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SCHOOL OF ARTS AND SCIENCES

DEPARTMENT OF EARTH & ENVIRONMENTAL SCIENCE

COLLEGE OF LIBERAL AND PROFESSIONAL STUDIES

ENVIRONMENTAL RESILIENCE & ADAPTATION ABSTRACTS

HOW DIGITAL TECHNOLOGIES ARE DRIVING THE NEXT ENVIRONMENTAL REVOLUTION

Michael D. Hughes

Readers:
Jnaneshwar Das, School of Engineering, University of Pennsylvania
James Hagan, Earth & Env Science, University of Pennsylvania

Our world faces no shortage of environmental challenges, many of which are accelerating in their impact, and humanity will need to bring every tool at its disposal to meet them. This paper focuses on examining solutions that digital technologies can bring into solving environmental and sustainability problems through innovative concepts and reworking technology for a civic purpose. This paper does so through a series of technology overviews and case studies across a set of domains including robotics & drones, 3D printing, sensors, artificial intelligence, and other emerging platforms. What results is a set of compelling examples of how technologies that may have been developed to meet a private sector objective can be leveraged into tackling some of the greatest challenges facing our planet. This will hopefully serve as a source of information and inspiration for fellow technologists and sustainability advocates to consider technology applications in their work, as well as drive further innovation as these tools evolve to meet humanity's aspiration for a healthy and vibrant world.

WATER MANAGEMENT BY DESIGN: GREEN INFRASTRUCTURE PLANNING AND STORMATER MANAGEMENT FOR A MORE RESILIENT CITY

Zifei Joyce Jiang

Readers:
Tom Daniels, School of Design, University of Pennsylvania
Allison Lassiter, School of Design, University of Pennsylvania

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Due to the increasing amount of polluted stormwater runoff, urban and agricultural areas have been recognized by the US EPA as one of the major national problems. One approach to deal with this complicated issue is through implementing Green Infrastructure (GI). However, there is a lack of stakeholder-oriented, city-wide holistic approaches to analytically identify both social and ecological benefits associated with GI and its siting. The purpose of this study is to create linkages between the current existing GI and the potential GI based on the current existing gap in the City of Philadelphia. To achieve this end, the study employs both statistical and spatial analysis to model the most suitable GI planning situations that integrate three benefits: 1) stormwater mitigation; 2) green space; 3) community appeal. Applying the models to Cobbs Creek Neighborhood in Philadelphia, the study compares the outcomes with the locations of current existing green infrastructure projects. As the model reveals, the potential GI projects could be implemented in certain locations that simultaneously reduce stormwater, enhance community appeal, and provide public green space. More broadly, the model suggests a systematic approach for planning future GI projects so that it maximizes both social and ecological benefits.

CREDIT DOWNGRADE THREAT AS A NON-REGULATORY DRIVER FOR FLOOD RISK MITIGATION AND SEA LEVEL RISE ADAPTATION

John A. Miller, P.E., CFM, CSM

Readers:

Howard C. Kunreuther, PhD, Wharton School, University of Pennsylvania
Larry A. Larson, Association of State Floodplain Managers

Federal policies and regulations with higher standards that respond to climate change and sea level rise are being rolled back by the current administration. In that void, the threat of credit rating downgrades is expected to be a developing non-regulatory driver to future risk planning and adaptation. Several exposed communities have been downgraded due to their lost tax base from major disasters. As sea level rise manifests along the coasts, impacts on revenue will present new challenges in servicing debt. Credit rating companies in the last few years have issued publications giving some notice on how climate change is to be considered in municipal credit ratings. Proactive communities, conducting planning and realizing adaptation practices now are likely to be spared the need to increase revenues to counter the higher borrowing costs that are coincident with a bond rating downgrade due to likely loss of taxable properties caused by sea level rise in the future. Municipalities that do not engage now in addressing the threats associated with climate change may have to increase taxes to offset the increased bond return demanded by investors.

