Sustainable Benefits of Urban Farming as a Potential Brownfields Remedy

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OVERVIEW

- **Sustainable Benefits of Urban Farming**
  - What is urban agriculture?
    - Why urban agriculture?
    - Policy issues and sustainability
  - Urban agriculture and risk assessment
    - Site conceptual model (SCM)
      - Direct contact risks
      - Risks from plant uptake
      - Risks from deposition
    - Urban agriculture challenges
      - Risk communication and social amplification of risk
  - Conclusions

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WHAT IS URBAN AGRICULTURE?

- **Urban agriculture is the Practice of Cultivating, Processing and Distributing Food in, or Around (peri-urban), a Town or City (Bailkey and Nasr, 2000)**
- **Urban Agriculture is <u>NOT</u> New**
  - Ancient Persia used wastes to facilitate farming
  - Allotment gardens (tended by collectives) were common throughout Europe in response to industrialization and rapid 19th century urbanization
  - "Victory gardens" were common during WWII in response to rationing

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URBAN AGRICULTURE *(continued)*

- **Why Urban Agriculture?**
  - Low cost, sustainable remedial action alternative
  - It is an effective form of anti-city planning, a proven permanent land use that meets city needs
  - Urban agriculture contributes to food security and food safety by increasing the amount of food in cities
  - It reduces transportation costs that are becoming prohibitively expensive
  - Creates a land bank of properties available for future commercial development

URBAN AGRICULTURE *(continued)*

- **Policy Issues Driving Urban Agriculture**
  - Approximately 80% of the U.S. population and 50% of the world's population live in cities
  - By 2015, 26 cities will have populations of 10,000,000 or more
  - Transportation costs are becoming prohibitively expensive
  - Office of Sustainable Communities (OSC) – created within the U.S. EPA to help communities take integrated approaches to environmental, housing and transportation decisions, supports urban agriculture as a Brownfields solution

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URBAN AGRICULTURE *(continued)*

- **OSC is a Collaboration Between EPA, HUD and the Department of Transportation (EPA 560-F-10-002, March 2010)**
  - Focuses on "next generation infrastructure" and public- private sector partnerships to leverage Brownfield investment
  - Urban agriculture is featured in OSC pilot projects in Indianapolis (Smart Growth Development District) and Denver (La Alma/South Lincoln Park)

Urban Agriculture (*continued*)

- **There are Significant Social, Economic, Public Health, and Environmental Costs Associated with the Current Food System**
  - Environmental costs of large-scale, industrial agriculture include: air pollution, surface and groundwater contamination, soil erosion, and reduced bio-diversity
  - Costs include $288 billion in farm subsidies, economic benefits tend to accrue outside of rural communities
  - May create domestic and international disruptions with food supplies

URBAN AGRICULTURE *(continued)*

- **Urban Agriculture and Sustainability**
  - Urban agriculture adheres to three main principles of sustainability: 1) it enhances environmental health; 2) it enables economic profitability; and 3) It ensures social welfare
  - Cities provide readily available markets and aggregate demand for urban agriculture (McLennan, 2004)
  - Environmental stewardship is enhanced through urban agriculture's greening of cities
  - Purchasing food that is locally grown decreases energy use associated with shipping and refrigeration

URBAN AGRICULTURE *(continued)*

- **Urban Agriculture is Sustainable Because it is *Market Driven***
  - It is a free market response to food safety and demand for fresh food
  - It reduces unemployment and underemployment
  - It kick-starts entrepreneurial activities in underrepresented populations
  - It addresses nutrition needs of urban residents who may be living near or below the poverty level

URBAN AGRICULTURE *(continued)*

- **The Food Sector Is a Significant Part of the Urban Economy**
  - Includes restaurants, supermarkets, specialty food stores, taverns, farmers' markets and food wholesaling
  - Urban agriculture is providing realizable economic benefits and it's use is gaining momentum
    - Allegheny FarmCorps, GrowPittsburgh, others, are examples

