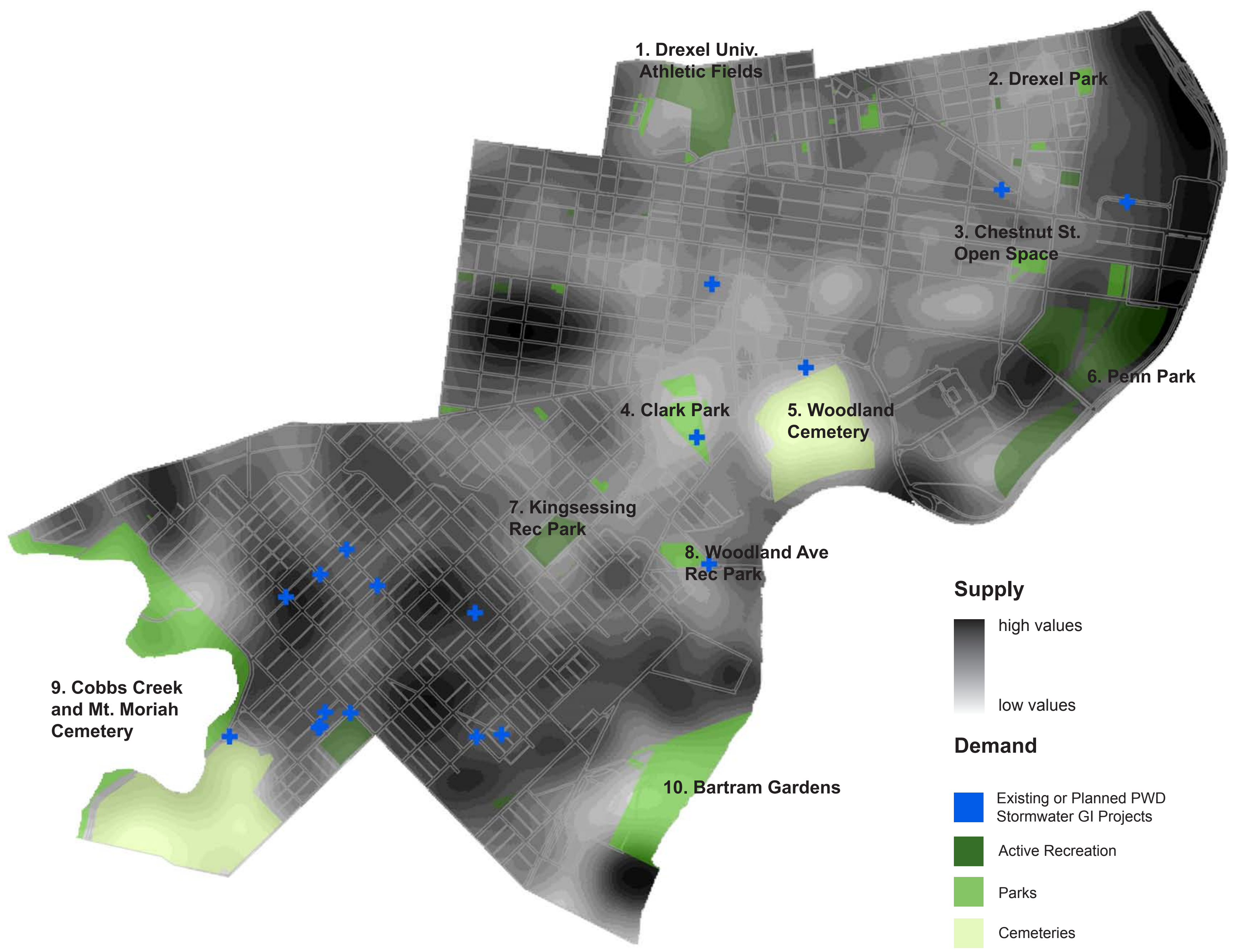
II. Articulating a Green Infrastructure Supply and Demand Model

While certainly not the only factors, both the interpolated land cover and water flow pattern index existing qualities and attributes across the broad landscape which are highly influential and relevant, not only in potentially siting specific green infrastructure projects, but pursuing an integrated landscape approach towards planning and designing green infrastructure systems. Because patterns of existing vegetation, impervious surfaces, and localized water flow are mapped and depicted along the same continua over the entire landscape, they may be combined to generate a new raster grid which provides additional interpretive value to these qualities and characteristics.

