San Antonio Climate Ready: A "Water Sponge/Carbon Sink" City

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Abstract: This white paper discusses the use of green spaces for soil water storage and carbon sequestration within San Antonio, Texas. When managed appropriately, these areas can be used as a mitigation strategy to assist the city in reaching its water and air quality goals by transforming into a "Water Sponge/Carbon Sink City". Additionally, this paper will discuss the economic benefits of utilizing Green Infrastructure (Nature-based)/Low Impact Development (GI/LID) to not only increase the soil water and carbon storage rates but also improve stormwater management in an economically feasible way.

Background

During the past 20 plus years, the city's planning documents have emphasized the goals for clean water, clean air, increased green spaces and parks while protecting floodplains and reducing flooding. The increased use of GI/LID was also an objective within the SA Tomorrow Comprehensive Plan and the 2019 Parks System Plan while the Climate Action and Adaptation Plan references the use of public green spaces to sequester carbon dioxide as a mitigation strategy.

The Greater Edwards Aquifer Alliance Task Force's Stormwater Management Recommendations include the recommendation to better protect and manage floodplains for improved water quality within our creeks and rivers while reducing flooding from peak flows.

The use of urban trees for improving water and air quality while reducing storm water runoff is well documented within the 2002 and 2009 Urban Ecosystem Analyses for San Antonio. These two (2) documents include the economic value for services provided by our urban tree canopy[1].

What is now emerging within the scientific community and a focus of this paper, is the incredible capacity within our soils to provide these same water and air quality improvement and storm water reduction services. Up till now, most of the research has focused on agriculture lands, but new research within urban areas is occurring. The results indicate that the same soil and vegetation practices that will improve stormwater management will also increase soil carbon sequestration and improve water quality. This effort can be increased exponentially through the use of GI/LID[2].

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[1] American Forest. "Urban Ecosystem Analysis of the San Antonio Region" sytemecology.com/4_Past_Projects/AF_SanAntonio.pdf and sierraclub.org/sites/www.sierraclub.org/files/sce/alamo-group/docs/UEA_San_Antonio-May_2009_small.pdf.

[2] Luedke, Heather. "Fact Sheet: Nature as Resilient Infrastructure – An Overview of Nature-Based Solutions." Edited by Anna McGinn, *EESI*, www.eesi.org/papers/view/fact-sheet-nature-as-resilient-infrastructure-an-overview-of-nature-based-solutions.

As discussed in the Environment and Energy Study Institute's fact sheet, retrofitting existing gray infrastructure with green infrastructure is often the better option as it can be higher-quality, lower-cost, more resilient and more beneficial to society than maintaining, repairing or replacing gray infrastructure[2]. And by doing so air pollution and peak flooding will be reduced, water quality will be improved, and a variety of co-benefits will be realized.

Current Knowledge

There is little local data available regarding the soil capacities for improving water quality, sequestering carbon dioxide, and reducing stormwater runoff. However, national, and even international data can be used to provide a basis for evaluating some of the ecosystems found within our urban areas.

Table 1: Capabilities of Ecosystems

Ecosystem	Stormwater Runoff Reductions	Sediment Removal Depending on size	Net Soil Carbon Sequestration (tons/acre)*
Turf Lawns with minimal inputs	10-57%	24-73%	0.7[3]
Prairie	37-98%	Up to 95%	1.2[4]
Forest/ Trees	65%	70-90%	0.6[5]
Active Riparian/ Floodplain Forest	9-100%	92-96% Mix vegetation with trees	3.8 [6]
LID Feature	First 1.5" of event	80%	0.87[7]
* = Sequestration rates are given for soil only. Total ecosystem rates would be greater when vegetation is included; the taller the vegetation, the more carbon sequestered for its growing period ie. Prairie more than turf, forest more than prairie.			

It is noteworthy that floodplains and their associated riparian areas have the greatest capacity for providing the most sought-after benefits and are therefore one of San Antonio's resources with a value beyond reclamation for development.

[3] Braun, Ross C. and Dale J. Bremer. 2019. Carbon Sequestration in Zoysiagrass turf under different irrigation and fertilization management regimes. Agrosystems, Geosciences & Environment. 2:180060.

