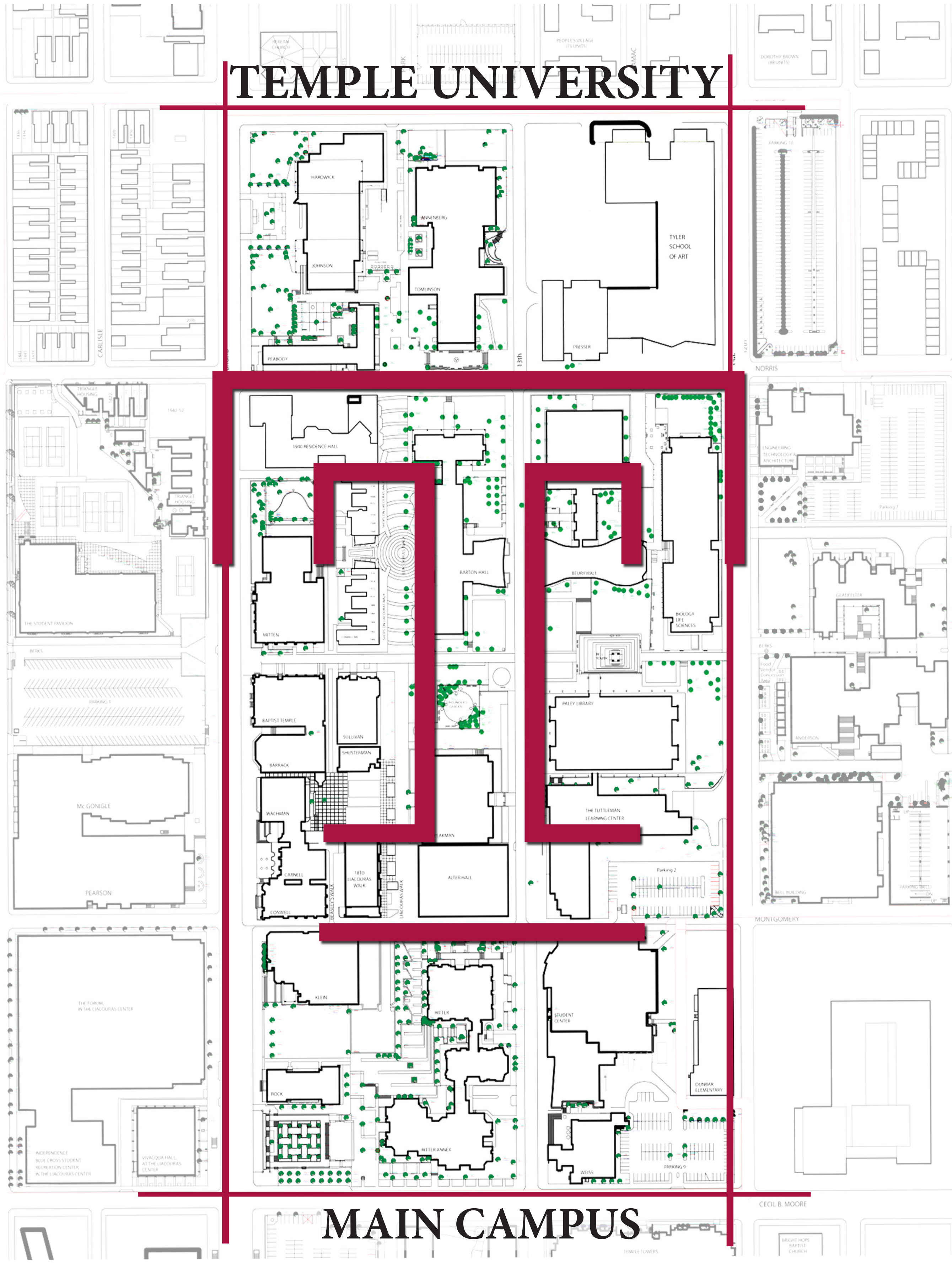
TEMPLE UNIVERSITY



MAIN CAMPUS

LANDSCAPE METRICS

Seminar on Landscape Performance — Spring 2014 — Professor Mary Myers

Authorship

Compiled and edited by Shannon Kelly and Sean Malloy
This class was supported with funding from the Landscape Architecture Foundation
Contributions from Anne Brennan, Jill Friedenberg, Thu Ngan Han, Alex Hoxsie, Marie-Claire Munnelly, Teresa Pereira and Margaret Shaw.

Acknowledgments

The students of The Seminar on Landscape Performance: Temple University Main Campus Landscape Master Plan, extend their gratitude to Margaret Carney, Jeff Featherstone, Brad Thornton, and Katharine Burgess for taking time to inform us about the Temple University Planning Process and Landscape Master Plan.

Funding and guidance for this performance metrics seminar were provided by The Landscape Architecture Foundation

Table of Contents

Introduction

The Seminar on Landscape Performance with a focus on the Temple University Main Campus Landscape was offered as an elective course in the Spring 2014 at Temple University. The main purpose of the course was to introduce Landscape Architecture students to the role of performance metrics in assessing built landscapes and informing the design of proposed landscapes. The course's focus on Temple University's Main Campus Landscape provided a setting where students could analyze the use of landscape performance metrics in an urban environment and develop a set of metrics and baseline data that could inform the Plan and track performance of the design over time.

We began the semester by learning what landscape performance is, how it is measured, and the importance of measuring the performance of designed landscapes to quantify the success of built environments and inform future design. We then conducted precedent studies on the use of landscape performance metrics on American universities and corporate campuses. The purpose of the precedent study was to gather information on how other campuses track landscape performance over time; the benefits of that performance; the academic programs are engaged in the monitoring process, and how the findings from those monitoring programs informed the university/corporation and discipline of landscape architecture.

The students in the class looked at 8 different schools as part of the precedent study. These schools included major public and private universities, and one elementary school located in various geographic areas. The findings of the precedent study were compiled and presented during a meeting with the Temple University Architect, Margaret Carney. During this meeting Ms. Carney took the time to inform the students about the long term planning and vision for Main Campus.

Students took the information gained from the meeting with Associate Vice Preseident Carney as a basis to research the tools and methods useful for monitoring performance. Students then chose a tool they were interested in, explored peer reviewed literature that discussed the use of the tool, and wrote a report on the toola purpose and functionality, pros and cons, and how the tool could be applied to performance monitoring on Temple's Main Campus. Those tools validated through peer review and through application were determined to be most useful to developing design and assessment scenarios for the Main Campus Landscape Plan. Due to the Temple University Main Campus Landscape Plan not being published in time for utilization by the class, a decision was made to use the tools to record and establish baseline data for the core area of main campus. Four tools were chosen to assess the current state of pedestrian quality; ecological health; the diversity of bird species, and carbon sequestration and avoided storm water runoff.

Finally, students took the data they gathered through use of the assessment tools to develop a strategy on the use of those tools in long term monitoring and assessment of the Landscape Plan after it is implemented.

eBird: Global tool for birders

by Jill Friendenberg

eBird is a computer program that was developed by the Cornell Laboratory of Ornithology and the National Audubon Society. The program was designed to “maximize the utility and accessibility of the vast numbers of bird observations made each year by recreational and professional bird watchers.” (About eBird, \ March 2, 2014). From the time of the program’s release to the public in 2002 until the year 2012, there were more than 3.1 million bird observations from North America entered into eBird ‘s data base (About eBird, March 2, 2014).

eBird collects data from bird checklists that a bird watcher (novice through expert) completes during each outing. Checklists are created based upon the birder’s location entered into the program at the start of the outing. During the bird-watch, the user completes the checklist by recording presence or absence of species, along with the date and time of a sighting. Other information recorded by the bird watcher are the length of the outing and the distance traveled.

Data collected by eBird are considered to be high-quality (Wood C, 2011). Regional editors scan the data for unusual user reports in order to clarify ambiguities with the user (Wood C, 2011). The majority of the data; 90% is from the top 10% of the persons who use eBird (Wood C, 2011}. The data is securely stored for use by all through the Avian Knowledge Network.

The nature of the data collected by eBird makes it an extremely powerful research tool. eBird data are recorded with information about bird species along with where and when they were seen. If other attributes such as weather, temperature, or human population are linked to eBird data, the result yields dynamic graphs and charts that examine populations of birds in relation to factors that may influence their population and distribution (Wood C, 2011).

eBird data and the birding enthusiasts who continuously provide it, have been used in a variety of ways in order to elucidate problems, clarify and discover information in bird populations. What follows is a review of some recent research that has utilized birders, as well as, the eBird data bank.

In order to investigate an observation that birds in eastern North America were migrating faster along their migratory paths, scientists utilized the eBird data bank. They were able to access some 48 million bird observations from approximately 35,000 contributors since 2002 (Allan H, 2012). Investigators were attempting to determine whether certain species of birds had responded to warming trends that have been more evident in the Northeast USA as opposed to Southeast USA. The investigators also wanted to determine how adaptable the species appeared to be considering changes in the species time to migrate due to temperature changes. What they found was that during migration, some species arrived more rapidly to the known stopping points - 3 to 6 days for each change in degree Celsius (Allan H, 2012). Investigators determined that the rate of migration for each species, along with the length of the migration path the species uses, determines species adaptability to temperature changes. Slow migrators are more adaptable to temperature changes since they are able to assess the conditions around them as they move and adjust the rate of their migration accordingly. But because of the relative rate of warming that is greater in the Northeast versus the Southeast, slower migrators may move even more slowly along their migration routes as they wait to sense certain temperature changes in their Southeastern destination, straining them for food supply (Allan H, 2012).

eBird data has been utilized to determine continued effects of urbanization upon the Chimney Swift population. Chimney Swifts are birds that exemplify adaptability to urbanization. Before European settlers arrived in North America and constructed homes with chimneys, Swifts were living in caves, vertical cliffs and hollow trees. The settlers' chimneys attracted the Swifts and caused them to abandon their former resting places. eBird data indicates that the breeding distribution is highly concentrated in eastern U.S. near major cities (State of the Birds, March 3, 2014). The Chimney Swift population has been declining 2.2% a year from 1966-2010 or a 65% total decline. The decline was determined to be caused by the fact that homeowners were eliminating the Swifts' homes by eliminating brick chimneys or building more modern chimneys with tiny flues. In an attempt to increase the Swift population, chimneys are being constructed specifically for the swifts for nesting purposes. In response to conservation efforts, eBird encouraged its users to count Chimney Swifts:

Another article details use of eBird in conjunction with another computer based tool called i-Tree. Using eBird data, the frequencies of occurrence were found for a group of nine species located in ten northeastern cities that were investigated. The study assessed the habitat potential for these species using information from i-tree which was already collected for these urban forests. Many variables such as density of dead wood, percent canopy cover, and density of tree cover were gathered from i-tree data and habitat models constructed for the bird species that were investigated. Of all the variables that were studied and assessed in the cities under investigation, canopy coverage had potential to predict habitat suitability. Habitat models may be used to predict the benefits of an urban location for a variety of bird species, and delineate ways to improve existing urban habitats to make them more sutitable for birds (Lerman 5, 2013).

