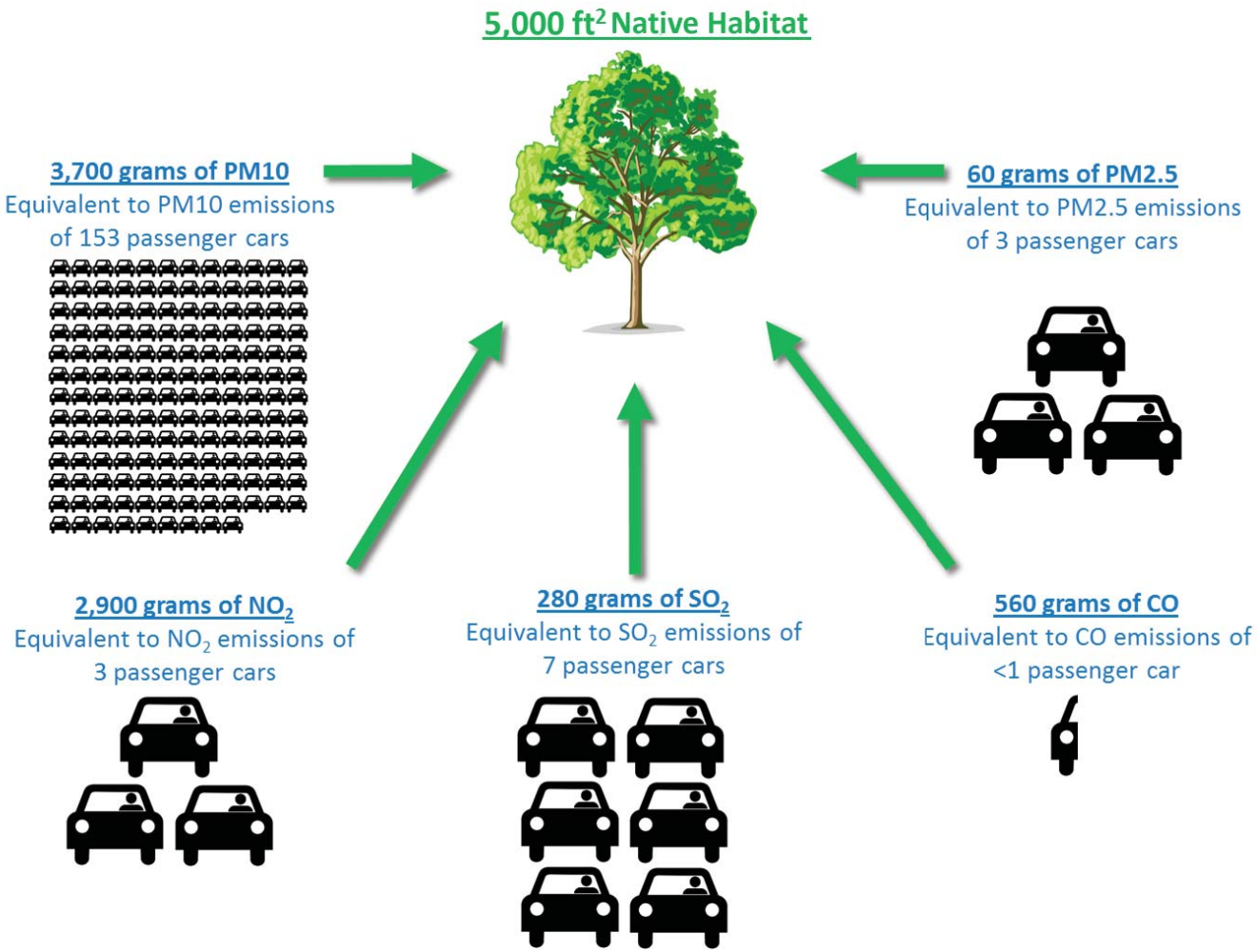
Air Quality & Public Health Benefits of Native Habitat In Urban Areas

Prepared by Tim Kidman and Jordan Chamberlain, WSP

July 2016



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Introduction

'Green Solution' Projects (GSP) that capture, clean and re-use storm water through the combined use of restored native habitat and engineered systems provide significant greenhouse gas (GHG) reduction and public health improvement benefits. Candidate GSP parcels evaluated by WSP in the Upper Los Angeles River Watershed can together create 19,000-30,000 acre feet of new water supply annually and prevent 304,000 – 595,000 metric tons of carbon dioxide-equivalent (mtCO2e) from being emitted into the atmosphere over a 20 year period – equivalent to 1.5 billion vehicle miles. In addition to these water supply and greenhouse gas (GHG) reduction benefits, GSP parcels also have the potential to create a number of other positive environmental and human health impacts. These include improved air quality, reduced incidence of respiratory ailments and obesity, improved academic performance and mental health, and decreased crime rates.

