ORAL PRESENTATIONS

Terris King II, The Baltimore Forest School Framework
InDiGO: Inward Discovery Grows Outdoors

The Baltimore Forest School (BFS) Flower grows within the Sacred Trinity Map, which triangulates schools, churches, and green spaces to facilitate community restoration and stewardship. The BFS Flower sits within this triangle, illustrating how focusing resources from the education, environment, health, and economic sectors toward children facilitates improvements that ripple into the broader community.

The BFS Framework is based on the premise that investing in children benefits the entire community immediately and in the long term. Programs aimed at young children grow into high school internships, summer jobs, and teacher training programs, introducing young people to practical roles in conservation, education, and environmental restoration. Researchers, foresters, and PhD students gather data, mentor youth, and oversee restoration efforts, building knowledge and capacity for present and future generations.

The trees we plant today will provide the shade we need in the future, but protecting our current canopy and nurturing future growth requires long-term commitment. Who will take on that responsibility? The children of today, guided by the pathways outlined in the BFS framework, can grow into the stewards of tomorrow. These pathways align with key initiatives like the Maryland 5 Million Trees Program, which prioritizes tree equity and environmental justice by planting 5 million native trees by 2031, with 500,000 specifically for underserved urban areas. Community engagement and restoration are essential to creating lasting change, ensuring that the green spaces being restored are sustained by those who live, learn, and grow in them.

Developed in partnership with Temple X, InDiGO, and informed by the Keystone project's Sacred Trinity Report, the Flower framework also aligns with the National Nature Everywhere Initiative and Baltimore's Connecting Children to Nature Alliance (BCCN), advocating for universal access to green spaces through the Children's Outdoor Bill of Rights. These efforts integrate environmental science with advocacy for children's access to nature, offering a powerful model for green space equity and sustainability. BFS builds on 30 years of Baltimore Ecosystem Study research to foster systemic change by connecting education, health, workforce development, and the environment to benefit communities.

Alan Berkowitz, Cary Institute of Ecosystem Studies
Co-Authors: Garner, K., Hood, A., Covitt, B., Grooms, J., Draney, K., Mitzel, E., Browning, L., Fischer, D., Caires, A., Mehta, S., Bean, J.
Our Evolving Partnership to Advance Earth, Science Across Baltimore City Public Schools' Biology, Chemistry, and Physics Courses

The EarthX research/practice partnership between Baltimore City School District science leaders and teachers, and collaborators at Cary Institute, George Washington, University of Montana, American University, and UC Berkeley, continues to evolve in response to deepened

understanding of the City Schools' instructional landscape. While our goals for integration of Earth science into high school Biology, Chemistry, and Physics courses in City Schools for all students remained the same, our strategy shifted towards the development of curriculum. We created new units for each course in an intense collaborative process that engaged scientists, science educators, classroom teachers, and school administrators during a Summer Curriculum Writing Academy. The resultant units have Earth science and local phenomena more seamlessly incorporated into the curriculum, along with strategically placed assessments to help teachers gauge and respond to students' understanding along the way. In addition, the units are now more closely aligned with the national standards that call for instruction following a storyline as students engage in three dimensional learning that weaves together core concepts, cross-cutting ideas, and science practices. The new units include "Urban Ecology: B'More Sustainable," "Ocean Acidification," and "Natural Hazards, Waves and Climate Change" in the Biology, Chemistry, and Physics curricula, respectively. Our 25 Design Team Teachers will be providing extensive student data and feedback as they implement the units this school year, and also will co-lead professional learning sessions for all District high school science teachers in the EarthX materials and instructional approaches. In this way, the project will reach the entire student population attending traditional City Schools. We will share examples of our new units and preliminary results, and highlight exciting new opportunities for a second round of urban ecosystem curriculum development that could bring even more BES science to all City high school students.

Michele Romonlini, Loyola Marymount University Center for Urban Resilience.
Co-Authors: McPherson, J.
Art-Based Engagement as a Tool for Community-Based Urban Forestry Research

Maryland's Tree Solutions Now Act will catalyze the planting of 500,000 trees in urban underserved areas by 2031. The benefit of these trees are intended to directly impact residents in Baltimore and other urban areas throughout the state. However, the legislation does not include a clear guideline on how to engage communities to participate. This is critical, as urban forestry research has identified recognition justice—acknowledging the different lived experiences of people across diverse communities—as critical to the success of tree planting efforts (Myers et al. 2023). Other researchers have put forth that urban forestry practitioners can explore new approaches to center marginalized communities' priorities, asking, "what if we were to focus not only on access, but also meaning, belonging, and connection to the urban forest? How might we strengthen the social meaning of the urban forest in whatever stage or state it is in? What sorts of programs might we produce?" (Campbell et al. 2022, p. 5). With this motivation, the Baltimore Healthy Trees Healthy Cities project aims aims to document the lived experience of urban and underserved communities in Baltimore and examine their sense of belonging and connection to trees/nature using art-based engagement methods. The intent is to use engagement insights to create programs (outreach, planning, design, and implementation) that support participation in and implementation of the TSNA, while recognizing the different lived experiences and motivations of urban forestry stakeholders. In the summer of 2024, we employed a short, spoken word poem and animated video, "To The Jungles That Be" by Baltimore poet Kondwani Fidel, as a vehicle to ask Baltimore residents about their truths, frustrations, memories, and dreams around urban trees and nature in their city. We partnered with community organizations to share the video