CALCULATING THE VALUE OF NATURE & THE COST OF HURRICANE HARVEY: LEVERAGING ECO-ADAPTATION VALUATION IN AMERICAN POLICY & PRACTICE

Karema Seliem

Readers:
Dr. Joseph Lisa, U.S. EPA
Prof. Michael Kulik, Earth & Env Science, University of Pennsylvania

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Ecosystem-based Adaptation (EbA) is a strategy that "uses biodiversity & ecosystem services…to help people adapt to the adverse effects of climate change" by taking "into account the multiple social, economic & cultural co-benefits for local communities" (SCBD, 2009). EbA valuation is a holistic process that calculates the cost, benefits, and impacts of ecosystem services in adaptation strategies. This research provides methods for valuing ecosystem services and a justification of ecosystem-based adaptation (EbA) in order to leverage effective resilience planning decisions. The goal of this research was to a) show that proactive, land-based adaptation is more cost-effective than reactive mitigation in resilience projects (i.e. EbA is more beneficial than grey infrastructure) and b) provide guidelines for understanding the EbA valuation process and recommendations for communicating EbA to stakeholders. The costly impacts of Hurricane Harvey on Texas are explored to highlight problems that can be addressed by EbA principles to potentially alleviate flooding from future storm surge. EbA valuation trends in policy, practice, and messaging are assessed to provide communication guidelines as methods for influencing resilience policy. This study culminates in visual aids and recommendations based on specific stakeholder values with the aim of generating EbA buy-in from American planners, policy-makers, and the public. The goal is to influence decision-makers into utilizing the example of Texas and this study's recommendations to potentially leverage EbA policy and mainstream EbA valuation in American resilience practice. The overall objective is to alleviate the increasing cost burden of storm surge impacts.

HADDINGTON WOODS "SOUTHERN SPECIES" EXPERIMENT: COMPARISON (FEBRUARY 2016- NOVEMBER 2017) OF SOUTHERN TREE AND SHRUB GROWTH AND HEALTH IN AN URBAN SETTING

Amanda Wood

Readers:
Sarah Willig, Earth and Env Science, University of Pennsylvania
Curtis Helm, Philadelphia Parks and Recreation

Climate change, one of the most significant global environmental issues, challenges natural land managers to consider both current conditions and the looming future obstacles that are expected to come. Philadelphia Parks and Recreation (PPR) is attempting to determine what species of woody plants will grow well with anticipated climate change conditions by planting trees and shrubs with more southern ranges within a deer exclosure in Haddington Woods in Cobbs Creek Park. The results of monitoring the relative growth and health of the 11 species that were planted in the fall of 2015 will influence their future use in urban plantings to maintain biodiversity and forest ecosystem services. In November 2017, the author measured and evaluated the growth of the 3 tree species and 8 shrub species that were previously monitored in February 2016 and September 2016 by John Jensen (PPR Seasonal Intern) using the same methodology. Between February 2016 and November 2017, there was an increase in the average height and caliper growth in the selected tree species, except for a decline in *Quercus falcata*'s average height. In general, selected shrub species increased in average height and spread except for *Halesia carolina, Leucothoe fontanesiana*, and *Morella cerifera* which declined in average height. Between February 2016 and November 2017, mortality rates were highest in *M. cerifera* (40%), *H. carolina* (30.6%), and *Q. falcata* (30.6%) with exposure to all site disturbances including a tree that was intentionally cut and fell across the plot. With removal of the impact of the fallen tree, the mortality rates showed a similar pattern with the highest three occurring in *M. cerifera* (28.6%), *H. carolina* (27.8%), and *Q. falcata* (27.8%). These initial findings based on a little more than one year's growth indicate that all 11 species can survive and grow in Philadelphia's urban forest under the prevailing climate and presumably under the predicted warmer, wetter climate of the future. These preliminary findings suggest that *M. cerifera*, *Q. falcata*, and *H. carolina* may not be well adapted to the region. However, additional years of data will be needed to more fully evaluate the suitability of all species. Project recommendations include continued monitoring to determine long-term trends, management of competing herbaceous, vine, and woody species including invasives such as Japanese angelica tree (*Aralia elata*) and Mile-a-minute (*Persicaria perfoliata*), and increased involvement of community members. This project can serve as a model for other cities desiring to plant a resilient forest that will thrive under anticipated climatic conditions. Recommendations for improving future experiments will be provided to PPR and others interested in doing a similar experiment.