Studies suggest that the benefits from the addition of green space to air quality and human health are strongly correlated with the density of a city. Los Angeles, which is one of the densest cities in America[1], therefore stands to benefit considerably from GSP parcels that use natural habitat and trees as key storm water capture and design elements. The ability for vegetation to reduce pollutants in the environment is of particular importance in the Los Angeles area, where disadvantaged communities routinely experience substandard air quality.

Candidate GSP parcels in the Upper Los Angeles River Watershed can reduce emissions of ozone , particulate matter, nitrogen dioxide, sulfur dioxide, and carbon monoxide. Reduction of particulate matter and other pollutants associated with asthma through the addition of native habitat has repeatedly been associated with lower levels of asthma, and there is strong evidence that native habitats in urban environments has positive respiratory health benefits. A number of studies have also found that access to urban green space can reduce the incidence of childhood obesity. Further, living or attending school in proximity to parks in urban areas improves mental health and academic performance.

Native habitat is long-lived, self-perpetuating, adapted to Southern California's hot climate, and has wide, evergreen leaf canopies and deep root systems that maximize carbon uptake while providing natural cleaning of runoff. By planting what will become a sustainable ecosystem with a range of tall, mature trees and robust, tree-sized shrubs and other key plants, well-designed GSP parcels can improve human health and academic performance while providing environmental benefits including habitat restoration, GHG mitigation, storm water and dry weather runoff management, and groundwater recharge.

Environmental Benefits

Air Quality

Trees, tree-sized shrubs and other plants clean the air we breathe by absorbing air pollutants including those produced by vehicles and electricity generating units. The pollutants are absorbed through pores on the surface of leaves, called stomata, as a part of the tree's and plants' respiration process, removing airborne pollutants such as ozone (O_3), particulate matter of less than 10 millionths of a meter (PM10), particulate matter of less than 2.5 millionths of a meter (PM2.5), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO), as shown in Figure 1[2]. According to the United States Forest Service, a single large tree can remove 2.8 lb. of ozone, 2.4 lb. of PM 10 and 1.6 lb. of NO_2 every year[3].

1. Florida, R. America's Truly Densest Metros. City Lab. Oct 15, 2012. Online at: http://www.citylab.com/housing/2012/10/americas-truly-densest-metros/3450/

2. United States Department of Agriculture. Trees and the Clean Air Act: Strategic tree planting in Sacramento. Online at: http://www.fs.fed.us/psw/programs/uesd/uep/products/psw_cufr696_SacramentoAirQuality.pdf

3. McPherson EG, Simpson JR, Peper PJ, Xiao Q. Tree Guidelines for San Joaquin Valley Communities. Western Center for Urban Forest Research and Education, US Forest Service, Davis, CA. 1999. Online at:

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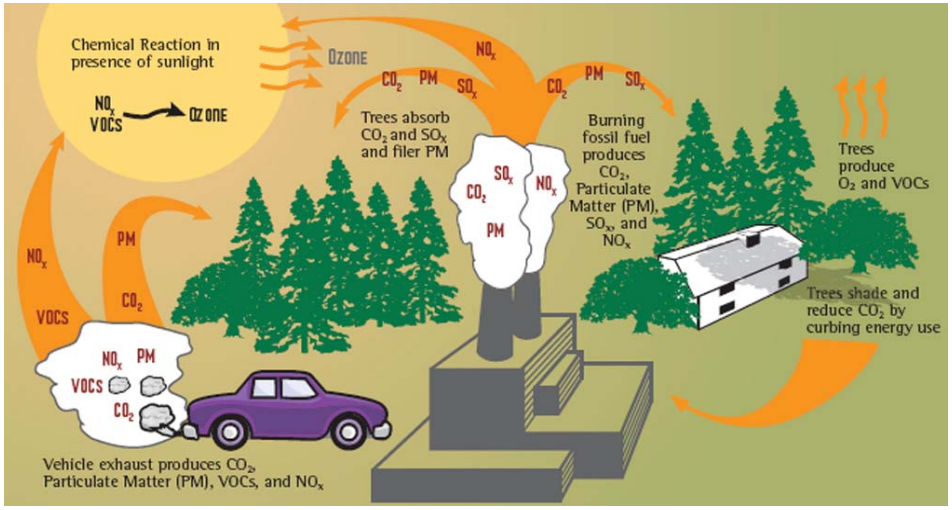

