NORTHEAST FORESTS: AN ASSESMENT OF CURRENT CARBON STOCKS AND POTENTIAL FOR BIOFUEL CREATION*

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Abstract. As atmospheric carbon continues to rise and U.S. fossil fuel use moves beyond 2000 million metric tons per year, the importance of carbon mitigation and fossil fuel offset grows. A mixture of spruce-fir and mixed hardwood forests covers the northeast landscape and has great potential to reduce atmospheric carbon through a combination of forest sequestration and biofuel creation from woody biomass. Through analysis of the US Forest Service's data, Forest Inventory Analysis, the current northeast forests were assessed for carbon storage, annual carbon increment, and average harvesting patterns. With use of the statistical computing program R and analysis of forest data, this study suggests northeast forests have yet to reach their carbon storage peak, while biofuel creation requires increased efficiency to make a larger impact on fossil fuel offsets.

INTRODUCTION

Currently, atmospheric carbon is estimated to be over 380 parts per million, significantly higher than even fifty years ago (NOAA). In 2009 alone, that number was expected to rise by 1.96 parts per million, further increasing the importance of options of carbon storage and mitigation. With U.S. forests covering over 33% of the landscape in 2005, this resource has the potential to reduce atmospheric carbon through both forest sequestration and fossil fuel offset by the creation of forest biofuels (Global Forest Resources Assessment 2005).

Forest carbon sequestration

Forest carbon sequestration is an ecosystem-wide process, beginning as plants pull carbon from the atmosphere during photosynthesis. Carbon is then stored in the forest's organic matter, including live and dead plants along with soil, for a given period of time. As the organic matter beings to decay, carbon is returned to the atmosphere, usually in the form of carbon dioxide. Forests act as a sink for carbon when the amount of carbon drawn into the forest exceeds the amount of carbon the forests releases. When the balance between carbon intake and carbon loss from respiration shifts, forests become a source of carbon to the atmosphere (U.S. Environmental Protection Agency).

The potential for a forest to act as a carbon sink, and the amount of carbon that can be sequestered, depend on an array of variables, including forest age and applied management practices (Stavins and Richards 2009). As a forest ages, the rate at which trees remove carbon from the atmosphere, along with the overall amount of carbon stored in the forest, changes. Younger forests take in higher amounts of carbon; however, total carbon storage is much higher in older forests, despite slowed carbon uptake rates (Nunery and Keeton 2009).

In addition to age, forest management practices also have been seen to affect the level of carbon storage in a forest. Along with soils, trees account for the majority of forest carbon storage. A particular aspect of management with the ability to strongly affect forest carbon storage is variation in rotation lengths. The ideal rotation length for a given forest is dependent, in large part, on the species (Liski et al 2004). However, despite fluctuation among species, a general trend favors increased rotation lengths to improve carbon sequestration (Stavins and Richards 2005). Besides decreasing carbon accumulation for trees, shortened rotation lengths also

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increase energy use and fossil fuel emissions as machinery enters the harvest site more frequently (Liski et al 2004). Along with altering rotation lengths, several additional management practices have the ability to affect forest carbon storage. Guidelines followed by the United States Forest Service for positively impacting forest carbon offsets include: restoration of native vegetation and wildlife, reforestation of harvested forest land, low impact harvesting and protection of current forests from conversion to non-forested land (Birdsey 2006).

Forest biofuels

Yet another way forests have the potential to reduce atmospheric carbon is through the production of biofuels as an alternative to fossil fuels. In 2004, the World Resources Institute estimated the United States alone used 2000 million metric tons of fossil fuel (Damassa). The high level of fossil fuel usage and the decreasing availability of fossil fuel sources have sparked an increased interest in alternative energy sources. U.S. Department of Energy estimates over twelve alternative energy sources to be in production or use today, with forest biofuels falling under the category of energy from biomass. A clean and renewable source of energy, the success of forest biofuels and all other biomassbased energy sources relies on the availability of the biomass feedstock (U.S. Department of Energy). In addition to feedstock availability, the method of biofuel production also has a strong influence on the possible carbon offsets through biofuel use (Fargione et al 2008). For example, conversion of carbonrich sites, such as mature forests, for the purpose of growing biofuel stock will have a negative carbon impact. Yet, biofuel stock from waste biomass, such as harvesting slash, or trees grown on degraded land has the potential for immediate greenhouse gas advantages (Fargione et al 2008). Additional scenarios for biofuel stock include creation fast growing species plantations and use of unmerchantable trees (USFS).

