Searching for
the Externalities of Green Urban Infrastructure

Because humanity has not yet begun the slow business of colonizing the rocky surfaces of our solar system: the moon, Mars, the asteroids, etc., land on Earth is finite. An economic function and price-point for terran plots of land are well-documented for millennia. Ecological functions and their benefits, however, have yet to be completely understood, let alone accounted for. Biodiversity preservation, heat and carbon sinking, food production, higher quality of air and life, increases in neighborhood value, communal or public regulatory practices, all become integral parameters in the cost-benefit analysis of green spaces. Because land value increases with population density, a higher premium is attached to urban greenscapes. These variables, along with an intangible serenity and existence value of wilderness make environmental economic equations difficult to formulate. Externalities of green spaces have yet to be properly accounted for in modern economic equilibria.

During the last couple centuries of economic theory, from 1776 Adam Smith onwards, classical models leave out ecology completely. Models are drawn in closed loops, with static actors, demanding ever increasing growth, based upon the 'rational' decision making man. In *Doughnut Economics*, Kate Raworth expounds the necessity of discarding such old economic diagrams entirely!

Spaceship Earth's carrying capacity becomes an ecological ceiling within her new model. This outer ring of the doughnut is limited by planet Earth's cycles of: water, carbon, nitrogen, ozone, biodiversity, land & ocean replenishment. The inner ring of the doughnut is bound by the human element. A bare minimum of energy, food, water, health, education, income, peace, justice, housing, and equality establish a flooring. This is the social foundation for a sustainable 'regenerative and distributive economy: the safe and just space for humanity.' [1] There is a continuous inflow of energy from the sun, and an outflow of energy and matter. Growth is not paramount, not ever-increasing, and certainly not the only measure of success. Humanity does not act in calculated selfishness for a monetarily optimum outcome… Classical economic theory eventually capitulates.

What transpires from this paradigm shift?

21st century economic modeling moves closer to capturing a true ecological value of human activity.

Earthbound, it is predicted that the vast majority of mankind will dwell in urban environments as early as 2025. Urban agriculture, as a societal endeavor will become increasingly important. City planners should designate space and funding for this. Urban landscapes that exhibit efficient use, yield higher food / plant output, and serve as information dissemination centers

[1] Kate Raworth, Doughnut Economics, pg. 38

will also grow, incubated within the growing number of cities. Sustainable development augments a circular set of efficiencies through urban agriculture that ensure economic and food security while, at the same time, underscore a verdant "social consciousness" that accounts for ecology.

Wetlands, coastal scenic regions, critical habitat for wild plants and animals, and spiritual / recreational open lands have a 'special environmental value.' In the United States, a federal, state, or local policy deliberates land-use decisions. Private investors or landowners may wish to develop an ecologically valuable parcel of land. Field & Field tabulate a net present value to either develop or preserve this parcel of land. Their calculation shows that, while pure preservation is most in the interest of the public, private owners would lose the opportunity cost of improving the land. A restricted land use policy can be forged that off-sets this amount, while preserving the ecological value. Further, they suggest a conservation group or the community may unite in order to protect that value by purchasing the parcel of land, development rights, or by rewriting zoning and ordinance laws. [2]

Typically, parcels of ecologically valuable earth: lakes and rivers, grazing fields, forests, etc. are mined for natural resources above and beyond their replenishing rates. Too much fishing, herding, or deforestation leads to the 'Tragedy of the Commons.' This happens all too often, and rapidly, as an urban density expands to its surroundings. 2009 Nobel prize winner, Elinor Ostrom, found real-life solutions to this tragedy. Voluntary communities that managed natural resource commons operated by mandating policies, fees, and subscriptions between the Nash equilibrium and a co-operative solution succeeded. Turkish inshore fisheries, Maine USA lobster catchers, and Midwestern US farmers' irrigation schemes- all formed stewardship communities to protect their environmental commons.[3] They collectively agreed upon rules and punitive sanctions. Ostrom found these guardian communities' stewardship outperformed state and markets in protecting and harvesting Earth's resources.

A dearth of green cityscapes, due to the demands of population density and development, make the price of urban ecological preservation heavier. Maintaining these sanctuaries seems costly because the true cost and complete benefit of the positive externality of green spaces are not properly modelled. Disjointed estimates, like McPherson's Chicago accounting of urban forests, Rosenberger & Stanley's 2007 meta-analysis of recreation space elasticity, Specht's lateral synergies of urban agriculture, several scholars' estimates of air quality, Ugai Takao's green roof points, etc. elude to the complexity of this problem.