Figure 1. Diagram of air pollutants absorbed and sequestered by trees. Source: USDA

The ability for vegetation to clean these pollutants is of particular importance in the Los Angeles area where disadvantaged communities routinely experience substandard air quality, even as the air quality of the region overall continues to improve. While air quality in the Los Angeles region has improved since the 1970's, it still exceeded the national standard on 92 days in 2014 according to data from the South Coast Air Quality Management District (Figure 2)[4].

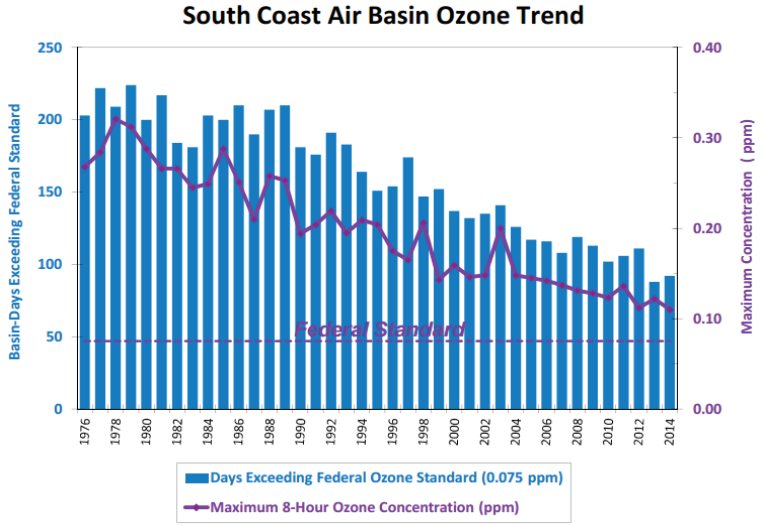

Figure 2. Trend of ozone levels in the Los Angeles Basin from 1976 to 2014. Source: SCAQMD[5]

The air quality benefits of trees and plants in urban areas are affected by many regional factors, including the pollution concentration, how long leaves are on the trees each year, and annual precipitation. A 2006 study which evaluated 55 cities across the United States found that Los Angeles had the highest pollution removal rate per unit of tree cover, and was almost four times higher than the city with the lowest pollution rate. The city's relatively high pollution concentrations, relatively long season for leaves on trees, and relatively low precipitation all play a role in its high pollution removal rate. Data for pollution removal rates in Los Angeles are

https://www.itreetools.org/streets/resources/Streets_CTG/CUFR_38_Inland_Valleys_CTG.pdf

4. South Coast Air Quality Management District (SCAQMD). Historic Ozone Air Quality Trends: Ozone, 1976 – 2014. Online at: http://www.aqmd.gov/home/library/air-quality-data-studies/historic-ozone-air-quality-trends

5. South Coast Air Quality Management District (SCAQMD). South Coast Air Basin Ozone Trend. Online at: http://www.aqmd.gov/docs/default-source/air-quality/o3fed8max76-13.pdf?sfvrsn=13

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provided in Table 1, indicating the effectiveness of trees in removing O_3, PM10, PM2.5, NO_2, SO_2, and CO. The study further estimated that the pollution removal benefit of trees to Los Angeles was over $23 million annually.[6]

Table 1. Annual pollutant removal rate for urban tree coverage in Los Angeles. Source: Nowak et al., 2006

