Analyzing whether there is enough to meet everyone’s right to food

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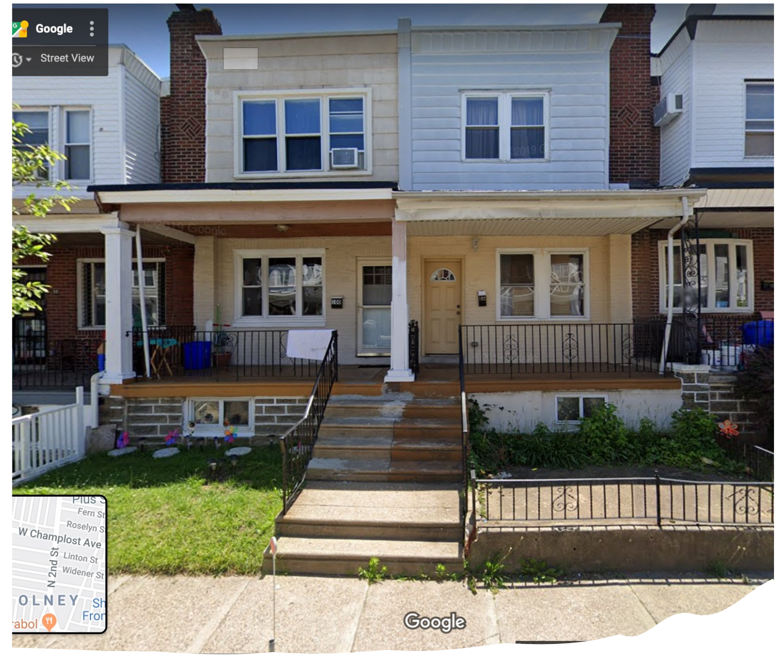
AFHVS-ASFS Conference Right to Food-Food as Commons
Syracuse, NY
June 7, 2024

PennState



Olney, Philadelphia, PA 19120

I fell for someone from rural NY and 20 years later, we have a small winery, distillery…I'm learning a lot!

Portland, NY. Seiche LLC. A farm-scale winery & distillery that I run with my partner and Misha Kwasniewski.

Industrial Ecology

"…systems-based, multidisciplinary discourse that seeks to understand emergent behavior of complex integrated human/natural systems" (Allenby, 2006, p. 33)

"Industrial ecology is the study of flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory, and social factors on the flow, use and transformation of resources." (Robert M. White (1994))

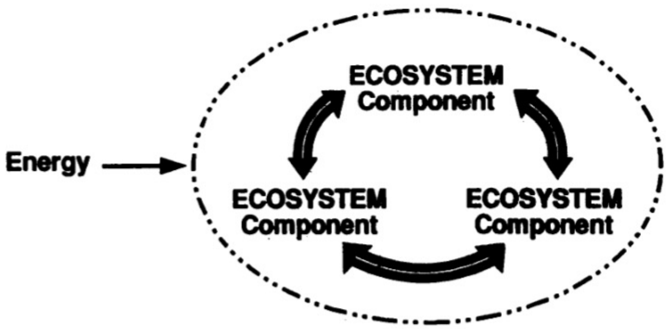


FIG. 3. Cyclic materials flows in type III ecology.