and a related paper survey at 6 events taking place in majority BIPOC communities, including five tabling events and one long-form workshop. We met with about 100 Baltimore residents and community leaders, and were able to obtain completed surveys from 54 participants. Qualitative analysis is underway to identify the major emergent themes. We will present our initial findings, discuss the utility of this methodology as a non-traditional approach to conducting community-based research, and describe next steps for how this work will inform future community engagement and technical assistance related to the Tree Solutions Now Act.

Peter Groffman, City University of New York.
Co-authors: Welty, C.
Dissolved gasses in streams provide insight into urban watershed function

Dissolved gas measurements of streams and groundwater provide information on integrated source/sink dynamics within urban watersheds. Carbon dioxide (CO2) concentrations are driven by weathering reactions and biological activity. Nitrous oxide (N2O) is an index of nitrogen enrichment in the landscape. Methane (CH4) and dissolved nitrogen:argon (N2:Ar) indicate presence of anaerobic conditions and nitrogen sinks. Gas data help to determine the interplay between nitrogen inputs and processing in urban watersheds. For example, high N2O (and nitrate) provide evidence of a shift from a source-controlled to transport-controlled system. Low N2O (and low nitrate) along with high CH4 and high dissolved N2:Ar also provide evidence of a similar shift but suggest the presence of significant anaerobic zones and provide insight into water pathways through the watershed. These dynamics vary along the latitudinal gradient and with the pre-urbanization structure of the watershed.

Jaleel Shujath, University of the District of Columbia.
Co-Authors: Behera, P.
Analysis of Extreme Storm Events in Baltimore

The recent trend of escalating extreme rainfall events in the Baltimore, Washington, and Richmond areas since 2010 has posed significant concerns in the domain of regional watershed science, groundwater studies, and water ecosystems. This study illuminates the changing rainfall patterns in the region and their potential ramifications for the broader Chesapeake Watershed. Increased extreme events indicate possible shifts in groundwater recharge rates, affecting local aquifers and water availability. More frequent and intense rainfall has also heightened the risk of surface runoff, carrying pollutants into local waterways and impacting water quality and aquatic ecosystems. This poses challenges for stormwater management, emphasizing the need to retrofit systems to handle increased rainfall volumes. The study advocates for proactive measures at both local and watershed scales, highlighting the importance of collaborative efforts in policy-making, urban planning, and community engagement.

Zach Clifton, US Geological Survey.
Co-Authors: Foss, E., Majcher, E., Psoras, A., Mejia, S., Chase, J.

Contaminated stormwater sediment source tracking for polychlorinated biphenyls within the Back River Watershed, 2022-2023

Fine-grained sediment runoff due to anthropogenic activities may act as a vector for persistent organic pollutants such as polychlorinated biphenyls (PCBs) to streams and rivers, particularly in older developed areas. Long developmental histories in urban areas can create complex sediment runoff dynamics from a variety of potential sources, each with their own, potentially unique, persistent organic pollutant signature. This study sought to identify the relative contributions of various sources of sediment from the Back River watershed in eastern Baltimore, Maryland, and investigated the applicability of using trace PCBs found in urban environments as discriminants between each source type. Trace PCBs were found to be poor discriminants when identifying the relative sediment contributions of watershed-scale land use categories. When not including PCBs in the development of a sediment fingerprinting model, we found that greenspaces and eroding streambanks contributed roughly equal portions (37.1% and 44.0%, respectively) of the total sediment contributions of all considered source categories. The results of this study may assist watershed managers in directing targeted sediment reduction activities.