Annual Pollutant Removal in Los Angeles (g/m2 tree coverage)							
	O_3	PM2.5	PM10	NO_2	SO_2	CO	Total
Range	1.0-7.1	na	3.1-12.6	2.1-7.4	0.4 – 1.2	na	7.7-29.2
Average	6.9	0.13	8.0	6.3	0.6	1.2	23.1

A 2013 study looking specifically at PM2.5 removal by trees in cities found that trees removed around 5 metric tons of PM2.5 annually, which reduced mortality by an average of one person each year. In New York, urban trees reduce mortality by 7.6 people each year.[7]

While several grams per meter may seem small, the cumulative impact of native habitat - which includes a rich complex of trees, tree-size shrubs and other plants - planted in GSP parcels can be significant. Each GSP parcel contains a series of habitat tiles, which are 5,000 square foot blocks of habitat containing native trees, shrubs, grasses, and perennials, that can be grouped together throughout a parcel to create restored habitat. The density of plants for native habitats evaluated and recommended for L.A. County ranged from as low as 157 plants per acre in riparian areas to 1,733 plants per acre in upland areas. In all densities and habitats, the canopy cover at maturity would equal or exceed the tile area, meaning 100% canopy cover or greater. Based on removal rates from Table 1 and vehicle emissions rate data for the SCAQMD air district, a 5,000 square foot habitat tile at maturity has the same pollution removal benefit as removing vehicles from the road (Figure 3)[8].

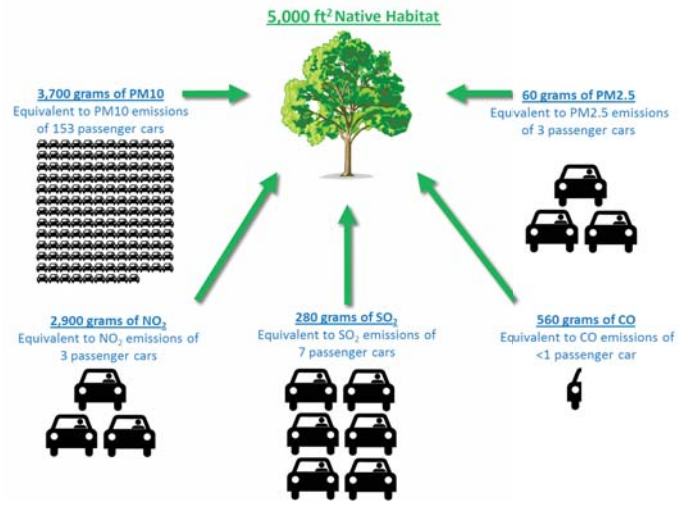

Figure 3. Pollutant removal of 5,000 ft2 of GSP habitat over the course of a year.

Several factors drive the ability of individual trees to absorb and mitigate air pollution. Tree species, leaf area, length of time the tree has leaves each year, and diameter all impact the pollution mitigation potential of a tree. A study conducted by the U.S. Forest Service that looked at pollution removal rates in Los Angeles' urban forest found that the diameter of a tree has a large effect on pollution removal, with wider trees removing more pollution. For example, tree with a diameter between 15 and 18 inches removes twice as much pollution as a tree with a diameter between 12 and 15 inches.[9] GSP parcels that include large trees, or plantings that will grow into large

6. Nowak, DJ, Crane, DE, Stevens, JC. Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening 4 (2006) 115 – 123. Online at: http://www.fs.fed.us/ne/newtown_square/publications/other_publishers/OCR/ne_2006_nowak001.pdf

7. Nowak, DJ, Hirabayashi, S, Bodine, A, Hoehn, R. Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. Environmental Pollution. Volume 178 (2013), pgs. 395 – 402. Online at: http://www.sciencedirect.com/science/article/pii/S0269749113001838

8. Values based on 2014 annual data for EMFAC2011 passenger vehicle. Source: California Air Resources Board. EMFAC 2014 Web Database. Online at: http://www.arb.ca.gov/emfac/2014/

9. Nowak DJ, Hoenn III RE, Crane DE, Weller L, Davila A. Assessing Urban Forest Effects and Values: Los Angeles' Urban Forests. United States Department of Agriculture (2010). Online at: http://

trees, and natural habitats which include a rich complex of trees, tree-sized shrubs with large, evergreen leaf canopies and other self-perpetuating plants, can contribute to reducing air pollution.