Specifically, they may be combined to create a new grid which may be thought of not just in terms of the existing assets and liabilities, or surplus and deficit, but more dynamically as the existing “supply and demand” of green infrastructure in the study area. Within this context, the green infrastructure connectivity environment may be conceptualized in terms of an optimization process, where ultimately, high “demand” areas may be prioritized and targeted when planning and designing potential linkages.

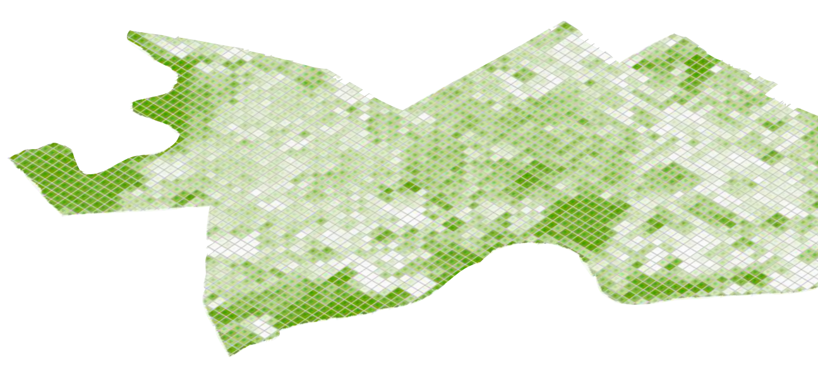
Once the values of the two grids are normalized to reflect values along the same scale of 1 - 100, they can be combined on a cell by cell basis by simply assigning their average values onto a new grid. Darker areas represent lower values and areas of demand where the presence of non-green impervious landscapes combine with areas of the stagnant water flow. On the other hand, lighter areas represent higher values, and areas where greener landscapes combine with areas of active and dynamic water flow. 10 discrete open and green spaces are selected to be used as anchoring urban green patches that form the basis of a potential green infrastructure network.



A Green Infrastructure Supply vs. Demand Surface

Interpolated Land Cover : Distribution of Existing “Greenness”

IDW Interpolation of Aggregated Values

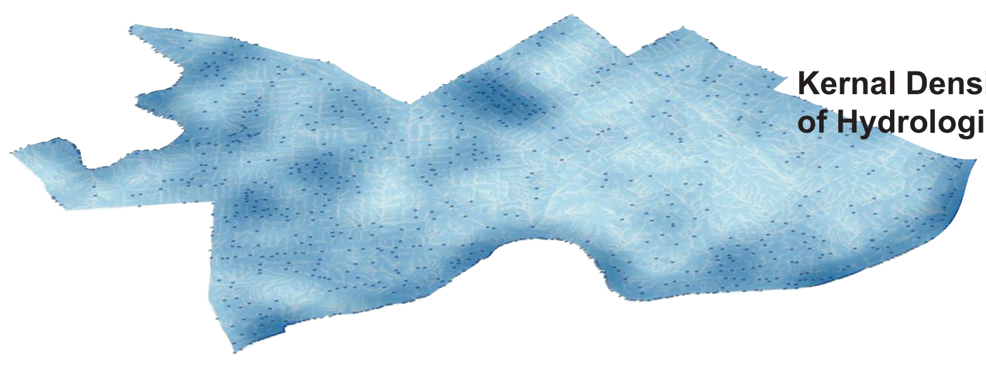


200’ x 200’ Area Unit Aggregation of Values into Points

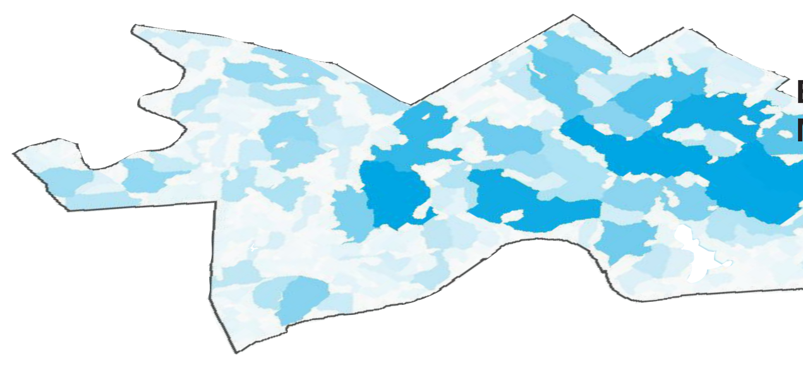
Reclassification into Soft Pervious vs. Hard Impervious Landscapes, 1 and 0