Ally Kido, University of Maryland, Baltimore County and Institute of Marine and Environmental Technology.
Co-Authors: Mansfield, N., Schott, E.
Using a Native Mussel to Sequester Nutrients in Baltimore Harbor

Urban estuaries are stressed by excess nutrients from stormwater runoff. Baltimore Harbor is no exception to this and faces intense and frequent algae blooms because of excess nutrients. The city has focused on efforts to reduce nutrients from upstream point sources, but in urban areas, there are limited alternative opportunities for nutrient reduction. One possible solution is to use a bivalve to reduce nutrients through suspension feeding, as exemplified by oysters in other parts of the Chesapeake Bay. However, Baltimore Harbor is a poor location for oysters because of a lack of substrate and poor water quality. We looked instead at the Dark False Mussel, Mytilopsis leucophaeata, which is native to the east coast of North America and grows abundantly in Baltimore Harbor. To determine if M. leucophaeata can reduce phytoplankton and the nutrients they contain, I performed clearance rate experiments to examine the rate of removal of phytoplankton from wild algae blooms. I measured levels of in vivo chlorophyll (IVCH), extracted chlorophyll, and nitrogen at different time points across a 24-hour time period. I found the M. leucophaeata can reduce IVCH, extracted chlorophyll, and nitrogen, and that the composition of the algae bloom may impact feeding rates. Overall, these results suggest that the Dark False Mussel can reduce nutrients and show promise for nature-based nutrient reduction in Baltimore Harbor.

Morgan Grove, US Forest Service.
Co-authors: Pickett, S., Buckley, G., Boone, C.
Forging just ecologies: 25 years of urban long-term ecological research collaboration

We ask how environmental justice and urban ecology have influenced one another over the past 25 years in the context of the US Long-Term Ecological Research
(LTER) program and Baltimore Ecosystem Study (BES) project. BES began after environmental justice emerged through activism and scholarship in the 1980s but spans a period of increasing awareness among ecologists and environmental practitioners. The work in Baltimore provides a detailed example of how ecological research has been affected by a growing understanding of environmental justice. The shift shows how unjust environmental outcomes emerge and are reinforced over time by systemic discrimination and exclusion.

Kim Grove, Baltimore City
DPW Update on research focuses

Provide an overview of observations, work completed, and research focuses.

Selena Livas, University of Maryland, Baltimore County
Co-Authors: Locke, D., Sonti, N.F.
An Analysis of Baltimore's STEW-MAP Networks

In 2007 the USDA Forest Service launched the first STEW-MAP project, or The Stewardship Mapping Project in New York City. The driving research questions of this project are who are the groups stewarding the environment within local communities, and how could they potentially boost their environmental impact? This survey has been conducted in several cities within the US and 12 locations worldwide. One key aspect of this survey is the collection of relational data, specifically the collection of various network ties amongst the respondents. In this study we focus on Baltimore, Maryland and use the 2019 STEW-MAP survey to better understand the relationship between environmental stewardship organizations across the city. We utilize exponential random graph models (ERGMs) to explore that factors that drive the formation of three distinct types of ties as well as general collaboration at the city level. Our data includes 1,190 nodes with 2,309 ties among them. This study will be the first to analyze this specific dataset and one of the few to conduct a network analysis of data collected through the STEW-MAP project. This work will help broaden our understanding of local environmental cooperation within a modern urban context.

David Newburn, University of Maryland
Co-Authors: Newburn, D.A., Johnston, R.J., Zawojska, E., Ndebele, T.
Household Preferences for Lawn Fertilizer Policy Instruments in the Baltimore Metro Region: Implications for Nitrogen Reductions

Improved management of nonpoint sources from lawn fertilizer is increasingly viewed as important for cost-effective strategies that mitigate nutrient emissions to meet water quality regulations. In this study, we present a study of household preferences for price, quantity and other potential instruments that can be applied to regulate residential fertilizer use and attendant nutrient runoff. Empirical data is derived from a discrete choice experiment (DCE) implemented

using a mixed-mode push-to-web approach over a random sample of 13,000 single-family households in the Baltimore metro region. The sample was screened from the spatially explicit complete parcel-level tax assessor database to select single-family homeowners. The DCE and its characterization of prospective policies were developed to reflect potential approaches to reduce residential lawn fertilizer applications. This survey data is used for econometric models to estimate household responses to price instruments (e.g., fertilizer surcharges), quantity instruments (e.g., fertilizer application restrictions) and other behavioral change instruments (e.g., free lawn assessments) that might help achieve nonpoint source pollution reductions and concomitant gains in local environmental conditions (e.g., improvements in river and stream health). The empirical models find evidence of strongly heterogeneous preferences for regulatory instruments, with households falling into two preference groups that reflect distinct categorical motivations for lawncare. Respondents are also strongly motivated by the capacity of these restrictions to improve the conditions of local rivers and streams and reduce the exposure of children and pets to lawncare chemicals.

Meghan Avolio, Johns Hopkins University.
Co-Authors: Hoffman, A., Cocciardi, J.
Cosmopolitan plants do not show consistent parallel urban evolution across five US cities

None provided.

