GREENNESS AND RESILIENCE TO SOCIAL AND BUILT ENVIRONMENTAL STRESS

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ABSTRACT
Background: Climate change (SDG 13) has the potential to dramatically effect nearly all aspects of life, including all other Sustainable Development Goals. One impact of climate change that deserves increased attention is the increase in global violence (SDG 1, 5, 16). By the end of the century, predicted changes in carbon dioxide emissions is estimated to increase global violence by a median probability of 1.5-5.4% (Climate Impact Lab, 2017). Carbon dioxide emissions raise the risk of abnormally high ambient temperatures, which is associated with violence, aggression, and other heat related stressors (SDG, 3). These stressors are known to affect physiologic hormonal mechanisms in the body. However, the biological mechanisms of the relationship between climate change and violence, and potential mitigating or exacerbating characteristics of built environments (SDG 1, 2), is understudied. The amount of living green vegetation in a given community, or greenness, contributes to sequestration of carbon dioxide and reduces ground level temperatures (SDG 15). In addition to mitigating temperature (along with air and noise pollution), greenness may increase physiologic resilience of individuals and communities exposed to violence and subsequent pathogenic stress response (SDG 11, 12).
Design and Methods: This mixed methods study examined the effect of greenness on stress and resilience among urban African American women with high exposure to interpersonal and community violence. Greenness was geospatially measured by remote sensing of chlorophyll at ground level along with factors of the social and built environment. Women (n=98) in the sample were between the ages of 18-44, living in an urban mid-Atlantic city of the United States of America, and at high risk of interpersonal and community violence. A multilevel regression model was used to determine the effects of greenness on physiological resilience (operationalized as the ratio of cortisol to dehydroepiandrosterone). Covariates in the regression model included sexual violence, crime, vacant property, traffic proximity, education, income, perceived stress and unprotected sex partners. We also utilized the analysis of interviews with key informants (n=10), observational field notes, historical records and images to understand the resilience potential of key communities within the highest and lowest greenness quintile of the sample.
Results: Multi-level analysis at the community statistical areas (n=55) revealed that one standard deviation (0.039) increase in greenness was associated with a 34% increase ($\beta\beta$= 7.5, p<.05) in physiological-resilience, adjusting for covariates. The analysis of qualitative data revealed that, according to key informants, green spaces have the ability to promote feelings of calmness. However, access to green spaces is restricted when traveling through social and built environments that are perceived as unsafe or unpleasant, potentially discouraging use.
Conclusion: This research highlights the relationship between climate change and violence and demonstrates the capability of greenness to support the resilient potential of communities vulnerable to violence. The greenness of communities—in addition to being an indicator of climate change—has significant mitigation and adaptation potential for communities affected by violence and related stressors. Increased collaboration between community, government, healthcare, and other stakeholders to promote urban greenness can help support safe, resilient, and sustainable environments.

Background

Climate Change and Violence against Women

One impact of climate change (SDG 13) that deserves increased attention is the increase in global violence (SDG 1, 5, 16). Increases in violent crime related to climate change are predicted to increase by 3% (95%CI, 1.5-5.4) by the end of the century .[1] In 2011, the economic costs of violence worldwide were over $10.5 trillion (2018 dollars), 98% of it from interpersonal violence and intimate partner violence .[2] As climate-related disasters increase, there is a potential for an increase in violence for individuals, families, and communities .[3] This violence may take place on a societal level as more individuals become environmental refugees, increasing tensions among governments as resources become depleted[4] , or it may take place on an individual level as disasters create unsafe living conditions .[5] As is the case for most outcomes from climate change, the burden of climate-related violence will not affect all individuals equally. Already facing multiple and systemic inequalities, climate-related violence will disproportionately affect women.

Climate change exacerbates existing conditions contributing to violence against women in multiple ways .[6] An increase in disasters related to climate change creates unsafe living conditions for women both during the event of a disaster and also during recovery phases. Under these circumstances women are at a high risk for sexual violence, sexual exploitation,

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[1] Solomon Hsiang et al., "Estimating economic damage from climate change in the United States," *Science* 356, no. 6345 (2017), https://doi.org/10.1126/science.aal4369, https://science.sciencemag.org/content/sci/356/6345/1362.full.pdf.

[2] Anke Hoeffler, "What are the costs of violence?," *Politics, Philosophy & Economics* 16 (11/01 2017), https://doi.org/10.1177/1470594X17714270.

[3] Úrsula Oswald Spring, "Gender, Climate Change and Sustainable Development Goals," in *Pioneer on Gender, Peace, Development, Environment, Food and Water. Pioneers in Arts, Humanities, Science, Engineering, Practice.*, ed. Úrsula Oswald Spring (Switzerland: Springer, 2019).

[4] Barry S. Levy, Victor W. Sidel, and Jonathan A. Patz, "Climate Change and Collective Violence," *Annual Review of Public Health* 38, no. 1 (2017), https://doi.org/10.1146/annurev-publhealth-031816-044232, https://www.annualreviews.org/doi/abs/10.1146/annurev-publhealth-031816-044232.

[5] UN Women, *Climate change, disasters and gender-based violence in the Pacific* (n.d.), https://www.uncclearn.org/sites/default/files/inventory/unwomen701.pdf.

[6] Oswald Spring, "Gender, Climate Change and Sustainable Development Goals."

and physical violence. Additionally, climate-related disasters limit women's access to crucial medical services as a result of violence .[7] Further, everyday violence, such as intimate partner violence or sexual assault, can impede women's ability to prepare and respond to disasters.[8] Systemic inequalities related to violence that women face impact their ability to cope with changes in their environment. By advancing efforts to support women's resiliency, development programs can help reduce inequalities and mitigate the impacts of climate change for diverse groups of women.[9]

Climate Change, Urbanization, and Violence against African American Women

Almost 52.2 million women (43.6%) in the USA will experience sexual violence in their lifetime.[10] Of those who experience sexual violence, 18.3% are by an intimate partner, and over thirty percent of women are survivors of physical violence by an intimate partner.[11] In 2010, reported life-time prevalence of partner and non-partner rape among Black women (22%) was 3.2% higher than White women (18.8%) and 7.4% higher than Hispanic (14.6%).[12] Reports of the experience of sexual abuse as a child by Black or African American women have been as high as 65%.[13]

African American women living in urban areas disproportionately experience threats to their health and wellbeing, including climate-related stressors from their social and built

