APPENDIX 1
Research Paper

Soil Building *through* Decentralized Modes *of* Care

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Abstract
Anthropic activity within urban and agricultural land use patterns generates high quantities of greenhouse gas (GHG) emissions and depletes ecosystems including those underground. Soil is a key site of carbon sequestration, however current land use practices disrupt this process.
At the same time, urban organic waste is a problem for most major cities, which typically send such waste to landfill or incineration plants, releasing further emissions and neglecting to harness the full potential of this resource. Rather, composting at a local level can reduce the burden on a city's monofunctional waste management while regenerating urban and agricultural soils. A case study is conducted in Buenos Aires to determine the viability of such a scheme in dense urban environments. An alternative urban model is then proposed.

Keywords
#soilhealth, #climatechangemitigation+adaptation, #posthumanism,
#agriculture, #naturebasedsolutions, #urbanization,

I Introduction

Extraction of profit, of resources, of life systems, is the reigning mode of anthropic production today. The IPCC, among others, continues to publish evidence that in order to prevent more than 1.5C of warming, emissions must peak by 2025, decrease by at least 43% by 2030 and reach net-zero globally by 2050 [1]. In essence, transition must happen quickly. As we explore innovative solutions to the climate and biodiversity crises, we often neglect to consider the world beneath our feet. Soil stores more carbon worldwide than is contained in all plant biomass above ground [2]. Healthy soil prevents erosion and mitigates drought and flood due to its ability to absorb and store high quantities of water. Soil is a living composition of multispecies entanglements that determines the viability of plant and animal life above ground. It's a complex, often unseen ecosystem that requires care [3]. Soil care, as determined by land use patterns, is an essential agent in reducing emissions and building resilience [4]. Humans are agents in soil production as much as ants, worms, bacteria and fungus, and thus locate their place within these systems of exchange, rather than without. In order to restore biodiversity below ground, we must transform anthropic activity above it.

At present, agriculture and urbanization are the two most consequential modes of anthropic land use, responsible for the acceleration of climate change, increasing global temperatures and loss of biodiversity [5]. Much of the current processes that occur within these pattern types are reliant on extractive frameworks that have left once flourishing ecosystems around the world fragmented or extinct. While these phenomena are present across the globe, they are on full display in the Pampean region of Argentina, near the capital of Buenos Aires. What used to form regenerative, closed-loops cycles based on local ecology now ends in a string of haphazard disconnected lines. Urban areas, which currently occupy only three percent of the planet's land surface [6], produce more waste than our species can manage, a large percentage of which is organic. Organic waste emits GHGs like methane as it decomposes in landfills and its leachate pollutes nearby land and waterways [7]. Billions of tonnes of this organic waste is often still edible [8]. Agricultural areas occupied more than 38% of land surface globally in 2020 [9] and contributed 25% of GHG emissions [10]. Neither urbanization nor agriculture are inherently bad for the environment. However in their most current and prominent iteration, they are inhospitable to biodiversity and lack the necessary structure to support complex ecosystems.

We've known for a while now that cities aren't the best place for other than human species [11]. But land under intensified agricultural production is perhaps more dire, given its much larger and ever-growing distribution. Its destructive footprint, mostly composed of monocultures treated with petrofertilizers, means that while cropland registers as green in satellite imagery, it may as well be paved in asphalt: its dead soil has little water retention capacity and is unable to hold nutrients necessary for maintaining carbon, nitrogen, phosphorus and sulfur cycles (among others) as well as myriad interwoven multispecies affiliations more broadly. Industrial agriculture is merely the unbuilt areas of the anthropocentric landscape; we should be classifying this land use pattern as a part of the process of urbanization and sprawl [12]. As more land is converted each year, forests and marshlands that had been a carbon sink now become a carbon source [13].

In these systems, soil becomes technosol, the term for human-augmented soils, which make up the majority of urbanized and agricultural areas. Within these patches, under the surface, compaction is widespread, resulting in only fifteen percent of rainwater infiltration and substantial biodiversity loss [14]. Above the surface, vegetation in urban and agricultural areas globally are more similar to each other than to the surrounding vegetation specific to the local biome [15]. At present, more than a third of earth's soil is degraded due to intensified agriculture as a result of petrofertilizers, monocropping and tillage [16]. Impervious surfaces like asphalt and concrete in urban areas, loss of organic matter and habitat, and changes in land use and the climate are among other key threats to soil health [17].