Pros

- Can be used with other tools such as I-Tree to increase the effectiveness
- Useful information on migration patterns in relation to temperature changes
- Informative and well monitored to provide accurate information

Cons

- Difficult for non-birders to submit data if previous bird knowledge doesn't exist
- App is confusing to use

InVEST: A tool that quantifies ecosystem services to inform policy decisions

by Marie-Claire Munnelly

InVEST is a tool developed by the Natural Capital Project designed to inform decisions about natural resource management. Decision makers that could benefit from InVEST include governments, non-profits, and corporations (Tallis et al, 2011). These organizations often make decisions on managing land and water for multiple uses through analyzing trade-offs. InVEST was designed to quantify such tradeoffs, providing decision makers with quantifiable information on the impacts of various scenarios. The InVEST Users' Guide lists a few types of questions the InVEST tool can address, including:

- How will climate change and population growth impact ecosystem services and biodiversity?
- What parts of a watershed provide the greatest carbon sequestration, biodiversity, and tourism values?
- Where do ecosystem services originate and where are they consumed?

As evident in the above questions, InVEST operates at a large scale. It has been applied to decisions made at the global, national, provincial, district, basin, and sub-basin levels, mainly internationally. The most appropriate spatial scale for InVEST models depends on the ecosystem services modeled, the resolution of the available data, and the decision context (Natural Capital Project, 2012). For example, hydrology models generally require a larger area, such as a watershed, while carbon sequestration can be done on a smaller scale.

Currently InVEST is in the beta stage and the Natural Capital Project intends to keep expanding and improving it. It's an open-sourced software, inviting users to submit suggestions and identify bugs (Tallis et al, 2011). The InVEST 2.0 Beta is separated into two main categories: marine systems and terrestrial systems. The models quantify, map, and value the benefits provided by each system component.

For this overview I will describe the models most applicable to Temple University's multi-year development plan: carbon sequestration and water purification.

Carbon Sequestration

The carbon sequestration model uses maps of land use and land cover types and data on wood harvest rates, harvested product degradation rates, and stocks in four carbon pools (aboveground biomass, below-ground biomass, soil, and dead organic matter) to estimate the amount of carbon currently stored in the landscape and/or the amount of carbon sequestered over time under different scenarios (Tallis et al, 2011). Since Temple University is not in the timber business, I will only focus on the data from carbon pools.

Aboveground biomass includes all living plant material above the soil. Below-ground biomass includes living root systems of the aboveground biomass. Soil organic matter constitutes the organic materials in the soil, while dead organic matter encompasses all dead wood and leaf litter. Of all these categories soil is the largest sink for carbon. A weakness in the model is that it does not account for photosynthesis or active soil organisms, which both sequester carbon (Tallis et al, 2011).

GIS software utilizes the raster format, which is a gridded map of cells. The user inputs a land-use map of the area and assign a land use and land cover ("LULC") to each of these cells. These categories can include forest, shrub layer, open/urban area, and agriculture, to name a few.

The user must then enter the amount of carbon stored in each "pool" by conducting fieldwork or using generalized tables (such as the IPCC's 2006 guide). To value future sequestration under different scenarios the user must create scenario land use maps. For example, the user can create a map with twice as much forest cover, or reduced urban area, to quantify different impacts. Below is an example of carbon pool values for different LULC's.

LULC	LULC Name	C Above	C Below	C Soil	C Dead
1	Forest	140	70	35	12
2	Pasture/Grass	15	35	30	4
3	Shrubs	30	30	30	13
4	Open/Urban	5	5	15	2

It is important to note that InVEST models apply the social value of ecosystem services to quantify tradeoffs. Though there are carbon markets that assign values to carbon sequestration InVEST only focuses on the value of damages avoided to society associated with the emission of CO2 (Tallis et al, 2011). Market prices have been criticized for being inaccurate because they reflect policies, subsidies and other factors that only indicate the true value of the service to society by chance (Murray et al, 2007). The social value of avoiding carbon emissions is also controversial however, ranging from USD $9.55 to $84.55 per metric ton of CO2 (Nordhaus 2007 and Stern 2007). That is not to say you cannot take the metrics from the carbon pools and calculate the market value—that is certainly an option.

Limitations

There are clearly limitations to the carbon sequestration tool. It oversimplifies the carbon cycle and assumes carbon sequestration is linear when in reality trees and plants absorb the most carbon in their early years. The InVEST user guide also lists potentially inaccurate discounting rates as an issue (Tallis et al, 2011). However, Ruckelshaus et al examined trends in 20 case studies and they identified simplicity as being a key characteristic to being effective in decision-making. Decision makers generally need high-level of information versus data from the micro-level, and InVEST is a tool that can be used in these decisions (Ruckelshaus et al, 2012).

Water Purification

The InVEST Water Purification Nutrient Retention model calculates the amount of nutrients retained on every cell on the land-use map and then sums and averages nutrients export and retention per sub-watershed (Tallis et al, 2011). It also calculates the economic value that nutrient retention provides through avoided treatment costs. To do this the model integrates the magnitude of overland flow, pollutant loading, the capacity of different vegetation types to filter pollutants, the cost of water treatment and the feasibility to meet water quality standards (Tallis et al, 2011).

The user must input a land-use map and quantify the runoff and pollutants for each cell (formulas are provided in the user guide). The model focuses on the interception of vegetation as the means to absorb water. The runoff and pollutants, called the load, can then be quantified into social and economic costs and/or benefits.

Limitations

The model does not account for point-source pollution; it can only quantify one pollutant per run, and does not consider biophysical or chemical interactions (Tallis et al, 2011).

Summary and Recommendations

I contacted both the World Wildlife Fund (WWF) and the Natural Capital Project on their opinion on apply InVEST to the campus setting. Amy Rosenthal of WWF authored many case studies on InVEST being used in policy decisions. The only instance Amy knew of in which InVEST was used in a school setting was for the Kamehama School in Hawaii, which was over 16,000 acres and was being faced with many land management issues (Natural Capital Project, Scenarios Case Study: Hawaii). If Temple was interested in using InVEST Amy recommended organizing a team of 3 to 4 people to run InVEST that were familiar with GIS and had some disciplinary knowledge of ecology and/or hydrology. She did think it could be a powerful tool to develop collaboration between the architects, the sustainability committee and the modeling team to understand the ecosystem service implications of different planning options (Rosenthal, personal communication, March 10, 2014). Elizabeth Rauer, Communications Manager at the Natural Capital Project said she was not familiar with InVEST being used on a campus setting but it was a terrific idea. She also recommended a team of folks familiar with GIS to expedite the process. The Natural Capital Project is creating a free online training, however, that could be useful in building a team (Rauer, personal communication, March 10, 2014).

In summary I think InVEST should only be used as a planning tool, not a metrics tool. It was not designed to measure ecosystem services over time. If Temple University wanted to do a 50-year plan that tied together all of its campuses, then I think InVEST would be useful. I also think if Temple wanted to partner with the Philadelphia Office of Sustainability in developing a long-term plan for the city great precedents could be set by applying InVEST.

Pros	Cons
• Quantifies current and projected ecosystem services through scenarios, informing planning decisions • Quantifies the ecosystem service impacts of alternatives in biophysical terms, such as tons of carbon sequestered, AND in economic value in dollar terms • Output includes spatial maps, a visual output, which aids in understanding by decision makers	• Takes a long time to gather data (almost one year is recommended) • Requires a team of 2 to 3 to be familiar with GIS (and ideally hydrology/ecology) to use it effectively • Does not provide actual metrics of ecosystem services over time, only estimates through scenarios—it's a planning tool • Requires a lot of data input that calls for formulas and assumptions, increasing the probability of user-error

i-Tree: A Qualitative and Quantitative Assessment on Tree Benefits for Urban Areas

by Thu Ngan Han

The United States Department of Agriculture Forest Service Division has developed a set of software tools that provide communities, non-profit organizations, consultants, and students with quantitative and qualitative data on urban forests and its benefits. It also provides baseline data for communities to assess their current urban forest conditions with the goal to make informed management decisions.

There are six urban forest analysis tools and three utility programs. The analysis tools are: i-Tree Eco, i-Tree Streets, i-Tree Hydro, i-Tree Vue, i-Tree Design, i-Tree Canopy. The utility programs are: i-Tree Species, i-Tree Pest Detection Module, i-Tree Storm.

i-Tree Eco is used to estimate the qualitative and quantitative benefits of urban forests. Users may enter data collected locally within their region or use a provided base sampling to compute the estimates. The estimates provide data on urban forest structure, hourly pollution removal, different tree species impact on air pollution removal, economic and health benefits of air quality improvements from trees, total carbon stored by urban forest, effects of trees on building energy use, yearly tree canopy rainfall interception, compensatory value of the urban forest, tree pollen allergenicity index, and pest risk analyses.