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[7] UN Women, *Climate change, disasters and gender-based violence in the Pacific*.
[8] V. L. Masson et al., "How violence against women and girls undermines resilience to climate risks in Chad," *Disasters* 43 Suppl 3 (Apr 2019), https://doi.org/10.1111/disa.12343.
[9] Masson et al., "How violence against women and girls undermines resilience to climate risks in Chad."
[10] S.G.; Chen Smith, J.; Basile, K.C.; Gilbert, L.K.; Merrick, M.T.; Patel, N.; Walling, M.; Jain, A, *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010-2012 State Report*, National Center for Injury Prevention and Control (Atlanta, GA: Centers for Disease Control and Prevention, 2017).
[11] Smith, *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010-2012 State Report*.
[12] M.C.; Basile Black, K.C.; Breiding, M.J.; Smith, S.G.; Walters, M.L.; Merrick, M.T; Chen, J.; Stevens, M.R., *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Summary Report*, National Center for Injury Prevention and Control (Atlanta, GA: Centers for Disease Control and Prevention., 2011); Black, *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Summary Report*; Black, *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Summary Report*.
[13] T. Bryant-Davis et al., "Struggling to survive: sexual assault, poverty, and mental health outcomes of African American women," *Am J Orthopsychiatry* 80, no. 1 (Jan 2010), https://doi.org/10.1111/j.1939-0025.2010.01007.x, https://www.ncbi.nlm.nih.gov/pubmed/20397989.

environmental stress. These stressors include violence[14], access to ecosystem services that mitigate the health effects of noise pollution[15], air pollution[16] and extreme weather events, including heat-related illnesses.[17] The relationship between climate change and violence may be exacerbated in urban areas from the urban heat island effect that stems from concentrated areas of concrete, asphalt, brick and stone that contribute to higher temperatures as compared to areas with more vegetation.[18]

The urban built environment can be hostile to humans, especially as global temperatures rise.[19] Urban heat island effect, the absorption of solar thermal energy by concrete and asphalt, increases the ambient temperature, and stores heat throughout the day releasing it at night, maintaining elevated temperatures.[20] The physiological result of the urban heat island effect impacts people in different ways: increasing the general discomfort, respiratory difficulties, heat cramps and exhaustion, non-fatal heat stroke, and heat-related mortality.[21]

Resilience and Greenness

The presence of environments that promote a healthy stress response may boost both individual and community resilience to the increasing heat related impacts of climate change in urban areas.[16] Resilience is defined as the capacity of an individual or community to prepare

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[14] Black, *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010 Summary Report*.
[15] A. M. Dzhambov and D. D. Dimitrova, "Urban green spaces' effectiveness as a psychological buffer for the negative health impact of noise pollution: a systematic review," *Noise Health* 16, no. 70 (May-Jun 2014), https://doi.org/10.4103/1463-1741.134916.
[16] B. L. Perry, K. L. Harp, and C. B. Oser, "Racial and Gender Discrimination in the Stress Process: Implications for African American Women's Health and Well-Being," *Sociol Perspect* 56, no. 1 (Spring 2013), https://www.ncbi.nlm.nih.gov/pubmed/24077024.
[17] Bill M. Jesdale, Rachel Morello-Frosch, and Lara Cushing, "The Racial/Ethnic Distribution of Heat Risk 2013;Related Land Cover in Relation to Residential Segregation," *Environmental Health Perspectives* 121, no. 7 (2013), https://doi.org/10.1289/ehp.1205919.
[18] "Climate Change Indicators: Heat-Related Deaths," Heat Islands, updated 2019, 2016, https://www.epa.gov/climate-indicators/climate-change-indicators-heat-related-deaths.
[19] E. P. Petkova et al., "Heat-related mortality in a warming climate: projections for 12 U.S. cities," *Int J Environ Res Public Health* 11, no. 11 (Oct 31 2014), https://doi.org/10.3390/ijerph111111371, https://www.ncbi.nlm.nih.gov/pubmed/25365060.
[20] "Learn About Heat Islands," Heat Islands, 2017, https://www.epa.gov/heat-islands/learn-about-heat-islands.
[21] EPA, "Climate Change Indicators: Heat-Related Deaths."

for, avoid and adapt to negative social, psychological, and biological consequences of extreme stress or shocks that would otherwise compromise their wellbeing.[22] Yet resilience has seldom been used to refer to community and environmental processes.[23] Both individual and community resilience are needed to mitigate the causes of climate change, adapt urban environments to increases in the associated violence, and reduce the body's chronic stress response.[17,24]

One potential method of community resilience and mitigating the causes of climate change may be from the presence of plant life, or green spaces, in a built environment.[25] Plant based CO_2 sequestration has the co-benefit in urban environments of facilitating adaptation by the shading of heat absorbing materials (concreate and asphalt), and through plant transpiration.[26] In urban areas, green spaces' ability to sequester CO_2 and reduce the urban heat island effect is significant, given the mediation of positive associations between raising average temperatures and aggressive behaviors over time.[27]

Green spaces are essential to human life, both in urban and rural environments. We interact with green spaces and depend on them too. The greenness of trees and other plants

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[22] S. L. Szanton and J. M. Gill, "Facilitating resilience using a society-to-cells framework: a theory of nursing essentials applied to research and practice," *ANS Adv Nurs Sci* 33, no. 4 (Oct-Dec 2010), https://doi.org/10.1097/ANS.0b013e3181fb2ea2, https://www.ncbi.nlm.nih.gov/pubmed/21068554.
[23] Mark Levene and Daniele Conversi, "Subsistence societies, globalisation, climate change and genocide: discourses of vulnerability and resilience," *The International Journal of Human Rights* 18, no. 3 (2014/04/03 2014), https://doi.org/10.1080/13642987.2014.914702, https://doi.org/10.1080/13642987.2014.914702.
[24] Natalia Petros, Jolanta Opacka-Juffry, and Jörg H. Huber, "Psychometric and neurobiological assessment of resilience in a non-clinical sample of adults," *Psychoneuroendocrinology* 38, no. 10 (2013/10/01/ 2013), https://doi.org/https://doi.org/10.1016/j.psyneuen.2013.03.022, http://www.sciencedirect.com/science/article/pii/S0306453013001170.
[25] National Research Council, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration* (Washington, DC: The National Academies Press, 2015). https://www.nap.edu/catalog/18805/climate-intervention-carbon-dioxide-removal-and-reliable-sequestration.
[26] S. J. Livesley, E. G. McPherson, and C. Calfapietra, "The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale," *Journal of Environmental Quality* 45, no. 1 (2016), https://doi.org/10.2134/jeq2015.11.0567, http://dx.doi.org/10.2134/jeq2015.11.0567.
[27] Diana Younan et al., "Long-Term Ambient Temperature and Externalizing Behaviors in Adolescents," *American Journal of Epidemiology* 187, no. 9 (2018), https://doi.org/10.1093/aje/kwy104, https://doi.org/10.1093/aje/kwy104.

can be remotely measured from space via satellites. By comparing the difference between near infrared (NIR) and visible red (RED) wavelengths of light, a validated measure of greenness can be measured and is known as normalized difference in vegetation index (NDVI).[28] Greenness has recently been associated with decreased health impacts from climate change, including physiological (e.g., respiratory illness and heat-related illness[29] and psychological (e.g., depression and stress) health impacts.[30] Greenness has also been associated with resilient mental health among adults and children.[31]

Exposure to higher levels of greenness has been associated with lower incidence of cardiovascular disease[32], respiratory illness, liver cancer, kidney disease[24], and lower rates of violence and crime.[33] Furthermore, greenness has been linked to increased physical activity[34];

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[28] Isaac C. Rhew et al., "Validation of the Normalized Difference Vegetation Index as a Measure of Neighborhood Greenness," *Annals of Epidemiology* 21, no. 12 (2011/12/01/ 2011), https://doi.org/https://doi.org/10.1016/j.annepidem.2011.09.001, http://www.sciencedirect.com/science/article/pii/S104727971100250X.