Anna Mothersole, University of Maryland, Baltimore County.
Co-Authors: Swan, C.
Freshwater Invertebrate Response to Urbanization: A Large Scale Analysis of Functional Diversity

Increasing urbanization has a profound effect on ecosystems worldwide, and the biological communities found in downstream freshwater ecosystems are no exception. Functional traits are an increasingly popular lens through which to study freshwater macroinvertebrates, as they allow for the potential effects that an organism, or the invertebrate community in general, may have on an environment to be clearly shown. Here, nine functional traits (voltinism, dispersal, drift, respiration, rheophily, size, thermal tolerance, habit, and functional feeding group) were used to characterize freshwater invertebrates sampled at over 300 sites by the Maryland Biological Stream Survey (USA). Community weighted means of these traits were calculated for each site, and analyzed as a function of impervious surface cover in the drainage area. My goal was to address 1) if increasing urbanization causes significant shifts in the community weighted mean traits of freshwater macroinvertebrates in Maryland and 2) if present, what these shifts might show about the urbanizing ecosystem.

Dexter Locke, US Forest Service.
Co-Authors: Ossola, A., Schmit, J.-P., Grove, J.M.
Social, spatial and temporal analyses of urban tree canopy: The need for Sub-parcel Analysis.

Urban tree canopy (UTC) cover is rarely distributed equitably across social groups, space, and time. Over the past 20 years, research on the social, spatial, and temporal dynamics of UTC has grown considerably as municipalities adopt ambitious tree canopy cover goals. Yet less is known about how these three dimensions of tree canopy intersect. This paper brings these research areas together by examining i) which sets of social variables--population density, socioeconomic status, or lifestyle--are associated with UTC cover on residential lands, ii) how those relationships vary from front to back yard, and iii) how those relationships are associated with tree canopy cover changes in Baltimore, MD from 2013 to 2018, to more wholistically understand UTC. Socially, population density and social stratification predict tree canopy cover on residential lands, but not as well as lifestyle and life stage factors. More detailed and finer-grain social categories perform best. Spatially, models that explicitly separate front and backyards fit the data better than all-residential statistical models. Ignoring the front yard vs back yard distinction may hinder future theory development, limit the generalizability of empirical research findings, and prevent managers from realizing their canopy goals. Temporally, UTC across residential yards had a positive, though not significant, change likely from the relatively short period (5 y) considered. A fruitful next step could be to model how much planting, maintenance, and loss minimization is needed to achieve the city's 40% canopy goal with various scenarios for mortality, longevity, and removal over several timesteps.

Beatriz Shobe, Johns Hopkins University.
Co-Authors: Avolio, M.L., Sonti, N.F.
Selection in the City: How artificial selection of trees impacts the genetic diversity of urban forests

Trees are a known to be an effective tool in mitigating the effects of climate change and as a result many urban centers are focusing efforts to increase the urban tree canopy cover. As government agencies, NGO's and non-profits work to supply trees to local communities, bulk purchases are often made from local nurseries. This leads to the concern that many trees will be closely related and therefore have limited genetic diversity. The extent to which these planted trees may influence the genetic diversity, biotic community structure, and resilience of urban forests remains unknown. To address this concern, a study was conducted to assess the genetic diversity of the native red maple (Acer rubrum) across land use types. Sample trees were identified across a wide variety of land use types from highly managed urban streets and parks, unmanaged residential and naturalized areas, to urban and rural forests. Trees were measured and sampled during the summer of 2021 throughout Baltimore City, Baltimore County and parts of Howard County. For Acer rubrum, genetic analysis has revealed that a few main cultivars dominate in highly managed urban areas and that these cultivars are hybridizing with wild type trees in urban forests.

Marus Tuah and Kajall Hylton, Baltimore Tree Trust
Tree Care and Technology in Baltimore City

As Baltimore's principal tree planting organization, Baltimore Tree Trust (BTT) is dedicated to advancing tree care practices tailored to the specific needs of and challenges faced by trees in an urban landscape. Guided by the principle that tree care should never be an afterthought in urban

forestry projects, we aim to provide an in-depth analysis of the skills, systems, and technologies that BTT uses year-round, and hope to emphasize that the impact of an urban forest is determined by the care we provide.

POSTERS

Max Carroll, Johns Hopkins University. Co-Authors: Avolio, M.L.
Examining Patterns of Urban Weeds Adaptation to Elevated Salt Levels

Plants provide many benefits to the residents of cities, but also face unique challenges from the urban environment, the fastest-growing ecosystem on the planet. There is increasing evidence that plants are undergoing adaptive evolution in response to urban conditions. However, most studies consider the response of a single species to an urban stress, such as habitat heterogeneity or the urban heat island. This creates a need for comparative studies with multiple species to understand if patterns of urban adaptation can be generalized. In this poster, I will discuss how expected results and preliminary data on two common weeds, red deadnettle (Lamium purpureum) and corn speedwell (Veronica arvensis) tolerate salinity. Some seeds have been collected from roadsides, where their lineages are exposed to elevated salt levels, and some from parks where they are less exposed to salt. Plants grown from these seeds are currently undergoing a common garden experiment with some from each line exposed to NaCl solution. The plants are reacting to the NaCl treatment but it is too early to draw any conclusions from the data.