A plant on the forefront of woody biofuel creation, the Burlington, Vermont based McNeil Generating Station focuses on the creation of energy from low grade trees. Seventy percent of wood used to run the McNeil station is composed of low quality trees, chipped in the forest. The remaining portion of wood needed for the station’s operation is obtained from mill residues and urban wood waste (Burlington Electric Department). Once received at the plant, the wood chips are converted to megawatts of electricity through the process of gastrifcation (National Renewable Energy Laboratory). At full station capacity, McNeil’s gastrification process, which converts biomass to fuel gas by heating the biomass under controlled pressure, temperature and atmospheric conditions, can generate fifty megawatts of electricity (Burlington Electric Department). With over twenty years of experience converting wood to energy, the McNeil Generating Station is an example of current, large scale biofuel technology (Schill 2007).

Study Objectives

The purpose of this study is to assess the current state of northeast forests and the ways in which they can aid in the mitigation of atmospheric carbon. The areas explored include current forest structure, carbon storage within forests, annual fluctuation in forest carbon, the status of current harvests, and the possible benefits of forest biofuels for offsetting fossil fuels given the present technology.

METHODS

Study Area

Data for this study came from four northeast states, Maine, New Hampshire, Vermont and New York. For New York the Mohawk River was used as a geographical division line. Only regions north of the river were included in the dataset. Across the study area, annual temperatures in Fahrenheit in 2008 ranged from mid 30s to mid 50s (NOAA) with annual precipitation ranging from 28 to 80 inches (PRISM Climate Group).

Throughout the study area, two major forest cover types are dominant, spruce-fir and mixed hardwoods. Within the mixed hardwood forests were found components of maple, beech, birch, oak, hickory, additional hardwoods and occasional conifers. The maple, beech, birch cover type was the most prevalent hardwood forest, dominating throughout Vermont and New Hampshire, New York and southern Maine. The spruce-fir forest type was most widespread across mid to northern Maine (USFS Forest Inventory Analysis).

Data

Data from the U.S. Forest Service Forest Inventory Analysis (FIA) were used. The large size of the dataset provided by FIA made it desirable for the large scale of this study. For the collection of FIA data, one sample plot was placed roughly every 6,000 acres throughout the United States. Plots were sampled following the national sample design, where one plot is composed of four subplots. The total area of one sample plot is equal to .067 hectares. On each subplot, trees five inches in diameter or greater are recorded. FIA sampling occurs in sampling cycles, where each plot is re-measured about every five years (USFS FIA). For this study only FIA data from cycle 5 and cycle 6, the most recent cycles, were used. Additionally, only trees above five inches in diameter were included.

Statistical model

A statistical model was used to determine trends within the northeast forests. The first step in the creation of this model was making a subset of the entire FIA dataset. The new dataset included only information from the northeast region and cycles of interest. Area and weight information from FIA plots was converted from acres and pounds to metric units of hectares and metric tons. Data were also specified to only include trees above five inches in diameter.

To determine what portion of the forests are dominated by which forest cover type, either spruce-fir of mixed hardwood, the data were divided based on supplied cover type information from FIA. The mixed hardwood cover type was defined to include any combination of the white, red, jack pine group, oak, pine group, oak, hickory group, elm, ash, cottonwood group, maple, beech, birch group, aspen, birch group and the generic other hardwoods group. Forests termed spruce-fir, contained plots falling within the FIA termed spruce-fir group.