Many well-known organizations such as the US EPA and US D.O.E. have utilized the i-Tree Analysis Tools to provide concrete data for their projects. Pennsylvania Representative Scott E. Hutchinson integrated the i-Tree tool in joint legislation concerning air and water pollution control (Environmental Synopsis). Not only is it utilized in the USA it is also becoming popular in Canada, Germany, and Great Britain. Its easy to understand directions and straightforward data allow government agencies, businesses, and communities to use it in their projects.

After giving the tool a trial, I thought that it was relatively straight-forward. There is a document with specific step-by-step directions to help people get started. The most important factor in creating quality and accurate information is inputting the correct data into the available survey. Explanations of what to look for and how to find the needed information can be found in the guide document. To start a project, a boundary must be defined with clear goals and objectives. Once that is settled, it is a matter of collecting information about the trees (i.e. name, height, width, location, condition, etc.). The data can be manually entered into the program or transferred from a PDA or mobile device. After completing the data collection and importing it into the program, it is then processed and analyzed. The results are a combination of charts, graphs, and annotations. The tool is great for collecting and analyzing data. It provides solid information that is understandable to the average user. However, it takes time to collect the data and input it into the program. Accuracy of field data may also be effected depending on the knowledge and experience of the data collector. Also, an update on weather patterns and climate change is needed. Currently, i-Tree create data based on 2005 weather patterns. After data is processed, there is the phase of sifting through the information. I-Tree is an easy to use tool but time investment is a requirement.

I think the i-Tree Eco tool can tremendously benefit the Temple University Master Campus Plan. It can be used to quantify and qualify tree benefits on campus before and after construction. We can use it to learn about current conditions pertaining to carbon sequestration, air quality, building energy use, and much more. After construction, we can use the i-Tree Eco tool, or any of the tools for that matter, to learn if our design strategies improved the campus' conditions. It is also ideal for long-term monitoring because it provides yearly analysis of tree benefits. Overall, I think the i-Tree tool is a reliable source for monitoring landscape performance.

Pros

• Clear, in depth directions that helps people get started
• Quantifies the information the user inputs into easy to understand charts, graphs and annotations
• App is free, simple and can be used on a variety of mobile devices

Cons

• Can be time consuming to gather data, only one tree can be entered at a time even if it is the same species
• Previous knowledge of tree species is required

Green Roof Energy Calculator

by Margaret Shaw

The Green Roof Energy Calculator is a quick estimate tool developed by Portland State University in collaboration with the University of Toronto and Green Roofs for Healthy Cities that allows the public (specifically architects, planners, etc.) to compare the energy performance of a building with a green roof versus a conventional roofing system (Portland State University, 2013). This project was funded primarily by the United States Green Building Council (USGBC) so that it could be incorporated into the Department of Energy's (DOE) EnergyPlus program, a whole building simulation software that models energy and water use (USGBC, 2013).

The Green Roof Energy Calculator was developed using EnergyPlus and ESP-r energy modeling software, as well as field data. It creates a model that represents the following physical characteristics of a green roof system: long- and short-wave radiation exchange (albedo), effect of canopy on heat exchange, thermal and moisture transport in the growing media with moisture inputs from precipitation, evaporation, and transpiration (Portland State University, 2013). The model was then calibrated to reflect real life conditions in 100 North American cities using climate zone benchmark data from the DOE and location specific data for utility rate schedules and annual precipitation profiles.

User input for this software includes place information (city and state), roof area, and a few questions about the green roof system (percentage of total roof, media depth, leaf area index). This information is then used to determine the impact of a green roof on that building. The results display annual energy savings of the green roof compared to conventional dark and white roofs. The energy savings are given in terms of electrical savings (kWh),gas savings (therms), and total cost savings (dollars). Additionally, the model shows comparisons of latent and sensible heat flux to the urban environment and the net water balance, considering precipitation, evapotranspiration, and irrigation.

To date, there doesn't seem to be a body of peer reviewed literature addressing the Green Roof Energy Calculator software. This is likely due to its relatively short lifespan and the fact that it is a rapid estimation tool (on the same order of magnitude for accuracy) rather than a detailed scientific study of individual roofs. However, it does receive mention in recent papers discussing available energy modeling systems as seen in Sananda Mukherjee's book on the subject (2013) and it is touted as a legitimate web-based alternative to EnergyPlus and ESP-r by the National Renewable Energy Laboratory (NREL, 2011).

In my own experience testing the Green Roof Energy Calculator, it strikes me as a simple and user-friendly tool. In a matter of seconds one can have an estimate of the energy saving benefits of a green roof, calibrated to that buildings dimensions, local weather conditions, and utility rates. Although it is a tool or estimation, its creation in long established universities and its sponsorship by the federal government give it a feeling of extra credibility. The only drawback I notice readily is the ambiguity around leaf area index (LAI). This variable is described in a drop down link, but the explanation does little to help the user choose an appropriate value. Perhaps instead of the explanation given, a chart defining the different LAI values or a formula for determining it would be more useful.

The Green Roof Energy Calculator could be a valuable tool going forward for Temple University. Due to its ease of use and accessibility, this tool could be used in the planning process to demonstrate the potential economic and environmental return on green roof projects. It could also be useful as an advertising or publicity tool, demonstrating the University's commitment to green infrastructure. Although it seems like a one-use tool, a long term study could be carried out actually measuring the savings realized on a green roof project. Comparing this real world data with the estimate would demonstrate how valuable it is (or perhaps isn't) as a tool and present an opportunity to expose the Green Roof Energy Calculator to peer reviewed study.

Pros

- Simple and user-friendly
- Quickly quantifies the energy savings based on information inputed into easy to understand charts, graphs and annotations
- Credible, used at universities and federal government

Cons

- Leaf area index is ambiguous
- A tool of estimation

The Pedestrian Environmental Quality Index Tool

by Sean Malloy

The Pedestrian Environmental Quality Index (PEQI) is a tool developed by the San Francisco Department of Public Health to prioritize improvements in pedestrian infrastructure during the urban planning process. The tool was designed to evaluate existing barriers to walking that exist along streets and at intersections and to prioritize future investments for increasing pedestrian safety and activity in the urban planning process. The PEQI is an observational survey that quantifies street and intersection factors that are known to affect people's travel behavior. The quantifiable observational data for the survey was developed by looking at published research from numerous cities and university researchers to assess how the physical environment impacts whether people walk through a neighborhood and how they select their routes of travel.

While the PEQI was developed to serve as an urban planning tool to identify and prioritize pedestrian infrastructure improvement, the tool can also be utilized to assist in the design of pedestrian infrastructure, establish a baseline against which to measure future design, and be modified to monitor the performance of pedestrian oriented landscape elements over time by assigning values based on the PEQI categories.

During review of scholarly articles on the use of San Francisco's Environmental Quality Index it was found that several articles discussed using the index as a planning tool. However, no articles were found on the use of the tool for measuring landscape performance. Two precedents were found for use of the PEQI in measuring landscape performance. The architecture firm Mithun along with a multidisciplinary planning team utilized the PEQI as a performance monitoring tool for The Lloyd Crossing Sustainable Urban Design Plan for the Lloyd District in Portland, Oregon and Taylor 28 Mixed Use Development in Seattle, Washington. For these projects, the PEQI was used to measure a baseline for pedestrian quality of the streetscape before and after the project was completed to quantify the success of streetscape improvements in combination with artful storm water designs in a high density environment.

The PEQI consists of five categories that contain a total of 31 indicators that reflect the quality of the built environment and were used as part of the data collection survey. The San Francisco Department of Public Health has aggregated these indicators to create a weighted summary index. Data are collected using an audit form designed to be used by a trained observer based on visual assessments of streets and intersections. Data are entered into a customized Microsoft Access database and automatically scored producing the PEQI score on a 0-100 scale with a higher number having more favorable pedestrian use qualities. Data can then be displayed visually when using the GIS database. The PEQI databases and training tools are available for free from the SFDPH website and provide data on how to modify the GIS database to cities outside of San Francisco.

Suitability for Temple University Main Campus Monitoring

The PEQI can be modified for use in Philadelphia and specifically the streets that cross through and surround Temple University's Main Campus. Setting up the software for use around main campus and training a data collector using the provided 40 page training manual can be accomplished within a day. It utilizes current computer systems and software that Temple already possesses. The PEQI is considered a Quantitative Observational Instrument. It takes qualitative data, which through the training process removes a certain amount of subjectivity on what the auditor is observing, and assigns a value to certain conditions thereby creating a quantifiable rating for pedestrian environmental quality. The PEQI audit forms and database were not specifically designed to measure the design performance of pedestrian use spaces over time. The PEQI in its current form is adequate for establishing a baseline by identifying deficiencies which can then inform the design process and hopefully produce a design that would create a higher PEQI score and therefore create a better pedestrian environment.

The PEQI can be utilized for more than just a planning tool. It can provide valuable data and assess the performance of pedestrian corridor design by assessing and monitoring changes in the 31 quality indicators over time, as well as comparing the built design to an established baseline. As part of a landscape performance monitoring program a series of assessments can be scheduled at specific intervals over a number of years with one PEQI being conducted immediately after construction completion. To use the PEQI successfully, it may be necessary to modify several of the categories to provide more qualitative choices on the condition of elements in the category. For example, The indicator "Public Seating" is a yes or no category. Depending on the type of seating and construction, age can effect condition, and condition can effect usability and therefore pedestrian environmental quality and should be assessed a lower score.

