Above-Ground Tree Carbon Estimation Protocols Georgia, USA

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Background

- Carbon dioxide is a minor atmospheric gas that is associated with a process that is generally known as the "Greenhouse Effect"
- Over the past century the concentration of Carbon Dioxide in the atmosphere has been rising (from somewhere around 280 ppm in the late 1800's to about 370 ppm today)
  - One source of the increase in CO_2 is burning of fossil fuels

Background

- Nevertheless – today we find ourselves in the situation where various organizations want to purchase "carbon offsets" to help mitigate climate change
- It really does not matter if such carbon offsets can or will have an impact on temperature patterns around the globe
  - All that matters is that there is a **perceived economic value** in these carbon offsets and therefore individuals and organizations that own various types of carbon offsets may realize an economic gain from their sale

Georgia Carbon Registry

- It is well known in the forestry profession that growth of timber results in the storage of carbon (i.e. as trees grow they make use of CO_2 from the atmosphere and store C in various ways):
  - Stem wood and stem bark
  - Branch wood and branch bark
  - Foliage
  - Roots
  - Soil

Georgia Carbon Registry

- Georgia is one of the largest timber growing centers in the country and the world – hence, if there is interest in purchasing carbon offsets – Georgia timber growers are well positioned to benefit economically from their sale (assuming that conditions of purchase do not impede routine timber management economics)

Georgia Carbon Registry

- We divide carbon sequestered in forests into:
  - Above ground carbon
  - Below ground carbon
- I will discuss Above ground carbon estimation protocol – Dan Markewitz will discuss Below ground estimation protocol

Above Ground Protocol

- Goals of the Protocol
  - Objective methods
  - Reliable (well tested) methods
  - Low cost methods
- Today, carbon is a low valued commodity and hence any procedure(s) used to obtain carbon estimates must be low cost while, hopefully, objective and reliable

Above Ground Protocol

- Above ground carbon estimates are limited to stem wood only (no stem bark, branch wood/ bark or foliage). WHY?
  - Many well studied/ tested, relatively simple methods available for estimation of stem wood in timber stands
  - Stem wood sequesters carbon for much longer periods of time than stem bark, branch wood/ bark and foliage

Above Ground Protocol

- Estimation of carbon stored in stem wood is essentially a timber inventory/ growth and yield exercise
- We need to obtain an estimate of the volume or weight of stem wood and then convert this estimate to tons of carbon
- NOTE – approximately one-half of dry wood weight is carbon, hence if we can estimate dry weight of stem wood we can easily convert it to weight of carbon by multiplying by ½

Above Ground Protocol

In general we define:

$$SG = \frac{D}{D_{Water}}$$

SG = specific gravity

D = density of liquid or solid

D_{Water} = density of water = 62.4 lbs/ ft^3

Above Ground Protocol

For wood we typically use

$$SG_B = \frac{W_D / V_G}{D_{Water}}$$

SG_B = basic specific gravity

W_D = dry weight of wood

V_G = green volume of wood

D_{Water} = density of water = 62.4 lbs/ ft^3

Above Ground Protocol

$$W_D = (SG_B)(D_{Water})(V_G) = 62.4(SG_B)(V_G)$$

$$W_C = (0.5)W_D$$

W_C = weight of carbon,

all else as previously defined

Above Ground Protocol

$$W_D = (SG_B)(D_{Water})(V_G) = 62.4(SG_B)(V_G)$$

$$W_C = (0.5)W_D$$

Example – we have 1000 cubic feet of loblolly pine wood per acre (green volume inside bark - V_G)

Average SG_B for loblolly pine is about 0.47, therefore we can estimate dry weight of wood as

W_D = 62.4*0.47*1000 = 29,328 lbs

W_C = 14,664 lbs or about 7.3 tons

Above Ground Protocol

- Note – we can estimate dry weight of wood from green weight of wood as:

$$W_D = (1 - MC_G) * W_G$$

Where:

W_D = dry weight of wood

W_G = green weight of wood

MC_G = moisture content of wood defined as:

$$MC_G = (W_G - W_D) / W_G$$

Above Ground Protocol

- Suppose we have estimated 75 standing green tons of wood in a loblolly pine stand
- From the work of Clark and Daniels (2000) we can obtain an estimate of MC_G to be 53.5% or 0.535
- Thus, we can estimate standing dry tons to be:

$$W_D = (1 - MC_G)^* W_G$$
$$= (1 - 0.535)^*75 = 34.875 \text{ tons}$$

- Of course, carbon is then estimated to be approximately 17.4 tons (1/ 2 of W_D)

Above Ground Protocol

- Clearly, to determine standing tons of carbon in a timber stand we can follow normal cruising practices to obtain one of the following:
  - Inside bark green volume (i.b. cubic foot volume equation - V_G)
  - Inside bark green weight (i.b. green weight equation - W_G) in conjunction with a legitimate estimate of moisture content
  - Inside bark dry weight (i.b. dry weight equation - W_D)
- Make the appropriate calculation to convert the available estimate to carbon weight

Above Ground Protocol

- Many equations have been developed to estimate these various quantities from typical cruise data (DBH and some measure of height)
- We are in the process of compiling a list of acceptable equations – however, the bottom line will be that any equation (table) that has been developed based on sound mensurational methods and published in a scientific journal or by a valid research unit (University, USDA Forest Service, private companies) will be acceptable.
  - NOTE – the equation/ table must be region and species specific