Transforming urban and agricultural land use to come within planetary bounds is a herculean task when confronting the full scope of the vast and varied challenges of this moment. First, the elimination of conventional tillage in agricultural areas will allow for decomposition of plant matter on the soil's surface to accrue, providing it with essential nutrients. During harvest, living roots should remain in the ground, as they contribute to complex soil structure, stratification and porosity. Maximization of the diversity of plants with various root structures through the adoption of agroforestry practices, increases niche opportunity for animals above and below ground and improves soil texture and moisture capacity [18]. Overtime, technosols will be transformed into humus, a dark, nutrient-rich material that forms from decaying matter on the surface. A choreography of cross-species interactions eventually integrates humus into soils underground. The same type of care could be applied to urban areas by exposing soil patches through the application of landscape urbanism principles and nature-based solutions that design with ecology in mind.

Furthermore, small-scale community-based waste management through composting could represent an opportunity to recharge soils with yet more nutrients and new life potentials while also diverting organic waste from landfill, thereby reducing GHG emissions. The application of compost has been shown to improve soil composition, reestablish connective sinews and facilitate rhizomatic exchange [19]. By decentralizing the monofunctional waste management network in cities – incineration, landfill or otherwise – and giving agency to urban inhabitants, more comprehensive change could accelerate the transition from linear, centralized infrastructure developed within twentieth century frameworks that are simply not sufficient in any scheme that seeks to extricate ourselves out of the Anthropocene.

So what Buenos Aires, a vast metro area that hosts more than thirty percent of the country's human population, must confront is not dissimilar from that which many cities globally must confront as well: how to urbanize sustainably. Through exploring a multispecies, multitemporal approach, can the city transform itself into a model for regenerative metabolic processes in an ecological age? Following Bratton [25], can the unintentional terraforming our species has been conducting for millennia be made conscious and altered into self-aware, coordinated planetary systems?

II Methodology

Based on literature review and analysis, the research integrates census data and waste figures from the government of Buenos Aires and independent reports to determine the viability of local waste management. The human population of each comuna, or district, is multiplied by the average waste production per capita per diem, and divided by the area of the given comuna. The results presented in this study are from the comuna with the highest density and thus the highest concentration of organic waste, the comuna with the lowest density and thus the lowest concentration of organic waste, and the average of all comunas throughout the Buenos Aires Metro Region.

The scale of intervention will be more finely detailed within each comuna to the level of the micro-neighborhood, or "superblock." This scenario has been proposed by the Superilles project currently underway in Barcelona and will be superimposed onto the existing city grid of the Buenos Aires Metro Area for the purposes of this study. Typically composed of a 3x3 block grid, a standard superblock is approximately 100 x 100 meters, or 100,000 m2. Irregularities throughout such a system will inevitably occur. The purpose of this study is not exact planning, but rather as a suggestive case study that illustrates how such a system can be implemented in densely populated urban areas. The superblock arrangement has been shown to have other beneficial effects including reduced air pollution and higher prevalence of green space in initial findings from Barcelona [26]. A composting system could be scaled to fit within an individual building's operational systems, though it is unlikely every building will be able to accommodate such infrastructure, thus making the superblock the best scale for this type of intervention.

The research then proposes a model by which local waste management could be achieved, transforming organic waste into valuable compost. A program by which the compost can be applied locally within the superblock is also detailed. The transformation of municipal waste management should be coupled with strategies that prevent food from becoming waste in the first place. Portions of organic food waste could also be diverted to farms as feed for pigs and chickens. While these animals are effective consumers of such waste, it will not be presented in the calculations or schematizations of this report, as it focuses on the feasibility of local waste management in dense urban areas. Finally, data and figures are in constant flux and subject to change. The research acknowledges this and proposes a scalable model.

Compost is a means by which our species can begin to reconcile the metabolic dissonance within anthropic landforms. Landfills and incinerators are an "erasure" that "abstracts the materialities of urban networks" [20] and obfuscates our species' prolific ability to generate unrelenting amounts of waste, while local composting programs can engage us directly. It is a daily reminder that confronts us with the impending climatic and ecological doom that awaits our species and many others on this planet if we do not transform the modes of care(lessness) that function as the status quo. It is also a light guiding us out of the darkness, making Earth, and its processes, visible and tangible.