From a performance standpoint, the PEQI could benefit the long term assessment of the Temple University Landscape Master Plan by allowing the University to assign a value to a landscape impact on pedestrian quality as it develops over time, whether that development is negative or positive, and what indicator scores change over time and why the score changes. Using the PEQI and monitoring the change in indicator status can provide valuable insight into future design. Several of the indicators that are part of the PEQI can and will change as the landscape ages. These include pedestrian lighting, graffiti, litter, empty space, public seating, sidewalk impediments, trees, high visibility crosswalk, planters and gardens, direction of vehicular traffic, and large sidewalk obstructions. The data gathered from these changes can provide performance insight by evaluating what about the design led to changes. It can include everything from the methods, materials, plant choices, sizes, location coupled with the maintenance, installation, quality, and then the either decay or improvement over time that leads to a higher or PEQI score.

<u>Pros</u>

- Can be used as an urban planning tool and a performance monitoring tool by identifying and ranking street condition and tracking changes over time
- Combines several different quantitative categories to develop a quantitative score of overall street quality.
- Can be used to assess design and develop a score for a proposed design

<u>Cons</u>

- Current database has a technical limitation that limits its use to 32bit Windows operating system. Most Temple systems are 64bit and updating the database will require additional programming
- The score derived from the database is somewhat dependent on zoning which as a default is based off of San Francisco's Zoning. The database will need to be updated for use in Philadelphia
- Collection of observed data is somewhat subjective and could vary by using different data collectors

Plant Stewardship Index (PSI): A Tool to Measure Native Plant Communities

by Anne Brennan

According to the Plant Stewardship Index (PSI) website, found at http://www.bhwp.org/plant-stewardship-index.htm, the PSI tool was "specifically developed to evaluate the ecological integrity of native plant communities in the Piedmont region of Pennsylvania, and in New Jersey." Developed by botanical experts at the Bowman's Hill Wildflower Preserve, the PSI database contains most of the plant species native to the Piedmont region of Pennsylvania and New Jersey.

The first step to using the tool is to compile a list of all the plant species found on a particular site. The user then uploads the list into the PSI Online Calculator. The tool then generates a report with a variety of metrics.

The main concept of the tool is that each plant species in the database has a coefficient of conservatism (CC) between zero and 10. From the website: "Higher coefficient numbers are assigned to those species that are 'conservative' in their requirements for stable native plant communities. Species with lower CC values are generally found in a broader range of habitats and are more likely to colonize disturbed ground, abandoned fields, waste ground and old pastures, etc."

Non-native species always have a CC of zero, as they are assumed to have no positive effect on ecological quality. Native species that grow in a wide range of environments will have a low CC value, while those that are only found in particular, very stable environmental niches have higher assigned coefficients. "Native" again is defined as native to the Pennsylvania Piedmont.

Four metrics are calculated by the PSI tool. See the User Guide at http://www.bhwp.org/psi/PSI-User-s-Guide-and-References.htm for more details about the calculations. The two basic metrics are:

1. Native Mean C = Sum of Coefficients / Number of Native Species
A higher number indicates a higher-quality native-plant community.
2. Total Mean C = Sum of Coefficients / Total Number of Native and Introduced Species
The difference between this number and the Native Mean C indicates the influence of non-native species on the plant community. A greater difference indicates a larger proportion of introduced species.

Applicability to Temple University Campus

Since the PSI tool is intended for use in natural areas, restoration projects, and other landscapes comprising mostly native species, the tool's plant database does not include many non-native, ornamental or "horticultural" plant species typically seen in the built environment. Therefore, of the total 86 species noted in the survey area only 44 species (including 24 natives) could be added to the site species list in the PSI tool. The remaindering 42 non-native ornamental species are listed in the Site Description field of the PSI report but were not used in calculations. The tool clearly has limitations in assessing cultivated or garden landscapes that contain many non-native plant species.

However, as time passes and the plant palette on campus changes, the PSI metrics will change as well.

Specifically, as more introduced (non-native) plant species are replaced in the landscape by native species, the Total Mean C will increase. If these native species are also of higher ecological quality than the current native palette, indicated by higher CCs, the Native Mean C will also increase over time. In a cultivated area, this could also be interpreted to mean that the soils and other conditions are being managed in a way that reduces disturbance to the growing environment; this is because high-CC species need stability to persist. The PSI tool can therefore be used to establish a baseline and set goals for increasing native plant diversity on campus that can be measured at specified time increments.

Pros

- User friendly
- Numbers outputted are understandable and good for comparisons

Cons

- Does not include non-native, ornamental or common plants used in built environment
- High level of herbaceous plant knowledge is needed

Urban Heat Island Mitigation Impact Screening Tool (MIST)

by Alex Hoxsie

The urban heat island effect describes the higher air temperatures in urban areas compared to nearby rural areas. Two contributing factors are reduction of ground-surface shading due to removal of trees for urban infrastructure, and the increased absorption and re-release of heat by buildings and pavement as compared to that of vegetation (Hoverter, 2012).

While the urban heat island effect has been widely correlated with unhealthy ground-level ozone levels and increased energy demand for cooling buildings on a city-wide scale (see next section), the same mitigation techniques can be implemented on a landscape scale of less than an acre with dramatic results, which can improve individuals' experiences of the space. The equipment needed to monitor and compare surface and air temperatures in a landscape over time are relatively inexpensive and simple to use, and are described in the Monitoring section.

The Landscape Architecture Foundation (www.lafoundation.org) includes the Urban Heat Island Mitigation Impact Screening Tool (MIST) in their online Landscape Performance Tookit. This tool "estimates the likely impacts of heat island mitigation strategies at the city-scale" (Sailor, 2005), based on the user's predictions of increased vegetated cover and/or albedo (reflectivity of non-vegetated surfaces) for one of 260 specific cities. MIST's calculated results include the estimated change in average temperature city-wide, and from that, average savings in heating/cooling costs and reduction in ozone levels. For example, increasing vegetative cover throughout the city of Philadelphia from 35% to 45% is estimated to reduce the average temperature of the city by 0.5-1.0°F, which would reduce the costs to cool a pre-1980 office building by 3%.

The MIST estimator, is not useful for landscape architects and designers who are interested in quantifying their success in reducing urban heat accumulation. While this tool can be useful for large-scale policymaking, it does not address the locally-significant effects that shade trees or light-colored pavement can have on a micro-environment along a city sidewalk or within a green space between campus buildings. Fortunately, quantifying these effects is relatively simple using logically-placed data loggers to measure temperature; these data can then be compared to established thresholds of human comfort.

<u>Pros</u>

- User friendly
- Useful for projects on a city scale or larger

<u>Cons</u>

- Does not provide or calculate data for specific sites

Alternative to MIST

Monitoring Surface and Ambient Temperatures at the Landscape Scale

Monitoring the effect of landscape enhancements on surface and air temperatures can be done with relatively simple equipment costing between $200 and $500, depending whether the project calls for occasional, manual data collection or automatic logging of temperature data over time.

Surface temperature: A simple tool for obtaining instantaneous surface-temperature readings for pavement, roofs, and other solid surfaces is a hand-held infrared thermometer made by Extech (www.extech.com), which I have personally used. A student or technician can be easily trained to take the temperature readings relevant for the project.

For example, temperature readings from shaded and non-shaded areas of the same paved plaza surface can be compared at the same time under various weather conditions or times of the year. Or, surface temperatures of an existing landscape under certain conditions can be recorded and compared with newer materials once a new design has been installed.

Ambient temperature: Air temperature can be easily measured manually with any digital thermometer as needed, keeping in mind that sunlight falling directly on the instrument will affect the reading and so should be avoided.

However, a small HOBO data-logger (http://www.onsetcomp.com) can record the air temperature on a continuing basis for weeks at a time until the data is downloaded to a PC for storage and analysis. Multiple loggers can be used to compare an existing landscape with a redesigned space under identical conditions, and loggers are available that also record ambient light levels. We have used the latter in the greenhouses at Temple's Ambler Campus with much success.

While landscape architects are likely to face pressure from municipalities to incorporate urban heat island-reducing features into their designs, at this time the performance monitoring is best done with on-site data loggers to draw comparisons over time or compare pre-existing elements with improved features.

The Value of Green Infrastructure: Quantifying Social Performance

by Shannon Kelly

"The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Social and Environmental Benefits" was put together by CNT (Center for Neighborhood Technology) and American Rivers in 2010. The purpose of this guide was to compile information on Green Infrastructure Benefits into one user friendly document to help "inform decision-makers and planners about the multiple benefits green delivers to communities" and to "guide communities in valuing the benefits of potential green infrastructure investments".

"The Value of Green Infrastructure" tool is a guide that provides its users with all the calculations necessary to get the quantitative data concerning the benefits and practices of green roofs, tree plantings, bioretention/infiltration, permeable pavement, and water harvesting. The guide breaks down the above green infrastructure practices into categories of the benefits each one has on water, energy, air quality, climate change, urban heat island, community livability, habitat improvement, and public education. Although this tool provides a broad range of information, an easy to read diagram (see following page) clearly breaks down the practices and which benefits each practice has. Four of these benefits (improving aesthetics, increases recreational opportunity, reduces noise pollution, and improves community cohesion) fall under the category of "improving community livability" which will be the focus for the remainder of the paper.