Above Ground Protocol

- Clearly, the implication from the discussion above is that valid timber inventory data can be used to obtain estimates of carbon tons (using appropriate unit conversions)
- However, timber inventory operations can be relatively expensive ($4-5/ acre and up depending on type and intensity of measurement)

Above Ground Protocol

- It is quite likely that some timberland owners who are interested in selling carbon offsets will not want to pay for such an inventory if their proceeds will not justify the cost of the inventory
- Thus, in addition to obtaining estimates directly from inventory operations – estimates can also be obtained indirectly using carbon tables produced for stand types in Georgia or from a scientifically defensible Growth and Yield System for the stand types of interest

Above Ground Protocol

- To allow for participation from the largest possible number of timberland owners, separate sets of protocols have been developed for:
  - Entities with reliable inventory information
  - Entities without reliable inventory information
- All contracts for sale/ purchase of carbon will most likely contain stipulations for some type of verification of estimates
  - This verification can take many different forms depending on who the buyer is and what purpose the carbon offsets will be used for (e.g. meeting government mandated carbon emission reductions may require more rigorous verification than carbon offsets purchased for a PR purpose)

Carbon Tables

- Carbon tables developed for:
  - Major timber types in Georgia
  - Tables present tons of carbon by fiber and solid wood products (only two categories – fiber is all stems <= 11.5” DBH to 3” top, solid wood is all stems > 11.5” DBH to 6” top – with 15% degrade of solid wood stems into fiber category)
    - Bottomline – we tried to be conservative in our estimates of solid wood carbon
- These tables will be used for both types of entities considered in the Above Ground Protocol
- A registered forester (also certified in Carbon Sequestration Protocol) must determine the appropriate information for the timberland in question so as to identify the correct carbon table/ software to use for estimating sequestered carbon tons

Entities With Reliable Inventory

- Stand level probability samples available with estimates of standing tree volume or weight
  - Conducted by registered forester
  - < 10 years old
  - Sample precision <= 20% estimated Allowable Error (AE) (note – draft protocol indicates <= 15%)

Entities With Reliable Inventory

- Procedure for calculating tree carbon from inventory
  - Clearly, it is straight forward to determine tons of carbon from timber inventory data
    - Estimate volume i.b., green tons i.b. or dry tons i.b. using appropriate volume or weight equation/table
    - Use the appropriate conversion process outlined above
  - NOTE – available inventory data may be from up to 10 years in the past, therefore it may be necessary to update the carbon estimates to present or to the year in which the carbon contract will begin

Entities With Reliable Inventory

- Procedure for updating carbon estimate to start of contract period (may be current year) – two general approaches (use of Carbon Tables and use of Growth and Yield (G & Y) software with appropriate conversions)
  - Carbon tables – find appropriate carbon table for stand type/age of inventory – determine average annual carbon accumulation from table for ages between inventory age and start of carbon contract – add the carbon accumulation from the table to the inventory estimate
  - Growth and yield software – enter starting inventory information into growth and yield software, obtain estimate of carbon at inventory point (based on G & Y system) – obtain estimate of carbon at start of carbon contract) (based on G & Y system) – take the difference and add this amount to the carbon estimate obtained from the inventory to obtain carbon at start of carbon contract.

Entities With Reliable Inventory

- Procedure for determining carbon accumulation during contract period – two general approaches (use of Carbon Tables and use of Growth and Yield software with appropriate conversions)
  - Carbon tables – determine starting carbon level as described above, use the appropriate carbon table to estimate standing carbon at end of carbon contract – take the difference to determine net accumulation (NOTE – harvested volume/tons must be deducted if any thinning/loss has taken place)
  - Growth and yield software – determine starting carbon level as described above, enter starting inventory information into growth and yield software, obtain estimate of carbon at start of carbon contract (based on G & Y system) and at end of carbon contract (allowing for any thinning operations that will take place) – take the difference – this is the carbon accumulation over the contract period

Entities Without Reliable Inventory

- Registered forester examines the stand and identifies
  - Major species
  - Stand origin (planted cutover site, planted ag. field, natural)
  - Stand age
  - Site quality (low 52, medium 62, high 72 at 25 for pine)
  - Stand density (low, high)
  - Thinning condition (pine stands only)
  - Management intensity (planted pine only)
  - Level of genetic improvement

Entities Without Reliable Inventory

- Use appropriate carbon table to assess carbon at start of contract period
- Use appropriate carbon table to assess carbon at end of contract period
  - Take the difference between end of period and start of period (on a stand by stand basis) and determine the carbon accumulation over the contract period
- NOTE – it should be understood by both buyer and seller that carbon accumulation estimates determined from regional tables will not be as accurate/ precise as those starting from inventory data

Example Carbon Table

Loblolly, Natural, SI Low, Low Intensity Mngt, Unimproved genetics, Regional avg., No Thinning

Age	Pulp Wood C	Saw Timber C
	-------tons-C/acre-------	
10	0.16	0
15	2.42	0
20	5.67	0
25	8.66	0.35
30	10.6	1.38
35	11.66	2.78
40	11.75	4.63
45	11.22	6.63
50	10.44	8.48
55	9.6	10.07

Questions/Comments?

To know that you do not know is the best. To pretend to know when you do not know is a disease – Lao Tzu, The Way of Lao-Tzu, Chinese Philosopher 604 – 531 BC