[4] Dold, Christian, et. al. 2019. Carbon sequestration in a reconstructed prairie site in Central Iowa. USDA Agriculture Research Service. Publication #355674.

[5] Sejido, Roger and Brent Sohngen. 2012. Carbon Sequestration in Forests and Soils. Annu. Rev. Resour. Econ. 2012. 4:127–53. pg 135 in download.

[6] Claire M. Ruffing, Kathleen A. Dwire and Melinda D. Daniels. Carbon pools in stream-riparian corridors: legacy of disturbance along mountain streams of south-eastern Wyoming. Earth Surf. Process. Landforms 41, 208–223 (2016).

Economic Justification

Creating a water sponge/carbon sink city that utilizes GI/LID practices has been found to have major economic benefits in addition to environmental benefits. This was demonstrated through a case study of China's Sponge City Program. In 2010, 35 major Chinese cities utilized GI practices in order to increase air and water quality. After a 5-year study was completed, it was found that the GI practices had sequestered 18.7 million tons of carbon at a rate of 0.87 tons/acre/year[7].

Utilizing GI/LID features also produce additional economic and ecosystem benefits as it reduces the use of concrete in urban areas. The use of concrete for stormwater management is counterproductive as approximately one (1) ton of CO^2 is emitted per ton of cement manufactured and the use of gray infrastructure is a leading cause of increased water pollution in our creeks, rivers and lakes. Reducing the surface area of concrete in high density urban areas through GI/LID will not only reduce carbon emissions but will also reduce the urban heat island effect providing, additional environmental and economic benefits[8].

San Antonio's Potential

Currently, there are about 15,337 acres of parkland including the 77 miles of creekway trails within San Antonio and 170,000 acres of protected land within the Edwards Aquifer Protection Program. These properties could be managed to store more stormwater and carbon while improving water quality regionally and recharging the Edwards Aquifer more effectively. Other public green space areas within the city, municipal golf courses (1,180 acres), school campuses and cemeteries could also be managed to maximize carbon sequestration and reduce stormwater runoff.

By the use of modified soil and vegetation management practices on the approximate 186,517 acres of parklands, conservation easements and golf courses, it can be estimated, from soils only, an approximate:

1) **186,517 tons of carbon can be stored each year.**
2) **3,730,340,000 gallons (The Natural Resource Conservation service states that a 1% increase in soil organic matter will store an additional 20,000 gallons of stormwater per acre.)**

Benefits:
Reduce: Greenhouse gases, storm water runoff, irrigation use, summer temperatures, urban heat island, energy use, carbon emissions from concrete production and maintenance equipment.

Improve: water quality, human health, aesthetics, recreational opportunities, biodiversity and wildlife habitat.

7 Chen, W. Y. (2015, February 20). The role of urban green infrastructure in offsetting carbon emissions in 35 major Chinese cities: https://www.sciencedirect.com/science/article/pii/S0264275115000153.
8 https://en.wikipedia.org/wiki/Environmental_impact_of_concrete.

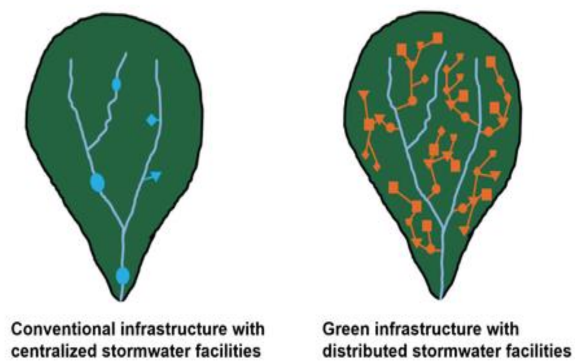
In San Antonio (16,517 acres), the removal of an approximate 330,340,000 gallons of storm water from a single event could also potentially reduce impact on our aging and inadequate drainage infrastructure.

While there are limitations and uncertainties related to saturation levels and land use changes[9] [10], it appears that we can count on these methods for some decades to come while other technologies are being developed and implemented. Additionally, the co-benefits will continue for the life of using the improved management practices.

