What Types of Urban Greenspace Are Better for Carbon Dioxide Sequestration?[1]

Mark Hostetler and Francisco Escobedo[2]

Introduction

Figure 1. A representative school site that is dominated by turfgrass in Miami-Dade.
Francisco Escobedo, UF/IFAS

Meeting Florida House Bill 697 requirements to reduce Florida's carbon emissions will require a judicious look at how human-dominated landscapes are performing. It has been suggested that conserved urban greenspace could be used for carbon credit. But are all types of open spaces equal in terms of their ability to sequester carbon? Intuitively, this is not the case because we know that different types of vegetation (e.g., hammock vs. turf) and how they are managed will sequester different quantities of CO_2. Using representative 400 m^2 plot measurements (Zhao et al. 2010) and modeling of tree carbon sequestration (Escobedo et al., 2009) and estimates of lawn sequestration from various land use types in Florida, including their maintenance emissions, we calculated the source/sink potential of a 4-hectare (9.88 acres) site. Only above-ground vegetation values were calculated; soils and below-ground organic matter were not included in the calculations.

The take home message is that highly maintained lawns and trees sequester much less CO_2 than more natural areas with little maintenance (Table 1). With more lawn cover than tree canopy cover, the balance can actually shift to emitting CO_2 (e.g., older residential areas in Miami-Dade).

Of note is that we did not calculate the impact of built surfaces, just vegetative. The calculations were simplified as we did not add the carbon cost of making and maintaining the power equipment or the carbon cost of growing and transporting sod. In particular, we did not calculate the emission of nitrous oxide (N_2O) from fertilization applications. Urban turfgrass typically emits N_2O after fertilization and/or irrigation. N_2O has a much worse global warming potential (GWP) as its heat-absorbing potential is approximately *300 times* more than CO_2. With these unmeasured factors, city parks with high maintenance regimes may have much larger impacts than reported here. Thus, urban open space that has a large amount of mowed, irrigated, fertilized lawns and pruned shrubs and trees can be a source of CO_2 rather than a sink. These CO_2 emissions are not trivial; for example, a 4-hectare greenspace in Miami-Dade with 85% of the land covered in lawn would emit over 11 tons of CO_2 per year (Table 1).

Further, because below-ground soil carbon sequestration was not calculated, full carbon credit could not be assessed and these above-ground numbers reported should be regarded as a first look at the potential carbon value of urban greenspace. At this stage, natural greenspaces in and around urban areas, with little to no maintenance, seem to be the best option for CO_2 sequestration. Natural urban greenspaces also have other benefits, such as biodiversity conservation, reduced stormwater runoff, and reduced fertilizer applications. Overall, the conservation of urban open space could play a role in reducing Florida's carbon footprint, but highly maintained urban greenspace could be regarded as a source of greenhouse gases. In relation to HB 697, these results indicate that if municipalities and developers are to use green spaces as CO_2 sinks, they will have to justify the creation of such high-maintenance parks and may have to mitigate their effects.

Additional Resources

For additional information on conservation subdivisions, urban forestry, and conserving urban biodiversity, a variety of online guides, books and other publications exist.

Books and Scientific Publications

Jo, H. and G. E. McPherson. 1995. "Carbon storage and flux in urban residential greenspace." *Journal of Environmental Management* 45: 109–133.

Nowak, D. J. and D. E. Crane. 2002. "Carbon storage and sequestration by urban trees in the USA." *Environmental Pollution* 116, pp. 381–389

Schlesinger, W. H. 1999. "Carbon sequestration in soils." *Science*, 284: 2095. doi:10.1126/science.284.5423.2095

Thompson, J. W. and K. Sorvig. 2008. *Sustainable Landscape Construction: A Guide to Green Building Outdoors* 2nd edition. Washington DC: Island Press.

Townsend-Small, A. and C. I. Czimczik. 2010. "Carbon sequestration and greenhouse gas emissions in urban turf." *Geophysical Research Letters* 37; l02707. https://doi.org/10.1029/2009GL041675

Zhao, M., F. Escobedo, and C. Staudhammer. 2010. "Spatial patterns of a subtropical, coastal urban forest: Implications for land tenure, hurricanes, and invasives." *Urban Forestry & Urban Greening* 9: 205–214. https://doi.org/10.1016/j.ufug.2010.01.008

Online

DelValle, T. B., J. Bradshaw, B. Larson, and K. C. Ruppert. 2008. Energy Efficient Homes: Landscaping. https://doi.org/10.32473/edis-fy1050-2008

Department of Wildlife Ecology and Conservation Extension. https://wec.ifas.ufl.edu/extension/

Escobedo, F., J. Seitz, and W. Zipperer. 2009. Carbon sequestration and storage by Gainesville's urban forest. Gainesville: University of Florida Institute of Food and Agricultural Sciences. FOR 210. (No longer available online.)

