zwischennutzung/Temporary Use and Urban Development in Berlin*; Jovis: Berlin, Germany, 2007; p. 192.
3. Oswalt, P. *Shrinking Cities*; Hatje Cantz Publishers: Ostfildern, Germany, 2005.
4. Econsult Corporation; Penn Institute for Urban Research. *Vacant Land Management in Philadelphia: The Costs of the Current System and the Benefits of Reform*; Technical Report; Redevelopment Authority of Philadelphia: Philadelphia, PA, USA, June 2010.
5. Branas, C.C.; Cheney, R.A.; MacDonald, J.M.; Tam, V.W.; Jackson, T.D.; Have, T.R.R. A difference-in-differences of health, safety and greening vacant urban space. *Amer. J. Epidemiol.* **2011**, *174*, 1296–1306.
6. Baltimore Ecosystem Study; Parks and People Foundation. Baltimore Vacant Lots: Plant Species Inventory, 2011. Available online: http://beslter.org/products/brochures/Brochure-VacantLots PlantSpeciesInventory.pdf (accessed on 12 May 2012).
7. *Reimagining a More Sustainable Cleveland*; Technical Report; Cleveland Urban Design Collaborative, Kent State University: Cleveland, OH, USA, 2008.
8. Finnerty, T.A., Jr.; D'Avignon, W.; Kobak, A.; Williams, J. *Youngstown 2010 Citywide Plan*; Technical Report; Urban Strategies Inc.: Youngstown, OH, USA, 2005.
9. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being: Synthesis*; Island Press: Washington, DC, USA, 2005.
10. Berry, B.J.L. Urbanization. In *The Earth as Transformed by Human Action*; Cambridge University Press: Cambridge, UK, 1990; pp. 103–119.
11. Odum, H.T.; Odum, E.C. *A Prosperous Way Down: Principles and Policies*; University Press of Colorado: Boulder, CO, USA, 2001.

12. Whitmore, T.; Turner, B.L.; Johnson, D.L.; Kates, R.W.; Gottschang, T.R. Long-Term Population Change. In *The Earth as Transformed by Human Action*; Cambridge University Press: Cambridge, UK, 1990; pp. 25–39.
13. Meadows, D.; Randers, J.; Meadows, D. *Limits to Growth*; Chelsea Green: White River Junction, VT, USA, 2004.
14. Alberti, M. Effects of urban patterns on ecosystem function. *Int. Reg. Sci. Rev.* **2005**, 168–192.
15. Werner, P. Urban form and biodiversity. In *Shrinking Cities: Effects on Urban Ecology*; Peter Land: Frankfurt, Germany, 2007; pp. 57–68.
16. Wiechmann, T.; Pallagst, K.M. Urban shrinkage in Germany and the USA: A comparison of transformation patterns and local strategies. *Int. J. Urban Reg. Res.* **2012**, *36*, 261–280.
17. Fisher, B.; Turner, R.K.; Morling, P. Defining and classifying ecosystem services for decision making. *Ecol. Econ.* **2009**, *68*, 643–653.
18. Douglas, I.; Ravetz, J. Urban ecology—The bigger picture. In *Urban Ecology*; Oxford University Press: New York, NY, USA, 2011; pp. 246–262.
19. McDonnell, M.J. The history of urban Ecology. In *Urban Ecology*; Oxford University Press: New York, NY, USA, 2011; p. 9.
20. Alberti, M. *Advances in Urban Ecology: Integrating Humans and Ecological Processes in Urban Ecosystems*; Springer: New York, NY, USA, 2008.
21. Crooks, K.R.; Soule, M.E. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* **1999**, *400*, 563–566.
22. Marzluff, J.M.; Endlicher, W.; Bradley, G.; Simon, U.; Shulenberger, E.; Alberti, M.; Ryan, C.; ZumBrunnen, C. *Urban Ecology: An International Perspective on the Interaction between Humans and Nature*; Springer: New York, NY, USA, 2008.
23. Endlicher, W. Urban ecology—Definitions and concepts. In *Shrinking Cities: Effects on Urban Ecology and Challenges on Urban Development*; Peter Lang: Frankfurt, Germany, 2007; pp. 1–13.
24. Tallis, M.; Taylor, G.; Sinnett, D.; Freer-Smith, P. Estimating the removal of atmospheric particulate pollution by the urban tree canopy of London, under current and future environments. *Landscape Urban Plan.* **2011**, *103*, 129–138.
25. Parlow, E. Urban climate. In *Urban Ecology*; Oxford University Press: New York, NY, USA, 2011; pp. 31–44.
26. Del Tredici, P. *Wild Urban Plants of the Northeast*; Cornell University Press: Ithaca, NY, USA, 2010.
27. Oke, T.R. Urban heat island. In *Routledge Handbook of Urban Ecology*; Routledge: London, UK, 2011; pp. 120–131.
28. *Tempelhof Parkland: Invitation to Tender*; Technical Report; Senate Department for Urban Development: Berlin, Germany, 2009; p. 93.
29. Pouyat, R.V.; Yesilonis, I.D.; Russell-Anelli, J.; Neerchal, N.K. Soil chemical and physical properties that differentiate urban land-use and cover types. *Soil Sci. Soc. Amer. J.* **2007**, *71*, 1010–1019.
30. Marcotullio, P.J. Urban Soils. In *Routledge Handbook of Urban Ecology*; Routledge: New York, NY, USA, 2011; pp. 164–186.

