Land Development, Landscaping and Greenhouse Gas Emissions

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GHG Emissions Estimates for Landscape Maintenance Activities

Management of landscapes results in GHG emissions from the energy used to treat and transport irrigation water, to produce and transport fertilizers and pesticides, from the operation of gasoline or electric powered equipment, and from more indirect but still related activities such as the production and transportation of commercial mulch or the energy used to remove nutrients that have entered water bodies from runoff. These represent GHG emissions from annual maintenance activities. A full analysis would also incorporate emissions resulting from growing, transporting, and establishing the landscape plants, unless a natural landscape is maintained.

Accurate estimation of total GHG emissions from maintenance landscaping activities requires site-specific details – each homeowner or landscape manager may use a different set of practices, depending on the site conditions, the plants chosen and individual preferences. To simplify this analysis, we have assumed that each homeowner would follow the recommendations of UF/IFAS for irrigation, fertilization and mowing practices.

To estimate GHG emissions from annual maintenance of an example residential Florida landscape planted in turfgrass, we used UF/IFAS recommendations for maintenance of St. Augustinegrass, a common Florida lawngrass. We calculated emissions from the recommended levels of the four main landscaping activities commonly practiced for St. Augustinegrass in Florida: irrigation, fertilization, pest control and mowing.

Irrigation

For turfgrass in the landscape, UF/IFAS recommends to water as-needed (Trenholm and Unruh 2008) in soils where vertical growth of roots is not limited, and where irrigation system run times are scheduled, to set frequency and run times based on irrigation system application rate, month, and climatic region of the state (Dukes 2008b). Irrigation water requirements have been predicted based on potential evapotranspiration (ET) (water lost to the atmosphere through the plant surface), which depends largely on climatic conditions (Augustin 2000; Dukes and Haman 2009). The net irrigation requirement is the difference between potential evapotranspiration and effective rainfall. Augustin (2000) used historical rainfall and temperature data to calculate net irrigation requirements for turfgrasses in various locations in Florida. Since irrigation water can be lost by evaporation, runoff and percolation, application efficiencies are applied to determine the total irrigation requirement. Based on historical ET and effective rainfall data (which accounts for the low water-holding capacity of Florida's soils) for three regions of the state, using Augustin's net irrigation requirements, and assuming 60% efficiency, Dukes and Haman (2009) converted depth of irrigation water needed to recommended irrigation run times for each month in three regions of Florida. We used those calculations for 80% of ET replacement rate and averaged results from the three regions to determine that irrigating a lawn area in Florida would require on average 38.68 inches/year beyond effective rainfall.

Tampa Bay Water (TBW) data on energy costs of the production of surface water, groundwater and desalinated water, and eGRID data on GHG emissions from that electricity generation (U.S. EPA. 2009) were used to estimate the energy costs needed for the production of irrigation water (Kipp et al 2010; Foerste et al 2010). Based on 2008 TBW data, using groundwater as the source results in 1,416 lbs. CO_2 per million gallons of groundwater produced. Using surface water results in 1,972 lbs. CO_2 per million gallons, while the production of desalinated water results in 24,007 lbs. CO_2 per million gallons. TBW's mix of sources produces 4,982 lbs. CO_2 per million gallons. That accounts only for production and treatment, and not for pumping the water from the utility to the end user.

The emissions from supply of groundwater as the water source are equivalent to 0.0014157 lbs. CO_2 equivalents (CO_2e) per gallon of water. The 38.69 inches of irrigation water are the equivalent of 24,114 gallons/1000 sq ft/yr. So irrigating each 1000 sq.ft. of turfgrass landscape each year with groundwater produces emissions of approximately **34 lbs. CO_2e**.

Fertilizers

UF/IFAS recommends applying nitrogen (N) and potassium (K) fertilizer at the same rate and not applying phosphorus unless a soil test shows a deficiency. For nitrogen fertilization, UF/IFAS provides recommendations for both homeowners and landscape maintenance professionals for the three Florida regions for the four turfgrasses recommended for home lawns in Florida (bahiagrass, centipedegrass, St. Augustinegrass and zoysiagrass) (Trenholm and Unruh 2009; Florida Dept. of Environmental Protection 2008). If half of the lawns are fertilized following the homeowner recommendations and half are fertilized following recommendations for landscape maintenance professionals, then an average of 3.33 lbs. N / 1000 ft^2 / yr. would be applied and the same amount of potassium would be applied.