To further assess the forest, a carbon variable was created from the given FIA carbon data. FIA reported a variable called CARBON_AG which gave the mass in pounds of carbon in all trees above one inch in diameter. From CARBON_AG a new variable was created, called Adult Aboveground Carbon (AAC). The AAC variable represents the carbon stored in the aboveground portion of trees that were above five inches in diameter. AAC additionally converted FIA data from pounds per tree to metric tons per hectare. To do this, all carbon measurements of a plot were summed and that number converted from pounds to metric tons using the conversion factor of one pound is equal to .00045 metric tons. Once all units of measurement were in metric tons, area was that converted from acres to hectares, using the measurement that one acre is equal to .405 hectares. The AAC on all plots was summed and divided by the total number of plots within the dataset to find the mean AAC within the dataset. To find the mean total AAC across the landscape, each plot was multiplied by the 6,000 acre conversion factor and then converted to hectares.

Another variable called Annual Carbon Increment (ACI) was created to represent the change in AAC throughout the plots for each year. To find the ACI, only plots that had not been harvested in cycle 5 and cycle 6 were used. The non-harvested plots were used as they represented potential changes in forest carbon without the influence of harvesting. The ACI was calculated by dividing the difference in Adult Aboveground Carbon between cycles 5 and 6 by the re-measurement period of each plot. Once ACI had been found for each plot the average ACI was calculated using the median as it was less sensitive to extreme values that appeared. The next step was to determine how ACI changed as the amount of AAC on plots changed. The first step in finding this change was to divide the range of AAC into 25 unit sections and examine the sample size of each section. For each section the sample size was acceptable, except for sample sizes in the 100 to <125section and the 125 to 150 metric tons per hectare section. The final two sections of AAC were combined to create one section, in order to increase the sample size. The final sections used in analysis of AIC as a function of AAC were 0 to <25 metric tons per hectare, 25 to <50 metric tons per hectare, 50 to <75 metric tons per hectare, 75 to <100 metric tons per hectare and 100 to 150 metric tons per hectare. The average AICs for each section of AAC were then found, again using the median.

Once an assessment had been made about Adult Aboveground Carbon and Annual Carbon Increment across all plots, current harvesting was evaluated. First, the percentage of plots experiencing harvests each cycle was found. This was done by dividing the number of harvested plots by the total number of plots in the dataset. To determine the annual percentage of plots harvested each year, the percentage harvested between cycles was divided by the re-measurement period.

Next, a new subset of the data was made to look specifically at plots with harvesting activity. Within harvested plots, the percentage of basal area removed during each harvest was found by dividing the amount of removed basal area in cycle 6 by the amount of live basal area in cycle 5. The percentage of basal area lost to additional mortality between cycles was found following the same method, just replacing basal area removed with basal area in mortality. Finally, the harvested basal area was converted to removed Adult Aboveground Carbon and then removed biomass. To do this, a linear model was fit to the graph of Adult Aboveground Carbon for cycle 6 as a function of total basal area in live trees for cycle 6 (Figure 1). The slope of the regression line, 2.20, was used as a conversion factor between basal area and Adult Aboveground Carbon. Next, biomass was said to represent twice the amount of AAC for the conversion of AAC to biomass. To set the amount of biomass harvested between cycles to an annual estimate, the amount of biomass removed between cycle 5 and cycle 6 was divided by the average re-measurement period. Next, the distribution of AAC on both cycle 5 and cycle 6 harvested plots was looked at to determine at what level of AAC the most harvesting occurred. The average AAC for cycle 5 and cycle 6 harvested plots was also calculated.