Community livability benefits are difficult to measure and literature on quantifying this benefit is not widely agreed upon or extensive. The Green Infrastructure tool aims to give its user the benefit values that have been proposed in various studies. The value of aesthetics can be gauged from the property values increasing when trees are located on the property and the larger the tree the greater the benefit. Also included is a user methodology guide from Stratus 2009 report. "One additional vegetated acre provides ≈ 1,340 user days per year", meaning the more vegetated space you have the more users. Noise pollution decreases with the presence of porous pavement and green roofs. In one study it was found that there is a decrease in property values when noise decibels are high. In a report done by Kuo and Depooter Sullivan "Exposure to green surroundings reduces mental fatigue and the feelings of irritability that come with it. . . . Even small amounts of greenery . . . helped inner city residents have safer, less violent domestic environments." (Kuo and Sullivan 2001b)

This tool is helpful in providing a brief overview, insight and quick facts/equations of green infrastructure. The drawback is that it doesn't go into great depth into any specific performance tool, but it does provide an appendix that compiles all the performance measuring tools they used in the guide. This is a great tool for beginners who want to know about green infrastructure as a whole and how it helps all areas of life. Temple can use this tool just as it was intended, as a guide of the values of green infrastructure that they plan on implementing. The guide is well researched and persuasive in that all the studies used have provided positive feedback on how beneficial green infrastructure can be on people. Also, this tool shows that there are gaps in the research on social benefits that have the potential to be filled and further investigated.

Green Infrastructure Benefits and Practices

This section, while not providing a comprehensive list of green infrastructure practices, describes the five GI practices that are the focus of this guide and examines the breadth of benefits this type of infrastructure can offer. The following matrix is an illustrative summary of how these practices can produce different combinations of benefits. Please note that these benefits accrue at varying scales according to local factors such as climate and population.

Benefit	Reduces Stormwater Runoff											Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Practice										CO_2								
Green Roofs	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Maybe	Yes	Yes
Tree Planting	Yes	Yes	Yes	Yes	No	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Yes
Bioretention & Infiltration	Yes	Yes	Yes	Yes	Maybe	Maybe	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	No	Yes	Yes
Permeable Pavement	Yes	Yes	Yes	Yes	No	Maybe	Yes	Maybe	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes
Water Harvesting	Yes	Yes	Yes	Yes	Yes	Maybe	No	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	Yes

Yes Maybe No

CNT © 2010 3

Pros

- Quick quide, great for beginners
- User friendly
- Great graphics and diagrams

Cons

- Attempts to cover a large amount of information
- Gaps in information

Water Harvesting Calculator

by Teresa Pereira

The Water Harvesting Calculator by Wasaho Water Harvesting Solutions was investigated. Though the calculator results returned error messages, (the website might be down) the format of the tool was found to be clear and concise. It would be useful in real-world applications. According to the LAF website, "this tool estimates the volume of water required for toilet flushing in a building and compares it to the amount of water that a rainwater harvesting system could capture from roofs and parking lots. Inputs include: information on building occupancy, average rainfall, and roof and parking lot catchment areas. Results are estimates of toilet flushing water requirements, volume of rainwater available, percent of toilet flushing that could be met, and volume of any additional rainwater available for irrigation or other uses."

The Calculator, first and foremost, is simple. There are 11 questions that include clarifications, examples, and links, which prevent any confusion for the user. As a side note, Washington State's Rainwater Harvesting Calculator was looked at and found to have a very complex format making the tool cumbersome. It was easy to feel overwhelmed by the process of inputting information because of its immensity and non user-friendly excel interface. The Wasaho Water Harvesting Calculator provided exactly the opposite experience. Links are included to encourage further education on methods to efficiently capture rainwater from a given location.

The questions within the calculator make for a good basis of information regarding buildings, landscape, and water usage. The calculator provides worthwhile considerations for those who are thinking about moving into a building, buying one, or installing a water harvesting system. For Temple University's purpose, the university can understand how much roof and parking area could be implemented to capture rainwater to understand the "percent of toilet flushing need that could be met, and volume of any additional rainwater available for irrigation or other uses." (LAF website) The calculator is also conducive to finding more information about specific buildings, and whether they are ideal candidates for catchment. It brings up questions about efficiencies and inefficiencies of architecture and its surrounding landscape. The calculator is a great way to quantify the performance of a building and the volume of water it uses. It's a tool that measures the relationship of the built environment and outdoor space.

Though Wahaso is a private company that uses the calculator as a way to market their services to install a capturing system, this tool can be applied to a larger institutional context. It could provide information to guide the transformation of our landscapes and buildings to ones that are beneficial and provide long-term ecological, economical, and social services.

<u>Pros</u>

• Clear and concise format
• Links included for further education
• Simple, user friendly

<u>Cons</u>

•Created by private company attempting to market their services

Use of Tools

A core study area to standardize and simplify data collection was defined within the borders of Temple's Main Campus. The area encompasses a rectangular area with Broad Street along the Western boundary, 12th Street along the Eastern boundary. Diamond Street along the Northern boundary and Cecil B. Moore along the Southern Boundary.

Selection of Tools

After conducting the individual student research on tools, we determined that the best course of action was to assess current landscape conditions and establish baseline monitoring data. Four tools were selected for use on Temple's Main Campus: The Pedestrian Environmental Quality Index (PEQI), The Plant Stewardship Index (PSI), eBird, and iTree. These four tools were selected because they could provide quantitative and qualitative data at a scale appropriate to Temple's Main Campus. Other tools were not used because they provided data for a large area beyond the scale of Temple's Main Campus or could not be easily applied.

The eBird database shows data for bird sightings at Temple Main campus submitted by individuals Jamie Zigarel and Jackie LaCorte. Their information indicated that a total of 14 bird species had been sighted on campus from September 2013 through February 2014. In order to investigate Main Campus attributes that may have attracted the sighted species, information was collected from eBird. Each species' habitat requirements and residence status (permanent or temporary) were noted. Temporary residents are birds that are traveling through an area during migration.

Temple Main campus attracted the following bird species:

Year-Round Residents:

House Sparrow, European Starling, American Robin, Gray Catbird, Red-Tailed Hawk

These species have adapted and thrived in close association with human beings and their man-made environments featuring tall buildings, lawns and refuse. Red-tailed Hawks take advantage of windy updrafts and open spaces that are created by city structures. They perch on telephone poles and hunt mice and voles. American Robins are nourished by the worms that they forage from lawns and the berries that they find in low growing trees and shrubs. European Starlings are the continent's most numerous songbirds. They travel in large noisy groups feeding off of sidewalks, parking lots and lawns. House Sparrows are as common in urban setting as Starlings and prefer their habitat close to human dwellings. Consequently, House Sparrows are not found in undisturbed forests or grasslands. The Gray Catbird finds safety in a habitat with few open spaces. It prefers to live amongst small trees, thickets and vines where it can find berries that it adores. With the exception of the House Sparrow, the other bird species sighted at Temple Main Campus can inhabit countryside or forest.

Temporary Residents: at Temple Main Campus comprise the remainder of the total sightings:

Hermit Thrush, Eastern Towhee, Wood Thrush, White Throated Sparrow, Ovenbird, Ruby-Crowned Kinglet, Blackpoll Warbler, Common Yellowthroat Blue-Throated Warbler

All of the birds in this group are migrating to and from other areas for the purposes of breeding and/or locating food when seasonal changes affect what resources are typically available. Many of the temporary resident species, such as the Ovenbird, Wood Thrush, Hermit Thrush and Eastern Towhee reside in forests- the understory, edges or deep within. These birds are not searching for similar habitat when they come to Temple Main Campus. They are searching for food to sustain them during calorie-demanding endeavors such as breeding or migrating. Other species in the group of temporary residents such as the Blue Throated Warbler, Common Yellowthroat, Blackpoll Warbler, Ruby Crowned Kinglet and White Throated Sparrow can also appreciate the habitat the Temple Main Campus offers. They, like the permanent residents are primarily in search of food and forage in leaf litter for invertebrates. Spiders, berries and buds in low bushes, thickets and trees are favored foods.

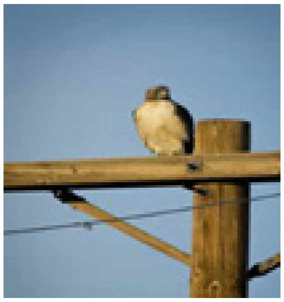
Temple University Main Campus is evidently valued by a variety of bird species. Whether year round residents or passing through during migration, birds are present on campus. It is hoped that the planning committee will remember, when selecting trees and shrubs for the campus, to consider the avian members of the Temple community. Choices of berry producing trees and shrubs, and low level greenery would satisfy many bird species. Perhaps a plan could be devised to purposely leave some fall leaves behind to serve as hiding places for invertebrate food sources that are favored by some birds? Careful use of pesticides on campus is necessary in order to prevent poisoning the food supply so important to all. Preventing birds' collisions with windows can be accomplished by window treatment that makes windows less transparent to birds in flight. Monitoring the bird species on Temple Main Campus should be continued by the individuals currently submitting reports via eBird. This information is important to all who have an interest the species and can obtain it using eBird. The information can potentially be of value to Temple University as evidence of both immediate and far-reaching effects that the landscape has on the world around them.

Species	Breeding Season	Seeds	Fruit	Insects
Eastern Towhee	Summer	Y	Y	Y
Hermit Thrush	Summer		Y	Y
Ovenbird	Summer		Y	Y
Blue-throated Warbler	Summer		Y	Y
Common Yellowthroat	Summer			Y
White-throated Sparrow	Doesn't nest locally	Y		
Ruby-crowned Kinglet	Migrates	Y	Y	
Wood Thrush	Summer			Y
Blackpoll Warbler	Migrates	N	Y	Y

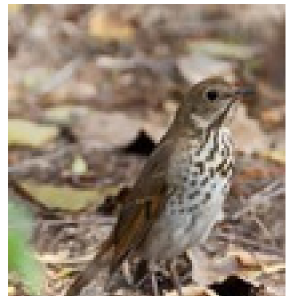
GENERAL SUGGESTIONS FOR THE WELFARE OF ALL BIRD SPECIES ON TEMPLE MAIN CAMPUS

Avoid use of pesticides that kill insects many species consume.
Avoid use of herbicides that destroy species' brushy habitat and weedy plant foods.
Leave a layer of leaves beneath shrubs in order to provide foraging areas for species that are insectivorous.
Screen windows or make them visible to prevent birds' collisions.
Keep pet cats indoors to keep them safe from outside hazards and to protect native birds. Remove feral cats from neighborhood.