[29] Peter James et al., "Exposure to Greenness and Mortality in a Nationwide Prospective Cohort Study of Women," *Environmental Health Perspectives* 124, no. 9 (2016), https://doi.org/doi:10.1289/ehp.1510363, https://ehp.niehs.nih.gov/doi/abs/10.1289/ehp.1510363.

[30] Greg Watts, "The effects of “greening” urban areas on the perceptions of tranquility," *Urban Foresty & Urban Greening* 26 (2017).

[31] Eirini Flouri, Emily Midouhas, and Heather Joshi, "The role of urban neighbourhood green space in children's emotional and behavioural resilience," *Journal of Environmental Psychology* 40 (2014/12/01/ 2014), https://doi.org/https://doi.org/10.1016/j.jenvp.2014.06.007, http://www.sciencedirect.com/science/article/pii/S0272494414000565.

[32] Qing Li et al., "Acute effects of walking in forest environments on cardiovascular and metabolic parameters," *European journal of applied physiology* 111 (03/01 2011), https://doi.org/10.1007/s00421-011-1918-z.

[33] Eugenia C Garvin, Carolyn C Cannuscio, and Charles C Branas, "Greening vacant lots to reduce violent crime: a randomised controlled trial," *Injury Prevention* 19, no. 3 (2013), https://doi.org/10.1136/injuryprev-2012-040439, https://injuryprevention.bmj.com/content/injuryprev/19/3/198.full.pdf.

[34] B. Jongeneel-Grimen et al., "The relationship between physical activity and the living environment: a multi-level analyses focusing on changes over time in environmental factors," *Health Place* 26 (Mar 2014), https://doi.org/10.1016/j.healthplace.2013.12.003, https://www.ncbi.nlm.nih.gov/pubmed/24448404.

decreased obesity[35] , improved birth outcomes[36] , decreased urban heat islands[37] and its effect on heat related illness[38], and decreased air pollution.[39] Trees, in particular, provide shade and evapotranspiration, mitigating the impacts of the urban heat island effect on human health.[40] Tree shade decreases the amount of thermal energy from the sun absorbed by concreate, asphalt and other surfaces.[41] In combination with evapotranspiration, trees can cool the air and ground level temperatures as much as 4°C.[42] Cooler ground surface temperatures and tree shade may also prove to mitigate violence associated with increased abnormally high temperatures.[43]

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[35] S. F. Suglia et al., "Why the Neighborhood Social Environment Is Critical in Obesity Prevention," *J Urban Health* 93, no. 1 (Feb 2016), https://doi.org/10.1007/s11524-015-0017-6, https://www.ncbi.nlm.nih.gov/pubmed/26780582.

[36] Perry Hystad et al., "Residential Greenness and Birth Outcomes: Evaluating the Influence of Spatially Correlated Built-Environment Factors," *Environmental Health Perspectives* 122, no. 10 (2014), https://doi.org/doi:10.1289/ehp.1308049, https://ehp.niehs.nih.gov/doi/abs/10.1289/ehp.1308049

[37] X. X. Zhang, P. F. Wu, and B. Chen, "Relationship between vegetation greenness and urban heat island effect in Beijing City of China," *Procedia Environmental Sciences* 2 (2010/01/01/ 2010), https://doi.org/https://doi.org/10.1016/j.proenv.2010.10.157, http://www.sciencedirect.com/science/article/pii/S1878029610001908.

[38] Wen-Ching Chuang and Patricia Gober, "Predicting Hospitalization for Heat-Related Illness at the Census-Tract Level: Accuracy of a Generic Heat Vulnerability Index in Phoenix, Arizona (USA)," *Environmental Health Perspectives* 123, no. 6 (2015/06/01 2015), https://doi.org/10.1289/ehp.1307868, https://doi.org/10.1289/ehp.1307868.

[39] Francesca Bottalico et al., "Air Pollution Removal by Green Infrastructures and Urban Forests in the City of Florence," *Agriculture and Agricultural Science Procedia* 8 (2016/01/01/ 2016), https://doi.org/https://doi.org/10.1016/j.aaspro.2016.02.099, http://www.sciencedirect.com/science/article/pii/S2210784316300997; Kenneth Olden, "Effects of air pollution on African-American and other minority populations," *Otolaryngology - Head and Neck Surgery* 114, no. 2 (1996/02/01/ 1996), https://doi.org/https://doi.org/10.1016/S0194-5998(96)70178-X, http://www.sciencedirect.com/science/article/pii/S019459989670178X.

[40] Dimitra Founda and Mattheos Santamouris, "Synergies between Urban Heat Island and Heat Waves in Athens (Greece), during an extremely hot summer (2012)," *Scientific Reports* 7, no. 1 (2017/09/08 2017), https://doi.org/10.1038/s41598-017-11407-6, https://doi.org/10.1038/s41598-017-11407-6.

[41] Qunshan Zhao et al., "Assessing the Cooling Benefits of Tree Shade by an Outdoor Urban Physical Scale Model at Tempe, AZ," *Urban Science* 2, no. 1 (2018), https://www.mdpi.com/2413-8851/2/1/4.

[42] Yupeng Wang and Hashem Akbari, "The effects of street tree planting on Urban Heat Island mitigation in Montreal," *Sustainable Cities and Society* 27 (2016/11/01/ 2016), https://doi.org/https://doi.org/10.1016/j.scs.2016.04.013, http://www.sciencedirect.com/science/article/pii/S221067071630066X.

[43] D. Mares, "Climate change and levels of violence in socially disadvantaged neighborhood groups," *J Urban Health* 90, no. 4 (Aug 2013), https://doi.org/10.1007/s11524-013-9791-1, https://www.ncbi.nlm.nih.gov/pubmed/23435543.

These health conditions and outcomes associated with greenness are also areas of health inequities between African Americans and white Americans .[44] Despite some initial findings on an association between greenness and resilience[45] , little is known about the impact of greenness on emotional and physiological resilience within the context of the built and social environment of African American women who live in urban neighborhoods. Potential biomarkers of physiological resilience are the ratio of cortisol and dehydroepiandrosterone (DHEA).[46] Exposure to higher levels of greenness has been associated with lower levels of cortisol[47] and allostatic load, and positively associated with DHEA.[48] Research on physiological resilience, or the body's ability to physiologically adapt to stress, including maintaining allostasis , suggests that DHEA has immuno-modulatory effects on the cortisol response to stress.[49]

Urban amenities, including parks, green spaces, street trees and urban vegetation that provide ecosystem services currently are inequitably distributed, where African Americans are twice (epp=2.31, (95% CI 2.09, 2.55) as likely to live on streets with no tree canopy, and at least 50% impervious surfaces.[50] Interventions to increase the amount of vegetation, including street