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Urban Agriculture Challenges and Risk Assessment

- **The Primary Concern for Urban Agriculture and Brownfields Reuse is Human Health**
- **Exposure and Risks Can Occur Through Multiple Transfer Processes**
  - Agriculture involves "High Risk" invasive activities
  - Contaminants present in urban soils may be uptaken by fruits and vegetables

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RISK ASSESSMENT *(CONTINUED)*

- **The Site Conceptual Model (SCM) is a Critical Component for Successful Implementation**
  - The history of the property and its location determines what contaminants might pose risks:
    - Soil characterization
    - Water use
    - Surface and groundwater impacts
      - Will determine the need for quantitative assessment
  - Human health exposures related to site-specific farming practices are identified
  - Risk communication requirements are identified to address potential perceptions and to solicit “buy-in”

RISK ASSESSMENT (*CONTINUED*)

- **Each Site is Different and Each Growing Season is Different**
  - Exposure to contaminants entrained on particulates may be more significant during dry seasons
  - Growing season lengths change and effect duration of exposure
- **Precipitation Determines Water Use for Irrigation**
  - Depending on contaminant types, irrigation may mobilize and spread contamination
  - Numerous contaminants can be involved in urban settings and Brownfields sites

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Risk Assessment (*continued*)

- **Types and General Sources of Contamination at Brownfields Sites**

Specific Contaminant(s)	General Source
Lead	Paint (manufactured before 1978)
Lead, Zinc, PAHs	High Traffic Areas
Arsenic, Chromium, Copper, PAHs, Pentachlorophenol	Treated Lumber
PAHs, Inorganics, Dioxins	Burning Wastes
Copper, Zinc	Manure
Molybdenum, Sulfur	Coal Ash
Cadmium, Copper, Lead, Zinc, PBTs	Sewage Sludge
PAHs, Benzene, Toluene, Xylenes	Petroleum Spills
PAHs, Petroleum Products, Solvents, Lead, Other Inorganics	Commercial/Industrial Site Use
Lead, Arsenic, Mercury (historical use), Chlordane, Other Chlorinated Pesticides	Pesticide Applications

Heinegg et al., 2000

RISK ASSESSMENT *(CONTINUED)*

- **Human Health Direct Contact Risks**
  - Urban farming activities lead to a variety of potential human exposure pathways
  - Direct soil contact scenarios
    - Dermal contact, accidental ingestion and inhalation risks
  - Ingestion of contaminated fruits and vegetables
    - There are two general modes by which produce may be Impacted
      - Plant Uptake
      - Deposition

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RISK ASSESSMENT *(CONTINUED)*

- **Potential Risks From Plant Uptake:**
  - Inorganic and some organic contaminants can be present in fruits and vegetables including strawberries, lettuce, spinach, endive, and kale
  - Lead and cadmium may be present in arable crops including barley and wheat as well as fodder crops including grasses and hay (Albering et. al, 1999)
    - Uptake of Inorganics From Soil by Plant Species is Influenced by Physico-chemical Characteristics
    - These Characteristics are Altered by Agricultural Practices (i.e., Human Factors)

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RISK ASSESSMENT (*CONTINUED*)

- **Some Important Human Factors Include:**
  - Irrigation - contaminants can be passively uptaken (generally) by plants from soil water via irrigation
  - Soil pH adjustments - alter the bioavailability of metals and may enhance uptake
  - Selection of plant species, variety and farming methods (i.e., raised bed versus tilling) can influence contaminant uptake
- **Human Factors Must be Considered BEFORE Implementing Urban Agriculture as a Brownfields Remedy**

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Risk Assessment (*continued*)

- **Potential Risk From Deposition**
  - Contaminants can also spread through air and deposit as dust or by precipitation (Shaylor et al., 2009)
  - Proper washing of plants will all but eliminate risks from deposited contaminants
  - Deposition can, however, with time impact soil quality
  - Deposition can be a major contributor to soil quality in urban areas (egs. PAHs)
- **Soil Quality Must be Monitored Periodically to Estimate the Potential for Exposures Resulting From Deposition**