Barriers

To transform San Antonio into a "Water Sponge/ Carbon Sink City", multiple barriers are faced that will require the attention and cooperation of city departments and external partners.

As maintenance practices are modified, there may also need to be an effort to work with public perception on aesthetics. A focus on public education will assist to create a foundation of understanding and awareness of the desired outcomes and the opportunities to obtain them. While modifying land and vegetation maintenance practices would seem easy to implement, this may prove more difficult and will require training of not only maintenance staff and their supervisors, but also maintenance contractors. Maintenance contracts, especially those for creeks and floodplains, will need to be modified to include appropriate practices needed to reach desired objectives.



Courtesy of A. Bhaskar C.E., Colorado State Univ.

Additionally, a review of needed policies and possible code changes for new development and flood control (and other public works) projects will be required. An overall priority by the city to include as much GI as possible, dispersed throughout the city's watersheds, will create the basic infrastructure that new private development can easily connect to. This will go a long way toward establishing a successful model. Finally, the development of policies, programs and incentives between the city and its external partners will assist to institutionalize and sustain changes.

[9] Canadell, Josep & Pataki, Diane & Gifford, Roger & Houghton, Richard & Luo, Yiqi & Raupach, Michael & Smith, Pete & Steffen, Will. (2007). Saturation of the Terrestrial Carbon Sink. 10.1007/978-3-540-32730-1_6.
[10] Levin, Kelly. "How Effective Is Land at Removing Carbon Pollution? The IPCC Weighs In." *World Resources Institute*, 27 Jan. 2020, www.wri.org/blog/2019/08/how-effective-land-removing-carbon-pollution-ipcc-weighs.

Conclusion

San Antonio is in position to take advantage of a major opportunity to mitigate some of its carbon emissions and stormwater runoff by protecting and increasing its green spaces while improving the management of its soils. Strategies would include the use of restoration practices while incorporating GI/LID strategies when possible. These strategies will also provide many co-benefits such as reducing the urban heat island effect, summer temperatures, energy use[11], and carbon emissions from concrete production[12] while improving water quality, water conservation, human health [13], biodiversity and wildlife habitat. Achieving these goals will necessitate the collaboration and cooperation of multiple external groups including the following local agencies; San Antonio River Authority, the Edwards Aquifer Authority, San Antonio Water System, City Public Service and the Alamo Council of Governments; Federal entities such as the military bases (Joint Base San Antonio), Department of Transportation and the Natural Resource Conservation Service; and local businesses and educational and non-profit organizations.

Fortunately, with a national preference for the use of GI for managing storm water runoff, funding sources are now currently available to assist the city to implement needed programs. Through these programs, San Antonio's abundant greenspaces can be restored, and additional greenspaces can be secured to create a living green infrastructure that will yield the desired environmental and economic benefits to transform this city into a nationally recognized "Water Sponge/ Carbon Sink City"[14]. Floodplains and their associated riparian areas have the greatest capacity for providing the most sought-after benefits and are therefore one of San Antonio's resources with a value far beyond reclamation for development.

For San Antonio to meet its water and air quality and stormwater management goals, mitigation strategies will be required. Utilizing a combination of public and private greenspaces to create a "Water Sponge/ Carbon Sink City" can provide a robust mitigation plan while creating multiple co-benefits. This strategy to maximize carbon sequestration and stormwater storage within city green spaces will require changes in policies, practices and development codes. It will also require developing new and effective incentives and public educational programs that focus on the importance of green spaces and their function.

[11] Boice, Daniel & Garza, Michelle & Holmes, Susan. (2018). The Urban Heat Island of San Antonio, Texas, from 1991 to 2010. Journal of Geography, Environment and Earth Science International. 17. 1-13. 10.9734/JGEESI/2018/43367.

[12] PDF. (2008, June). "Concrete CO2 Fact Sheet" June 2008. NRMCA: National Ready Mixed Concrete Association.

[13] Why You Should Consider Green Stormwater Infrastructure for Your Community. (2019, July 19). Retrieved from https://www.epa.gov/G3/why-you-should-consider-green-stormwater-infrastructure-your-community.

[14] The Nature Fix by Florence Williams, published by WW Norton & Company, NY. 2017.