Aiden Kirchgraber, Smithsonian Environmental Research Center. Co-Authors: Nowakowski, A.J., Bennett, S.K., Wernoch, R., Cawood, A.
The resilience of bird vocalization behavior to extreme heat events in urban forest settings

Bird populations in cities face greater thermoregulatory challenges than their rural neighbors, as the urban heat island effect exacerbates local temperature extremes under climate change. An expansion of managed urban greenspaces through forest protection and restoration may help reduce regional biodiversity losses driven by land use and climate change. By measuring changes to avian vocalization behavior before, during, and after extreme heat events, we are evaluating the effects of temperature buffering in forest patches on avian vocalization activity at exurban and urban sites. We deployed audio loggers and microclimate sensors in 17 sites across Baltimore, Annapolis, and the Smithsonian Environmental Research Center campus in Edgewater, MD. Using BirdNET, a machine learning algorithm, we are quantifying the vocalization activity of bird species detected in audio recorded from May to September of 2024. We are combining acoustic data with information on the intensity and frequency of extreme temperature events at each site to examine the resilience of several resident bird species to extreme heat events. Although the analyses are preliminary, we expect to find that bird vocalization activity decreases on extreme heat days, especially those accompanied by high vapor pressure deficit and/or wet bulb globe temperatures, and that the degree of activity reduction is mediated by landscape (exurban versus urban) and local-scale forest cover.

Mary McWilliams, University of Maryland, Baltimore County. Co-Authors: Welty, C., Duncan, J., Lagrosa, J.
Use of long-term, high-frequency sensor data to evaluate interannual trends in stream metabolism in an urban watershed

We have evaluated stream metabolism in Dead Run watershed in suburban Baltimore, MD, using high frequency data and the USGS R package streamMetabolizer. Water quality parameters including temperature, specific conductance, dissolved oxygen, stage, and discharge have been collected along with photosynthetic active radiation and barometric pressure at a 5-minute interval at two sites within the watershed. DR5 is located ~500m downstream of a restoration project that was completed in 2018, with data collection ongoing since December 2012. Keithmont is located within the restored reach and includes data since August 2019. DR5 data has revealed seasonal patterns of GPP/ER with ratios higher in the spring and winter, and lower in the summer and fall. Mean GPP/ER values appear to be decreasing across all seasons at this site since 2012. Although Keithmont is located within the stream restoration, which included the removal of vegetation allowing more solar radiation to the stream, the GPP/ER ratios are lower than DR5 over the same time period for all seasons. Both sites tend towards respiration, indicating a predominantly heterotrophic system. Additional sensor stations are located at sites within the DR5 and larger Dead Run watershed, allowing for future comparisons across multiple scales for evaluation of potential downstream nutrient transport.

Mary McWilliams, University of Maryland, Baltimore County. Co-Authors: Welty, C., Miller, A.J., Duncan, J., Groffman, P.
Initial lessons learned from a year of high-frequency data at BES stream chemistry stations

To complement 26 years of weekly stream chemistry data collected by the Baltimore Ecosystem Study, in fall 2023 we deployed high-frequency water quality sensors at 5 of the stations (POBR, BARN, GFGB, GFVN, GFCP) in addition to DRKR that had been in place since 2013. YSI EXO2 sondes are outfitted with specific conductance, temperature, turbidity, pH and dissolved oxygen probes and co-located with USGS stream gages. Unanticipated complications in initial deployments included (1) spring pollen deposition giving rise to a turbidity signal at POBR; (2) ice at BARN knocking out periods of record at the USGS stream gage, thus impairing the ability to quantify loads; and (3) vandalism of electronics at the GFCP site. Despite these setbacks, we have gleaned new insights on the behavior of the stream system from data evaluation. Initial analysis has focused on (1) old-water/new water separation of stormflow using specific conductance, and (2) estimates of sediment loads based on turbidity and previously-established correlations with suspended sediment from nearby stream stations. The old-water/new-water analysis over a range of storm sizes shows that the fraction of groundwater comprising streamflow is greatest for smaller storms, and that for a given storm size, this fraction varies across watersheds. This likely is related to fraction of vegetated area, with a greater fraction of precipitation contributing to infiltration and shallow groundwater flow for a given storm size. Suspended sediment loads, derived from multiplying stream discharge by suspended sediment concentrations, exhibit spatial variability across the urban to rural gradient. Future plans include deployment of S-can sensors for collection and evaluation of TOC, DOC, and nitrate data across

watershed scales. This work is part of the Baltimore Social-Environmental Collaborative Urban Integrated Field Laboratory, supported by DOE.