Existing Land Cover

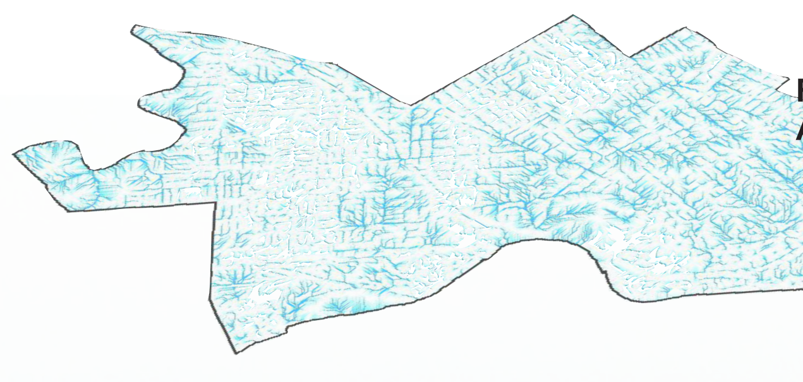
Characterization of Water Flow : Active Flow vs. Stagnant Flow Areas



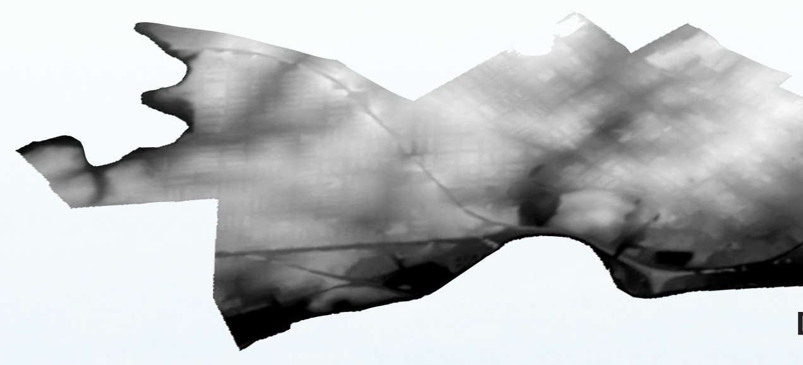
Kernal Density of Hydrological Sinks



Basins According to Maximum Flow Accumulation



Flow Direction and Accumulation Pattern



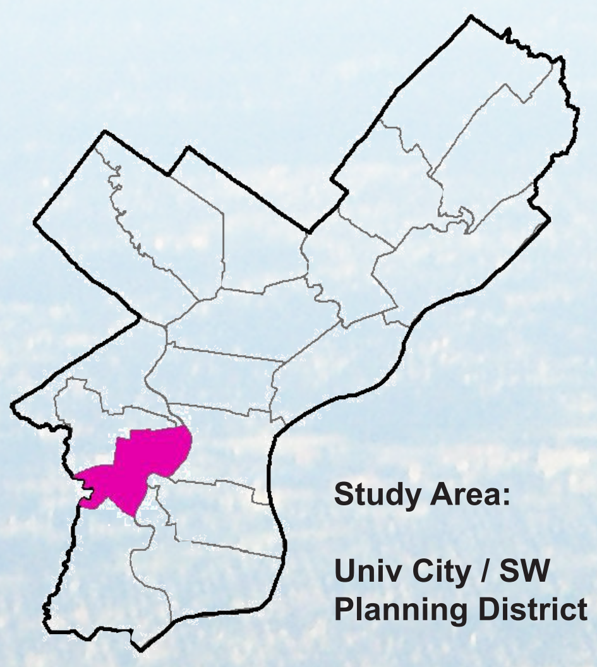
Digital Elevation Model

I. Purpose

Philadelphia is among several large cities who has made a significant commitment to developing green infrastructure for the future. With a particular emphasis on green stormwater management techniques, it has become one of the national leaders in its planning scope and ambition. A strategic plan to invest over $2 billion into green infrastructure development over the next 20 years has been developed.