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[44] Perry, Harp, and Oser, "Racial and Gender Discrimination in the Stress Process: Implications for African American Women's Health and Well-Being."
[45] Flouri, Midouhas, and Joshi, "The role of urban neighbourhood green space in children's emotional and behavioural resilience."
[46] Frederick R. Walker et al., "In the search for integrative biomarker of resilience to psychological stress," *Neuroscience & Biobehavioral Reviews* 74 (2017/03/01/ 2017), https://doi.org/https://doi.org/10.1016/j.neubiorev.2016.05.003, http://www.sciencedirect.com/science/article/pii/S0149763415303602.
[47] Jenny J. Roe et al., "Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban Communities," *International Journal of Environmental Research and Public Health* 10, no. 9 (2013), https://www.mdpi.com/1660-4601/10/9/4086.
[48] Andrey I. Egorov et al., "Vegetated land cover near residence is associated with reduced allostatic load and improved biomarkers of neuroendocrine, metabolic and immune functions," *Environmental Research* 158 (2017/10/01/ 2017), https://doi.org/https://doi.org/10.1016/j.envres.2017.07.009, http://www.sciencedirect.com/science/article/pii/S0013935117304826.
[49] Petros, Opacka-Juffry, and Huber, "Psychometric and neurobiological assessment of resilience in a non-clinical sample of adults."
[50] Jesdale, Morello-Frosch, and Cushing, "The Racial/Ethnic Distribution of Heat Risk 2013;Related Land Cover in Relation to Residential Segregation."

trees, parks and other green spaces disproportionately benefited areas with higher incomes and levels or income and potentially contribute environmental gentrification .[51]

Despite some initial findings of an association between greenness and resilience (e.g., mental wellbeing) among children and non-Hispanic whites to stress[52] little is known about the impact of greenness on emotional and physiological resilience within the context of the built and social environment of African American women.

Since most studies on the impact of greenness on stress have used actual immersion (e.g., forest bathing) , or measured greenness as percentage of tree canopy[53], this study aims to understand the complex interactions of total greenness (NDVI), stress (cortisol awakening response) and physiological resilience within contextual factors of the social and built environment (experience of trauma) of the neighborhoods and lives of urban dwelling African American women.

Therefore, this study uses quantitative and qualitative methods to examine the effect of greenness on stress and resilience to stress among African American women in Baltimore, Maryland.

Methods

Setting and Sample

Quantitative

Recruitment of participants for the quantitative portion of this study took place at two public health sexually transmitted disease (STD) clinics in Baltimore City, Maryland as part of

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[51] Pearsall Hamil and Isabelle Anguelovaski, "Contesting and Resisting Environmental Gentrification: Responses to New Paradoxes and Challenges for Urban Environmental Justice," *British Sociological Association* 21, no. 3 (2016), https://doi.org/10.5153/sro.3979.

[52] S. Bogar and K. M. Beyer, "Green Space, Violence, and Crime: A Systematic Review," *Trauma Violence Abuse* 17, no. 2 (Apr 2016), https://doi.org/10.1177/1524838015576412, https://www.ncbi.nlm.nih.gov/pubmed/25824659.

[53] Eileen K. Nehme et al., "Environmental Correlates of Recreational Walking in the Neighborhood," *American Journal of Health Promotion* 30, no. 3 (2016), https://doi.org/10.4278/ajhp.130531-QUAN-281, https://journals.sagepub.com/doi/abs/10.4278/ajhp.130531-QUAN-281.

the ESSENCE project (NIH R01HD077891, PI: Jamila Stockman). Baltimore is in the 90th percentiles of the country for traffic proximity. In 2016, 226 pedestrians were hit by cars and 17 died.[54] Violent crime rates were seven times the national average, with 343 homicides in 2017.[55] Inclusion criteria for the quantitative data analysis included: self-identification as a Black or African American woman, between the ages of 18-44, living in Baltimore City, Maryland, in a sexual relationship with a man in the past six months, and at high risk for HIV. For the quantitative analysis of the current study, participants were required to self-collect saliva samples for two days at waking and 30 minutes post-waking, to measure cortisol and dehydroepiandrosterone (DHEA).

Participants from the parent study were divide into two groups: previously exposed to sexual violence and previously unexposed to sexual violence. The exposed informants all reported sexual trauma including adult forced sex, gang rape, adult stranger rape, and partner sexual abuse. The exposed informants were between ages of 20-30, similar to the study as a whole (mean=26.7, 95% CI [25-28]) (see Table 1). The median number of sex partners was two, and partner risk behaviors were 1 (max=4). The median numbers of crime within 100 meters was 22, and traffic proximity and vacant properties were both in the highest quintiles.

Qualitative

Key informants (n=7) were purposively sampled from the same community statistical areas (CSA) including Penn North-Reservoir Hill (highest quintile) and Madison-East End (lowest quintile).

Measures

Resilience

[54] Maryland Department of Transpiration, *FFFY Highway Safety Plan* (2017), http://www.mdot.maryland.gov/.

[55] K. Rector, "Baltimore has now had 343 homicides in 2017, sets record for killings per capita," *The Baltimore Sun (Online)* 2017, Dec 27.

Physiological resilience is the body's ability to physiologically adapt to stress.[56] The physiological resistance to stress is a complex interaction among systems that support response to environmental changes.[57] As the ratio of cortisol and DHEA has been suggested as a potential biological marker of physiological resilience and will be operationalized this way for this study.

Violence and the built environment

Covariates included cumulative experience of sexual violence, unprotected sex, income, education, crime, traffic proximity, and vacant property. Cumulative experience of sexual violence was a categorical variable representing those unexposed to sexual violence (58%), those exposed as adults only (9%), and those both as adults and children (33%). Income was a binary variable representing those making above (33%) and below (77%) 200% of the US Federal Poverty Level.

Public records (crime, vacant properties and traffic proximity)

Crime data was collected from the City of Baltimore as in a CSV file.[58] This file included the Global Positioning System (GPS) latitude and longitude of each crime. These latitude and longitude data were added to the layer with the existing participant data.

Additionally, longitude and latitude of vacant properties in 2016 was downloaded from the City of Baltimore in a CSV file[59], geocoded, and added to the participant point pattern data. Data on traffic proximity were gathered from the Environmental Justice Screen and downloaded as polygon shape file at the statistical block group for Baltimore City (n=653) The traffic

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[56] Petros, Opacka-Juffry, and Huber, "Psychometric and neurobiological assessment of resilience in a non-clinical sample of adults."

[57] Gen Xiang Mao et al., "Effects of Short-Term Forest Bathing on Human Health in a Broad-Leaved Evergreen Forest in Zhejiang Province, China," *Biomedical and Environmental Sciences* 25, no. 3 (2012/06/01/ 2012), https://doi.org/https://doi.org/10.3967/0895-3988.2012.03.010, http://www.sciencedirect.com/science/article/pii/S0895398812600610.

[58] City of Baltimore, "BPD part 1 victim based crime data " (Baltimroe City, Maryland: City of Baltimore's open data catalog, 2018). https://data.baltimorecity.gov/Public-Safety/BPD-Part-1-Victim-Based-Crime-Data/wsfq-mvij/data.