A conversion was made between metric tons of harvested biomass and metric tons fossil fuel offset by wood energy. Information for this conversion came from the McNeil Generating Station in Burlington Vermont. The efficiency with which McNeil converts woody materials to megawatts of energy was then compared to the efficiency with which fossil fuels can generate the same amount of energy. Units of measurement were then converted to metric units. The created conversion factor was next applied to the previously found harvest data. To create comparisons, four harvesting scenarios were run. For each harvesting scenario, plot level harvests were scaled up to landscape level harvests, based on the FIA assumption that one plot represents 6,000 acres. The first scenario asked how much fossil fuel could be offset under current harvesting practices, the second scenario doubled the amount of biomass harvested, the third scenario doubled number of hectares harvested, and the fourth scenario doubled both the amount of biomass harvested and the number of hectares harvested. The energy conversion factor was then applied to biomass from all four scenarios to see the potential fossil fuel offset under the variety of harvesting options.

The future forest

Lastly, a projection was made to determine how current harvesting and Annual Carbon Increment might affect Adult Aboveground Carbon in a future forest. To begin, the ACI across all plots was found for the five brackets of AAC previously mentioned. The ACI for each bracket was found using the previously mentioned methods (Table 7). Next, the annual harvesting across all plots associated with each bracket of AAC was found (Table 8). To do this, the basal area removed associated with each bracket of AAC was determined. Basal area removed was then converted to carbon removed using the previously mentioned conversion factor of 2.20. The annual amount of harvesting was calculated by dividing removed carbon by the re-measurement period. The simulation began with a plot containing the average amount of AAC as the starting point. To the starting AAC, the correlating amount of ACI was added and the correlating amount of harvested carbon was subtracted. The simulation continued to move through the dataset summing the total AAC present and always applying the associated amount of ACI and subtracting the associated amount of harvest. The simulation was run for a 100-year time step. Five simulations were run to determine if any trends were present (Figure 10).

Analysis of this research was completed using the statistical software R.

Additional Information

This study was part of a larger project completed with Dr. Charles Canham of the Cary Institute of Ecosystem Studies.

RESULTS

The current northeast forest

The northeast forest currently has a normally distributed stand age structure with the highest number of plots falling between sixty and eighty years old (Figure 2). The mean average stand age is 60.78 years. Stand age ranges from very young stands, to over 150 years old. Above 100 years, the number of plots within each age group steadily decreases.

The two major forest cover types across the study site include spruce-fir and mixed hardwoods (Figure 3). The majority of plots fall within the mixed hardwood cover type.

Within northeast forests, the distribution of Adult Aboveground Carbon is skewed to the left (Figure 4). The highest concentration of AAC is in plots containing zero to ten metric tons of carbon per hectare. For each increasing ten metric ton per hectare unit, there is a visible decrease in the number of plots. The distribution of AAC ranges from zero to over 100 metric tons per hectare. The AAC across all plots is 35.11 metric tons per hectare which translates to 302,555,593 metric tons across the northeast landscape.

The Annual Adult Carbon increment covers a wide range, with plots falling between negative five and five metric tons of carbon per hectare (Figure 5). The mean annual adult carbon increment is .62 metric tons per hectare (Table 1). The majority of plots have positive annual carbon increment; however a notable number of plots do have negative carbon increments.

Fluctuation can be seen in Annual Carbon Increment when plotted against Adult Aboveground Carbon (Figure 6). As AAC increases there is a gradual increase in ACI. The affect of AAC on ACI can be seen in more detail when ACI is broken down into five sections based on AAC (Table 2). Annual Carbon Increment increases steadily with each twenty-five unit increment until metric tons of AAC per hectare is above 100, after 100 metric tons of AAC per hectare there is a slight decrease in ACI. The peak of ACI is 1.22 metric tons of AAC per hectare, occurring on plots with 100 to 150 metric tons of AAC per hectare. The lowest ACI, .36 metric tons per hectare, occurs on plots with the lowest amount of AAC, ranging from zero to twenty-five metric tons of AAC per hectare.

Current harvesting

Within the Northeast forests, 3.45% of current plots experience some level of harvesting each year (Table 3). The distribution of harvested plots within the distribution of all plots show the small impact harvesting has on the dataset (Figure 7 and Figure 8). In cycle 5, the overall distribution of AAC on plots is skewed to the left. The small subset of harvested plots in cycle 5 has a normal distribution of AAC. In Cycle 6, the distribution of AAC for all plots remains skewed to the left. The subset of harvested plots in Cycle 6 however, now has a distribution of AAC that is skewed to the left.

