Department of Animal Science

ADDRESSING URBAN LIVESTOCK CHALLENGES IN THE UNITED STATES WITH SILVOPASTURE, AGROFORESTRY AND BACKYARD CHICKENS

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Silvopasture (the intentionally managed combination of trees, forage, and livestock) incorporation into urban agriculture (UA) has the potential to provide several environmental and ecological benefits and provides an opportunity to enhance food production and improve food system durability in densely populated urban and peri-urban areas. As the interest in UA gains momentum across the country, many municipalities are struggling to update local codes to meet public demands. Agroforestry practices (particularly silvopasture) have the potential to help address these demands in urban and peri-urban areas. The proliferation of small urban livestock species – particularly backyard chickens, rabbits, honeybees, and goats – has poised unique regulatory challenges (McClintock et al., 2014). Urban agriculture is the production of food for human consumption in urban spaces and can include crop production, animal husbandry, and mixed crop/livestock systems (Halvey et al., 2021). Earlier in the 20th century, many municipalities restricted or prohibited livestock ownership, citing public health risks of keeping farm animals near humans. Therefore, from a historical perspective, at least until recently, the presence of livestock inside cities was a controversial topic (McClintock et al., 2014). However, today **many municipalities are taking a second look at livestock in the city**. As a result, UA operations may now be privately or publicly owned, be commercial or non-commercial, and exist in various forms, including household; school and community gardens; urban farms; backyard chicken coops and beehives; aquaculture, aquaponics, and hydroponics facilities; and rooftop, vertical, or indoor farms (Santo et al., 2016). Urban agriculture has become **more than farming in the city**, recognized for its potential to provide sociocultural, public health, environmental, and economic development benefits (Horst et al., 2017; Santo et al., 2016). In addition, UA is championed as a place-based response to alleviate shortfalls and disparities in the

global food system, enhancing cities' resiliency to climate change, resource shortages, and other social, political, and environmental crises (Cohen, 2020).

Urban livestock in the United States

In the early 1900s, nearly 40 percent of Americans lived on farms, compared with one present in 2000, and much of the food bought and consumed in the United States was produced locally (Martinez et al., 2010). Communities gained knowledge of the quality of foods through direct **contact with the farmers and ranchers** who produced the food. Aside from canning, dehydrating, salting, or smoking, few foods were processed or packaged (Giovannucci et al., 2010). That same desire of knowledge for food quality and how food (fruits, vegetables, and livestock) is produced is driving much of the urban agriculture movement today, as consumers have a greater interest in **where, how, and by whom their food is produced**.

Reliable access to high-quality feed is considered one of the key reasons livestock production was shifted out of urban areas in the United States during the early 20th century (Bath, 1985; Grace et al., 2015). Passage of the 18th Amendment to the U.S. Constitution and the banning of alcohol production in the 1920s meant that many city-dwelling livestock owners who relied on the spent brewers' grains for livestock feed were unable to find feed for their animals. Additional local regulations later excluded most animals from urban spaces, and the movement to regulate farm animals to rural areas of the United States was sealed (Grace et al., 2015). Thereafter, until the beginning of the 21st century, a policy vacuum existed around UA that caused conflict or ambiguity of UA practitioners in many cities (Meenar et al., 2017). Up to that point, municipal planning and policy efforts around UA focused on community garden development or animal husbandry. Existing UA policies relating to livestock were largely prohibitive, having been enacted in the early 20th century with one of the primary goals being **to restrict animal agriculture to rural areas** due to sanitary, nuisance, and class issues (Butler, 2012; Brinkley and Vitiello, 2014).