[59] City of Baltimore, "Vacant buildings " in *City of Baltimore's open data catalog* (Baltimore City, Maryland, 2018). https://data.baltimorecity.gov/Housing-Development/Vacant-Buildings/qqcv-ihn5/data.

proximity and population data were added to the existing participant. The community statistical area (n=55) data was used for cluster analysis.[60]

Greenness

Remote sensing of chlorophyll (greenness) from satellites, a validated measure called normalized difference vegetation index (NDVI)[61], were additional quantitative data sources. Additionally, to contextualize the quantitative findings, data from multiple sources was used: 1) aerial and ground level images for specific areas of the city were analyzed in combination with 2) in depth qualitative interviews of purposively sampled key informants (KI) and "exposed" informants (EI), 3) field notes, and 4) historical records of Baltimore. "Exposed" informants (n=3) were primary study participants who reported sexual violence and lived in neighborhoods within community statistical areas from the highest quintile (NDVI scores between 0.15 to 0.21) and lowest quintile (NDVI scores between 0.043 to 0.078).

Data analysis

We analyzed data with univariate analysis by looking at the means, medians, standard deviations, skewness, kurtosis, histograms, frequencies, stem and leaf plot, and scatter plots. Due to a positive skew and curvilinear distribution of the ratio of cortisol to DHEA, a Gamma (Family) and logarithmic (log) transformation distribution in the model was used.[62] After initial exploratory analysis including bivariate associations and multivariate regression, a generalized linear model (GLM) of the association of greenness (NDVI) with physiological-resilience (ratio of cortisol to DHEA) was built. Qualitative findings resulted by exploring interviews with informants that began with initiation of a conversation through a grand tour question.

Results

[60] Baltimore Neighborhood Indicators Alliance, "Vital signs 2016," (2016). Retrieved from https://bniajfi.org.
[61] Rhew et al., "Validation of the Normalized Difference Vegetation Index as a Measure of Neighborhood Greenness."
[62] W. G. Manning and J. Mullahy, "Estimating log models: to transform or not to transform?," *J Health Econ* 20, no. 4 (Jul 2001), https://www.ncbi.nlm.nih.gov/pubmed/11469231.

Quantitative

Greenness (NDVI) ranged from 0.044 to 0.214 (mean=0.11, SD=0.039) at 100-meter buffers (about the size of a typical city block) around participant's homes (see Figure 1). The ESSENCE Research Team also analyzed salivary biomarkers: cortisol, ranging from 1.3795 to 312.843 nmol/L (mean=13.162, SD=36.36), and dehydroepiandrosterone (DHEA), ranging from 0.305 to 6.874 nmol/L (mean=2.446, SD=1.41). The ratio of the two biomarkers ranged from 1.9 to 190 (mean=11.87, SD=22.43, 95% CI [7.38, 16.37]).

The ratio of cortisol to DHEA was calculated using the two-day averages of each biomarker at waking. The biomarkers were averaged across the two days of cortisol (mean=0.48, [2.1,7.4]) and DHEA (mean=414.0, [366.1, 461.9]. The mean of cortisol (mean in ug/dl * 27.59=13.2nmol/l) and DHEA (mean in pg/ml *0.0028=1.2nmol/l) were transformed into nanomoles per liter (nmol/L) to facilitate comparisons with the literature[63] and for calculating their ratio. Then we divided cortisol by DHEA to create a value representing the ratio (M=11.9, SD=22.4) of the two values (Cortisol/DHEA)) and our defined measure of resilience. Post-hoc analysis included calculation of the rise in cortisol from waking (M=13.3, SD=36.4) and at thirty minutes (M=10.5, SD=5.1) and the difference in the two as a measure of the rise (M=2.45, SD=4.4).

The null model of the association between greenness and resilience (cortisol/DHEA) while positive was not significant (β=4.72, p=0.26). To account for spatially correlated data, for the rest of the analysis we used clustered robust standard errors, though the null model was still not statistically significant in its association of greenness with physiological-resilience (operationalized as the ratio of cortisol to DHEA (β=5.54, p=0.26).

Greenness was non-significant (β =7.5, SE=4.9, p=.124, 95% CI [-2, 17]) in the full adjusted model; however, when we clustered with community statistical areas (CSA) (n=55), we

[63] Petros, Opacka-Juffry, and Huber, "Psychometric and neurobiological assessment of resilience in a non-clinical sample of adults."

found one standard deviation (0.039) increase in greenness associated with a 34 % increase (β = 7.5, SE=3.39 p=.026, 95% CI [.89, 14.2]) in physiological-resilience (operationalized as the ratio of cortisol to DHEA) (see Table 2). In other words, increased greenness was associated with increased capability to respond to physiologically-anticipated waking stress adjusting for the community and societal level factors. The final variance inflation factor to test for collinearity was acceptable (VIF=2.11).[64]

The significant negative associations of greenness at 100-meters with population adjusted crime (β=-0.246, p<.01) was also found with population adjusted traffic proximity (β=-0.011, p<.01) and vacant properties adjusted for population (β=-0.19, p<.01). In other words, the more greenness there was, the less crime, less traffic, and fewer vacant properties there was. Age had a small but significant negative association with greenness (β=-0.001, p<.05), suggesting in our sample that the higher in age someone is, the less greenness on their block.

Seventy-eight percent (n=32) of the women in the quantitative analysis who reported sexual violence sexual (n=41) also reported sexual violence as children. Neighborhoods where participants live have rates of crime 4-12 times higher than the national average.[65] In terms of community level or built environment, traffic proximity was in the 70-90th percentile of the nation, and vacant property rates 2-3 times higher than the Baltimore city average. Even with all of these stressors, the physiology of this vulnerable group still strives to maintain resilience, anticipating stress, and responding in a resilient manner.

We found significant (p<.05) economic differences between those who reported sexual violence (88%) and those who did not (68%), and for individual income less than $30,000 (200% of the Federal Poverty Level). Furthermore there were significant differences in the

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[64] D. A.; Kuh E.; Welsch Belsley, R. E.;, *Regression diagnostics: Identifying influential data and sources of collinearity*, vol. 4, Wiley Series in Probability and Mathematical Statistics, (New York: John Wiley & Sons, 1980). https://onlinelibrary.wiley.com/doi/abs/10.1002/jae.3950040108.

[65] FBI, *2016 Crime in the United States*, Federal Bureau of Investigation (2017), https://ucr.fbi.gov/crime-in-the-u.s/2016/crime-in-the-u.s.-2016/tables/table-1/table-1.xls.

number of unprotected sex partners for those reporting sexual violence (mean=3.9, 95% CI [2.31, 5.63]) and those who did not (mean=2.45, 95% CI [2.1, 2.8]). When looking at unprotected sex partners, those living below 200% of the federal poverty level were more likely to report sexual violence (mean=4.1, 95% CI [2.28, 6.1]) and had 1.7 more partners (p=.068) than those who did not (mean=2.46, 95% CI [2, 2.9]). While this does not show causality, it does speak to the potential of income as a factor in negotiating sex and safe sex practices.