Hostetler, M. E., G. Klowden, S. Webb, S. W. Miller, and K. N. Youngentob. 2003. Landscaping backyards for wildlife: top ten tips for success. https://edis.ifas.ufl.edu/UW175

Florida Fish and Wildlife Conservation Commission—Planting a Refuge for Wildlife https://myfwc.com/viewing/habitat/refuge/

Florida's Urban and Urbanizing Forests Program https://www.sfrc.ufl.edu/urbanforestry/

Living Green https://livinggreen.ifas.ufl.edu/

Program for Resource Efficient Communities http://www.buildgreen.ufl.edu

Sustainable Site Initiative https://www.sustainablesites.org/

USDA Forest Service. Urban forests and climate change resource center https://www.fs.usda.gov/ccrc/topics/urban-forests

Table 1. Annual carbon sequestration by trees and lawns in different types of Florida urban greenspaces.

Greenspace type	Tree cover (m²)	Lawn cover (m²)	Tree seq.	Lawn seq.	CO_2 emitted - lawn	CO_2 emitted - tree	Net annual (CO_2 kg/yr) sequestration for a 4 hectare site
Miami-Dade	**Tree/lawn cover per 400 m² plot**		**Tree/lawn CO_2 sequestration per 400 m² plot (kg CO_2/yr)***		**CO_2 emissions - tree/lawn maintenance per 400 m² plot (CO_2 kg/yr)[T]**		**(CO_2 kg/yr)**
Hammock	380	0	4653	0	0	0	465,330
Pine Rockland	120	0	70	0	0	0	6,980
Mangrove	400	0	3031	0	0	0	303,060
Commercial	72	8	247	0.3	3	6	23,860
Residential old	280	380	25	16	153	23	-13,570
Residential new	180	52	7	2	21	15	-2,640
Park/school	20	340	17	14	137	2	-10,800
Gainesville							
Pine hardwood	240	0	699	0	0	0	69,910
Swamp cypress	300	0	904	0	0	0	90,360
Plantation	200	0	162	0	0	16	14,570
Commercial	200	0	237	0	0	16	22,050
Residential old	360	100	428	4	36	29	36,660
Residential new	100	260	124	11	93	8	3,350
Park/school	0	88	0	4	32	0	-2,800
Orlando							
Pine palmetto	260	0	445	0	0	0	44,520
Oak pine	360	0	102	0	0	0	10,240
Cypress dome	320	0	1102	0	0	0	110,170
Commercial	40	80	39	3	29	3	1,020
Residential old	340	140	442	6	50	28	36,960
Residential new	60	80	63	3	29	5	3,280
Park/school	0	284	0	12	102	0	-9,050

*Lawn sequestration rate (grass stubble only)[1] is 48.1 g CO^2 m^{-2} yr^{-1}

**Lawn maintenance numbers are from three sources of carbon: fuel to maintenance equipment (122 g CO_2 m^{-2} yr^{-1})[2], energy for irrigation (193 g CO_2 m^{-2} yr^{-1})[3], and fuel inputs to manufacture fertilizer (1.436 moles of C per mole of N produced)[5]. Tree maintenance[2] is 81 g CO_2 m^{-2} yr^{-1}.

[T]Low fertilization rate recommended by UF/IFAS for St. Augustine grass in south Florida[4] - 4lbs 1000 ft^{-2} yr^{-1}

[T]Low fertilization rate recommended by UF/IFAS for St. Augustine grass in central Florida[5] - 2lbs 1000 ft^{-2} yr^{-1}

[1]Jo, H. and McPherson, G. E. 1995. "Carbon storage and flux in urban residential greenspace." *Journal of Environmental Management* 45: 109-133.

[2]Townsend-Small, A. and Czimczik, C. I. 2010. "Carbon sequestration and greenhouse gas emissions in urban turf." *Geophysical Research Letters* 37: L02707. https://doi.org/10.1029/2009GL041675

[3]Schlesinger, W. H. 1999. "Carbon sequestration in soils." *Science* 284: 2095. https://www.science.org/doi/10.1126/science.284.5423.2095

[1] This document is WEC279, one of a series of the Department of Wildlife Ecology and Conservation, UF/IFAS Extension. Original publication date March 2010. Revised January 2013 and February 2025. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

[2] Francisco J. Escobedo, former associate professor, UF/IFAS School of Forest Fisheries and Geomatics Sciences, Gainesville, FL ; Mark E. Hostetler, professor and Extension specialist, Department of Wildlife Ecology and Conservation; UF/IFAS Extension, Gainesville, FL 32611.