Today, most communities **regulate residential livestock through animal codes** that may be separate from land development regulations, although large numbers of jurisdictions are adding urban livestock provisions to their zoning codes. Some municipalities have adopted a comprehensive set of regulations addressing all types of farm animals, while others have focused only on one or two specific types of animals, backyard chickens or honeybees, for example. Backyard chickens (and perhaps other fowl) and goats are becoming more widely permitted in residential districts. Common ordinance provisions often include limits on the number of chickens or goats per lot, minimum lot sizes, prohibitions on noisy roosters or slaughtering birds on-site, setback distances from property lines and neighboring structures, coop or enclosure design and construction standards, and waste disposal and feed storage requirements. Additional ordinances may address on-site sales of eggs, milk, or honey. Some communities require an annual license or permit for keeping urban livestock. For beekeeping, which is becoming more popular, local beekeeping standards typically establish limits on the number and location of hives based on lot size or zoning district where the bees are being kept. Many codes specify minimum distances between hives and adjacent buildings or property lines, require flyway barriers to prevent bees from flying to adjacent properties, and require on-site water sources to keep bees from flocking to neighboring swimming pools or bird baths. Beekeepers may also be required to obtain a local permit in addition to state licensing requirements.

Increasing urbanization necessitates developing innovative and adaptive food production systems. With the interest in food security and local food systems increasing, more and more communities are amending their animal control and zoning codes to allow the keeping of chickens, bees, rabbits, goats, and other nontraditional animals in residential districts. Appropriate regulations are important to protect communities from nuisance or public health complaints and address potential downsides such as noise, odor, and disease concerns. However, **numerous benefits are associated with urban livestock** that include production of fresh, local food products such as eggs, meat, milk, and honey; the critical pollination roles played by bees; and the educational aspects associated with understanding food production and caring for livestock. In addition, urban agriculture and livestock offer an opportunity to increase food production at a time when food insecurity is a growing global concern. However, UA and the reappearance of livestock keeping in urban areas in the United States faces several challenges for effective implementation. Despite the upsurge in urban agriculture in the United States, research on urban livestock keeping, policy and planning remains limited, especially in developed countries, creating an information void that requires immediate attention.

Challenges with urban livestock keeping

Urban agriculture faces numerous challenges, some unique to the urban setting. Specifically, **urban farmers often face significant knowledge gaps and institutional barriers** (Pearson et al., 2010). Regulations on zoning, city planning ordinances, and building codes may limit site access. Other potential obstacles include access to credit, lack of municipal support, land availability, lack of infrastructure for marketing and processing food raised on urban farms, environmental contamination, and limited access to water (Kaufman and Bailkey, 2000; Hendrickson and Porth, 2012; Castillo et al., 2013; Raes Harnes et al, 2013). In addition, urban farmers often do not receive adequate support to ensure success. Although a growing number of state land-grant universities and their Cooperative Extension programs are allocating resources and personnel for urban agriculture assistance (Reynolds, 2011; Surls et al., 2014), there is a lack of research and literature regarding urban agriculture.

Livestock production plays an important role in rural and urban economies worldwide with meat and eggs providing a significant source of protein in humans' diet. As the global population continues its march toward approximately 10 billion people by 2050, we can expect an **increase in the demand for livestock products** of as much as 35 percent over the next 30 years (Ramos-Tanchez, 2020). Livestock production offers benefits such as conversion of food wastes (e.g., cereal by-products) back into the food chain, the transformation of non-edible plants into food products for humans, and the diversification of farm systems, among others. However, without proper management, livestock can have negative impacts on natural resources in the areas of freshwater consumption, water quality deterioration, greenhouse gas emissions, and competition for human-edible grains (Ramos-Tanchez, 2020). To address the environmental impacts, the livestock sector has been working to improve livestock productivity, feed use efficiency, crop productivity, and efficiency of resource utilization. Reliable access to high-quality feed can be a significant challenge to urban livestock keeping (Conway and Nieman, 2022). Because urban livestock keeping has primarily been studied internationally, there is an information gap and little literature is available describing feed access issues or needs in the U.S. urban context. However, urban livestock keepers need to be aware that, even in the U.S., **feed costs account for approximately 60-70 percent of livestock operation costs** and are subject to price volatility based on commodity market fluctuations (Schnepf, 2011).