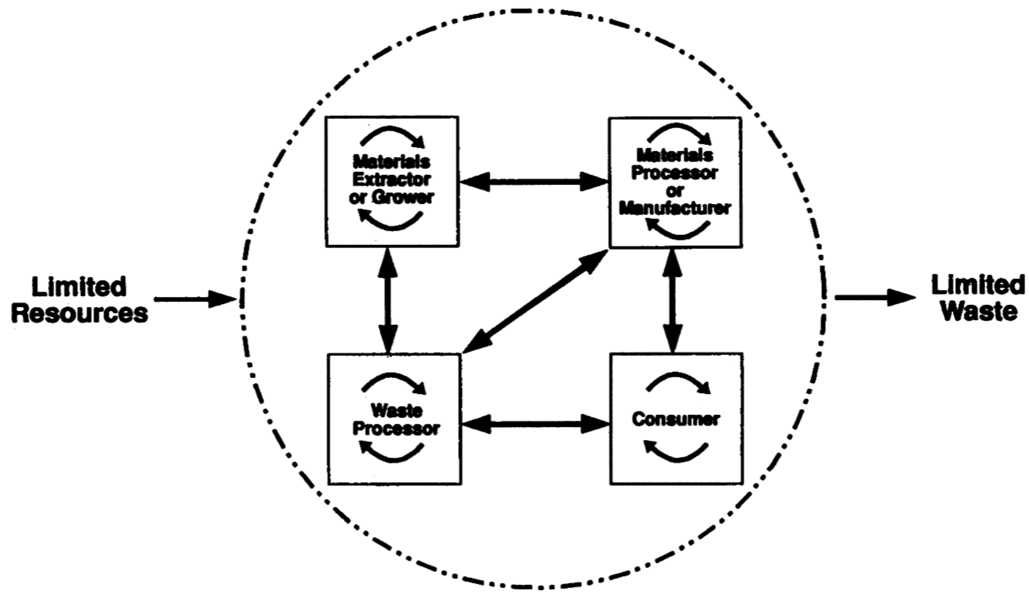


FIG. 4. Type III model of the industrial ecosystem.

Jelinski et al.

Urban Metabolism

- The evaluation of flows into and out of cities.
- Helps to quantify the dependence of urban people on often distant natural systems.

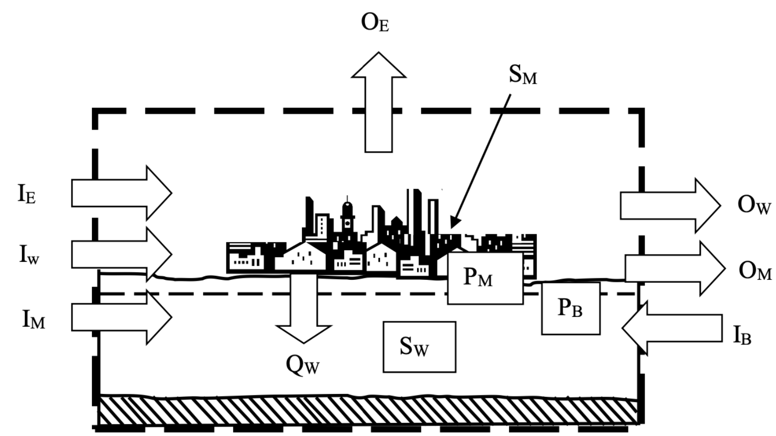


Figure 1: Urban metabolism framework showing inflows (I), outflows (O), internal flows (Q), storage (S) and production (P) of biomass (B), minerals (M), water (W), and energy (E)

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Hoornweg et al., 2012.
https://www.researchgate.net/publication/258240161

Graduate Education

2006 - 2011

Carnegie Mellon University

Green Design Institute

A major interdisciplinary education and research effort to make an impact on environmental quality through green design.

Dissertation Title: *Relating Land Use and Select Environmental Impacts to U.S. Consumption with a Focus on Agricultural Products.*

Primary method: input-output LCA

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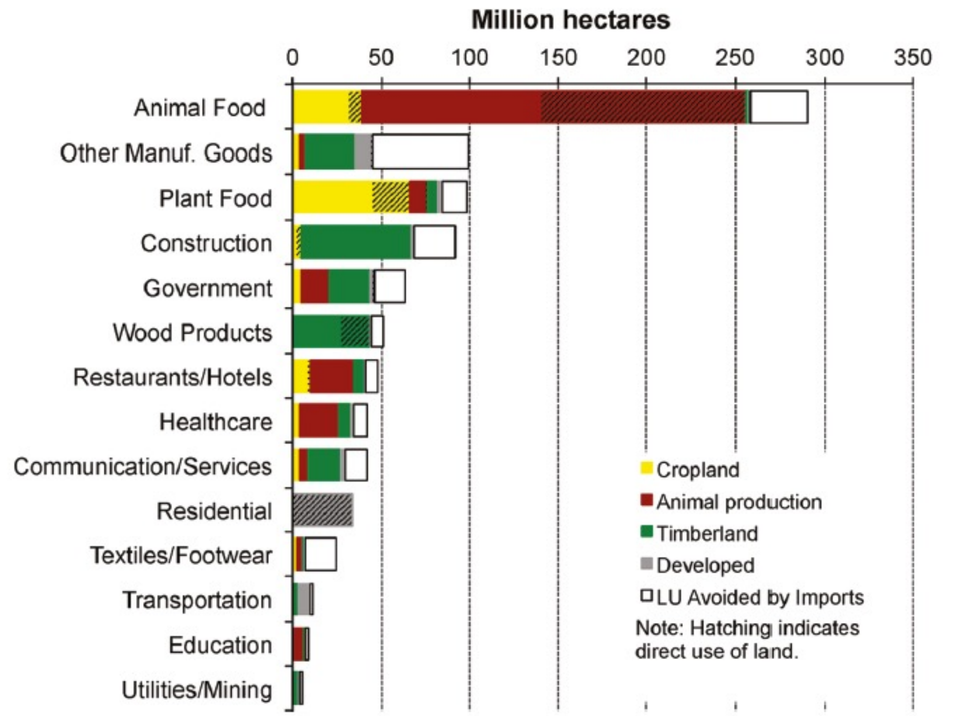