The linear model used to convert from basal area to Adult Aboveground Carbon had an R squared value of .92. When harvesting does occur on a plot, there is an average basal area removal of 40.89% over the re-measurement period, or 8.04% of the basal area removed each year. The average amount of biomass harvested off of plots is 7.35 metric tons per hectare each year.

On harvested plots, a noticeable shift occurs in adult aboveground carbon between cycle 5 and cycle 6 (Figure 9). Prior to harvesting, AAC for cycle 5 has a relatively normal distribution. The highest number of plots contain between thirty and forty metric tons of AAC per hectare. The average AAC is 44.99 metric tons per hectare (Table 4). Following harvest, the distribution of AAC on harvested plots shifts to the left. The highest number of plots now contain between zero and ten metric tons of carbon per hectare, with a mean Adult Aboveground Carbon of 28.71 metric tons per hectare (Table 4).

Mortality

On plots where some level of harvesting occurs there is an average 9% basal area lost to mortality between each cycle aside from that removed during harvesting each cycle, which translates to 1.77% of the basal area removed each year.

Conversion of biomass to biofuel

Metric tons of woody biomass are compared to metric tons of fossil fuel offset through the substitution of wood based biofuel, following the previously described methods (Table 5). One metric ton of woody biomass converted to biofuel offsets .36 metric tons of fossil fuel. Annually 7.35 metric tons of biomass is harvested per hectare, when converted to biofuel this biomass offsets 2.65 metric tons of fossil fuel per year.

Increases and decreases in harvesting levels create a variation in the amount of fossil fuel offset through the creation of biofuel from woody biomass (Table 6). Current harvesting within plots has an annual removal of 7.35 metric tons per hectare across 3.34% of all plots. The resulting fossil fuel offset from harvesting across the landscape is 748,359 metric tons each year. Two scenarios, doubling the amount of biomass removed and doubling the amount of hectare harvested, resulted in the same offsets of 1, 469,718 metric tons of fossil fuel each year.

The future forest

Annual Carbon Increment across all plots increases as Adult Aboveground Carbon Increases (Table 7). The highest ACI occurs on plots with 100 to 150 metric tons of AAC per hectare. The lowest ACI occurs on plots containing zero to twenty-five metric tons of AAC per hectare.

The amount of carbon harvested across all plots decreases as the amount of AAC across all plots increases (Table 8). The highest amount of harvesting occurs on the plots with the lowest amount of AAC, while the lowest amount of harvesting occurs on plots with the highest amount of AAC.

If current harvesting and Annual Carbon Increment are applied to current Adult Aboveground Carbon on the landscape, in 100 years there would be a positive increase in Adult Aboveground Carbon (Figure 10). For five simulations there was a positive trend seen in AAC. There was variation seen between the five simulations, AAC was seen to range between doubling and tripling over a 100 year period.

DISCUSSION

Forest structure

The results of this study show the majority of forests in the northeast region are composed of mixed hardwood stands, with stand successional stages ranging from very young to old growth. Stand age however, may vary from the numbers in the dataset as CARBON STORAGE

Study results also show northeast forests are storing a notable amount of carbon in the aboveground portion of adult trees. Across the study area, the highest number of plots are holding carbon in levels below fifty metric tons per hectare. Each year, the average plot gains carbon, yet some are losing as much as five metric tons of carbon per hectare. Across all plots, Annual Carbon Increment as a function of Adult Aboveground Carbon follows a positive trend. Only when Adult Aboveground Carbon exceeds 100 metric tons per hectare does the trend begin to decrease; however, the overall Annual Carbon Increment still remains positive. The average plot currently holds just over thirty-five metric tons of AAC per hectare, which is below the range of AAC at which ACI peaks. Given the current average AAC and the corresponding ACI, northeast forests still have time to reach their carbon storage peak. It is assumed that FIA carbon data is half of biomass found within the field, this assumption could cause variations between the calculated carbon within the forest and the actual amount of carbon present in the forest. FIA data is also does not take into account measurement errors made in the field which could also cause variations between calculated and actual numbers.