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Risk Assessment (*continued*)

- **The SCM Can Also Provide Information About Potential Acute versus Chronic Health Effects**
  - Acute risks are those which result in immediate harmful effects. Acute exposures are defined as contact with a substance that occurs once or for only a short time (up to 14 days)
  - Chronic risks are those which show up only after prolonged exposure. Chronic exposures are defined as contact with a substance that occurs over a longer timeframe (i.e., more than 1 year - ATSDR, 2010)
- **Both Chronic and Acute Risks are Possible in Urban Agriculture**

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Urban Agriculture Challenges Related to Risk

- **Social Amplification of Risk**
  - Because risk is a perception, the severity (or lack thereof) is governed by heuristics and biases (Kasperson et. Al, 1992)
  - Some perceptions about risk contrast with the results of formal reasoning
  - Equity issues (race, socio-economic, etc.) and timeliness of management responses are examples of potential contrasts
  - No comprehensive communication theory exists to deal with minor risks or events that cause massive public reactions

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CHALLENGES RELATED TO RISK (*CONTINUED*)

- **Health and Safety Risks are Classic Examples of Risk Amplification (i.e., Three Mile Island, Toyota Recalls, etc.)**
  - Risk communication must be targeted to address community concerns before soliciting community acceptance
  - Standard public notification is not sufficient to address potential risk amplification liabilities

Conclusions

- **Urban Agriculture is a Sustainable Alternative for Brownfields Remediation**
  - Serves the local community requiring minimal capital costs
- **Urban Agriculture Lacks Integration into the Urban Economy**
  - Rigidity of urban planning overlooks social issues like food security
- **Anti-City Planning Has Long Been a Permanent Land Use that Meets City Needs**
- **Regardless of Typology, Urban Agriculture Links Environmental, Social and Economic Strategies**

CONCLUSIONS (*CONTINUED*)

- **Urban Agriculture Allows for Reuse of Smaller Parcels not Suitable for Major Redevelopment**
  - Fits well into local community initiatives for addressing blighted properties
  - Creates a property land bank for future use
- **Risk Assessment and Risk Communication are Vital to Urban Agriculture Success**
  - Standard risk assessment practices are not sufficient to address farming risks
  - Standard risk communication is a potential liability
  - Social and cultural issues need to be considered and integrated into communications strategies

THANK YOU!

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Sustainable Benefits of Urban Farming as a Potential Brownfield Site Remedy

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ABSTRACT

In many American cities, anti-city planning is a significant part of urban planning as populations flee to suburban and exurban areas or more dynamic regions with positive job growth. For brownfield sites where infrastructure improvements aren't economically feasible, urban farming may be a realistic and sustainable alternative to costly redevelopment projects that have provided equivocal returns on investment.

Contaminant types, concentrations, occurrence and distribution are important factors to consider when evaluating candidate sites for agricultural use. Human Health Risk Assessment (HHRA) can be used to identify the best potential crops and safest agricultural practices for a given property by providing a framework for decision making relative to future property use. Risk prioritization and socio-cultural assessment techniques can also be employed to evaluate whether urban farming is a realistic alternative.

For brownfield sites where HHRA indicates that the nature and extent of contamination prohibits agriculture for food consumption because of uptake concerns, returning properties to a more natural state or farming to support an emerging industry like cellulosic ethanol production may be viable alternatives. From an urban planning and policy perspective, converting brownfield sites into urban farms also creates a "land bank" that provides planners with resources for future redevelopment opportunities. When evaluated both quantitatively and qualitatively, using HHRA to support urban farming as a remediation alternative gives stakeholders a viable and flexible alternative to conventional brownfield redevelopment.