31. Palm, C.; Sanchez, S.; Ahamed, S.; Awiti, A. Soils: A contemporary perspective. *Annu. Rev. Env. Resour.* **2007**, *32*, 99–129.
32. Illgen, M. Hydrology of urban environments. In *Urban Ecology*; Oxford University Press: New York, NY, USA, 2011; pp. 59–70.
33. Ferguson, B.K. *Porous Pavements*; Taylor and Francis: New York, NY, USA, 2005.
34. Sukopp, H. On the early history of urban ecology in Europe. In *Urban Ecology*; Springer: New York, NY, USA, 2008; pp. 79–97.
35. Liu, J.; Dietz, T.; Carpenter, S.R.; Alberti, M.; Folke, C.; Moran, E.; Pell, A.N.; Deadman, P.; Kratz, T.; Lubchenco, J.; *et al*. Complexity of coupled human and natural systems. *Science* **2007**, *317*, 1513–1516.
36. Byrne, J. The human relationship with nature. In *Routledge Handbook of Urban Ecology*; Routledge: New York, NY, USA, 2011; pp. 63–73.
37. Faeth, S.H.; Warren, P.S.; Scochat, E.; Marussich, W. Trophic dynamics in urban communities. *Bioscience* **2005**, *55*, 399–407.
38. Crooks, K.R. Relative sensitivities of mammalian carnivores to habitat fragmentation. *Conserv. Biol.* **2002**, *16*, 488–502.
39. *Global Biodiversity Outlook 3*; The Convention on Biological Diversity: Montréal, Canada, 2010.
40. McKinney, M.L. Urbanization as a major cause of biotic homogenization. *Biol. Conserv.* **2006**, *127*, 247–260.
41. Kowarik, I. Wild urban woodlands. In *Wild Urban Woodlands*; Springer: Berlin, Germany, 2005; pp. 1–32.
42. Woodell, S. The flora of walls and pavings. In *Nature in Cities*; Wiley and Sons: Chichester, UK, 1979; pp. 135–157.
43. Vessel, M.F.; Wong, H.H. *Natural History of Vacant Lots*; University of California Press: Los Angeles, CA, USA, 1987.
44. Bernt, M. Six years of Stadtumbau Ost. In *Shrinking Cities: Effects on Urban Ecology and Challenges for Urban Development*; Peter Lang: Frankfurt, Germany, 2007; pp. 95–103.
45. Bauer, N. Attitudes toward wilderness and public demands on wilderness areas. In *Wild Urban Woodlands*; Korner, I.K.S., Ed.; Springer-Verlag: Berlin, Germany, 2005; pp. 47–66.
46. Mathey, J.; Rink, D. Urban wastelands—A chance for biodiversity in cities? In *Urban Biodiversity and Design*; Blackwell: Oxford, UK, 2010; pp. 406–424.
47. Rink, D. Surrogate nature or wilderness? Social perceptions and notions of nature in an urban context. In *Wild Urban Woodlands*; Korner, I.K.S., Ed.; Springer-Verlag: Berlin, Germany, 2005; pp. 67–80.
48. Flanary, W.; McGinley, M.; Johnson, G. *Environmental Effects of the Chernobyl Accident*; Environmental Information Coalition, National Council for Science and the Environment: Washington, DC, USA, 2008.
49. Odum, H. *Environment, Power and Society: The Hierarchy of Energy*; Columbia University Press: New York, NY, USA, 2007.
50. Hobbs, R.J.; Arico, S.; Aronson, J.; Baron, J.S. Novel ecosystems: Theoretical and management aspects of the new ecological world order. *Global Ecol. Biogeogr.* **2006**, *15*, 1–7.

51. Meurk, C.D. Recombinant ecology of urban areas. In *Routledge Handbook of Urban Ecology*; Routledge: New York, NY, USA, 2011; pp. 198–220.
52. Müller, N.; Werner, P. Urban biodiversity and the case for implementing the convention on biological diversity in towns and cities. In *Urban Biodiversity and Design*; Müller, N., Werner, P., Kelcey, J.G., Eds.; John Wiley and Sons: Oxford, UK, 2010; pp. 3–33.
53. McDonnell, M.J.; Pickett, S.T.A.; Groffman, P.; Bohlen, P.; Pouyat, R.; Zipperer, W.C.; Parmelee, R.W.; Carreiro, M.M.; Medley, K. Ecosystem processes along an urban to rural gradient. *Urban Ecosystems* **1997**, *1*, 21–36.
54. Kowarik, I. Novel urban ecosystems, biodiversity and conservation. *Environ. Pollut.* **2011**, *159*, 1974–1983.
55. Odum, H.T. *Systems Ecology*; Wiley and Sons: New York, NY, USA, 1983.