Harvesting

Within the entire dataset, harvesting is found to occur on 3.45% of all plots, making it a minimal part of annual forest landscape. However, harvests occur on a much longer rotation length, making them a larger part of the overall forest landscape. Figure 7 and Figure 8 further show the small impact of harvesting on the overall distribution of Adult Aboveground Carbon over a five year period, but again harvesting occurs on a longer rotation length than five years which could result in a larger impact. Figure 7 shows the overall distribution of plots in cycle 5, while the subset histogram shows the distribution of Adult Aboveground Carbon on harvested plots. Figure 8 shows the same information for cycle 6. In cycle 6, the distribution of harvested plots has shifted from normal to skewed to the left, yet the shape of all plots remains skewed to the left, minimally affected by harvesting. The change in distribution of AAC on harvested plots also shows that the most carbon is harvested from plots containing thirty metric tons or higher. Specifically plots in the range of thirty to forty metric tons of AAC per hectare and fifty to sixty metric tons of AAC per hectare. The number of plots harvested begins to decrease when metric tons of AAC per hectare climbs over sixty. A possible cause for this decrease in harvesting on plots over sixty metric tons per hectare is the limited number of plots containing sixty metric tons of AAC per hectare. If more plots were present, harvesting might not decrease. A final point to consider is changes in the distribution of Adult Aboveground Carbon due to the role of mortality. Mortality levels are noted for harvested plots, yet mortality is not factored in to the final distributions of AAC.

Biofuel conversions and fossil fuel offsets

Finally, results from the conversion of harvested biomass to biofuel show that current technology for creation of biofuel is slightly more than a third as efficient as the technology used to create fossil fuels. For current harvesting practices, just less than 750,000 metric tons of fossil fuel could be offset annually. Should all aspects of harvesting be doubled, the number of hectares harvested and the amount of biomass removed, just less than three million metric tons of fossil fuel could be offset. However, the United State was using 2000 million metric tons of fossil fuel in 2004, a number that has likely increased over the past five years. To make forest biofuels more competitive with given technology, harvesting levels would need to be increased dramatically, raising the question of sustainable forestry. Another option would be to increase the efficiency with which biofuels are created. The conversion of woody biomass to biofuel does not take into account the distance between the biomass source and the site of biofuel creation, a distance that should be below fifty miles or less to make the entire process both economically and environmentally beneficial (US Department of Energy, Federal Energy Management Program). Additionally, the assumption is made that all harvested materials were converted to biofuel, an action currently not practiced and not expected to occur in the future.

The future forest

Over a 100 year period, five simulations for Adult Aboveground Carbon showed that AAC will continue to increase. However, there was a large amount of variation between the five simulations. Variations between simulations can be attributed to variation in the amount of Annual Carbon Increment occurring and the amount of harvesting on a plot. Yet, regardless of variation, each trend shows AAC positively increasing over the 100 year period, further suggesting that northeast forests have the potential to positively continue storing carbon.

Future study directions

Outside of this study are additional areas in which northeast forest have the potential to store atmospheric carbon. A large site of carbon storage within forests, not touched upon in this study, is forest soils, which store much of the carbon from decomposing vegetation (Gorte 2007). Another area of potential carbon storage includes the additional biomass harvested for wood products, whether in active use or in landfills (Skog 2005).

Aside from the additional carbon pool, results of this study did not touch upon carbon, biofuel, or harvesting variations by species. A change in harvesting was not examined by state either. A breakdown of this study by species or state has the potential to produce different results.