Post-hoc analysis comparing women exposed (n=41) and unexposed (n=58) to sexual violence revealed non-significant differences in cortisol (difference=1.18, p=0.87), DHEA (difference=0.4897, p=0.49), and the ratio of cortisol to DHEA (difference=-0.28, p=0.9). Experience of sexual violence exposure as a child and adult to sexual violence as a categorical variable (unexposed, exposed as adult, exposed as adult and child) in bivariate analysis of cortisol, DHEA, and the ratio of cortisol were all non-significant. We did see trends in the comparison of these categorical groups in linear predictions clustered at the community statistical area. There were non-significant differences in greenness (difference=0.01, p=0.2) between women exposed and unexposed to sexual violence.

The non-significant but positive association between the greenness of where people lived with cortisol (β = 9.3, p=.097), DHEA (β = .71, p<.61) and the ratio of cortisol to DHEA (β = 4.7, p<.33) were in the direction expected. This sample of women was highly stressed related to their low income, lack of employment, living in neighborhoods characterized by crime and vacant houses, and relationship characteristics putting them a risk for HIV whether or not they had also experienced sexual abuse. As a group they had average waking cortisol (mean=13.2, SD=36.4) higher than at 30 minutes (mean=10.5, SD=5.1) similar to other stressed groups.[66] Slightly higher levels of cortisol and significantly higher DHEA levels in this study

[66] Ricardo J. Pinto et al., "Cortisol awakening response among women exposed to intimate partner violence," *Psychoneuroendocrinology* 74 (2016/12/01/ 2016), https://doi.org/https://doi.org/10.1016/j.psyneuen.2016.08.024, http://www.sciencedirect.com/science/article/pii/S0306453016306096.

(cortisol=13.6nmol/L, [5.8, 20.5], DHEA=1.15 (95%CI [1.03, 1.29) compared to those in Prall and Muehlenbein (cortisol=12nmol/L SD=4.94, DHEA=0.35, SD=0.25)[67], as well as being similar to teachers in a long term stress experience[68] suggests anticipation of stress and compensatory action . We found a non-significant association of greenness with log transformed cortisol (β =9.3, p=.097), DHEA (β =.71, p=.61) and the ratio of cortisol to DHEA (β = 4.7, SE=4.1 p=.255, 95% CI [-3.4, 12.8]). What is not captured in these findings is the quality of the green spaces, how well they are maintained, and how accessible they are to vulnerable populations.

Qualitative data

Key informants included young (n=4) and middle-aged adults (n=3). Key informants were not asked about sexual violence, and none disclosed any experience of sexual violence. However, in the USA over thirty percent of women report physical violence by an intimate partner, including sexual violence[69], with African American women being at disproportionately higher risk, so there is the potential that at least two of the Key Informants experienced violence from a partner. The themes about barriers to access to green spaces came directly from participant quotes, including Boarded Houses, High Speed, A lot of Crime, It's beautiful…it's green, It has a calm to It, Maintained, Community Builders, and You do know when people don't care about you. Potential benefits of green spaces from passive engagement are in competition with active engagement of potential and experienced threats including sexual violence and a high prevalence of vacant property, traffic, and crime. Vacant property attracts "rats and trash" and serves as a constant reminder of neighbors who have lost their homes. When maintained

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[67] Sean P. Prall and Michael P. Muehlenbein, "Dehydroepiandrosterone and multiple measures of functional immunity in young adults," *American Journal of Human Biology* 27, no. 6 (2015), https://doi.org/10.1002/ajhb.22724, https://onlinelibrary.wiley.com/doi/abs/10.1002/ajhb.22724.

[68] Shuhei Izawa et al., "Effects of prolonged stress on salivary cortisol and dehydroepiandrosterone: A study of a two-week teaching practice," *Psychoneuroendocrinology* 37, no. 6 (2012/06/01/ 2012), https://doi.org/https://doi.org/10.1016/j.psyneuen.2011.10.001, http://www.sciencedirect.com/science/article/pii/S0306453011002897.

[69] Smith, *The National Intimate Partner and Sexual Violence Survey (NISVS): 2010-2012 State Report*.

by the city or the community, green spaces were described as “community builders” and spaces that have “a calm to it,” similar to findings in literature.[70] NDVI scores among qualitative participants ranged from 0.041 to 0.217. Where some might have a garden or park on their block, others have to walk “A mile” through neighborhoods with “High Speed” (β =-0.011, p<.01), “A lot of Crime” (β =-0.246, p<.01), and “Boarded house” (β =-0.19, p<.01). These barriers to green spaces determine how much individuals are able to enjoy the potential benefits.

Discussion

This study analyzed the complex interactions of total greenness (NDVI), stress (cortisol awakening response) and physiological resilience within contextual factors of the social and built environment (experience of trauma) of the neighborhoods and lives of African American women living in urban Baltimore, Maryland. Women’s exposure to crime was inversely related to green space, supporting findings elsewhere.[71] We also examined the association between greenness and traffic, finding women living in spaces with more greenness were also less exposed to traffic. As far as we know, there has been no direct analysis describing the negative relationship we found between greenness and traffic density or vacant properties.

Our findings suggest the importance of nurturing existing green spaces, especially in neighborhoods living with systematic institutional oppression, segregation, and disinvestment, resulting in communities who struggle to leverage influence over their environment.[72] Creation of green space by community members out of vacant lots creates space for people to come

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[70] William C. Sullivan, Frances E. Kuo, and Stephen F. Depooter, "The Fruit of Urban Nature:Vital Neighborhood Spaces," *Environment and Behavior* 36, no. 5 (2004), https://doi.org/10.1177/0193841x04264945, https://journals.sagepub.com/doi/abs/10.1177/0193841X04264945.

[71] Garvin, Cannuscio, and Branas, "Greening vacant lots to reduce violent crime: a randomised controlled trial."

[72] Jules Pretty and Hugh Ward, "Social Capital and the Environment," *World Development* 29, no. 2 (2001/02/01/ 2001), https://doi.org/https://doi.org/10.1016/S0305-750X(00)00098-X, http://www.sciencedirect.com/science/article/pii/S0305750X0000098X.

together and build community. The negative correlation in this study between greenness and crime (β =-0.246, p<.01) supports the hypothesis that greener communities are safer .[73]

More broadly, we found inequity in environments, including levels of greenness, traffic proximity, vacant property, crime, violence, income and education, similar to what has been described in the literature.[74] These inequities may be the result of neglect[75], historical power imbalance[76] and the ability of communities to leverage influence over their environment.[77] All of these threats exist where people live and cue individuals into a built and social environment that causes stress. Green spaces may offer the opportunity for passive engagement of non-threatening stimuli, facilitating decreased mental fatigue.[78,79]

There were non-significant differences in greenness (difference=0.01, p=0.2) between women exposed and unexposed to sexual violence. While this finding has not explicitly described in the literature, greenness has been negatively associated with income[80] and positively associated with residential segregation.[81]

Increased greenness was associated with increased capability to respond to physiologically-anticipated waking stress adjusting for the community and societal level factors.