Despite the massive commitment, except for *Green2015*, a study by PennPraxis which outlines a strategy to identify the first 500 acres of green space conversion, little has been done to date to examine some of the broader conditions on the ground at the landscape scale to see how green infrastructure, as a functioning system and a network of both designed and existing ecological assets, may be spatially incorporated intelligently into the existing fabric of the city in the long term. The PennPraxis study utilizes a GIS modeling approach, examining various natural, infrastructural, and socioeconomic conditions to identify potential areas of green space conversion and map out a series of large scale urban corridors that serve as potential conduits for green infrastructure in the future.

With the *Green2015* plan as a departure point, this study explores the potential for GIS and cartographic modeling to become a generative tool for iteration, ideation, and scenario building, to help construct a physical and spatial “blueprint” for future green infrastructure planning and design. It also aims to demonstrate how cartographic modeling may interpret, visualize, synthesize, and project new data that are meaningful in mapping urban landscape patterns to provide a context to examine some of the relationships between the existing landscape patterns and built forms of the city that support the productive collaborative ground often needed among planners and designers working together.



Study Area:

Univ City / SW Planning District

From PennPraxis *Green2015*

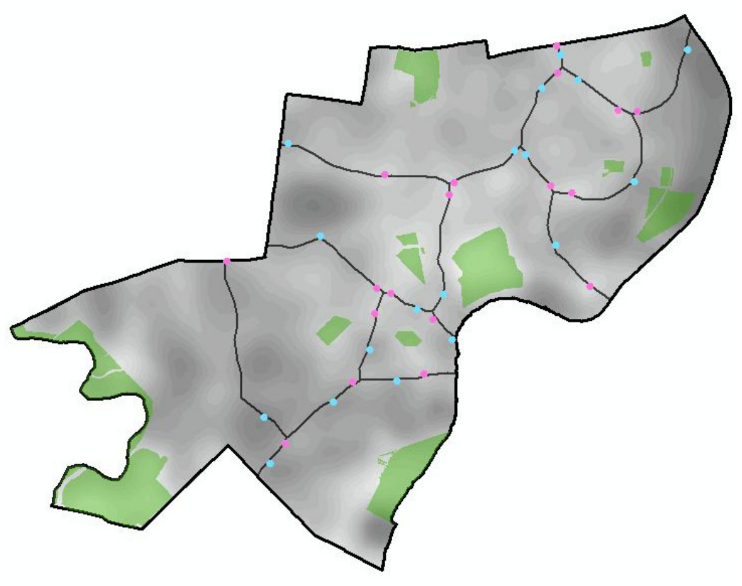
III. Mapping Optimum Connectivity Patterns

By using the supply and demand surface as a base friction grid, cost-based distance and path making operations are employed to start investigating potential connectivity patterns. Through a cost allocation operation, each open space may be assigned a share of the entire territory over the landscape based on the levels of nearby friction present in the supply and demand grid. Through a combination of focal and zonal operations, points along each open space allocation border representing the lowest and hightest cost values, which in turn would represent the highest levels of demand and supply, are identified and marked as pale blue (demand) and red (supply) dots (1).

These points and the selected open spaces form the inputs for least cost path operations that trace “optimum” paths among these elements across the landscape. Depending on where the open space lies, between 2 - 5 least cost paths are traced to their neighboring supply and demand points. Once the paths are traced, a cost distance operation is performed from the paths over the supply and demand friction grid to generate, in addition to the singular optimal paths, a range of connectivity levels surrounding these paths. The paths are represented as blue and red lines, and the connectivity pattern grids are shown in shades of green to pale yellow, with the intensity dissipating as distance increases from the least cost paths (2 & 3).

Total supply and demand networks shown over the original supply and demand friction surface show the demand network (in thicker lines) meandering through low value (dark) areas as it links the open spaces, and the supply network (in thinner lines) meandering through high value (light) as it does the same (4).