Introduction

When brownfield sites are properly remediated and redeveloped, many environmental benefits accrue. An often overlooked benefit is that brownfield redevelopment absorbs development that would occur on greenfields. This helps communities to preserve open space located elsewhere in the community. A recent study estimates that for every acre of brownfield that is redeveloped, more than four acres of open space are preserved (1). Many innovative remediation approaches have been used at brownfield sites to expedite their cleanup and eventual reuse. Municipalities have teamed with the private sector to underwrite the cleanup of brownfield properties. The objective is to return these distressed properties to useable and tax bearing community assets. These public-private arrangements provide guaranteed cleanup costs and serve to limit land developers and communities from future liabilities.

Brownfield redevelopment interest has rebounded thanks to economic incentives and changing policy approaches to redevelopment at the federal level. More than 300 local jurisdictions have received federal support from U.S. Environmental Protection Agency's (U.S. EPA) national brownfield pilot program (2). Moreover, techniques for brownfield site remediation are better, more innovative and more cost effective, such that remediation costs combined with government financial incentives provides prospective developers and communities with financial data to strategically balance risks and rewards associated with reuse.

Because brownfield sites are remediated to protect both human health (and to a certain extent, the environment), remediation efforts are still complex and costly. Sites that cannot be quickly redeveloped become liabilities for communities by remaining in "mothballed" condition. The owner of such a site must, therefore, incur the additional costs of insurance, site esthetics (grass cutting, landscaping, trash collection, etc.) and security, relative to any land use restrictions that may be associated with the site. Urban agriculture is a sustainable solution for brownfield sites that are not amenable for immediate redevelopment. With proper risk assessment and risk communication, urban agriculture can be integrated into the local economy and create immediate benefits for municipalities and residents alike.

Background

Urban agriculture is the practice of cultivating, processing and distributing food in, or around a village, town or city (3). Urban agriculture as a brownfield site remedy can vary considerably with the typology (i.e., size and use potential of the parcel) and other factors. It can include animal husbandry, aquaculture, agro-forestry and horticulture. In general, urban agriculture is practiced for income-earning or food-producing activities, but some urban farming initiatives are also undertaken for recreation, relaxation or to engender other community outcomes.

Urban agriculture is certainly not new. Community wastes were used in ancient Persia as fertilizer and compost for urban farming and in ancient Machu Picchu, water was conserved and reused as part of stepped city architecture. Vegetable beds were designed to benefit from stepped architecture and to gather sun to prolong growing seasons. When large numbers of people migrated from rural areas to cities to find employment during the Industrial Revolution, many people suffered from inadequate housing, malnutrition and neglect. To improve the overall situation, cities (particularly those in western European cities) allow city residents to grow their own food. Administrators, church leaders and even employers provided open spaces for gardening purposes. These early collectives initially were called “gardens of the poor”, but as they became more sophisticated, they became known as “allotment gardens” (4). More recently, victory gardens were planted and maintained during WWI and WWII in response to rationing and shortages and by citizens seeking to participate in war efforts by reducing pressure on food production necessary to sustain war fighting capabilities (5).

Despite its rich history and post WWII era trends toward ant-city planning, urban agriculture has not received serious consideration by urban planners or city authorities, who prescribe patterns of land use to address issues related to urbanization. Critical aspects of land use planning in urban areas include housing, transportation, and conservation. The food system, however, is conspicuous by its absence. This isn’t surprising because the food system and urban agriculture is all but absent from planning curricula and the writing of university scholars. It is therefore not surprising that it receives so little consideration as part of long-term plans prepared by urban planners (6).

As opposed to other commercial or private activities in cities, urban food production has never been addressed properly by regulations or the planning process (7). Because the food system is the chain of activities connecting food production, processing, distribution, consumption, waste management, as well as the associated regulatory institutions and activities, there are conceptual and practical reasons why planners should devote more attention to it. It is paramount in the improvement of cities to better serve the needs of people. As a brownfield site remedy, urban agriculture's effect on the food system and the environment addresses new policy initiatives and legislation designed to incorporate linkages between various aspects of the environment, housing, transportation, and economic empowerment. As such, urban agriculture embodies the three pillar definition of sustainability. It enhances environmental health by greening cities, it enables economic profitability and jump-starts entrepreneurial activities in under-served communities and by providing a food source to otherwise food insecure people in urban areas, it ensures social welfare and issues of equity that frequently surround redevelopment activities (8).