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[73] Frances E. Kuo and William C. Sullivan, "Aggression and Violence in the Inner City:Effects of Environment via Mental Fatigue," *Environment and Behavior* 33, no. 4 (2001), https://doi.org/10.1177/00139160121973124, https://journals.sagepub.com/doi/abs/10.1177/00139160121973124.

[74] Bogar and Beyer, "Green Space, Violence, and Crime: A Systematic Review."

[75] Garrett Power, "Apartheid Baltimore Style: the Residential Segregation Ordinances of 1910-1913," *Maryland Law Review* 42, no. 2 (1983), https://digitalcommons.law.umaryland.edu/mlr/vol42/iss2/4.

[76] M. B. Gomez, *Race, class, power, and organizing in east Baltimore: Rebuilding abandoned communities in America* (Lanham, MD: Lexington Books, 2012).

[77] Pretty and Ward, "Social Capital and the Environment."

[78] Marc G. Berman, John Jonides, and Stephen Kaplan, "The Cognitive Benefits of Interacting With Nature," *Psychological Science* 19, no. 12 (2008/12/01 2008), https://doi.org/10.1111/j.1467-9280.2008.02225.x, https://doi.org/10.1111/j.1467-9280.2008.02225.x.

[79] Ming Kuo, "How might contact with nature promote human health? Promising mechanisms and a possible central pathway," Mini Review, *Frontiers in Psychology* 6, no. 1093 (2015-August-25 2015), https://doi.org/10.3389/fpsyg.2015.01093, https://www.frontiersin.org/article/10.3389/fpsyg.2015.01093.

[80] Wahida Kihal-Talantikite et al., "Green space, social inequalities and neonatal mortality in France," *BMC Pregnancy and Childbirth* 13, no. 1 (2013/10/20 2013), https://doi.org/10.1186/1471-2393-13-191, https://doi.org/10.1186/1471-2393-13-191.

[81] Jesdale, Morello-Frosch, and Cushing, "The Racial/Ethnic Distribution of Heat Risk 2013;Related Land Cover in Relation to Residential Segregation."

To our knowledge, the measurement of cortisol and DHEA at waking has only been studied twice before.[82,83]

Age had a small but significant negative association with greenness (β=-0.001, p<.05), suggesting in our sample that the higher in age someone is, the less greenness on their block. To our knowledge there is has been no study exploring the relationship between age and greenness.

We did see trends in the comparison of these categorical groups in linear predictions clustered at the community statistical area. We hypothesize that the non-significance stems from our inability to account for the frequency and ages of the experience of sexual violence for which participants were exposed to over their lifetime.[84] There were non-significant differences in greenness (difference=0.01, p=0.2) between women exposed and unexposed to sexual violence. While this finding has not explicitly described in the literature, greenness has been negatively associated with income[85] and positively associated with residential segregation.[86]

Limitations and Strengths

The non-probabilistic sample for the quantitative salivary and survey are not generalizable and the nature of the sampling introduces selection bias since all of the sample are more likely to have experienced sexual abuse and other traumatic events compared to women living in other communities. As described above, the collection of waking saliva should be compared with caution to other studies using saliva as a biological measure. The data were

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[82] Prall and Muehlenbein, "Dehydroepiandrosterone and multiple measures of functional immunity in young adults."
[83] Izawa et al., "Effects of prolonged stress on salivary cortisol and dehydroepiandrosterone: A study of a two-week teaching practice."
[84] J. M. Sundermann, A. T. Chu, and A. P. DePrince, "Cumulative violence exposure, emotional nonacceptance, and mental health symptoms in a community sample of women," *J Trauma Dissociation* 14, no. 1 (2013), https://doi.org/10.1080/15299732.2012.710186, https://www.ncbi.nlm.nih.gov/pubmed/23282048.
[85] Kihal-Talantikite et al., "Green space, social inequalities and neonatal mortality in France."
[86] Jesdale, Morello-Frosch, and Cushing, "The Racial/Ethnic Distribution of Heat Risk 2013;Related Land Cover in Relation to Residential Segregation."

from a cross sectional study and causal inference cannot be determined. In spite of the limitations, to our knowledge this study is the first to examine at the association of greenness using remote sensing with physiological-resilience operationalized as the ratio of cortisol to DHEA among African American women at high risk of HIV.

Implications for Sustainable Development

The findings of this study provide foundational data for the development of targeted health interventions to mitigate climate change by increasing the modifiable factor of community greenness. These findings provide development policy makers, health professionals, and health systems a clear understanding of greenness as an instrument for the promotion of health of communities. Development efforts would be benefit from increased funding for the creation as well as protection of parks and forests as part of supporting health. This study expands knowledge on the factors contributing to morbidity and mortality from violence among those most vulnerable to environmental injustices.

The finding that one standard deviation (0.039) of greenness above the mean (0.11) was associated with increased physiological-resilience (operationalized as the ratio of cortisol to DHEA) among vulnerable groups living with inequitable social and built environmental stresses supports ongoing initiatives to increase the amount of green spaces in urban areas. Differences in greenness is something we can actually measure and compare.

The potential co-benefits of increased greenness in urban environments through decreased ground surface temperature[87], aggression[88], crime[89], depression[90], and the

[87] Marco Napoli et al., "Modeling Tree Shade Effect on Urban Ground Surface Temperature," *Journal of Environmental Quality* 45, no. 1 (2016), https://doi.org/10.2134/jeq2015.02.0097, http://dx.doi.org/10.2134/jeq2015.02.0097.
[88] Younan et al., "Long-Term Ambient Temperature and Externalizing Behaviors in Adolescents."
[89] Garvin, Cannuscio, and Branas, "Greening vacant lots to reduce violent crime: a randomised controlled trial."
[90] Eugenia C. South et al., "Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults: A Cluster Randomized TrialEffect of Greening Vacant Land on Mental Health Among Urban ResidentsEffect of Greening Vacant Land on Mental Health Among Urban Residents," *JAMA Network*

promotion of resilient physiology[91] are life- and cost-saving. Mitigation of the causes of abnormally warm temperatures (plant CO2 sequestration)[92] and adaptation of urban environments to lessen the heat island effect (i.e., shade and tree transpiration)[93] are central to building the resilience potential of individuals and communities to the increasing impacts of climate change.[94]

Conclusions

Since the dawn of the agricultural revolution, humans have been conducting a planetary experiment in the transformation of forests into fields, which increased exponentially with the dawn of the industrial revolution. The most vulnerable species, including the most vulnerable humans are already feeling the stress of global urbanization and deforestation. The health of all species, including humans and our civilizations are dependent on the resilience of the planet. Now is the time to participate in a global transformation with trees. In order to achieve the SGD (13) on climate change, the development community must consider the mechanisms that are impeding successful action and increasing negative impacts. Therefore, efforts to prepare for and respond to the effects of climate change must take into account the unique challenges of vulnerable populations. Women are not only recipients of aid but necessary allies in creating solutions that will directly impact them and their communities. Because women intersect with many SDGs, it is integral to their success that actions are identified that will increase resilience and overall gender equality for women.

