Hixon Center for Urban Ecology

Student Research Fellows

Life Cycle Assessment of a Land Management Project

The PlaNYC Afforestation Initiative in the Kissena Corridor Park, New York

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Problem Investigated

Urban Ecology plays a pivotal role in finding solutions and navigating a sustainable urban future. A variety of land management projects like urban afforestation programs have been launched in big cities to mitigate negative environmental impacts.

Among current approaches to quantify the impacts, two major ones are often employed but they both have some drawbacks: 1) biophysical and ecological studies focusing on ecological dynamics and certain categories of environmental impacts (they fails to consider the role of human induced activities in an urban ecological context); and 2) cost-benefit analyses that consider projects' economic meanings (they don't elaborate the biophysical effects on air, water and soil environment specifically).

I applied the Life Cycle Assessment (LCA) analytical tool to evaluating the life-cycle environmental impacts of altering land use and cover. By encompassing the off-site resource extraction, transportation, agricultural, manufacturing and end-of-life processes, the environmental impacts can be quantified more precisely so as to lend people multiple angles of understanding.

Background

The New York City (NYC), as the biggest metropolis in US, is actively exploring such solutions. The PlaNYC Afforestation Initiative, under the MillionTreesNYC program, pledged in 2007 to plant more than 370,000 trees in parklands and other public spaces (2021 acres in total over five boroughs) in NYC by 2030. It aims to "enhance water and air quality, mitigate climate change, and increase open space".

The Kissena Corridor Park (KCP, in the Borough of Queens, see Figure 1 below) is among the first three sites under research and construction of the PlaNYC initiative. I collected firsthand materials regarding upfront plantation, material used to construct the park and logistic and operational information from the Department of Park and Recreation of the City of New York. Based on the study of the Kissena Park case, I quantified the life-cycle environmental impacts of (1) greenhouse gas (GHG) emissions, (2) energy consumptions, (3) water intake and (4) ecosystem value of the provision of 95ha open, urban, afforested space.

Figure 1. The Kissena Corridor Park layout (left) and site categorization results (right)

Methods

- Selected three time horizons (30, 50, 100 years) to investigate the accumulation of environmental benefits over time and to calculate the "payback" period for upfront environmental costs;
- Simulated three scenarios in terms of different park designing patterns: (1) current mix, (2) low-diversity plan, and (3) high-diversity plan;
- Used EIO-LCA model to estimate the upfront environmental footprint of building such an urban afforestation park;
- Applied iTrees model to predict the growing pattern and environmental credits of the trees planted in an urban context;
- Conducted sensitivity analysis surrounding discount rate, tree-growing parameters and per-unit environmental impacts.

Results and Discussion

- The Kissena project has approximately five thousand and occupies an area of 95ha (functional unit). Each square meter of land can contribute 120.8 MJ energy saving, 135.5 kg-CO2eq GHG mitigation, and 2.73 m2 water saving effects, with an ecological footprint of 27 folds at the construction phase, based on current plan in a 100-yr time horizon.
- The Kissena project can generate an overall ecosystem benefit of 42.2 million USD in a 100-year time horizon; with a 2% discount rate, the valuation of the asset is estimated to be 14.1 million USD without the consideration of the termination value.

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Time Horizon	Energy Intake (TJ)	GHG Emissions (Gg-CO2eq)	Water Withdrawal (1000m3)
Construction (time 0)	20.7	1.9	257.5
0-30 year	-7.9	-5.4	-145.5
30-50 year	-22.7	-15.4	-398.7
50-100 year	-105.0	-68.4	-2448.1
Water Balance (100-year)	-114.8	-87.2	-2734.8
Payback period	41.3 years	10.7 years	35.6 years

Table 1. Summary of environmental impacts of the current plan

In the near term, the environmental balance for all three categories are negative (i.e. credits do not exceed burden yet), so the longevity of the parklands determines whether positive life-cycle environmental impacts can be ultimately realized.

The selection of species and design of biodiversity can significantly affect the life-cycle environmental impacts of the project. In this study, Northern Red Oak and American Basswood, among other nine species, appear to be promising to generate large benefits in the long run.

Some important contribution processes are identified:

Plantation in the nursery has the single largest potential to improve to save water and energy;

Invasive management (especially herbicide application) is the second largest contributor of the environmental burden.

Ultimate disposal technology can largely influence the life-cycle environmental cost (around 15% of construction phase).

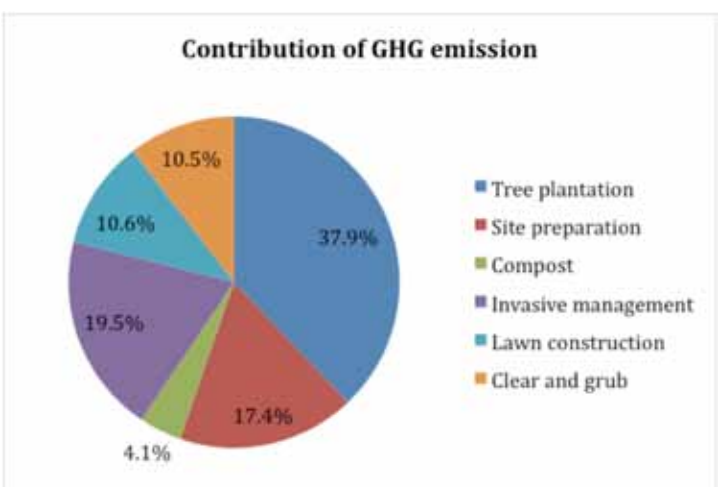

Figure 4.4 GHG emissions of major contribution processes