Legislative Trends Toward Urban Agriculture

Since 1995, U.S. EPA has provided cities, counties, and local governments with pilot grants to redevelop brownfield properties. This has provided a useful inventory of brownfield sites that in turn, has stimulated private-sector investment.

With the passage of federal legislation that separates brownfield cleanup from the highly bureaucratic Superfund program, responsibility for property assessments and final disposition of contaminated industrial properties has reverted to states and communities. This shift has promoted green and smart-growth concepts, thereby giving the private sector an opportunity to evaluate brownfield sites and establish market prices for restoration and redevelopment. As such, brownfield properties moved from liabilities to community assets. This success was recognized by the federal government when in 2009, The American Recovery and Reinvestment Act (ARRA) provided $100 million to the U.S EPA brownfield program for clean up, revitalization, and sustainable reuse of contaminated properties to stimulate the U.S. economy. An additional $55 million was made available to supplement the brownfields revolving loan program, providing more resources to communities seeking to revitalize and redevelop idled former industrial/commercial properties (9).

Currently, U.S. EPA estimates that there are approximately 490,000 sites and nearly 15 million acres of potentially contaminated properties across the United States. This estimate includes Superfund, Resource Conservation and Recovery Act (RCRA), Brownfields, and abandoned mine lands. Cleanup goals have been achieved and controls put in place to ensure long-term protection for more than 917,000 acres. EPA Office of Solid Waste and Emergency Response (OSWER) Center for Program Analysis (CPA) is seeking opportunities to facilitate the reuse of contaminated properties for renewable energy generation. The program called RE-PAL (Re-Powering America's Land) is attempting to coordinate and establish partnerships among federal, state, tribal and other government agencies, utilities, communities and the private sector, to develop new renewable energy facilities to "power" American cities as fuel costs and demand continues to rise (10). According to the U.S. Energy Information Administration, U.S. electricity production will need to increase by nearly 30 percent to meet growing demand. It is estimated that the equivalent of more than 300 mid-sized, coal-fired power plants would be needed to increase U.S. electricity production capacity to meet this rising electricity demand by 2030 (11).

EPA has teamed with the National Renewable Energy Laboratory (NREL), to look for innovative, community based alternatives to fossil fuels. NREL and EPA are specifically targeting brownfields sites that may or may not contain contaminants. Many of these sites are ideal for renewable energy projects like growing switch grass for biofuels/ethanol because they are already appropriately zoned and they are accessible to critical infrastructure such as rivers, roads and manpower.

In addition to regulatory and policy initiatives, the U.S. Department of Housing and Urban Development (HUD), U.S. Department of Transportation (DOT), and the U.S. EPA formed the Partnership for Sustainable Communities. This interagency effort is designed to coordinate federal housing, transportation, and environmental investments to protect public health and the environment while promoting equitable development; and building sustainable communities. EPA's Brownfields Program is actively involved with DOT and HUD to oversee community pilot projects that receive direct technical assistance from EPA. The goal is to plan for the eventual assessment, cleanup and sustainable redevelopment of brownfield sites in ways that positively affect long-term quality of life and to address specific improvements including affordable housing; access to transportation; air and water quality improvements; access to fresh local food; renewable energy strategies; and access to green space for recreation. Brownfields sites in Denver, Colorado and Indianapolis, Indiana are considering urban agriculture as part of final remediation strategies (12).