Figure 2. Land use required to meet demand by consumption group.

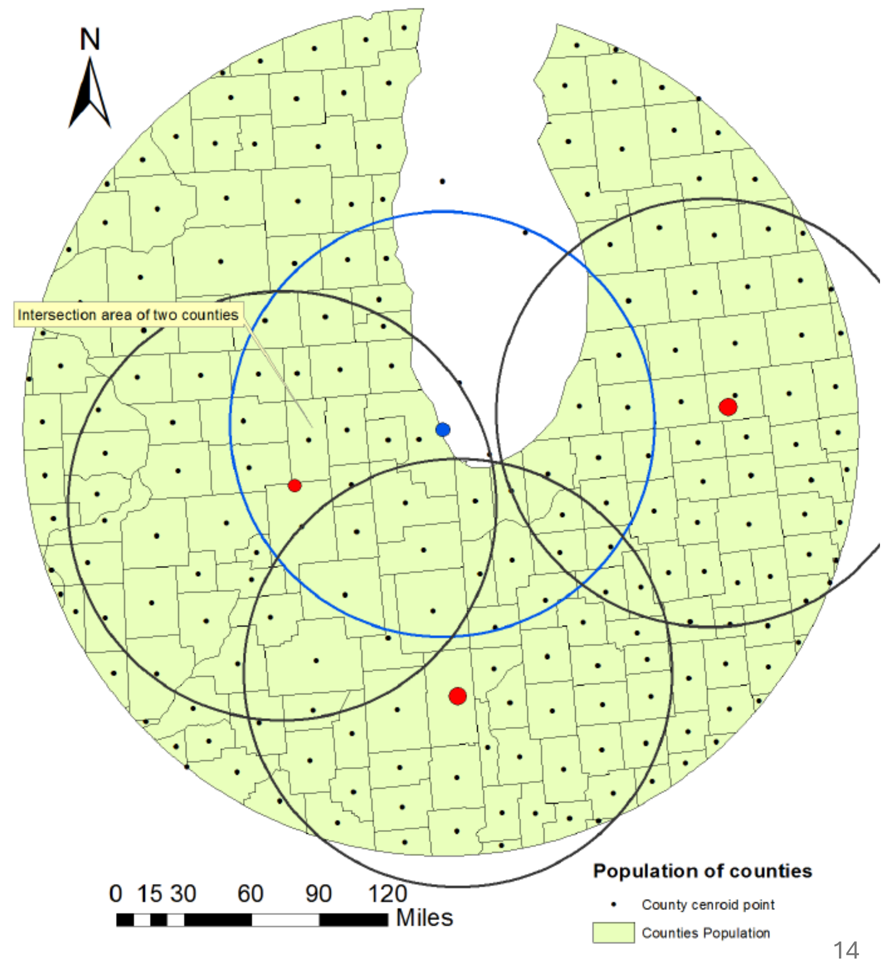
Exploring the feasibility of localized food

Or…calculating how much land is needed to meet the nutritional needs of a population with the least land.

- In this work we are starting simply by asking: **What land area does a specified population need to meet their nutritional needs?**
- How does this answer change through the introduction of novel food production options, such as **soil-based urban agriculture** and **rooftop farming**.
  - I'd love to integrate more food production options, for example:
    - Agroforestry
    - Vertical farming
    - Cultured Meats
    - Insect-derived proteins
    - And anything else that makes sense ☺