Fertilizer carbon emissions were taken from literature values for the production, transportation, storage and transmission of fertilizers (Lal 2005), averaging 1.3 kg carbon equivalent (CE)/kg N and 0.15 kg CE/kg K. Lal (2005) estimates that 1.25% of applied N is emitted as nitrous oxide (N_2O), so we used the EPA Greenhouse Gas Equivalencies Calculator (http://www.epa.gov/RDEE/energy-resources/calculator.html) to convert kg CE and kg N_2O to metric tons (Mt) CO_2 equivalent. GHG emissions from nitrogen fertilizer production, transportation, storage and transfer were therefore estimated at 0.0065376 MtCO_2e /1000 ft^2 /yr. Adding the nitrous oxide that is released (0.00586 Mt CO_2e 1000 ft^2/yr) and the emissions from potassium (0.00075 Mt CO_2e /1000 ft^2/yr), the total emissions from fertilizers was estimated to be 0.01315 Mt CO_2e /1000 ft^2/yr), or approximately **29 lbs CO_2e/1000 ft^2/yr.**

Mowing

Mowing frequency depends on several factors including turfgrass species and fertilizer applications that affect plant growth rate. UF/IFAS recommends mowing St. Augustinegrass every 5-14 days, or about 35 times per year (Trenholm et al 2009; Busey and Evert 1979). We estimated GHG emissions from the use of a gasoline-powered mower with current emission controls (EPA 2005). Mower fuel use estimates are from the Outdoor Power Equipment Institute (1.0 gal/acre for a typical new model walk-behind mower and 0.75 gal/acre for a riding mower, with 80% of mowing conducted with walk-behind mowers) (Sahu n.d). We converted those fuel use estimates to CO_2 emissions/gallon of gasoline using the EPA Greenhouse Gas Equivalencies Calculator Calculations and References (http://www.epa.gov/cleanenergy/energy-resources/refs.html), giving an estimate of 0.00889 Mt CO_2e/gal. The average emissions accounting for the percent of mowing events using walk-behind mowers came to 0.000194 Mt CO_2e/1000 ft^2/ mowing event. When multiplied by 35 mowing events/yr., that gives an estimate of 0.000679 MtCO_2e/1000 ft^2/yr., or approximately **15 lbs CO_2e/1000 ft^2/yr.**

Pesticides

We calculated average pesticide use in lbs. of active ingredient (a.i.) from estimates of total annual home and garden pesticide usage for the U.S. (96 million lbs a.i./yr) (Fishel 2007) and total area of lawns in U.S. (163,812 sq km) (Milesi et al 2005). Any inflation in the estimate as a result of having used the value for all home and garden use as opposed to lawn use only is more than made up for by the fact that the value for total pesticide usage is a national value. Home and garden pesticide use in Florida would be expected to be higher than the national average given the impact of the state's warmer climate on pest populations. Equivalent carbon emissions for pesticides were taken from literature values of 38 herbicides, insecticides and fungicides from Lal 2005. The average of those values was 5.00294 kg carbon equivalent/kg a.i. We used the EPA Greenhouse Gas Equivalencies Calculator (http://www.epa.gov/RDEE/energy-resources/calculator.html) to convert kg carbon equivalent to metric tons (Mt) CO_2 equivalent. The 96 million lbs a.i./ 163,812 km^2/yr represent 0.0247 kg a.i./1000 ft^2/yr, which when multiplied by 5.000294 kg CE/kg a.i. and converted to CO_2 equivalents results in **0.999 lbs CO_2e/1000 ft^2/yr for pesticide use.**

Total emissions from the four principal activities (irrigation, mowing, fertilizers and pesticides) for conventional lawn maintenance are therefore equal to **79.093 lbs CO_2e/1000 ft^2/yr**

Additional Notes

Contributions to GHG emissions not included:

This estimate does not include all of the activities that contribute to GHG emissions from land-scapes and their maintenance. Some of the GHG emissions that the analysis does not take into account include those resulting from:

- Emissions from activities related to cleaning up impaired waters that have received nutrient and pesticide loads from runoff / leaching
- Pumping water from the utility to the irrigated area
- Producing, transporting and installing sod or other landscape plants
- Using other gasoline-powered landscape equipment like weed wackers or leaf blowers (only lawn mowing was included)
- Using older mowers (fuel estimates are from manufacturers and therefore represent new engines, while many older model equipment that was produced before current air quality standards is still in use)
- Transporting landscape maintenance crews to work sites

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