In order to contribute to this body of literature, we hope to summarize background literature related to urban agricultural amenities, or rather endeavors that may be undertaken simultaneously at a single site in order to establish a value add regression. These "amenities" might be divided into the following non-exclusive (or exhaustive) categories:

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[2] B. Field, Martha Field, *Environmental Economics* pg. 367-8.
[3] Nick Hanley, et. al. *Environmental Economics* pg. 140

Urban Agriculture		Descriptors			Requirements	
Type	Products	Externality	Prominence	Locations	Land	Capital
Horticulture	fruits, vegetables, flowers, herbs, spice plants	novel ethnic flavors	5	core	small	1
Apiculture	bees, honey, wax	pollenization	3	peri-urban	small	3
Vermiculture	Worms, compost creation; silk	fertilizer; recycling	2	core	small	2
mycoculture	mushrooms	decomposer	1	core	small	2
Poultry	chicken, eggs	sustainability	4	peri-urban	medium	4
Small livestock	rabbits, rodents, goats	organic waste sink	3	peri-urban	medium	4
Hydroponics	fish, frogs, flowers, fruit	circular economy	4	peri-urban	medium	3
Aqua-terra farming	fish-breeding, rice-like grains	circular economy	2	peri-urban	medium	3
Arboriculture	trees, ornamental plants, berries, wood	tourism	1	periphery	medium	4
substitute crop	water treatment	natural pest prevention	3	periphery	large	4
Agroculture	natural bio-engineering; crops; ornamental plants	ecology preservation, research	2	boundary	large	4
Forestry	wildlife preserve, biodiversity	eco-system creation, tourism	3	boundary	large	5
Large livestock	cows, milk, beef, pigs	fertilizer, organic waste sink	3	boundary	large	5

Using Taylor and Lovell's divisions:

of small (< 20m sq),
medium (<50 m sq),
large (<100 m sq),
and very large (>100 m sq)

plot sizes within the City of Chicago as identified through the visual analysis of high-resolution aerial images, 428 single-plot vacant lot gardens were located in 2012. It is feasible for a small, single sized urban plot to specialize in more than one type / category of urban agriculture listed above. In fact, where the land requirement is small - medium, a number of agricultural products can be grown, and therefore, priced. Because a full ecological accounting would be too difficult of a calculation as a dependent variable, we may use base-line externality constants. An overall price - value for the site may then serve as a dependent variable.

Positive independent variables may include:

- Biodiversity preservation,
- heat and carbon sinking,
- food production / agricultural output value
- increased quality of air
- recreational / increased quality of life
- potential rise in neighborhood housing value

Negative independent variance is based upon:

- cost of communal or public regulatory practices
- cost of land , ie. the opportunity cost
- cost of operations (for initial & secondary endeavor)

Forested Lands:
Arboriculture as an example of city peripheral farming

51% of US forested lands are privately owned. Keohane discusses how to calculate an ideal point to harvest timber via: the mean annual increment, the Wicksell rotation, and the Faustmann Rotation… all of which use a marginal cost-benefit equation based upon volume. Forest externalities are acknowledged. Keohane cites a Victoria, Australia study that accounted for watershed protection and carbon sequestration. That analysis concluded that the 'standing tree benefits' were so high that the forest should never be harvested.[4]

Scherr et al. produce estimates of non-timber forest products (NTFP). Hanley et al. state that 53% of Earth's forested land falls within the borders of five countries: Russia, Brazil, Canada, USA, and China. During the 1990s, 16 million hectares of forested land were lost each year! Between 2000-2010, the rate of deforestation decreased slightly to 13 million hectares / year. Their calculations of the optimal area of natural forest for a region require significant revision. Simply accounting for local and global benefits do not at all address the externalities enumerated above. [5] Both Keohane and Hanley use present value discount rates in their equations. Neither attempt, at all, to parameterize increased biodiversity, air quality, or human life positive gains.

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[4] Nathaniel Keohane *Markets and the Environment pg. 108*

[5] Hanley et al. *Environmental Economics* pg. 206

Finally, careful observation notes that these independent variables are contingent upon size, perhaps a “thickness of foliage, canopy, and sustainable web-of-life cycle. What then could be considered a minimum threshold for a ‘stand of trees’ to become a forest? At what bare minimum level can the smallest grouping of trees, the smallest forest, generate a positive value within the externality variables? This delicately balanced ecosystem is certainly larger than a couple ‘small Chicago plot sizes…’

In conclusion, a “forested” peripheral site in the outer limits of Chicago would require more than 100 square meters. Arboriculture too, would require a greater amount of land input. Additionally, other activities like mycoculture (fungi), small livestock raising, and apiculture (bees) could also be undertaken upon the same plot of land, if supervised carefully by conservationists.

This outlines a beginning to urban sprawl control, forest size designation, as well as ecological externality accounting. More quantitative research, with land-value data and tree pricing hope to shed more light into the verdant complexities of these equations.

Works footnoted and mentioned within the article will be attached as a bibliography… later