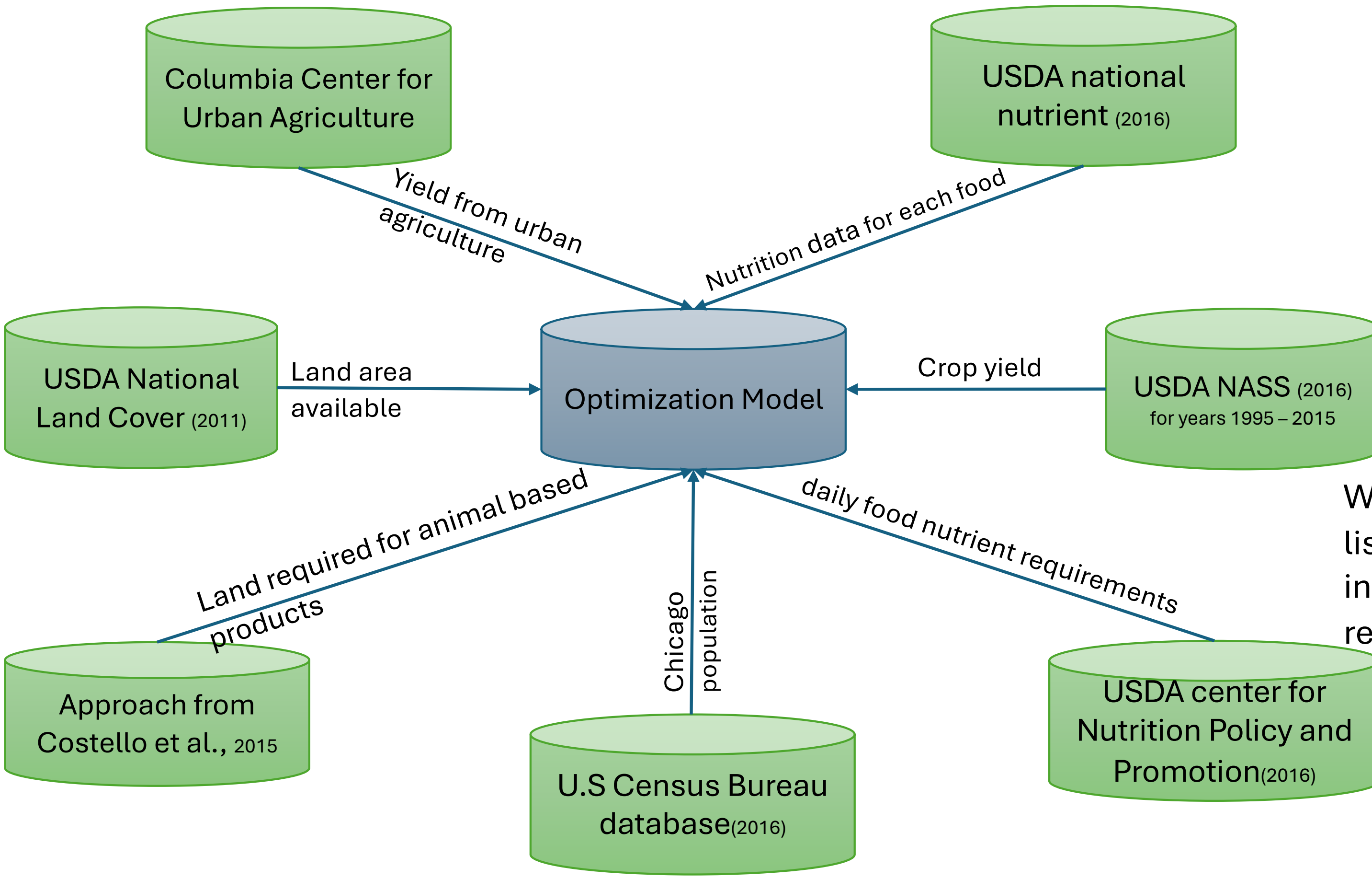
Case study; Chicago

- In this research, we start by defining local as being within a circle of radius 150 km.
- Total area is 70,676 km^2, with 43.2% of the land defined as cropland and 3.3% defined as pasture.
- Using Robust Optimization Techniques to incorporate yield variation. This means linear algebra that constructs a logic problem that solves for the “best” criteria.
- Data from Columbia Center for Urban Agriculture.