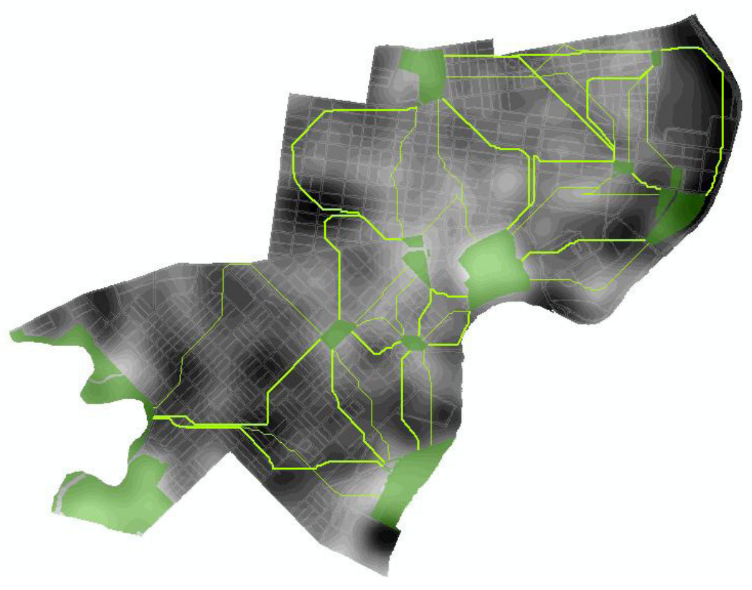
An optimum connectivity pattern may be calibrated by creating a weighted sum combination of the supply and demand connectivity patterns. For example, an 80/20 weighted sum would privelege demand patterns significantly more, while still giving some weight to the supply patterns (5). Ultimately, the specific articulation of optimal connectivity patterns depends on what “optimum” implies in a given context and should be constructed carefully and deliberately by the planner or designer depending on specific objectives.



1. Maximum Supply and Demand Points along Open Space Cost Allocation Borders

2. A Green Infrastructure Connectivity Pattern based on the Supply Network

3. A Green Infrastructure Connectivity Pattern based on the Demand Network



4. The Total Path Networks of Supply and Demand

5. An 80/20 Weighted Sum Green Infrastructure Connectivity Pattern

A Conceptual Aerial Rendering by Philadelphia Water Department

www.phillywatersheds.org

IV. Application Snapshots

A Residential / Industrial Area between Cobbs Creek, Bartram Gardens Kingsessing Park, and Woodland Park

While it may be insightful in and of itself to map these connectivity patterns, without associating those relationships to the “building blocks” of planning and urban design, such as parcels, existing land use patterns, and streets, it would be difficult to move beyond the pedagogical and theoretical towards any form of implementation. The specific optimum least cost path between open spaces (from no. 3 above) are dotted in black, and blue crosses represent existing stormwater projects as references. By converting values present in optimum connectivity patterns shown in shades of green into points, they may be spatially joined to any discrete object features in GIS.

Connectivity Values Attributed to Streets

The darker blue streets indicate the most favorable or the most in demand since they lie directly within the most optimum portions of the connectivity pattern. This type of information may be considered in conjunction with other street features, such as their R.O.W.’s, existing traffic and pedestrian patterns, their proximity to public transit, etc., to formulate a highly informed decision-making and prioritization process regarding which streets to target for greening projects. In the illustration, dotted lines with arrows simply trace a hypothetical configuration of potential mini green street corridors based on a pattern of most demand.

Connectivity Values Attributed to Land Use Parcels

Parcels with the most optimum connectivity values are shown in darker greens. When viewed in conjunction with the presence of vacant parcels, which are shown in red, or other land use characteristics, it may inform what to specifically plan for those vacant parcels. Highlighted by the box is a cluster of vacant parcels situated in a larger grouping of parcels showing the most demand. This combination may indicate that these particular vacant parcels may be prime candidates for garden and community farm conversions, instead of infill projects, which may be more appropriate for vacant parcel clusters outside the connectivity range.

Shaping Green Infrastructure Networks in Philadelphia:
Blueprints for Potentials and Possibilities

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