CONCLUSION

Through this study, forests of the northeast were found to contain a high ratio of mixed hardwood to spruce-fir stands, with an average age class of slightly over sixty years. Significantly, current levels of Adult Aboveground Carbon across the landscape were found to be well below the peak at which Adult Carbon Increment begins to decrease. The gap between current Adult Carbon Increment and peak Adult Carbon Increment suggests that northeast forest have not yet reached the maximum carbon storage. Northeast forests can be expected to continue working as a positive sink for atmospheric carbon. The role of harvesting in northeast forests was found to minimally influence the distribution of Adult Aboveground Carbon across the landscape. When all harvested material was converted to biofuel, the amount of fossil fuel offset was not enough to match the amount of fossil fuel used. Before a balance can be found between forest carbon sequestration and forest biofuel creation with the aim of reducing atmospheric carbon, the forest as entire ecosystem must be considered and the efficiently of biofuel technology increased.

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APPENDIX

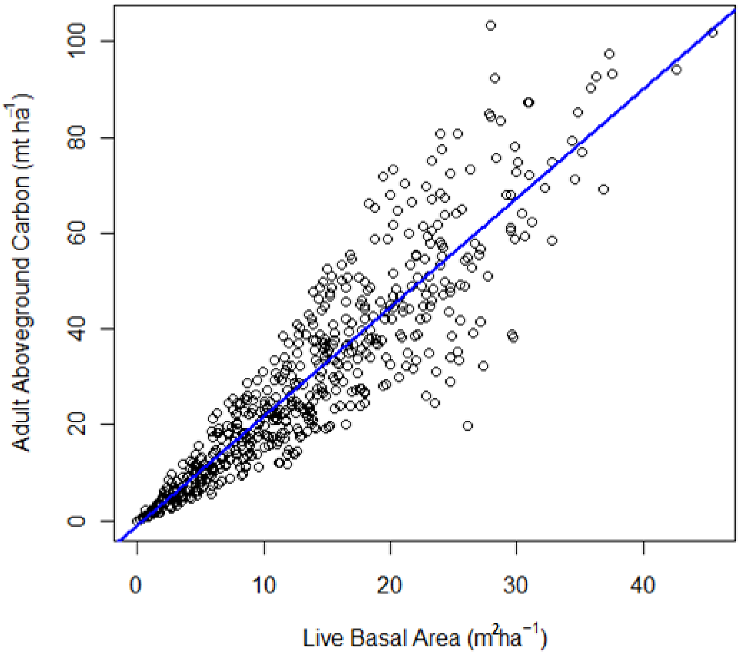


FIGURE 1. Adult Aboveground Carbon as a Function of Basal Area.

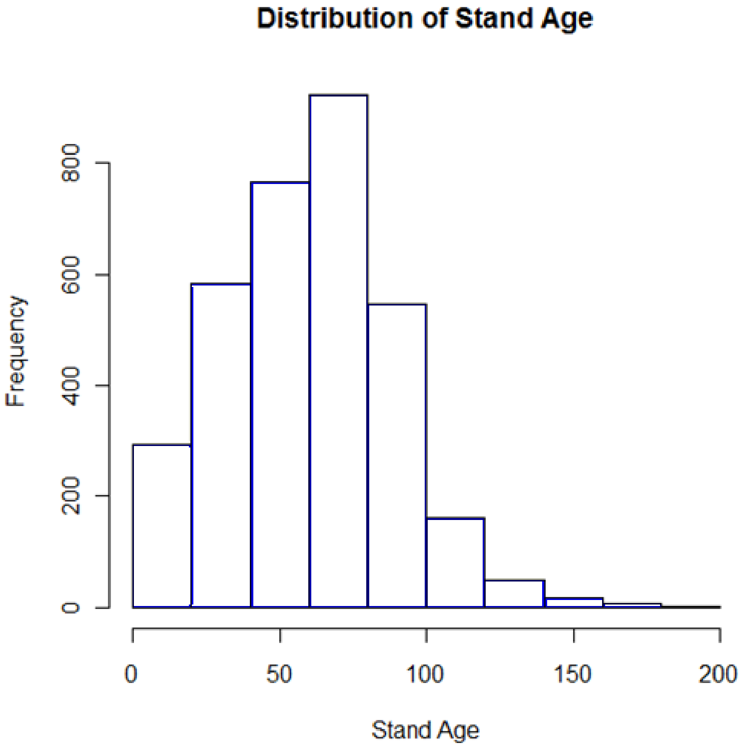


FIGURE 2. Distribution of Stand Age for Trees over 5 inches in Diameter.