Open 1, no. 3 (2018), https://doi.org/10.1001/jamanetworkopen.2018.0298, https://doi.org/10.1001/jamanetworkopen.2018.0298.

[91] Egorov et al., "Vegetated land cover near residence is associated with reduced allostatic load and improved biomarkers of neuroendocrine, metabolic and immune functions."

[92] Council, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration*.

[93] Livesley, McPherson, and Calfapietra, "The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale."

[94] National Center for Environmental Health, *Building resilience against climate effects* Climate and Health (Centers for Disease Control, 2015).

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Figure 1

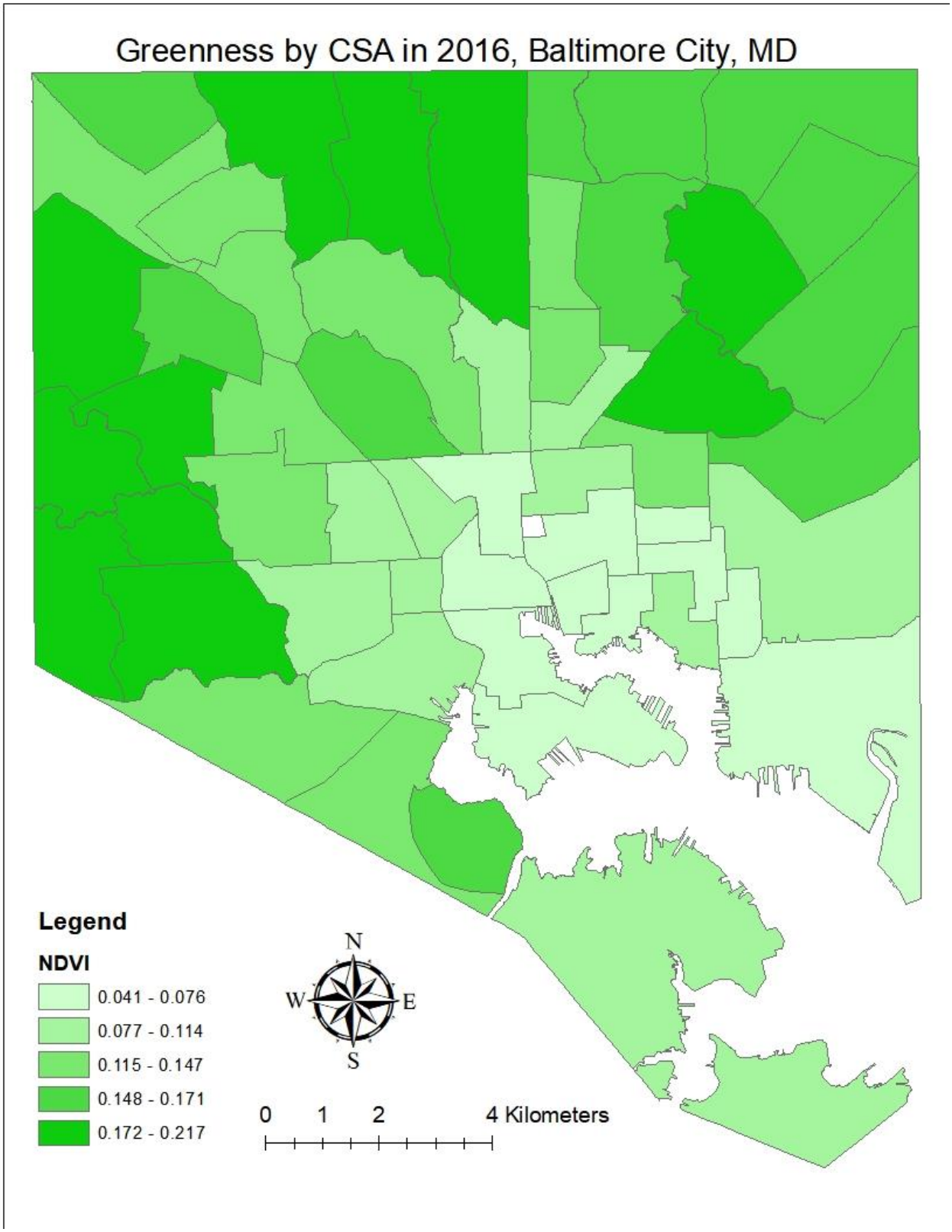
Greenness by CSA in 2016, Baltimore City, MD
Legend
NDVI
0.041 - 0.076
0.077 - 0.114
0.115 - 0.147
0.148 - 0.171
0.172 - 0.217
N
W
E
S
0 1 2 4 Kilometers

Table 1
Demographic data

(*=p<.05)	**Exposed (n=41) Mean [95%CI]**	**Unexposed (n=57) Mean [95%CI]**	**Total Sample (n=98) Mean [95%CI]**
Cortisol nmol/L	12.47 [3.03, 21.92]	13.66 [2.88, 24.44]	13.16 [5.8, 20.45]
DHEA nmol/L	1.10 [.89, 1.33]	1.19 [1.02-1.36]	1.5 [1.03, 1.29]
Cortisol/DHEA	12.2 [6.2, 18.2]	11.6 [6.2, 18.2]	11.9 [7.3, 16.4]
Greenness	.109 [.097, .120]	.118 [.108, .129]	.114 [.107, .123]
Age*	29.9 [27.7, 32.1]	24.4 [22.9, 25.8]	26.67 [25.34, 28.01]
Childhood Sex Abuse	n=32 (78%)	n=0	n=32 (32%)
Unprotected Sex part*	3.9 [2.31, 5.63]	2.45 [2.1, 2.8]	3.09 [2.37, 3.18]
Stress (n=84) *	0.35 [.049, .66]	-0.033 [-0.62, -0.034]	-.051 [-2.04, 1.86]
Education: High School or Less	n=30 (73%)	N=37 (65%)	n=67 (68%)
Income <$29,999*	n=36 (88%)	n=39 (68%)	n=75 (77%)
Traffic proximity by block group population	1.08 [.709, 1.46]	1.13 [.85, 1.42]	1.11 [.89, 1.33]
Crime by block group population	.0233 (.018, .028)	.0197 [.0149, .0244]	.0211 [.0177, .0246]
Vacant property by block group population	.015 [.0081, .0224]	.0109 [.0048, .0168]	.0127 [.0081, .0173]

Table 2
Full Model

Physiological-Resilience		Unadjusted		Model 9	
		Coef	pvalue	Coef	pvalue
Greenness		4.72	0.26	7.55	0.03*
Sexual Violence	Adult	-0.11	0.88	-0.27	0.27
	Adult & Child	0.09	0.83	0.38	0.29
Unprotected sex		0.02	0.69	0.04	0.08
Perceived Stress		-0.06	0.69	-0.12	0.42
Income		-0.30	0.49	-0.09	0.67
Education		-0.44	0.24	-0.56	0.02*
Crime		-0.24	0.98	6.11	0.43
Vacant property		-0.21	0.98	4.55	0.16
Traffic		0.00	0.99	0.03	0.79