Red-tailed Hawk



Hermit Thrush

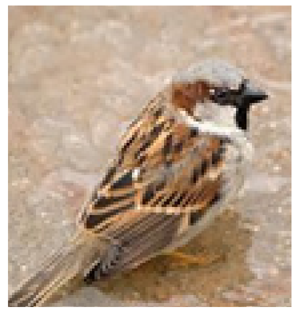


European Starling

Gray Catbird

Eastern Towhee

House Sparrow



American Robin

Ovenbird

White-throated Sparrow

Ruby-crowned Kinglet

Common Yellowthroat

Woodthrush

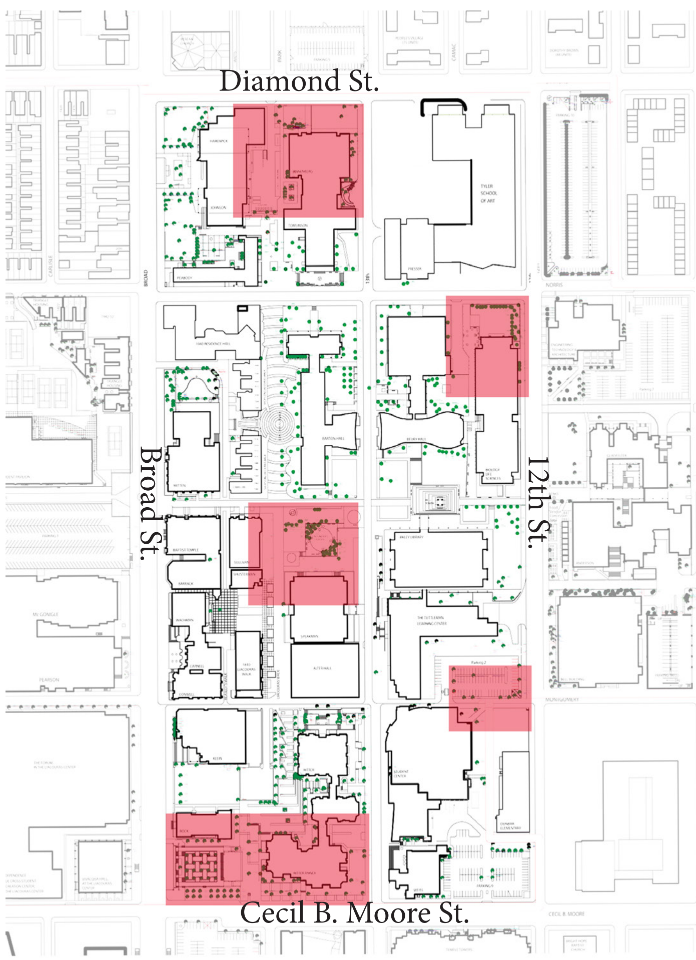
Blackpoll Warbler

Blue-throated Warbler

Metrics/ **i-Tree**

i-Tree Eco was used to synthesize tree data gathered on-site at Temple University Main Campus (TUMC). The objective was to quantify and qualify existing tree benefits relating to carbon storage and sequestration; pollutant removal; surface runoff reduction; and functional value in an urban landscape. Thu Ngan Han and Shannon Kelly collected on-site information that was submitted to i-Tree. From the results, a preliminary baseline has been created and can be utilized to strategize designs that may encourage environmental stewardship at TUMC. An overview of our results, taken from a small sample of trees on campus, show us that the sample of existing trees on campus are estimated to store 4 tons of carbon, an annual value of $302. These numbers would increase greatly if every tree on campus were put into the i-Tree system. i-Tree provided us with data on specific species. Their carbon storage capabilities can be seen in the charts below. Additionally, i-Tree Eco provided information on the different tree species and how each contribute to water runoff reduction. Overall, TUMC Master Plan committee can use the results gathered to stay informed on the type of trees to use and their structural and functional advantages.

Map of sample areas



IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power plants [4].

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Temple Master Plan trees is about 1 tons of carbon per year with an associated value of $64. Net carbon sequestration in the urban forest is about 1 tons. Carbon storage and carbon sequestration values are calculated based on $71 per ton (see Appendix I for more details).

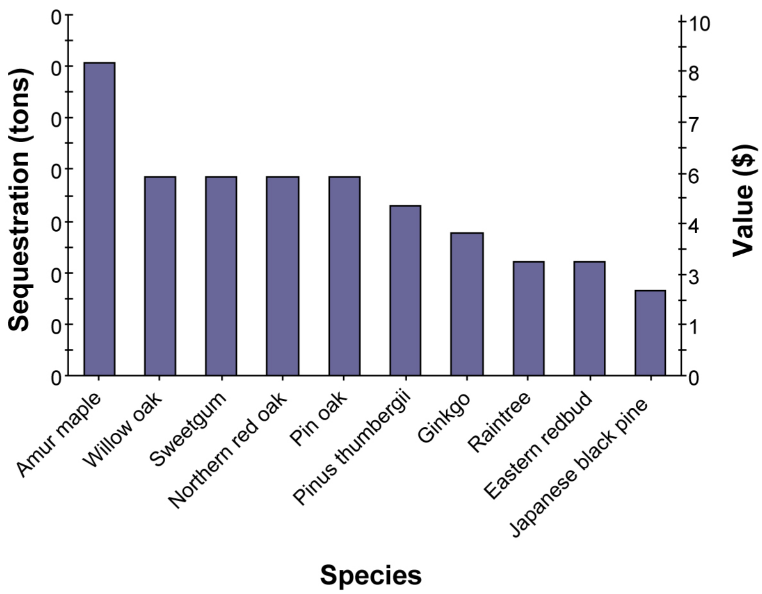


Figure 7. Carbon sequestration and value for species with greatest overall carbon sequestration in Temple Master Plan

I. Avoided Runoff

Surface runoff can be a cause for concern in many urban areas as it can contribute llution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some rtion of the precipitation is intercepted by vegetation (trees and shrubs) while the other rtion reaches the ground. The portion of the precipitation that reaches the ground and does t infiltrate into the soil becomes surface runoff [6]. In urban areas, the large extent of pervious surfaces increases the amount of surface runoff.

Urban trees, however, are beneficial in reducing surface runoff. Trees intercept ecipitation, while their root systems promote infiltration and storage in the soil. The trees of mple Master Plan help to reduce runoff by an estimated 70,800 cubic feet a year with an sociated value of $4.72 thousand (see Appendix I for more details).

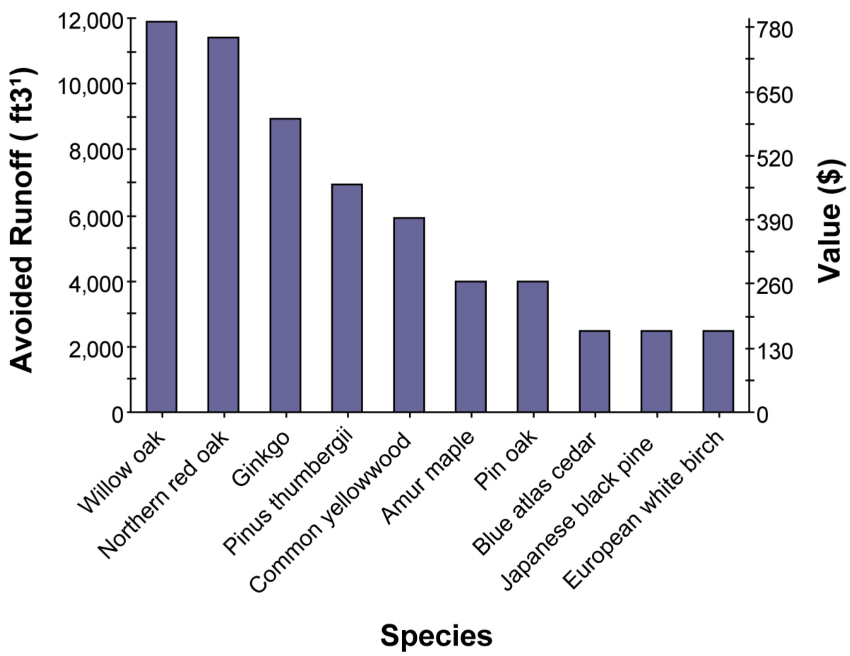


Figure 8. Avoided runoff and value for species with greatest overall impact on runoff in Temple Master Plan

Metrics/ **PEQI**

The Pedestrian Environmental Quality Index was utilized to assess the pedestrian quality of several streets and intersections throughout Temple University's Main Campus. We wished to determine if the tool would be suitable for use in performance monitoring and to develop a baseline rating for walkability. The study area encompassed a rectangular area with Broad Street along the Western boundary, 12th Street along the Eastern boundary. Diamond Street along the Northern boundary and Cecil B. Moore along the Southern Boundary. The data was collected on April 10, 2014. The collectors were Sean Malloy and Teresa Pereira. The data collectors reviewed the 40 page instruction manual and utilized several cheat sheets to assist with data collection. Data were recorded on the standard street and intersection data record form. A blank example is depicted below. After data were collected they were entered into the Microsoft Access database by Alex Hoxsie. Below is a further breakdown of the collection and data entry process.

Data Collection

The data collectors began their collection at the intersection of Diamond Street and 12th Street. From there they proceeded South to Cecil B. Moore, West to Broad Street, and North to Diamond where they completed the assessment at the intersection of Diamond Street and Broad Street. During the assessment, all intersections and street segments along the route were assessed and recorded on the standard street and intersection data record form, seen below. The assessment of streets and intersections is easily accomplished using the knowledge gained through the training booklet and referring back to the PEQI cheat sheet. However, there were several instances where the observed qualitative data could be interpreted in several ways by different collectors. Because of this, it is probably best that the same observer collects all data to reduce the possibility of errors. A number of photographs were taken during the assessment showing the various street segments and intersections. These photographs are not required for inclusion in the PEQI dataset, but are helpful for depicting existing conditions. Several photographs are shown on Page 29 along with the corresponding score for those segments.