The Energy Independence Security Act of 2007 mandates the production of 36 billion gallons of biofuels by 2022, including 21 billion gallons of advanced biofuels produced from cellulosic biomass feedstocks. The expansion of biofuel production on local and global scales could result in significant environmental, social, and economic impacts (13). The extent and nature of these impacts will determine the sustainability of biofuels. The consequences of feedstock production, conversion, distribution, and end use are unknown and both short-term and long-term outcomes, particularly economic outcomes are important variables for clear public policy decision making (14). The use of tillable land for feedstock production is perhaps the most significant factor in evaluating the sustainability of biofuel production. Agricultural subsidies and influences on the cost of food commodities have the potential to adversely impact the lives of food-insecure people (15). Clearly, urban agriculture has the potential to provide food security either directly (by providing fresh produce to citizens of highly urbanized areas) and also by providing an alternative to the use of tillable land for biofuels feedstock production.

A criticism of urban agriculture is that it isn't a serious business enterprise. Benefits continue to be subjects of debate, particularly the economic viability and political support necessary to make urban agriculture a long-term success. Critics of urban agriculture argue that urban agriculture is a response to market distortions and can only be considered a transient undertaking. If true, scarce public resources that support urban agriculture should not be re-directed, especially given the high land costs in urban areas and the fact many urban neighborhoods suffer from a lack of suitable housing and appropriate infrastructure (16). Moreover, urban agriculture is subjected to many types of pollution and can act to pollute the environment depending on the types of farming practices employed, use of fertilizers and pesticides that are a function of the mix of crops being grown. These arguments tend to be rather parochial, however, focusing on individual sites in the most populated cities. They suffer from a lack of economic data and they tend to emphasize economic conditions ceteris paribus.

While there is no national estimate of the total number of urban or community gardens, the American Community Gardening Association (ACGA) estimates that there are more than 18,000 community gardens in the U.S. and Canada. In some cities, community gardens are managed by parks departments, while in others are managed by volunteer organizations affiliated with food banks or religious organizations. According to the U.S. Department of Agriculture, the number of farmers markets increased by 6.8% from 2006 to 2008, and there are currently 4,600 farmers markets, nationwide. Urban communities are responding to this trend by transforming contaminated properties into locations where communities can grow and buy food locally (17).

Urban Agriculture and Human Health Risk Assessment

Human health risks are the most significant challenges to implementing urban agriculture at brownfield sites. Under an urban agriculture scenario, default Human Health Risk Assessment (HHRA) exposure scenarios and pathways are not realistic options for evaluating near-term or future health risks associated with potentially impacted media including soil, surface water sediment or groundwater that have been remediated to standard residential or commercial land use scenarios. A site conceptual model (SCM) must be established that addresses potential direct contact exposures specific to farming activities, as well as ingestion risks associated with the consumption of site-grown produce.

The SCM is a schematic, prepared by the risk assessor that describes primary sources of contamination in the environment, potential points of release, contaminant mobility in the environment, human populations (e.g., resident, workers, recreational visitors) that may contact contaminated media and lists potential exposure pathways (e.g., ingestion of contaminated water, inhalation of chemicals in air, dermal contact with contaminated soil) that may occur for each population (18). The SCM is not only created to plan and inventory required risk assessment activities, but it also serves as a tool that under certain circumstances should be updated periodically to accommodate new data and changing conditions at a brownfield site where urban agriculture is identified as a remedy.

Farming activities require a “hands-in-the-dirt” approach to risk assessment and hazard communication. For example, intrusive activities, even in raised beds containing “clean soil” may result in unacceptable human health risks from direct dermal contact and incidental ingestion. Exposures experienced by those engaged in urban agriculture will be rather acute – with plowing and planting happening during early to mid-spring. Potential for exposure will also depend on the crops selected and the typology (i.e., the size, use and function) of the site. During the spring, soils are likely to contain higher moisture levels and therefore greater adherence factors are possible depending upon the soil type. When crops are sown, the potential for exposure shifts to activities like weeding and pruning, where the potential for direct dermal and incidental ingestion contact are somewhat reduced during this period. However, the potential for inhalation of dusts emitted from urban farm plots increases. Inhalation exposure is generally not a significant exposure pathway unless volatile chemicals and/or intrusive activities are conducted at a site. With urban farming and farming in general, evidence exists that indicates activities on and around tillable lands can create situations where particulate inhalation is more prevalent. In studies concerning dusts containing quartz and silica, levels of respirable dusts were significantly increased in breathing zones of agricultural workers (19). Respirable dusts are also a concern in greenhouses where the closed environment tends to concentrate dusts, thereby making inhalation a greater concern for potential exposure (20). Potential inhalation exposures at brownfields sites can be addressed on a site specific basis to evaluate the potential for risks associated with farming and harvesting activities.