Costello et al., 2021. Environ. Sci. Technol. 2021, 55, 2684−2694

Data Collection and Integration



We included the full list of nutrients included in USDA-recommended diets

Costello et al., 2021. Environ. Sci. Technol. 2021, 55, 2684−2694

Chicago Scenarios

Table 2. Scenarios explored in the two robust optimization models to identify food production options in Chicago

Scenario	Rooftop production[1]	Ground-level urban agriculture **within the boundary of** the City of Chicago	Soil-based urban agriculture, **outside the boundary of** the City of Chicago
	kilometers squared (km^2)		
1	0	0	0
2	44.23	0	0
3	0	2.33[2]	10% DOS (variable as a function of radius)
4	44.23	2.33[2]	10% DOS
5	44.23	59.63[3]	10% DOS

Notes: 1. Calculated as 7.4% of the total area within the city limit of Chicago based on Saha and Eckleman (201X). 2. Represents 10% of developed open space (DOS) within the city limit of Chicago. 3. Represents 10% of the total land area of Chicago.

Total area is 70,676 km^2, with 43.2% of the land defined as cropland and 3.3% defined as pasture.

Costello et al., 2021. Environ. Sci. Technol. 2021, 55, 2684−2694

Rooftop & Soil-based urban agriculture reduce the total land requied

- **Scenario 1**: results in the largest radius, **185 km** when we didn't allow yield to vary and **220 km** when we did.
- **Scenario 2**: rooftop farming. Reduced the radius to **180 km** or **215 km** with yield variation.
- **Scenario 3**: soil-based urban ag only (SBUA). Reduced the radius to **180 km** or **215 km** with yield variation.
- **Scenario 4 & 5**: rooftop & SBUA. Radius **175 km** and **205 km**.
- With vitamin B_{12} fortification, the radii were reduced to **105 km** and **115 km** in Scenarios 4 & 5.

Results for scenarios when vitamin D is supplemented and vitamin B_{12} is not.

Scenario	Radius (km)	Land type	Available land within the radius (km^2)	Non-robust model, area utilized (km^2)	Robust model, area utilized (km^2)	Robust - worst case model, area utilized (km^2)
1	185	Cropland	50,790	50,790	infeasible	infeasible
		Pastureland	5,129	5,129		
	220	Cropland	74,266	69,896	61,236	67,349
		Pastureland	9,279	9,279	6,840	7,985
4	175	Cropland	44,497	44,497	Infeasible	
		Pastureland	4,090	4,090		
		Rooftop	44.23	44.23		
		DOS[1]	461	461		
	205	Cropland	63,839	58,758	50,105	54,841
		Pastureland	7,327	7,327	5,413	6,244
		Rooftop	44.23	44.23	44.23	44.23
		DOS[1]	636	636	490	636
5	175	Cropland	44,497	44,497	Infeasible	
		Pastureland	4,090	4,090		
		Rooftop	44.23	44.23		
		DOS[1]	465	461		
	205	Cropland	63,839	58,758	50,103	54,848
		Pastureland	7,327	7,327	5,413	6,244
		Rooftop	44.23	44.23	44.23	44.23
		DOS[1]	639	639	501	639

Results for scenarios when vitamin D and vitamin B_{12} are supplemented.

Scenario	Radius (km)	Land type	Available land within the radius (km^2)	Non-robust model, area utilized (km^2)	Robust model, area utilized (km^2)	Robust - worst case model, area utilized (km^2)
1	125	Cropland	18,910	18,910	infeasible	infeasible
		Pastureland	1,437	1,437		
	150	Cropland	30,527	30,527	26,603	30,527
		Pastureland	2,355	2,355	1,570	1,995
4	125	Cropland	18,910	18,910	16,277	18,910
		Pastureland	1,437	1,437	958	1,217
		Rooftop	44.23	44.23	44.23	44.23
		DOS[1]	244	244	191	244
5	125	Cropland	18,910	18,910	16,280	18,910
		Pastureland	1,437	1,437	958	1,217
		Rooftop	44.23	44.23	44.23	44.23
		DOS[1]	244	248	199	199

Costello et al., 2021. Environ. Sci. Technol. 2021, 55, 2684–2694

A few take-aways

- Current forms of urban agriculture supply relatively small amounts of base calories and protein, but can decrease the radius in some cases.
  - Increase in diversity and availability of produce & key micronutrients is a positive outcome.
- Identification of critical nutrients can reduce land requirements for food production considerably.

Why am I talking about this here?

- I want to communicate the scale of the challenges to change in US agriculture and food systems.
- I'd like to expand to include more novel food systems.
- I wonder how people can organize to bring about lower environmental impact and more just food systems.
- I'd love to connect to find better paths forward.

Thank you!

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A link to the paper(s).