Compost is often a land-intensive process. This research investigates if such a process can be managed vertically in order to function within dense urban areas. Buenos Aires will serve as a case study, where approximately 96% of waste in the metro region is directed to the Norte III landfill. This means, on average, more than 7,000 tons of organic waste enters this landfill daily, transported by some 700 diesel powered garbage trucks [21]. As a result, the landfill is responsible for more than half of the city's total methane emissions [22], which are 25 times more potent than those of carbon dioxide. CEAMSE, the agency that manages the Norte III landfill, is attempting to capture these emissions and utilize them to generate energy for several thousand homes in the vicinity; however it is possible to capture no more than forty percent of these emissions [23]. While the government understands that composting represents a mutually beneficial and pragmatic strategy for managing organic waste, few large scale programs exist. Furthermore, as the current agricultural system is based on pollutive, reductionist and degenerative methods, new modes of regenerative agricultural production are urgently necessary. Decentralized composting facilities could help in this transformation, as compost can also replenish depleted soils and close the loop of this otherwise linear food-to-waste model.

The common horizontal management of organic waste, known as the compost pile or windrow, is verticalized into what will be called the compost (sub)tower. The (sub)tower will represent a new urban infrastructure that facilitates new processes, rituals and stories [24], where food waste becomes nutrients (or resources) for more food (or more resources). Coupled with food markets supplied by local farms using agroforestry practices will further emphasize how the end of one cycle is the beginning of another.

A typical scheme within a superblock could be defined as a multistep process as follows:

Step 1: The average household in Argentina was 3.1 people in 2020 [27]. This means on average one household generates approximately 0.04 m3 of organic waste per week, or almost 50 liters (see calculation in **APPENDIX 2**). As organic waste collects within the home, it is stored in a 250mm diameter PVC (or similar material) threaded pipe with screw caps on both ends, to be provided and maintained by municipal managers within each superblock. Each tube is 50 centimeters in length, equivalent to 25 liters. Households can have as many containers as needed. It is advised that a mixture of effective microorganisms (EM) be applied to the collection bin at home which will begin the fermentation process and prevent attracting flies and other pests, reducing the necessary time for decomposition upon arrival to the tower.

Bokashi: This is an anaerobic process that operates within a 10-day cycle. Bokashi, the Japanese word for "fermented organic matter," was developed in the 1980s by Dr. Teuro Higa, professor at the University of Ryukyus, Okinawa, Japan. It is a simple process where a layer of Bokashi inoculant is added to food scraps. Usually, the inoculant consists of either wheat germ, wheat bran, or sawdust combined with molasses, warm water and EM. The Bokashi process reduces initial waste bulk by up to 25% [28]. Once full, the inhabitant will transport the filled container to their closest tower within the superblock.

Step 2: Upon delivery at the (sub)tower, a new container – empty and cleaned – will include a small paper bag of EM mixture that is ready for use for the next week's waste. These containers could also double as baggage for goods purchased at an adjoining food market.
For the unable or unwilling, a pick up service can be arranged where waste is collected and transferred by bicycle to the tower. In other areas, an in-building or block pneumatic tube deposit system, which carries waste to the tower through an underground pipe network could also be implemented. This method requires large investment and is much less malleable than a human delivery system, as the pipes that make up such a network would inevitably be subject to the various maladies that impact other similar systems like plumbing networks, where constant maintenance and replacement of parts is required. While this report will not integrate this approach into the design proposal, it nevertheless could serve some areas of a city where such investment is possible or desirable.

Step 3: This is where waste first encounters the compost tower. The tower is a collection of components each with their own processes and schedules, composed of modular parts common within agricultural and industrial sites for ease of assembly, replacement and reduced costs.

Maceration: After the 10-day Bokashi cycle is complete, the remaining waste is first processed by maceration, which reduces particle size, increases surface area and thus speeds the decomposition process.

Vermicompost: A verticalized vermicomposting process is proposed to "finish off" the fermented waste into something resembling finished compost. This is an aerobic process. Piles that are infrequently turned can take up to 3-6-months to generate compost. Because the food has already been macerated and fermented in this scheme, fibers within the waste have been broken down enough to expedite the process. In combination with mechanical aerators that constantly turn the pile, the total vermicomposting process is anticipated to last between 10 to 14 days. Because worms and helpful microbes are present within this system, it is ideal that temperatures remain between 13°-32°C.

Vermicomposting also requires a specific carbon to nitrogen ratio of 30:1. The fermented food waste will be almost entirely nitrogen. Carbon sources for this can come from dried, woody yard clippings. Another large and reliable source is paper waste, which is roughly 18% of the city's total wastestream [29](Savino, 2008). Buenos Aires has a special method for paper recycling: throughout the city, cartoneros collect paper recyclables with hand trucks and carts from sidewalks and businesses. Currently, they deposit these at designated locations in exchange for money. Once the composting scheme is implemented, the cartoneros will simply deliver their goods to the towers instead.