Hannah Obenaus, Smithsonian Environmental Research Center. Co-Authors: Cawood, A., Wernoch, R., Bennett, S., Nowakowski, J.
Effects of forest restoration on insect communities in urban and exurban forests

Deforestation is one of the leading causes of biodiversity loss globally. One mechanism leading to the loss of species in deforested areas is exposure of organisms to extreme temperatures outside of their physiological limits. Forest restoration may reverse species loss, in part, by cooling the understory over time. However, the diversity and structure of forest undergoing restoration may be important factors shaping understory microclimates and the trajectory of community reassembly. We studied the effects of forest structure and microclimate on diversity of ground beetles in a tree planting experiment at the Smithsonian Environmental Center and insect diversity at Stillmeadow Peace Park in Baltimore, a forest undergoing restoration efforts. As ectotherms, insects are very susceptible to changes in microclimate caused by deforestation and reforestation. Insects also occupy many different ecological niches; so, their responses can provide insight into broader ecosystem health and functioning. We used pitfall traps to collect ground beetles at both sites. The sampling at Stillmeadow Peace Park was conducted as part of an environmental education and outreach program, and data were collected by community members and volunteers. Our initial results show that ground beetle abundance and richness in the tree planting experiment were greatest in cooler plots, which were associated with higher tree diversity and structural complexity. At Stillmeadow, initial results suggest insect abundance and richness differ between open and forested areas at the site. The broader goal of this work is to inform restoration efforts that aim to enhance cooling and biodiversity outcomes, among other co-benefits of restoration.

Gabrielle Pezich, Pennsylvania State University. Co-Authors: Duncan, J.M., McPhillips, L., Groffman, P.
Quantifying spatial and temporal variability of biogenic greenhouse gas emissions in Baltimore

The Baltimore Ecosystem Study has a 20+ year record of monthly greenhouse gas (GHG) emissions across an urban land use gradient, the longest running data set of its kind. Yet, the role of biogeochemical discrete portions of the landscape (hot spots) and brief periods of time (hot moments) on ecosystem scale greenhouse gas (GHG) emissions is not well understood in heterogenous urban landscapes. This study will investigate as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions in Baltimore, Maryland, while explicitly considering the heterogenous nature of urban landscapes. We hypothesize that ecosystem (watershed) scale fluxes are dominated by hotspots and hot moments following rainfall events. To test this hypothesis, we will employ a multi-scale experimental framework. Our approach will involve deploying gas collars across four different urban land uses—lawns, forests, ponds, and riparian zones. We will use LiCOR GHG analyzers and Smart-Chambers to collect data at regular intervals (monthly) in sunny-day conditions and after storm events (4 per season, 16–20 in total), capturing variability in precipitation and emissions. In our analysis, we seek to integrate flux estimates with land cover area to evaluate the relative impact at a watershed-scale. This approach

will help us understand how significant hot spots, though they occupy a small proportional area, are in relation to various land cover types. This methodology reflects the interconnected nature of urban systems, where infrastructural elements (storm drain networks, stormwater infrastructure, etc.) affect greenhouse gas emissions. By integrating principles of spatial ecology, this research aims to address the uncertainties and feedback mechanisms inherent in urban climate resilience.

Gabriel Pickus, The Baltimore Forest School Flower. Co-Authors: Terris King II.
InDiGO: Inward Discovery Grows Outdoors

See the first oral presentation abstract above.

Margaret Schaefer, University of Maryland College Park. Co-Authors: McGurrin, K., McCloskey S., Pierre, A-L., Burghardt, K.
Does a history of redlining or higher urban temperatures across Baltimore neighborhoods affect young street tree health?

Urban street trees contribute valuable ecosystem services such as mitigating urban heat island effects, improving air quality, storing carbon, and even providing aesthetic value. However, street trees are not always equally distributed across neighborhoods. Previous research demonstrates socioeconomic factors and policy history contribute to which neighborhoods have access to healthy street trees. Further, different tree species may respond differently to the higher urban temperatures and urban stressors, which vary across these neighborhoods. In the summer of 2024, we revisited young street tree cohorts of several native species originally sampled in the 2018 Baltimore Tree Inventory. These neighborhoods varied in redlining history and in air temperatures recorded over the summer of 2018. We quantified growth over the past six years and assessed many tree health, damage, and insect population metrics. We present preliminary results on the impact of urban stressors on tree health. The goal of this project is to gain a more complete picture of what impacts the ability of these trees to survive and thrive in a gradient of temperature and urban stressors.

Rashmi Sharma.
Study of plants to reduce environmental temperatures.