Feed and nutrition are not the only challenges. Water quality and livestock production are inextricably linked but are often at odds with each other (Conway and Nieman, 2022). This contentious relationship is often upheld as evidence that animals should be further removed from urban and peri-urban areas to preserve clean drinking water (Hooda et al., 2000; Nash et al., 2009; Khatri and Tyagi, 2015). There is a common need to provide clean drinking water to both humans and livestock. Creating opportunities to mitigate water pollution is already a priority for urban areas, so **considering agroforestry strategies** to address both livestock keeping and water quality should be further explored (Ehui et al., 1996; Wen et al., 2017). Addressing 1) contamination by excessive displaced nutrients such as nitrogen and phosphorus, and 2) contamination by virulent zoonotic waterborne pathogens are the two primary considerations for water quality when discussing livestock integration (Hooda et al., 2000; Wen et al., 2017). Both issues can be either the direct result or exacerbated by unmanaged livestock waste entering the watershed via runoff or point-source pollution. Silvopasture is ideally designed to address such issues, as it is the practice of **intentionally integrating trees, forage, and livestock** in a mutually beneficial way.

More than simply growing food in the city, UA is linked with economic, social, ecological, and physical infrastructure components of the urban environment (Van Veenhuizen, 2006), which clouds the overall picture. This **multifunctionality of UA can address many urban challenges** (Wadumestrige Dona et al., 2021); hence, there is a trend in urban planning to introduce agriculture into cities to mitigate urban challenges (Diehl et al., 2020). Even though urban planners are keen on using urban agriculture for urban planning (Aubry et al., 2012), it is only partially integrated into policy and planning due to numerous reasons including most urban agriculture initiatives often being discounted and isolated (Lovell, 2010), inconsistencies between actual usage and planning intentions (Huang et al., 2015), often not being considered as urban green space (Contesse et al., 2018), as well as a lack of connection between urban agriculture and ecology of the city (Pearson et al., 2010). This makes holistic approaches such as silvopasture essential to promote urban agriculture and create efficient urban sustainability.

Soil quality can be an issue because contaminated soils and atmospheric pollution in urban agriculture settings are a challenge for integrating livestock in urban areas. Zinc (Zn), cadmium (Cd), lead (Pb), and copper (Cu) are the primary pollutants of urban soils (Efremova et al., 2013). The greatest concentrations are generally observed for Pb (Attanayake et al., 2014) because of the **historical use of lead in paint and gasoline**. Copper, zinc, and cadmium also are important contaminates sometimes referred to as traffic-related elements, which accumulate from atmospheric deposits or direct soil deposits (Gunawardena et al., 2013). Car exhaust and turbulence causes atmospheric pollution, with contamination levels increasing with proximity to roadways and dense vehicle traffic (Horstmeyer et al., 2016; Huang et al., 2018) complicated by polluted air continually recontaminating sites from atmospheric deposits.

Urban agriculture solutions

Integrating livestock into UA by using principles and practices of agroforestry may mitigate or alleviate some of the challenges (Conway and Mieman, 2022). Silvopasture has the potential to address many of the challenges as a multi-tier food production and sustainable land management system. Silvopasture systems require management of animals with trees and forage, and therefore an understanding of appropriate livestock management, in addition to agronomic,

horticultural, and silvicultural management knowledge (Jose and Dollinger, 2019). While this may sound complicated, silvopasture designs are exceedingly flexible, with nearly limitless combinations of animal, tree, and forage species that are best suited to a specific climate, geography, and production goal.