HHRA activities must also consider the impacts of amending, fertilizing and irrigating soil that may contain low levels of brownfield site contaminants. Table 1 presents common contaminants found at brownfield sites (21). Inorganic contaminants including lead and arsenic can be mobilized by urban agriculture activities. Mobilization may make these contaminants more susceptible to uptake by plants. Lead, cadmium and arsenic may be present in arable crops including wheat and barley. Hay and grasses used as fodder crops may uptake these and other organic contaminants under certain circumstances. Changing the pH of soil and irrigation to enhance crop growth may also affect

Specific Contaminant(s)	General Source
Lead	Paint (manufactured before 1978)
Lead, Zinc, PAHs	High Traffic Areas
Arsenic, Chromium, Copper, PAHs, Pentachlorophenol	Treated Lumber
PAHs, Inorganics, Dioxins	Burning Wastes
Copper, Zinc	Manure
Molybdenum, Sulfur	Coal Ash
Cadmium, Copper, Lead, Zinc, PBTs	Sewage Sludge
PAHs, Benzene, Toluene, Xylenes	Petroleum Spills
PAHs, Petroleum Products, Solvents, Lead, Other Inorganics	Commercial/Industrial Site Use
Lead, Arsenic, Mercury (historical use), Chlordane, Other Chlorinated Pesticides	Pesticide Applications

Table 1. Common contaminants found at brownfield sites (Heinegg, et. al, 2000)

the redox potential of the soil microenvironment making inorganic contaminants more amendable to uptake by strawberries, lettuce, spinach, endive and kale (22). The SCM must consider these possible exposures to those working on the site, but also to members of the local community who consume fruits and vegetables grown on brownfields sites.

Finally, atmospheric deposition to urban crops and soils can be a significant source of continuing contamination at brownfields sites. Contamination of foods and soil by polynuclear aromatic hydrocarbons (PAHs) from atmospheric deposition on plants and foodstuffs has been well established (23). While PAHs and other deposited contaminants can be washed from fruits and vegetables prior to consumption, their impact on soil quality can be significant. Atmospheric deposition continues throughout the year and is not limited to the growing season. The SCM can therefore serve as a guide to identify the most protective agriculture approaches by balancing the potential for human exposure against the accumulation of contaminants as a function of site typology.

Perhaps the most important role of the HHRA in determining the sustainability of urban agriculture as a brownfield site remedy is risk communication and controlling the potential amplification of risks that may result. Recent failures in risk communication include Toyota's problems with automobile braking systems and perceived delays in management response and the ChemNutra, Inc. pet food scare in 2007. In both cases, risks associated with Toyota brakes and melamine in dog food were greatly exacerbated by awkward or non-existent risk communication strategies that failed to adequately address important health and safety issues. One of the most significant challenges faced by the risk assessor is why seemingly innocuous events elicit strong, even visceral public reactions. The challenge for the risk assessor is to not only predict hazards that may result from various activities but also to design communication strategies that avoid certain issues of equity and fairness that tend to amplify public responses to risk events (24).

Because brownfield site remediation focuses narrowly on the probability and magnitude of risks and consequences, there is an assumption that the public should be indifferent toward low consequence/high probability and high consequence/low probability risks. This makes urban agriculture a prime target for possible risk amplification. Because communities have more comprehensive conceptions of risk that include voluntariness and familiarity with potential hazards, the standard HHRA conducted to remediate brownfield sites generally fails to inform these aspects of possible public response. As such, a comprehensive strategy is required at the earliest stages of the urban agriculture remedy that is capable of integrating technical analysis of risk with cultural, social and individual response structures that shape public perceptions.