Public Health

Pollution reduction is not simply an abstract priority. Childhood asthma rates have increased by 50% in the U.S. in the last 30 years with poor urban communities being the hardest hit. Indeed, the California Communities Environmental Health Screening Tool, Version 2.0 (CalEnviroScreen 2.0) uses asthma-related emergency room visits as one metric in identifying disadvantaged communities (Figure 4).[10] Native vegetation, by reducing air pollution and encouraging children to play outdoors, has repeatedly been associated with lower levels of asthma, and there is strong evidence that urban vegetation has positive respiratory health benefits.[11,4] Researchers with the U.S. Department of Agriculture (USDA), for example, estimated that in Los Angeles from 2007 to 2008, 936 incidents of asthma exacerbation were avoided due to PM2.5 reduction from trees, and acute respiratory symptoms were reduced by 1,264 incidents.[12] Another study, from researches at Colombia University, found that rates of childhood asthma in New York fell by 25% for every extra 340 trees per square kilometer.[13] GSP parcels that include natural habitats, with their rich complex of trees, tree-sized shrubs and other plants can contribute to lowering asthma rates in disadvantaged communities even further.

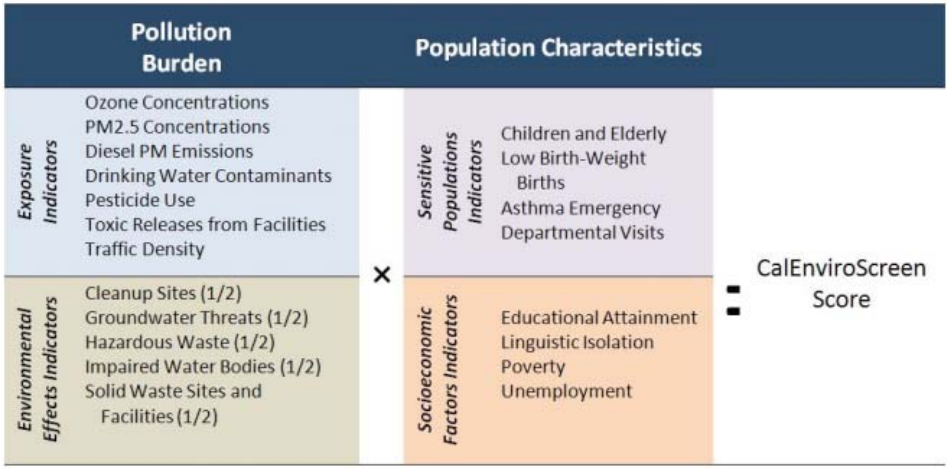

Figure 4. CalEnviroScreen 2.0 indicator and component scoring. Source: California Environmental Protection Agency

Childhood obesity rates have also been on the rise in the United States, doubling for young children and adolescents and tripling among 6 – 11 year olds over the course of three decades.[13] A number of studies have found that access to urban green space can reduce incidence of childhood obesity. A study in Indianapolis found that after two years of living near urban green space, children were significantly less likely to be obese.[14] One study in Europe found that the likelihood of being obese is about 40% lower when living near green space.[15] This relationship is believed to result from

www.nrs.fs.fed.us/pubs/rb/rb_nrs47.pdf

10. Office of Environmental Health Hazard Assessment. California Communities Environmental Health Screening Tool, Version 2.0 (CalEnviroScreen 2.0): Guidance and Screening Tool. 2014. Online at: http://oehha.ca.gov/media/CES20FinalReportUpdateOct2014.pdf

11. Lovasi, GS, JW Quinn,, KM Neckerman, MS Perzanowski, and A Rundle. "Children Living in Areas with More Street Trees Have Lower Prevalence of Asthma." Journal of Epidemiol Community Health 62 (2008): 647-49. Online at: http://www.ncbi.nlm.nih.gov/pubmed/18450765

12. Nowak DJ, Hirabayashi S, Bodine A, Hoehn R. Modeled PM2.5 removal by trees in ten U.S. Cities and associated health effects. Environmental pollution 178(2013) 395 – 402. Online at: http://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_nowak_002.pdf