Conway and Nieman (2022) proposed a theoretical model (Figure 1) to visually demonstrate the co-benefit relationships of an **urban silvopasture system centered on chickens and honeybees**. The model incorporated chickens as the key livestock species to integrate into an already existing urban agroforestry system. The system also could be considered with other domestic fowl and with the addition of honeybees, the latter of which could have an additive effect because of the enhanced pollination services. The model anticipates several situation-specific challenges and opportunities: limited space and the likelihood of zoning restrictions limiting animal species and number; high likelihood of vegetable production based on community need, potential presence of industrially contaminated soils, and the need to mitigate excess nutrients in water runoff; and increased accessibility to low-input, high-quality foods with local distribution systems for either income generation or social service. One of the key barriers to urban agriculture, particularly with livestock, is municipal regulation and zoning restrictions (McClintock et al., 2014; Pfeiffer et al., 2015). Unfortunately, the model does not directly address this issue, and it assumes a certain level of access to land.

Chickens often take center stage as the **livestock species of choice** in many urban agriculture settings. Their small size, excellent feed conversion ratio (less than two pounds of feed per pound of meat), and egg production give them advantages over other livestock. However, other forms of livestock have potential in urban agriculture as well. Meat rabbits offer lean nutritious meat. They require slightly more than three pounds of feed to produce a pound of meat. Rabbits are clean and quiet, so they aren't disruptive to neighbors, and their manure can enrich the soil without composting. Goats can provide milk, cheese and meat while keeping weeds and overgrowth problems at bay. Goats are popular amongst urban farmers because of their manageable size, and they are relatively inexpensive to feed. Available space and zoning restrictions may dictate what livestock species are compatible with UA in various communities.

Urban agriculture is unlikely to provide most of the world's food supply, now or in the future. However, the USDA National Law Library estimates around **15 percent of the world's food** is grown in urban areas (US-EPA, 2023). In addition, UA is more than just food production, and it can link socioeconomic and health systems, support education and societal engagement, and contribute to a range of conservation goals, including nutrient recycling and biodiversity conservation (Nogeire-McRae et al., 2018). At its heart, however, UA can produce substantial amounts of food (Gosh, 2014; Eigenbrod and Gruda, 2015), and history teaches that during World War II, households produced approximately 40 percent of the United States' demand for fresh vegetables as part of the Victory Garden movement (Brown and Jameton, 2000). Urban agriculture can **contribute to food security** and encourage dietary intake of nutritious foods and produce strong social networks (Kortright and Wakefield, 2011). In addition, taking part in UA activities can help people overcome potential personal or cultural barriers such as age, ethnicity, class, or gender while instilling pride in communities and increasing community revitalization, safety, and quality of life (Aguilar, 2016).

Backyard chickens offer an ideal solution to integrating livestock into an urban agriculture enterprise. Agroforestry practices can help ensure the success of UA programs, as across the nation, cities and metropolitan areas and their adjoining peri-urban communities are seeing their