For example, filtering information about hazards that a community may encounter if urban agriculture is undertaken on a former brownfield site early in the risk assessment process may have profound implications on how the form and content of risk information is perceived in the future. This may spawn difficult to predict behavioral responses to remediation activities that heighten a community's sensitivity to brownfield site reuse well into the future. The SCM can be used to identify activities and possible events that lead to risk amplification. Once known, communication strategies can be designed to transmit risk information in a way that avoids issues of equity and fairness that are not addressed by probabilistic risk analysis.

The SCM may also indicate that the presence of persistent contaminants pose unacceptable health risks that cannot be accepted by the community. Using the site to grow non-food crops may be the most responsible alternative. With the advent of federal programs like NRELs RE-PAL, communities may still engage in urban farming activities by participating in emerging alternative energy markets. NREL is conducting research on the conversion of cellulose to ethanol to comply with 2022 federal biofuels mandates. Brownfield sites can be converted into urban agriculture where switch grass or poplars are grown as opposed to food and food products. As biofuel production efforts ramp up, the use of open spaces in urban and peri-urban locales may provide the key factor to biofuel sustainability.

Conclusions

Urban agriculture is a sustainable solution for brownfield sites that are not well positioned for immediate redevelopment. It embodies the three pillar definition of sustainability by enhancing environmental health, enabling economic profitability and by providing a food source to otherwise food insecure people in urban areas, it ensures social welfare and issues of equity that frequently surround redevelopment projects. It is not surprising, therefore that legislation and policy making at the federal level is favoring urban agriculture as a possible economically viable remedy at brownfield sites.

Urban agriculture as a brownfield site remedy has its challenges, particularly the potential human health risks associated with urban farming and the harvest. Under an urban agriculture scenario, default Human Health Risk Assessment (HHRA) exposure assumptions are not representative of "hands-in-the-dirt" activities and future potential health risks associated with impacted site media. Because brownfield site remediation focuses narrowly on the probability and magnitude of risks and consequences, there is an assumption that the public will be indifferent toward low consequence/high probability and high consequence/low probability risks. This misunderstanding makes urban agriculture a prime target for significant risk amplification in the event of direct contact or food-borne illnesses. Because individuals and communities have more comprehensive conceptions of risk, the standard HHRA conducted to remediate brownfield sites generally fails to inform social, cultural and individual aspects of possible public response.

With proper risk assessment and risk communication, urban agriculture can be integrated into the local economy and create immediate benefits for municipalities and residents alike regardless of the typology or location of the site. Smaller sites can be accumulated and used for community-building activities or as subsistence plots until greater numbers of smaller sites become available. As such, the urban planner can begin to "land bank" properties while overcoming blighted appearances. Furthermore, smaller sites among larger ones can be used as green zones, creating effective mixed use scenarios. Finally, brownfield sites not amenable for development or urban agriculture for human consumption can be used for myriad other purposes such as growing feedstocks for biofuels or even grazing livestock. With early involvement of community stakeholders, urban agriculture is proving to be a sustainable alternative at brownfield sites and an important tool for planners in uncertain economic times.

ABOUT THE MAHFOOD GROUP LLC

THE MAHFOOD GROUP LLC (TMG) is a new generation environmental science and engineering consulting firm that works with clients and decision makers to deliver comprehensive results. Corporations and government agencies rely on TMGs expertise and insight to find people centric solutions.

TMG combines the experience of senior consultants and their unique problem-solving skills with an understanding of the needs of people to help clients achieve success. It is the focus on people and their needs that sets TMG apart from traditional engineering consulting firms and their standardized approaches to problem solving.

The Healthy Roots Project is an example of this innovative approach and our desire to extend the benefits of our environmental engineering expertise to families and their most important possessions – their children and their home.

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