Christmas Tree Carbon Science, Part II: Current Research Projects

By Keith Reinhardt, Research Assistant, NCSU Christmas Tree Genetics
Ryan Emanuel, Assistant Professor, Department of Geology, Appalachian State University

In the previous article on carbon science, we introduced the basics of carbon dioxide (CO2) and explained why CO2 is important in the context of climate change. Also, we discussed what a "CO2 budget" for a Christmas tree farm is. As a quick reminder: like a checkbook, a CO2 budget is simply the net balance of CO2 "inputs" into a farm minus the CO2 "outputs". Here, inputs are made up of CO2 absorbed by plants during photosynthesis, and outputs are all the activities that release CO2 back into the air, such as tree and soil respiration and emissions from gasoline engines. Ultimately, a desirable CO2 budget is one that is "carbon negative"—that is, carbon inputs exceed carbon outputs.

As you can imagine, researchers do not have exact numbers for all of the inputs and outputs of a Christmas tree CO2 budget, and the budget of an individual farm can change from year to year depending on management activities, harvesting and even the weather. Why is it important for us to understand these inputs and outputs? One reason is so that we can accurately predict, and then prepare for, future climate conditions. Another reason is that the real Christmas tree industry would like to market itself as a "greener" alternative to artificial Christmas trees, but there is still very little scientific evidence to show this. Therefore, several groups of researchers are actively studying the CO2 dynamics associated with Christmas tree farming in North Carolina. This article will summarize their current efforts.

In part I of this article, we mentioned that Dr. Ryan Emanuel at Appalachian State University has been monitoring net CO2 fluxes on Christmas tree farms in Mitchell and, now, Alleghany Counties. Using eddy covariance methods, he calculated an annual uptake for the Mitchell County farm of nearly 1 ton of C/acre between June 2008 and May 2009 (Figure 1). This quantity, known as net ecosystem production, can be thought of as the net input to the CO2 budget. Ideally for Christmas tree farmers, we want all CO2-releasing activities involved with growing and transporting Christmas trees to customers to be less than net production in order to be considered a green, or carbon-negative product. To do this, we can work to increase net CO2 inputs (through farming practices that increase tree growth, for example), we can decrease the amount of CO2 released by farming activities, or we can do both of these things.

In the last article we also mentioned a report by an environmental consulting firm in Canada, Ellipsos, that calculated that the carbon balance for an individual natural Christmas tree is about +53 lbs CO2 over its entire life in the field (six years in this study). The "+" indicates that the full-cycle process of growing a Christmas tree in Canada actually releases more CO2 into the atmosphere than the tree removes from the air (though much less than the CO2 budget for an artificial tree, +106 lbs CO2). But this study just investigated tree production in one farm, and in Canada. How do these numbers compare to figures for farms in North Carolina?

In another North Carolina study, Drs. Ron Gehl, John Frampton, John King and Cari Furiness from NCSU are comparing differences in carbon content in Christmas trees between stands of different rotation ages (1st vs 4th rotation), in both above-ground matter (stems, branches, needles) and below-ground matter (roots). They predicted that carbon content in trees and soils in older rotation fields would be greater than in younger rotation fields, due to higher quality soil and undecomposed roots from Christmas trees in previous rotations. However, they found no real differences in carbon in trees or soil between the rotations, although they did find out that below-ground carbon content was more than above-ground carbon content. This indicates that Fraser fir invests more of its energy to the root systems, rather than to growing new branches. Another NCSU researcher, Dr. Eric Hinesley, also has been studying carbon content in Christmas trees. Dr. Hinesley's research is part of a nationwide study with researchers in the Pacific Northwest, Michigan, and Pennsylvania attempting to track biomass accumulation (and thus carbon content) through whole rotations of Christmas trees. His study highlights the nationwide interest by the Christmas tree industry to understand carbon dynamics in Christmas tree production. These NCSU studies underscore that soil carbon fluxes are an important part of the CO2 budget of a Christmas tree farm (also highlighted in part I of this article). This is because trees may invest a lot of their carbon input from photosynthesis to root systems, and respiration (breathing) from soil microbes can be substantial, especially in agricultural areas, where soils are exposed to considerable warmth and moisture.

In a complementary study, Drs. Samantha Chapman and Adam Langley from Villanova University aim to determine how Christmas tree farming affects soil carbon storage in and around farms. These researchers took soil samples from farms of different rotation ages, and in various locations in Christmas tree farms (for example, under and around trees, and in surrounding pastures and forests). They found that the soil carbon content in newer rotation field was about the same as in soils of older rotations as well as in pastures surrounding Christmas tree farms. This suggests that, in the long term, Christmas tree production does not significantly impact soil carbon reserves, or the soil component of a Christmas tree CO2 budget (either for better or for worse). However, these scientists did find the soil respiration rates in the Christmas tree fields were lower than in nearby forests. This means that the Christmas tree farms "breathe out" less CO2 than their ecological neighbors. In terms of a farm CO2 budget, this means that their CO2 outputs are less than the CO2 outputs of a forest, which is a good thing (because less of the CO2 inputs are being lost)!

As you can see, there is quite a lot of interest in Christmas tree carbon science nationwide, and North Carolina seems to be in the forefront of this research. We have numerous studies investigating carbon inputs and storage in tree farms at multiple scales. Future research projects will need to accurately determine the carbon outputs for Christmas tree farms, which varies by farm according to machinery use and transportation mileage.

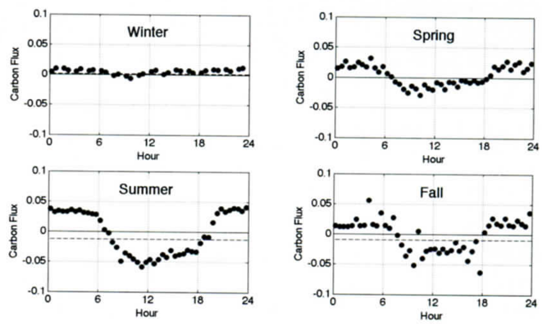

Figure 1. Caption:

Typical daily carbon flux (mg C/ m*s) on a Mitchell County Christmas tree farm for each season during the period from June 2008 through May 2009. Circles show average carbon flux for each 30-minute period of the day. Negative fluxes are sequestration or CO2 input to the tree farm, and positive fluxes are outputs, or CO2 losses to the atmosphere. The dashed line is the average of all 30-minute carbon fluxes. Total Winter flux is slightly positive (13 g C/m2, or 116 lbs/ac), total Spring flux is nearly 0, and total Summer and Fall fluxes are slightly negative (-98 g C/m2or -872 lbs/ac Summer, -74 g C/m2 or -660 lbs/ac Fall).