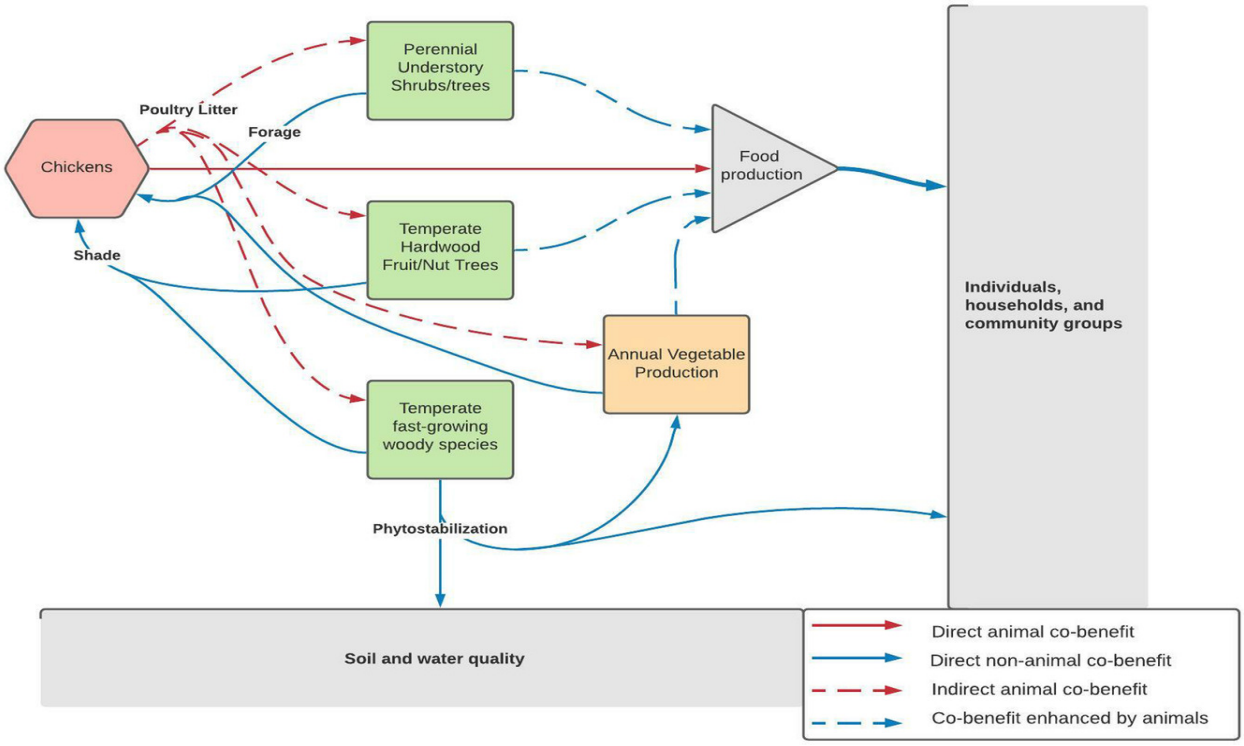

Figure 1. Proposed theoretical model of a lot silvopasture system for urban livestock integration. The model identifies key recipients of ecosystem services (humans, environment), and highlights potential co-benefit interactions between the selected livestock species (chickens), trees and shrubs generalized into functional groups, and other components of the system (supplementing vegetable production). The model does not capture the potential magnitude of co-benefit interactions and provides a conceptual framework for developing integrated urban livestock systems in the United States. Source: Conway and Nieman, 2022.

landscapes and neighborhoods reflect a growing UA movement. Not only backyard chickens, but also farmers markets, community gardens, and community supported agriculture programs (CSAs) continue to gain support as locally grown food increases in popularity among urban residents. Many cities now see UA as a strategy for business development, job training, community development, health education, democratic process, sustainable planning, and more (Gordon, 2013). However, a major challenge to urban agriculture in the U.S. that must be addressed is the lack of relevant information and technical assistance.

Summary

Despite the challenges and knowledge gaps, of which there are several, UA can serve as part of a sustainable food system. Silvopasture and agroforestry offer a path for livestock to take their place in urban agriculture. With the increasing urbanization of our population and a rapidly changing climate, there is serious need to pursue animal production strategies that provide food, nutrition, and economic security without compromising environmental or ecological stability.

Chickens are a **key ingredient to integrating livestock into UA systems**. Small-scale urban and peri-urban livestock keeping is a potential strategy to meet this demand, but sustainable and effective integration of livestock under these conditions creates barriers to adoption for animal feed resources, water quality and nutrient recycling, and environmental pollution (Conway and Nieman, 2022). Although largely untested, agroforestry practices such as silvopasture may provide solutions to the challenges facing UA. Small-scale **silvopasture offers a new frontier of investigation** as a means to address the issues facing UA, particularly integrating chickens (and perhaps other small livestock) into the UA setting. Urban livestock offer much potential and even though challenges exist, these can be overcome and the gaps that exist in the knowledge base can be filled in. Urban agriculture and local food system activities can produce far-reaching, diverse positive impacts throughout the many facets of a community. At a time when global food insecurity is a growing concern, we must not let livestock's potential to UA slip away or leave that potential untapped.

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