At the end of the cycle, approximately twenty days, the food waste will have been transformed into ready to use compost. Compost "tea," a potent liquid runoff full of nutrients, will be collected separately to be used within agricultural sites or home gardens.

Step 4: Finished compost can be applied locally within the superblock to regenerate urban soils, increase water retention capacity and promote biodiversity above and below ground. Because the superblock prioritizes humans over cars, new green space will become available where compost can be applied. On average, a superblock will have approximately 6,000m2 of new planting space as compared to a current standard block. If compost is applied twice per year, as recommended by most horticulturists, at a depth between 10-20 centimeters, a total of 2,400m3 of compost can be applied within each superblock annually.

III Results

A superblock in Avellaneda, the district with the lowest human density, on average, was found to produce 288m3 compost per year at current density rates. If compost is applied twice per year at an average depth of 20 centimeters to exposed soil with plantings within a superblock, a total of 2,400m3 can be applied per superblock per annum. This means approximately 2,112m3 of additional compost could be applied within the standard superblock in the Avellaneda district. In Comuna 3 superblocks, the most densely human populated of the comunas, each yield around 1,287m3 per year, leaving 1,113m3 where more could be applied in future scenarios. Finally Comuna 13, the average density study area, produces 703m3 per year with 1,697m3 left over. The full calculations, located in the **APPENDIX 2**, demonstrate the feasibility of this scheme.

If this scheme were to be implemented throughout the Buenos Aires Metro Area, more than two thirds of the total waste currently going to landfill would be immediately diverted and all related methane emissions would be stopped.

IV Conclusion

This study demonstrates how local decentralized waste management is feasible in densely populated urban areas and can have profound impacts on urban and ecological systems from city dwellers, rural farmers and nonhumans. Multifunctional, distributed infrastructure supports a regenerative land use model. It advocates for a complete reconceptualization of linear anthropic systems that contribute to runaway emissions and mass extinction. The compost (sub)tower will allow municipalities regardless of location or socioeconomic status to manage organic waste and food production locally and sustainably while reducing emissions and deepening the interrelation between multispecies communities. This new mode of symbiotic care values multitemporal schedules between organisms as their interactions promote healthy soil building. It also engages humans in a mode of public activity that lies outside of typical consumer practices.

The remaining surplus of space within each superblock, as shown in the results, means that as the city's human population density increases, local management is capable of handling the expanded population and waste. If waste mitigation efforts were to be implemented, this figure would be reduced further. Single use items, regardless of their material composition, should be phased out. Packing from woody materials like paper and cardboard can be collected and utilized as beneficial carbon sources in the composting process. In conjunction with food waste also being composted, items sent to landfill would be substantially reduced, eventually making such land use irrelevant. Like the mycorrhizal fungi networks beneath them, superblocks are able to share resources. If one has higher yields than a neighbor, exchange is encouraged.

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APPENDIX 2
Calculations

<u>DENSITY</u>

IN THEORY, A BLOCK IN BUENOS AIRES IS 100 X 100 METERS. IN ACTUALITY, PROPORTIONS VARY. A SUPERBLOCK OF 9 BLOCKS AND STREETS IS ROUGHLY 100,000M2. THIS IS THE BASE UNIT OF MEASUREMENT FOR LOCAL WASTE MANAGEMENT.

<u>TOTAL WASTE</u>

TOTAL WASTE RECEIVED BY NORTE III		14,000 TONS
50% ORGANIC (NEA, 2021)		7,000 TONS
BSAS METRO REGION POP (GOBIERNO DE ARGENTINA, 2011)	÷	15,600,000