13. Koplan, JP, KT Liverman, VI. Kraak (Eds.) Preventing childhood obesity: health in the balance. The National Academies Press, Washington DC. 2005. Online at: http://www.nap.edu/read/11015/chapter/1

14. Bell, JF, Wilson, JS, Liu, GC. "Neighborhood Greenness and 2-year Changes in Body Mass Index of Children and Youth." American Journal of Preventive Medicine 35.6 (2008): 547-53. Online at: http://www.ajpmonline.org/article/S0749-3797(08)00734-4/fulltext

15. Ellaway, Anne, Sally Macintyre, and Xavier Bonnefoy. "Graffiti, Greenery, and Obesity in Adults: Secondary Analysis of European Cross Sectional Survey." British Medical Journal 331 (2005): 611-12. Online at: http://www.bmj.com/content/331/7517/611

increased exercise and social interactions that green spaces often encourage.[16] Based on these findings, a GSP parcel that promotes exercise or sociocultural activities, could play a role in reducing obesity levels.

Mental Health and Academic Performance

In addition to the physical health benefits of green spaces and natural habitats, there is evidence that mental health and academic performance may be improved through exposure to the environments created by GSP parcels. A study that analyzed data for Los Angeles from 2004 – 2008 found that living within 1.6 kilometers of a park in an urban area improved mental health, with even greater benefits accruing to those participants living within 400 meters.[17] Another study found that people with depression had an improved mood after walking in nature for less than one hour. The study also found improved retention (i.e. memory) following the nature walk.[18]

A 2014 study in Massachusetts found that Math and English performance was positively correlated with the proximity of green space to a school. Evaluating 3rd graders, the study examined the relationship between green spaces adjacent to the school and academic performance, showing that having green space within 2,000 meters of a school significantly improved performance.[19] A more targeted study examined children with Attention-Deficit Disorder (ADD) or Attention-Deficit/Hyperactivity Disorder (ADHD). Comparing children who walked for 20 minutes in a park to those who walked 20 minutes in a city or neighborhood, researchers found improved concentration among those walking in the park environment. In fact, after a walk in nature, the children with ADD or ADHD exhibited concentration abilities similar to those of a child without either disorder. The effects were comparable to a standard dose of methylphenidate, the most common medication used to treat ADD and ADHD.[20] These results suggest that candidate GSP parcels at schools may be particularly beneficial to students.

Incidence of Crime

Although crime rates in Los Angeles have fallen in recent years, as of 2014, violent crime rates in Los Angeles were 37% above the U.S. average.[21] Increasing the amount of urban green space in a city has the potential to reduce these crime rates. Adding green space in a city has been linked to the reduction of a variety of crimes including violent crimes, property crimes, assault, robbery and burglary. However, dense vegetation that obstructs views may promote crime by providing hiding places for criminals and illegal goods. Additionally, perceptions of safety can increase or decrease with the addition of urban green space, based on the location and type of vegetation. High canopy trees that do not block views were correlated with increased perception of safety and reduction of crime.[22] GSP parcel habitat design carefully considers these issues to increase public health and safety while creating valuable habitat.

A study in 2001 looked at vegetation surrounding apartment buildings in cities and

16. Chee Keng Lee A, Jordan HC, Horsely J. Value of urban green spaces in promoting healthy living and wellbeing: prospects for planning. Risk Management and Health policy (2015) 8:131-137. Online at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4556255/

17 Sturm R, Cohen D. Proximity to Urban Parks and Mental Health. The journal of mental health policy and economics. 2014;17(1):19-24. Online at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4049158/

18. Berman MG, Kross, E, Krpan KM, Askren, MK, Burson, A, Deldin, PJ, Kaplan, S, Sherdell, L, Gotlib, IH, Jonides, J. Interacting with nature improves cognition and affect for individuals with depression. Journal of Affective Disorders , Volume 140 , Issue 3 , 300 – 305 (2012). Online at: http://www.jad-journal.com/article/S0165-0327(12)00200-5/abstract