PEQI: Intersection Form *(sample only- download original form from website)*

Team (names):	Date:

Intersection ID: ______

This is the intersection of : Street 1 and Street 2

		0 directions	1 directions	2 directions	3 directions	4+ directions
1. Crosswalks						
2. Ladder crosswalks						
3. Pedestrian signals	a. WITH countdowns					
	b. NO countdowns					
4. Stop signs						
5. No Turn On Red signals/signs						
6. Curb cuts at pedestrian crossings						

7. Signal at intersection ☐ yes ☐ no → if no, skip to item 8

Cross street ONLY with a green light or walk signal. Measure across larger street.

a. Crossing time: Measure crossing time (in seconds): _______ seconds

b. Crossing distance: Measure crossing distance (in paces): _______ paces

Length of my stride: _______ feet in my stride

8. Crosswalk scramble ☐ yes ☐ no

9. Intersection Traffic Calming Features

Indicate if any of the following are present

Yes No
- ☐ ☐ pavement treatments
- ☐ ☐ median or middle-divider
- ☐ ☐ mini-circles or roundabouts
- ☐ ☐ speed tables, speed humps or speed bumps
- ☐ ☐ bike lane at intersection
- ☐ ☐ partial closures
- ☐ ☐ drains, dips or other unintentional features that slow traffic
- ☐ ☐ curb extensions/bulb-outs
- ☐ ☐ lights set in crosswalk
- ☐ other (explain: ________________________________)

10. Additional signs for pedestrians ☐ yes ☐ no

Data Entry

Alex Hoxsie entered data by using a computer with a 32 bit operation system obtained from the Temple Ambler Technology Center. There were limitations to the data entry because the database is not specifically set up for use according to the City of Philadelphia's zoning categories. Zoning categories within the PEQI change the weight of different streetscape elements based on San Francisco's Zoning Categories. To accurately assess the streets that pass through main campus it is necessary to adapt the database to the zoning system. Also, because of the program's specificity to San Francisco, it didn't allow this study to take advantage of the tool's GIS functionality. This feature would be useful for visualizing the data collected spatially. For a relatively small site like the one evaluated, graphics could still be made relatively quickly without a GIS interface.

Main campus data entered into the database were entered under the same zoning category (Commercial Business District) to prevent variation in scores. The scores could change if in the future the database is adapted for specific use in Philadelphia. Even with the limitations the data collected from the street and intersection assessment revealed some patterns providing a score for each segment or intersection.

The following tables (Tables 1-3) present the findings of this baseline survey. By taking average scores and sorting the collected data, we can begin to identify patterns and/or make recommendations for prioritizing improvements.

- Table 1 shows a general trend of higher intersection ratings along Broad Street than 12th Street. Proving pedestrian quality of the intersections along 12th Street should be a priority over Broad Street based on the ratings generated by this system. However, considerations for pedestrian volume/usage should also be considered, which may act to reduce this priority due to Broad Streets prominence on the campus.
- Table 2 shows a general trend of a better walking experience along the 12th Street than Broad Street.
- The higher walkability rating of 12th Street compared to Broad Street indicates that improving the low PEQI intersection scores along 12th Street should be a priority. If we expect pedestrians to navigate campus according to the quality of the walking experience, it is imperative to improve the clarity and safety of the intersections along this route (12th Street)
- Conversely, since the existing infrastructure generates higher scores along Broad Street, efforts should be taken to improve the pedestrian experience along this thoroughfare, for reasons of pedestrian safety.
- Table 3 sought to combine the PEQI scores for intersections and streets by averaging corresponding scores. Combining the two aspects would help planners prioritize problem areas without having to decide whether to focus on intersections or streets. However, this approach is not outlined by SFDPH and the table does not appear to present a spatial pattern for prioritizing pedestrian experience improvements.

LOCATION	INTERSECTION SCORE	STREET SCORE 1	STREET SCORE 2	AVERAGE STREET SCORE	TOTAL AVERAGE SCORE
Broad and Montgomery	74	67	76	71.5	72.75
Broad and Diamond	72	NA	NA	NA	NA
Broad and Cecil B Moore	70	51	60	55.5	62.75
Broad and Polette	65	54	62	58	61.5
12 and Polette	60	72	58	65	62.5
12th and Norris	60	49	73	61	60.5
13th and Montgomery	60	49	54	51.5	55.75
13th and Cecil B Moore	58	58	71	64.5	61.25
Broad and Norris	57	52	69	60.5	58.75
12th and Cecil B Moore	55	63	61	62	58.5
12th and Diamond	50	60	64	62	56
12th and Montgomery	48	50	55	52.5	50.25

Table 1: Pedestrian environmental quality scores arranged by highest rated intersections.

LOCATION	INTERSECTION SCORE	STREET SCORE 1	STREET SCORE 2	AVERAGE STREET SCORE	TOTAL AVERAGE SCORE
Broad and Montgomery	74	67	76	71.5	72.75
12 and Polette	60	72	58	65	62.5
13th and Cecil B Moore	58	58	71	64.5	61.25
12th and Diamond	50	60	64	62	56
12th and Cecil B Moore	55	63	61	62	58.5
12th and Norris	60	49	73	61	60.5
Broad and Norris	57	52	69	60.5	58.75
Broad and Polette	65	54	62	58	61.5
Broad and Cecil B Moore	70	51	60	55.5	62.75
12th and Montgomery	48	50	55	52.5	50.25
13th and Montgomery	60	49	54	51.5	55.75
Broad and Diamond	72	NA	NA	NA	NA

Table 2: Pedestrian environmental quality scores arranged by highest average street survey score.

LOCATION	INTERSECTION SCORE	STREET SCORE 1	STREET SCORE 2	AVERAGE STREET SCORE	TOTAL AVERAGE SCORE
Broad and Montgomery	74	67	76	71.5	72.75
Broad and Cecil B Moore	70	51	60	55.5	62.75
12 and Polette	60	72	58	65	62.5
Broad and Polette	65	54	62	58	61.5
13th and Cecil B Moore	58	58	71	64.5	61.25
12th and Norris	60	49	73	61	60.5
Broad and Norris	57	52	69	60.5	58.75
12th and Cecil B Moore	55	63	61	62	58.5
12th and Diamond	50	60	64	62	56
13th and Montgomery	60	49	54	51.5	55.75
12th and Montgomery	48	50	55	52.5	50.25
Broad and Diamond	72	NA	NA	NA	NA

Table 3: Pedestrian environmental quality scores arranged by highest average of intersection and street scores.

The scores obtained through the use of PEQI are somewhat indicative of what was observed. While the total score that can be obtained in PEQI is 100, the total score obtained in our assessment may be lower because the PEQI database is not configured fir Philadelphia. To provide a better idea of what the differences are between the worst and best street we've included photographs of each below. The photographs below relate to the scores obtained that are shown in the above tables.

Below is a view of Cecil B. Moore St. looking East between Broad Street and 13th Street. This street segment received a score of 71.

Below is a view of 12th St. looking South between Montgomery St. and Cecil B. Moore St. This street segment received a score of 50.

Metrics/ **PSI**

Plant Stewardship Index (PSI) is a tool utilized to quantify the value of native plant communities and assess the value of plant species within a given area. The PSI tool was used on Temple University's main campus to establish a baseline and set goals for increasing native plant diversity on campus that can be measured at specified time increments.

Interpretation of Main Campus Baseline Assessment

The survey area for vegetation assessment was the portion of Main Campus bounded by Broad Street, Cecil B Moore Avenue, 12th Street, and Diamond Street. The tree inventory data used came from Morris Arboretum's Draft Tree Inventory and Management Plan (provided by Brad Thornton, landscape architect at LRSLA). Anne Brennan, Horticulture Supervisor of Temple University Ambler, inventoried shrub and herbaceous plant material on April 6, 2014. As noted above, 86 species were found.The report generated by the PSI Online Calculator can be found below. The Native Mean C of the study area's current plant palette equals 4.6. In our cultivated landscape, this can be interpreted to mean that proper siting of the native plants has allowed for some of the higher-CC species to become established and persist. (The assumption is that repeated disturbance would kill these plants.) If only highly-adaptable "generalist" native species were present, the Native Mean C would be much lower. The Total Mean C of 2.5, which is significantly lower than the Native Mean C, indicates that introduced plants make up a large component of the plant palette. Considering that 42 additional non-native ornamental species with CC=0 were present but could not be included in the calculation (because they aren't available in the PSI database), the true metric should be even lower. The list below and on the next page contains all of the plant species identified on Main Campus and their associated PSI scores. Other species were found, but not in the list. These species were all exotic invasive that would carry a PSI score of 0 and are not part of the PSI database.

Genus	Epithet	Common Name	PA List	PA CC	PA Rank	Wetlands	Planted	Comments
Acer	ginnala	Amur maple	I	0			2014	Cultivated and escaped to a brushy field.
Acer	rubrum var. rubrum	Red maple	N	1		FAC	2014	Dry to moist woods, swamps and bogs. NJ: throughout.
Acer	saccharum var. saccharum	Sugar maple	N	5		FACU	2014	Moist woods, wooded slopes, ravines and alluvial areas.
Amelanchier	canadensis	Shadbush; Juneberry	N	8		FAC	2014	Woods and peaty thickets.NJ: Brackish coastal swamps.
Amelanchier	laevis	Shadbush, smooth	N	6			2014	Rocky woods, thickets and roadside banks.
Berberis	thunbergii	Barberry, Japanese	I	0		FACU	2014	Disturbed woods, roadsides and hedgerows.
Betula	lenta	Birch, sweet	N	4		FACU	2014	Woods and stream banks.
Betula	nigra	Birch, river	N	7		FACW	2014	Floodplains, stream banks, wet woods and swamps.
Carya	tomentosa	Hickory, mockernut	N	5		FACU	2014	Moist, open woods and slopes.
Cercidiphyllum	japonicum	Katsura-tree	I	0			2014	Cultivated and occasionally naturalized in disturbed woods.