TONS		0 .00044872
KG/PERSON/DAY		0.407
463 LBS/YARD3	=	192 KG/M3
M3/PERSON/DAY		0.002
LITERS/PERSON/DAY		2

<u>PER HOUSEHOLD</u>

PEOPLE PER HOUSEHOLD (BAUER, 2021)		3.1
WASTE/PERSON/DAY	x	0.002M3

WASTE/HOUSEHOLD/DAY	=	0.0062M3
WASTE/HOUSEHOLD/WEEK	=	0.0434M3
	=	4.34 LITERS

<u>PER DISTRICT</u>

AVELLANEDA

POPULATION (GOBIERNO DE ARGENTINA, 2011)		342,677
ORGANIC WASTE/PERSON/DAY	x	0.002M3

TOTAL ORGANIC WASTE/DISTRICT/DAY	=	685M3
AVELLANEDA AREA		52KM2

ORGANIC WASTE/KM2/DAY	=	13M3
ORGANIC WASTE/ 100,000M2/DAY	=	1.3M3

DAYS OF 1 BOKASHI CYCLE	X	10
ORGANIC WASTE/10-DAY CYCLE/100,000M2	=	13M3
ORGANIC WASTE/100,000M2/YEAR	=	481M3
VOLUME REDUCTION (BREITENBECK & SCHELLINGER, 2013)	-	40%
TOTAL COMPOST YIELD/YEAR	=	288M3
AVERAGE SUPERBLOCK COMPOST DEMAND/YEAR	=	2400M3
REMAINING SPACE FOR ADDITIONAL COMPOST/YEAR	=	2112M3

COMUNA 3

POPULATION		187,537
ORGANIC WASTE/PERSON/DAY	x	0.002M3
TOTAL ORGANIC WASTE/DISTRICT/DAY	=	375M3
COMUNA 3 AREA	÷	6.4 KM2
ORGANIC WASTE/KM2/DAY	=	58M3
ORGANIC WASTE/100,000M2/DAY	=	5.8M3
DAYS OF 1 BOKASHI CYCLE	x	10
ORGANIC WASTE/10-DAY CYCLE/100,000M2	=	58M3
APPROXIMATE BOKASHI CYCLES/YEAR	x	37
ORGANIC WASTE/100,000M2/YEAR		2146M3
VOLUME REDUCTION	-	40%
TOTAL COMPOST YIELD/YEAR	=	1287M3
TOTAL COMPOST YIELD/DAY	=	3.5M3
TOTAL COMPOST YIELD/WEEK	=	24.5M3
	=	24,500L
50L TUBES/WEEK (250CMX50CM)	=	980
50L TUBES/DAY (250CMX50CM)		140
AVERAGE SUPERBLOCK COMPOST DEMAND/YEAR	=	2400M3
REMAINING SPACE FOR ADDITIONAL COMPOST	=	1,113M3

COMUNA 4

POPULATION		218,245
ORGANIC WASTE/PERSON/DAY	x	0.002M3

TOTAL ORGANIC WASTE/DISTRICT/DAY	=	436.5M3
COMUNA 4 AREA	÷	21.6 KM2

ORGANIC WASTE/KM2/DAY	=	20M3
ORGANIC WASTE/ 100,000M2/DAY	=	2M3
DAYS OF 1 BOKASHI CYCLE	x	10

ORGANIC WASTE/10-DAY CYCLE/100,000M2	=	20M3
ORGANIC WASTE/100,000M2/YEAR	=	740M3
VOLUME REDUCTION	-	40%

TOTAL COMPOST YIELD/YEAR	=	444M3
TOTAL COMPOST YIELD/DAY	=	1.2M3
TOTAL COMPOST YIELD/WEEK	=	8.5M3
	=	8,500L
50L TUBES/WEEK (250X50CM)	=	340
%0L TUBES/DAY (250X50CM)	=	48
AVERAGE SUPERBLOCK COMPOST DEMAND/YEAR	=	2400M3
REMAINING SPACE FOR ADDITIONAL COMPOST/YEAR	=	1956M3

COMUNA 13

POPULATION		231,331
ORGANIC WASTE/PERSON/DAY	x	0.002M3

TOTAL ORGANIC WASTE/DISTRICT/DAY	=	462.7M3
COMUNA 13 AREA	÷	14.6KM2

ORGANIC WASTE/KM2/DAY	=	31.7M3
ORGANIC WASTE/100,000M2/DAY	=	3.17M3
DAYS OF 1 BOKASHI CYCLE	x	10

ORGANIC WASTE/10-DAY CYCLE/100,000M2	=	31.7M3
APPROXIMATE BOKASHI CYCLES/YEAR	x	37

ORGANIC WASTE/100,000M2/YEAR	=	1172M3
VOLUME REDUCTION	-	40%

TOTAL COMPOST YIELD/YEAR	=	703M3
TOTAL COMPOST YIELD/DAY	=	1.9M3
TOTAL COMPOST YIELD/WEEK	=	13.5M3
	=	13,500L
50L TUBES/WEEK (250X50CM)	=	270
50L TUBES/DAY (250X50CM)	=	38
AVERAGE SUPERBLOCK COMPOST DEMAND/YEAR		2400M3
REMAINING SPACE FOR ADDITIONAL COMPOST/YEAR	=	1697M3