MANAGING CLIMATE RISK THROUGH SECURITIZATION, AN INSURANCE PERSPECTIVE

Yefei Yu

Readers:
Dana Qu, Aon Benfield Securities
James Hagan, Earth and Env. Science, University of Pennsylvania

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The threat of climate change, increased urbanization to coastal and hazard prone areas, and a rise in global asset values have brought the importance and necessity of effective risk transfer solutions to the forefront of world disaster resilience efforts in recent years. While many have taken the initiative to manage long term risks such as the rising sea level and global temperature, the risk management for short term volatility caused by unpredictable natural catastrophe is still at a premature stage and remain less covered by major government bodies and businesses. Yet, the natural catastrophe risk is not a part of climate change risks that should be overlooked. In fact, there has been an ever-increasing protection gap between economic losses induced by natural disaster and the insured losses covered by insurance companies. To narrow this "gap", a new asset type – Catastrophe Bond, or CAT bond, has been structured to securitize and transfer risks. Compared to traditional reinsurance risk transfer, CAT bonds diversified risks by opening the risk pool to a larger investor universe and thus allowing the traditional capital markets to participate in natural disaster risk hedging. With such an innovative tool, the insurance sector has a responsibility and opportunity to be at the forefront of innovation and the development of efficient, affordable risk transfer solutions for people, businesses, and institutions in all corners of the world to better manage the volatile side of climate change.

USING STREET TREES TO ADDRESS HEALTH DISPARITIES IN VULNERABLE NEIGHBORHOODS: A GEOSPATIAL ASSESSMENT OF URBAN HEAT ISLAND (UHI) IN PHILADELPHIA

Laura Barron

Readers:
Stan Laskowski, Earth and Env Science, University of Pennsylvania
Yvette Bordeaux, Earth & Env Science, University of Pennsylvania

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The Urban Heat Island (UHI) effect, which refers to the significantly warmer temperatures of a metropolitan area compared to its rural surroundings, is a phenomenon that impacts the health and environment of cities. It is expected to increase in prevalence as rapid urbanization and the impacts of climate change increase. In order to sustainably mitigate the adverse impacts of UHI, strategic greening interventions must be utilized. One such intervention, the use of street trees, can assist this urban heat phenomenon by reducing ambient temperatures and decreasing the air pollution that can cause urban heat retention. Street trees facilitate positive health and environmental impacts, not only by decreasing the effects of UHI, but also by reducing stormwater runoff, improving air quality, and decreasing greenhouse gas emissions. Importantly, street trees are a tool that the city of Philadelphia can use to combat the adverse impacts of climate change without relying on individual behavior change of Philadelphians. In an effort to design targeted interventions and identify those neighborhoods, which are most vulnerable to UHI in Philadelphia to a "Heat Vulnerability Index" (HVI), demographic data from the *American Community Survey* was calculated at the block level. Adapting the HVI model to determine areas with the fewest street trees to map street tree vulnerability – a "Street Tree Vulnerability Index" (STVI) was also applied. By running a high-low cluster (Moran's I) analysis, areas of most significant vulnerability were identified at the block and neighborhood levels. Assessment of neighborhoods with the highest risk factors for both categories (HVI and STVI) will allow for more effective and targeted interventions and recommendations for planting street trees in the city of Philadelphia to reduce UHI in its most vulnerable neighborhoods.