19. Wu C-D, McNeely E, Cedeño-Laurent JG, Pan W-C, Adamkiewicz G, Dominici F, et al. (2014) Linking Student Performance in Massachusetts Elementary Schools with the "Greenness" of School Surroundings Using Remote Sensing. PLoS ONE 9(10): e108548. doi:10.1371/journal.pone.0108548

20. Taylor, AB, Kuo, FE. Children With Attention Deficits Concentrate Better After Walk in the Park. Journal of Attention Disorders. Vol 12 No 5: 402-409 (2009). Online at: http://jad.sagepub.com/content/12/5/402.abstract

21. City-Data. Crime rate in Los Angeles, California (CA). Online at: http://www.city-data.com/crime/crime-Los-Angeles-California.html

22. Kondo, MC, South, EC, Branas, CC. Nature-Based Strategies for Improving Urban Health and Safety. Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 92, No. 5 (2015). Online at: http://www.fs.fed.us/nrs/pubs/jrnl/2015/nrs_2015_kondo_003.pdf

found that increasing vegetation reduced occurrence of property crimes and violent crimes (Figure 5). Domestic aggression and violence decreased by as much as 25%, when trees and natural landscapes surrounded a residence.[23] A study looking at urban canopy coverage and crime rates in Baltimore, Maryland found that a 10% increase in canopy led to about a 12% decrease in crime rates. This study included both private and publicly owned trees, and the negative correlation was stronger by a magnitude of about 40% for publicly owned trees.[24] Based on these findings, GSP parcels that include urban trees and green space can contribute to lowering crime rates.

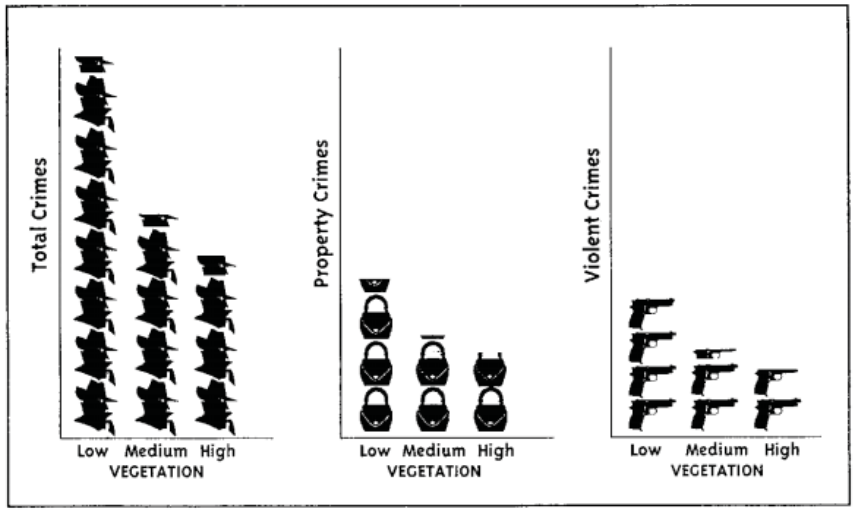

Figure 5. Mean Number of Crimes Reported Per Building for Apartment Buildings With Different Amounts of Vegetation (each icon represents one reported crime). Source: Kuo & Sullivan, 2001.

Conclusion

Quantitatively estimating the precise public health and pollution prevention benefit from native habitats created to capture, clean and re-use storm water at GSP parcels is difficult, but the qualitative benefits are clear. Urban greening and trees planted in urban areas reduce air pollution, improve respiratory health and lower obesity, improve academic performance and mental health, and can lower crime. Strategically deploying GSP parcels in disadvantaged communities such as those identified through CalEnviroScreen 2.0 will allow CCS to target these benefits toward the communities that are most affected by pollution and which will benefit the most.

23. Kuo, FE, Sullivan, WC. Environment and Crime in the Inner City: Does Vegetation Reduce Crime? Environment and Behavior. Vol 33 No 3 (2001): 343 - 367. Online at: http://www.outdoorfoundation.org/pdf/EnvironmentAndCrime.pdf

24. Troy, A., Morgan Grove, J., & O'Neil-Dunne, J.. The relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region. Landscape and Urban Planning, (2012) 106:3, 262–270. Online at: http://www.fs.fed.us/nrs/pubs/jrnl/2016/nrs_2016_troy_001.pdf?