Long term carbon storage in Black Rock Forest: conversion of historical data to modern units
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Introduction

In 1929 a Growth and Density Plan was constructed for a majority of the Black Rock Forest which at the time had an area of 3,109 acres. This Plan included classifying the forest land into one of six types depending mainly on the species composition and development. After the forest was divided into these forest types, the average density and wood volume of the areas were determined and labeled in cords per acre (Tyron 1930). Wood volume was estimated to range from zero to 30 cords per acre with most of the forest in the range from 11 to 20 cords per acre. These classifications were based on extensive cruises of the forest under the supervision of Henry Tyron, the then Director of the forest.

Due to the role of atmospheric carbon dioxide in regulating climate much recent emphasis has been placed on carbon accumulation rates in various ecosystems of the world. Evidence seems to indicate that the largest terrestrial sinks for carbon are in aggrading temperate zone forests (Fan et al. 1998). This fact, along with the excellent forest inventory record make Black Rock Forest an excellent location for assessment of carbon storage rates. However to successfully do this one must first determine how to convert historical data into modern units such as kilograms of carbon per hectare.

Starting in the 1930's, a number of plots were established at Black Rock for the purpose of monitoring forest growth and succession patterns. These plots, which ranged from 0.1 to 0.25 acres in size, were inventoried when they were created at several subsequent intervals. Critical information collected included the diameter at breast height (dbh) of all trees on the plot. Above ground carbon content can be estimated by using dbh data in previously derived regression equations (Pastor et al. 1984).

Methods

In 1929 Tyron estimated the cords per acre for most of the forest. Then in the 1930's numerous plots were established and the dbh for the trees on these plots were measured. The dbh of the trees were again measured anywhere between five and 10.5 growing years after the time that the first measurement was taken. We used the equations from Pastor et al. (1984) to determine the carbon content at both of these times to calculate an annual carbon growth rate. Using this information, it was possible to back extrapolate to determine an approximate carbon content for each plot in 1929. The approximate location of 12 plots were determined on Tyron's 1929 Growth and Density Plan Map. On this map, the areas were classified into one of six densities in cords per acre: 0-5, 6-10, 11-15, 16-20, 21-25, 26-30. The median number of cords per acre (e.g. 3,8,13 etc.) was chosen to be compared to the carbon content for the 12 plots to derive a relationship that could be used for converting cords/acre to carbon content. With such an equation, it will be possible to determine carbon content for any area for which Tyron had classified the cordage.

Results

The equation we derived to describe the relationship between cords per acre and carbon content is y (carbon content – kg/ha) = 2588.8x (cords per acre). The carbon content for the median cord per acre values is given in Table 1.

Table 1. Mass of above ground carbon for median cord values (1929 data).

Cords per Acre	Mass of Carbon (kg)/ha
3	7766
8	20710
13	33654
18	46598
23	59542
28	72486

The R^2 value for this relationship is 0.4737 ($r = 0.67$, $p<?$). Graphs of all appropriate relationships are included in the appendix.

Discussion

According to these calculations above ground carbon content in 1929 for most of the forest ranged from 31,000 to 47,000 kg/ha. Accurate modern census data for the remaining long term plots indicate carbon content ranging from 80,000 to 100,000 kg/ha. Clearly the Black Rock Forest has been a significant carbon sink with carbon content tripling on average over the past 70 years.

This relationship between cords per acre and carbon content per hectare is only approximate and needs to be used with some caution. First, the dbh values for 1929 had to be back-calculated. This was done by determining an average growth rate during the 1930's. The growth rate was determined based on the growth between the first time the plot was measured, which occurred in the early 1930's (31-36), and the second time they were measured, during the late 1930's (36-40). Not all plots were measured at the same time, so the gap between the two measurements ranged from 5 to 10.5 years. Thus, the growth rates determined were not based on a standardized growth period. Second, for two plots, carbon content decreased between the first and second measurement due to a significant loss of trees on the plot. This loss was most likely linked to natural causes e.g. windfall, disease etc. For these two plots, the carbon growth rate was calculated omitting the trees that had died. This seemed like a reasonable technique because beside the trees that died, nearly all of the remaining trees in each plot showed positive carbon growth.

On Tyron's 1929 map, he assigned each area a volume range, e.g. 0-5, 6-10 cords per acre. As stated above, for use in comparing to the carbon values, the median value of each division was chosen, e.g. 3,8,13 etc. Therefore, each area was assigned only one value. This seemed the most accurate way to get a number to compare to the carbon content. However, determining exactly the volume (cords/acre) of trees in 1929 on each plot is not possible.

Knowing the estimated cords per acre and the computed carbon content in 1929 for 12 plots, an equation was determined for a regression line for the given data points. While the correlation coefficient is only 0.71 this value is significant at the 0.01 level. Thus this relationship presented should prove useful in predicting above ground carbon quantities for all areas which Tyron classified in 1929.

Literature Cited

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