Cercis	canadensis	Redbud	N	7		FACU-	2014	Wooded slopes and ravines in dry to moist, rich soils on limestone or diabase.
Cornus	florida	Dogwood, flowering	N	5		FACU-	2014	Rich, moist woods and woods edges.
Euonymus	alatus	Burning-bush; Winged euonymus	I	0			2014	Cultivated and occasionally naturalized in disturbed woods, stream banks, fencerows and edges.
Euonymus	fortunei	Wintercreeper	I	0			2014	Cultivated and occasionally naturalized in woods and wooded floodplains.
Forsythia	viridissima	Forsythia	I	0			2014	Cultivated and occasionally escaped to roadsides.
Fraxinus	americana var. americana	White ash	N	1		FACU	2014	Woods, fencerows and old fields.
Fraxinus	pennsylvanica	Ash, red	N	3		FACW	2014	Alluvial woods, stream banks and moist fields.
Ginkgo	biloba	Maidenhair tree	I	0			2014	An occasional garden escape, naturalizing in disturbed woods.
Gleditsia	triacanthos	Honey-locust	I	0		FAC-	2014	Wooded slopes, river banks and floodplains, also frequently planted in urban and suburban areas.
Gymnocladus	dioica	Kentucky coffee-tree	I	0		N	2014	Rich, moist woods and bottomlands, also occasionally planted.
Hedera	helix	Ivy, english	I	0			2014	Cultivated and occasionally naturalized in disturbed woods.
Hydrangea	arborescens	Hydrangea, wild	N	7		FACU	2014	Rich woods, slopes and stream banks.
Ilex	crenata	Japanese Holly	I	0			2014	Escaped from cultivation to disturbed wooded areas
Ilex	opaca	Holly, American	N	5		FACU+	2014	Moist, alluvial woods and wooded slopes, also cultivated and frequently escaped.
Juniperus	communis var depressa	Common juniper/ Dwarf Juniper	N	7		N	2014	Dry slopes or pastures.NJ:open woods
Juniperus	virginiana	Eastern red-cedar	N	2		FACU	2014	Old fields, serpentine barrens and other moist to dry, sterile soils.
Koelreuteria	paniculata	Golden rain-tree	I	0			2014	Cultivated, seedlings occasionally becoming established in waste ground or along roadsides.
Ligustrum	amurense	Amur privet	I	0			2014	Cultivated and rarely spreading to thickets or rubbish dumps.
Liquidambar	styraciflua	Sweet-gum	N	5		FAC	2014	Low, wet, coastal plain woods.
Magnolia	kobus	Kobus magnolia	I	0			2014	Deciduous tree to 10 m tall w pubescent winter buds
Magnolia	virginiana	Magnolia, sweetbay	N	8	PT	FACW+	2014	Moist woods and swamps, in sandy, peaty soils.

Prunus	subhirtella	Higan cherry	I	0		N	2014	Disturbed woods.
Pyrus	calleryana	Pear, bradford	I	0			2014	Cultivated/escaped
Quercus	coccinea	Oak, scarlet	N	4			2014	Dry upper slopes and ridges, in poor soil.
Quercus	imbricaria	Oak, shingle	N	0		FAC	2014	Moist, rich bottomlands of southwest counties.
Quercus	macrocarpa	Oak, bur	I	0		FAC-	2014	Dry to moist forests, in neutral or calcareous soils. NJ: Prairie fen.
Quercus	palustris	Oak, pin	N	3		FACW	2014	Low, moist or seasonally wet woods or swamps.
Quercus	phellos	Oak, willow	N	8	PE	FAC+	2014	Low, moist or seasonally wet woods.
Quercus	rubra	Oak, northern red	N	4		FACU-	2014	A dominant forest tree on moist to dry sites.
Rhus	typhina	Sumac, staghorn	N	1			2014	Dry, open soil of old fields, roadsides and woods edges.
Taxus	cuspidata	Japanese yew	I	0			2014	
Tilia	americana var. americana	Basswood	N	5		FACU	2014	Rich woods.

Conclusions

The metrics that we collected provide a sample of the baseline measurements that can be obtained using several readily available tools. Any landscape plan could be evaluated using the tools to assess existing conditions, inform design scenarios, and to monitor built design over time. However, this first attempt at using these tools revealed their shortcomings resulting in some data discrepancies. Nevertheless, the data we collected is a starting point. This report can help in establishing an official monitoring program for Temple University. This program could be intertwined with educational classes on campus. The School of Environmental Design, the College of Science and Technology, the College of Engineering, Fox School of Business and Management, and Tyler School of Art are some of the colleges that would be able to incorporate these tools into their educational programs.

Programs that are focused on sustainable sciences, urban planning, or landscape architecture/ horticulture can incorporate these tools into their curriculum. During peak migration season students can bird watch and record species seen on campus for eBird. Students can you i-Tree to gauge how much CO2 a specific outdoor space is sequestering. Intersections can be assessed for walkability using the PEQI tool. The PSI tool can be used in restoration projects for landscape architecture, especially in the master's program which emphasizes ecological restoration. Continuing to include students in measuring landscape performance would be a good way for temple to get useful quantifiable information for "free". These tools are continuing to evolve and improve. The shortcomings of some tools opens up opportunities for research and the possible development of new tools by students and faculty at Temple University. Encouraging the study of landscape performance metrics, while it is a developing field, could distinguish Temple University as a leader in performance monitoring.

Appendix I. i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects [41], including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<2.5 microns and <10 microns).
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants.
- Structural value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian longhorned beetle, emerald ash borer, gypsy moth, and Dutch elm disease.

In the field 0.50 acre plots were randomly distributed. Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Within each plot, typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings [42, 43].

Invasive species are identified using an invasive species list [2] for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations [44]. To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1. Carbon storage and carbon sequestration values are based on estimated or customized local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States [45] and converted to local currency with user-defined exchange rates.

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net O2 release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition [46].

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models [47, 48]. As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature [49, 50] that were adjusted depending on leaf phenology and leaf area. Removal estimates of particulate matter less than 10 microns incorporated a 50 percent resuspension rate of particles back to the atmosphere [51]. Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values [52, 53, and 54].

Air pollution removal value was calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter <2.5 microns using the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP). The model uses a damage-function approach that is based on the local change in pollution concentration and population [55].

National median externality costs were used to calculate the value of carbon monoxide removal and particulate matter less than 10 microns and greater than 2.5 microns [56]. PM10 denotes particulate matter less than 10 microns and greater than 2.5 microns throughout the report. As PM2.5 is also estimated, the sum of PM10 and PM2.5 provides the total pollution removal and value for particulate matter less than 10 microns.

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis.

The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilized and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series [57].

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature [7] using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU are utilized.

Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information [58]. Structural value may not be included for international projects if there is insufficient local data to complete the valuation procedures.

Potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality. Pest range maps from the Forest Health Technology Enterprise Team (FHTET) [9] were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively [9].

Sources

About eBird: Global tools for birders, critical data for science, Retrieved March 2, 2014 from http://ebird.org/content/ebird/about.

Allen H. Hurlbert, Zhongfei Liang. Spatiotemporal Variation in Avian Migration Phenology: Citizen Science Reveals Effects of Climate Change. PLoS ONE 2012: 7(2): e31662.

Benefits Toolkit. Landscape Architecture Foundation. Retrieved March 10, 2013, from http://landscapearchitecture.com.

City of San Francisco, "http://www.sfphes.org/elements/24-elements/tools/106-pedestrian-environmental-quality-index." Accessed March 04, 2014.

Hoverter, S. Adapting to Urban Heat: A Tool Kit for Local Governments. Georgetown Climate Center, August 2012. Web. Accessed Mar. 11, 2014. https://www.law.georgetown.edu/academics/academic-programs/clinical-programs/our-clinics/HIP/upload/Urban-Heat-Toolkit_RD2.pdf

i-Tree Homepage. http://www.itreetools.org/ (accessed April 10, 2014).

Lerman S, Nislow K, et al. Using urban forest assessment tools to model bird habitat potential. Jan 4, 2014. Landscape and Urban Planning 122 (2014) 29-40.

Mithun Knowledge Article: The Evolution of Performance Metrics in Practice http://mithun.com/mobile/knowledge_article/the_evolution_of_performance_metrics_in_practice/ Accessed March 09, 2014

Plant Stewardship Index. http://www.bhwp.org/plant-stewardship-index.htm (accessed March 15, 2014). Rainwater Harvesting Calculator. Department of Ecology, State of Washington. Retrieved March 10, 2013, http://www.ecy.wa.gov/programs/wr/hq/rwh.html

Sailor, D. and N. Dietsch. "The Urban Heat Island Mitigation Impact Screening Tool (MIST)." Oct. 3, 2005. Web. Accessed Mar. 11, 2014. http://www.heatislandmitigationtool.com/Documents/detailed_help.pdf

The State of the Birds 2013. Retrieved March 3, 2014 from http://www.stateofthebirds.org/urban-suburban-landscapes.

The Value of Green Infrastructure. (2010) Retrieved April 2014. http://www.cnt.org/repository/gi-values-guide.pdf

Water Harvesting Calculator. Wasaho Water Harvesting Solutions. Retrieved March 10, 2013, from http://wahaso.com.

Wood C, Sullivan B, Iliff M, Fink D, Kelling S (2011) eBird: Engaging Birders in Science and Conservation. PLoS Biol 9(12): e1001220.