P.J. Terhune, University of Maryland, Baltimore County. Co-Authors: McWilliams, M., Welty, C., Moore, J., Bain, D., Gomes, M.
Analysis of sulfate concentrations in riparian soils of headwater streams in Dead Run watershed

Intensive sampling of the Dead Run stream network from 2021-2024 has revealed unexpectedly high concentrations of sulfate at locations where headwater streams emerge from concrete drain pipes to natural stream channels. In an effort to link stream sulfate concentrations to source materials, we have embarked on a program of sampling riparian soils near identified stream “hot spot” locations. Since June 2024, we have collected 12 soil core samples from two of these locations in Dead Run. Soil cores of ~ 1 m in depth were collected 2 m downstream of pipe

outfalls at approximately the same longitudinal location where the stream has been sampled for sulfate. At each location, cores were collected on both sides of the stream at distances of ~ 1 m, 2 m, and 5 m from the stream edge (6 cores in total at each location). A soil auger was used to retrieve soil cores in ~0.15 m depth increments, with each core increment placed in a plastic bag to return to the lab for analysis. Samples were dried at 150℉ for two days or until all water content evaporated, then stored at room temperature until analysis. Samples were sieved to retain the fraction < 2 mm in diameter. A soil extraction procedure using a 0.01M CaCl2 solution was used to elute sulfate from the soil samples. Chemical analysis was carried out on the extracts using a YSI 9500 Photometer, which has a detection limit of 1 mg/L sulfate. Preliminary data show concentrations of extractable sulfate increasing with depth and proximity to the stream, ranging from non-detect near the land surface to 200 mg SO4/kg soil at 1 m depth. Next steps for this project include sampling soils near additional stream hotspots in Dead Run and additional analysis of all collected samples using ion chromatography.

Samantha Votzke, Johns Hopkins University. Co-Authors: Szlavecz, K., Avolio, M.L., Johnson-Bond, O.
An assessment of photosynthetic activity in tree species across Baltimore City

BSEC Vegetation and Soils Team Update—TBD

Darryn Waugh, Johns Hopkins University. Co-Authors: BSEC
BSEC Weather Station Network: Spatial and Temporal Variations of Heat within Baltimore

Understanding neighborhood-scale variability of weather within cities is critical for developing equitable solutions for urban heat, flooding, and air pollution, as these conditions are not evenly distributed across cities and low-income communities generally encounter the highest temperatures and air pollution and most frequent flooding. However, there is lack of surface weather measurements within Baltimore, especially in under-served neighborhoods. To address this lack of data, the Baltimore Social-Environmental Collaborative (BSEC) is working with community partners to deploy a network of surface weather stations across Baltimore City. In addition, temperature measurements have been made from local networks of fixed sensors and from bicycle transects.

Dick Williams, St. James Development Corporation.
Streetscape Green Infrastructure as Environmental Justice in 21217

St. James Development Corporation's Environmental Justice Projects A and B are tandem demonstrations of Stormwater Best Management Practices as environmental justice projects.

Project A will principally feature the green infrastructure (GI) Best Management Practice (BMP) of constructed bio-retention systems that, among benefits, will: (1) Increase permeable land surface in Baltimore City for cleaner water entering the Gwynns Falls and Baltimore Harbor watersheds; (2) Reduce the volume of polluted stormwater runoff into the aging city storm sewer system; (3) Filter water-borne pollutants through plant materials and soil particles; (4) Provide

micro-habitats for natural communities amidst newly planted trees, shrubs, perennial flowers and grasses—that also knock down airborne particulate matter; and, (5) help reduce COPD-related public health issues by reducing airborne particulate matter.

Project A also addresses the Baltimore City MS4 Restoration and TMDL with reference to the 20% impervious restoration requirement--0.05 ac. or 2,480 sq. ft. depave--and TMDL waste load allocations--0.08 ac or treatment area--to the Gwynns Falls and Baltimore Harbor watersheds. Project A, located on streetscape in both Harlem Park and Sandtown-Winchester, a HIgh Priority Trust Fund Zone, encompasses the City's Project Selection Criteria: Neighborhoods with large numbers of vacant properties AND in or adjacent to Vacants to Value development clusters. Our civil engineer estimates that Project A through its BMP streetscape GI strategies can intercept and treat about 161,200 gallons of polluted rainwater per year which otherwise would discharge, untreated, into the city's antiquated stormwater system directly into the Baltimore Harbor; or, potentially backed up, causing flooding elsewhere in the Harlem Park or Sandtown-Winchester neighborhoods.

When completed, Project A, when combined with the tandem plan, Project B, will allow for a more scalable green workforce program so greater labor efficacy and financial cost effectiveness. The SJDC Project Team has contacted Greater Baltimore Wilderness Coalition leadership about working with its Maryland Climate Crew Network which query was positively received. Other related resources include: Turnaround Tuesday; the Living Classrooms Foundation; and, Clean Corps, a Baltimore City Planning Department initiative currently providing maintenance services in Harlem Park.

Dick Williams, St. James Development Corporation.
The Rev. Donald O. Wilson Park as Environmental Justice at an Inner Block in 21217

St. James Development Corporation’s Environmental Justice Projects A and B are tandem demonstrations of Stormwater Best Management Practices as environmental justice projects.

Project B entails the founding of a park on privately owned and managed land for public use, located on a 1-acre parcel combining an Inner Block and four street-front-facing vacant rowhouse properties.

The combined properties of 1026 W. Lanvale (the inner block parcel) and 808-810-812-814 N. Fremont Avenue lots are vacant of vertical structures, but include a net depave area of 5,477 sq. ft. of impervious surface alley and parking area, and a brick and stone leveling/retaining wall to be demolished and removed from the western area of the site. Running eastward from N. Arlington Avenue through the combined properties out onto N. Fremont Avenue, the downslope of land in the block is about 16.5 ft. (as per the 4/2023 topographical survey). This creates considerable stormwater runoff into the city’s antiquated storm sewer system.

The following stormwater BMPs will be installed in the Park:

- Conservation landscaping
- Urban tree planting and restoration

- Microbioretention / raingarden
- Impervious surface removal / urban soil amendment-restoration
- Downspout disconnect
- Rainwater harvesting

These BMPs, when installed, will feature two key BMPs strategies: (1) stemming stormwater flow from a 16.5 ft. higher elevation of land along N. Arlington Avenue across significant impervious surface square footage—proposed for the Park—eastward to N. Fremont Avenue; and, (2) establishing a native-landscaped Park for respite and enjoyment by deserving neighborhood residents and other nearby West Baltimore residents.

Two rain garden BMPs were originally planned, but soil perk testing and certain engineering analysis of the land proposed for the Park indicated three microbioretention/raingarden practices would be necessary. The addition of rain hogs to receive the BMP downspout disconnect rooftop rainwater along the eastern wall of the church building will facilitate seasonal irrigation of the Park, particularly during the 2-year landscape establishment period, and save potable water money.

A beautiful native-planted Park will create a micro ecosystem where for decades there's been abandonment and in more recent years a plethora of illegal dumping. The visual layering of new native over-story trees, to include two existing, magnificent American sycamores (Plantanus occidentalist) at the northern edge of the Park boundary, and new, native flowering or other under-story trees, shrubs and grasses portend a calming and healthy place. To enhance the mental de-stressing offered in this Park is a labyrinth, particularly popular with middle-age and older adults, and benches for resting and relaxing. As the ecosystem matures, the urban heat island effect on mental stress will be significantly lessened in the Park and the public health stressor of asthma will be reduced by airborne particulate matter being captured by new tree and plant structure, including leaves, and grasses. Rounding out the betterment to human health is the social-capital-increasing play areas which will feature a performance stage and permanent games, benches and picnic tables. Let us say these amenities will be afforded by greater funding of the total Park design.

When completed, Project B, the Park, when combined with the tandem plan, Project A, will allow for a more scalable green workforce program so greater labor efficacy and financial cost effectiveness. The SJDC Project Team has contacted Greater Baltimore Wilderness Coalition leadership about working with its Maryland Climate Crew Network which query was positively received. Other related resources include: Turnaround Tuesday; the Living Classrooms Foundation; and, Clean Corps, a Baltimore City Planning Department initiative currently providing maintenance services in Harlem Park.

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Understanding water flow dynamics in urban soils: Implications for stormwater management

In urban areas, managing stormwater and erosion is important for environmental sustainability. Understanding water flow dynamics through urban soils improves management. Soil moisture conditions in urban environments vary widely, from unsaturated to fully saturated, complicating modeling efforts and prediction of water movement. This study aims to characterize both saturated and unsaturated flow in urban soils. We investigated three prevalent land cover types—park, forest, and vacant land. We took surface (0 - 5 cm) and deep (1 m) soil cores and measured bulk density and soil organic matter content. Unsaturated flow was lowest in the forest (0.6 ± 0.19 cm hr-1) and highest in vacant lots (3 ± 0.72 cm hr-1), with parks falling in between these two extremes ($p < 0.05$). A significant correlation was found between unsaturated flow and both bulk density ($r^2 = 0.14$, $p < 0.05$) and soil organic matter (0-5 cm; $r^2 = 0.14$, $p < 0.05$). In contrast, saturated flow showed less variation across land uses, ranging from 32 cm hr-1 in forests to 35 cm hr-1 in vacant lots. The findings from our study contribute to improving the modeling and prediction of water movement in this complex urban system.