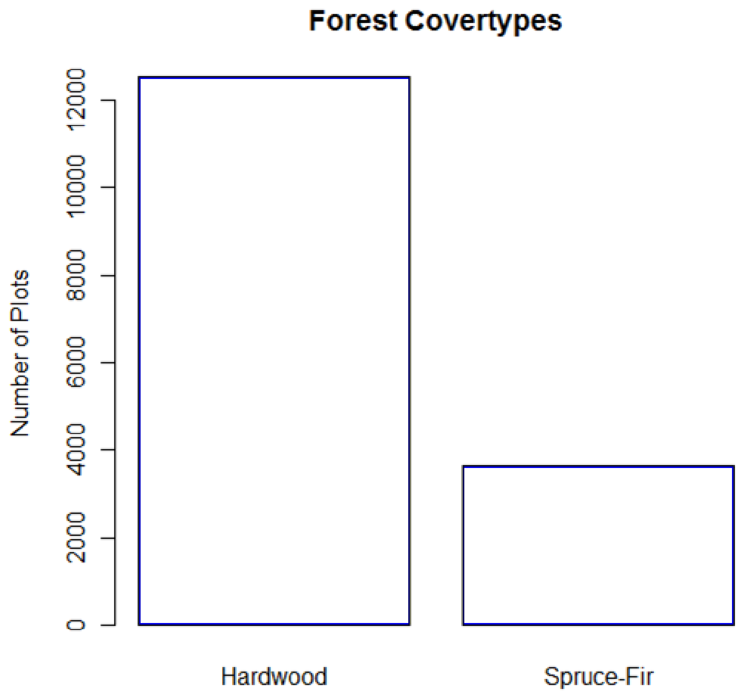


FIGURE 3. Number of Plots within each Forest Cover Type.

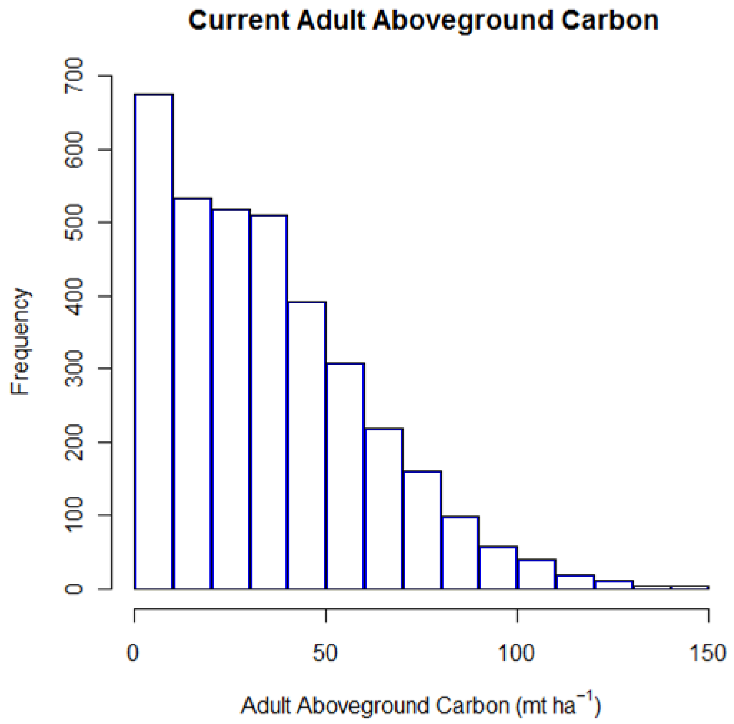


FIGURE 4. Distribution of Current Adult Aboveground Carbon.

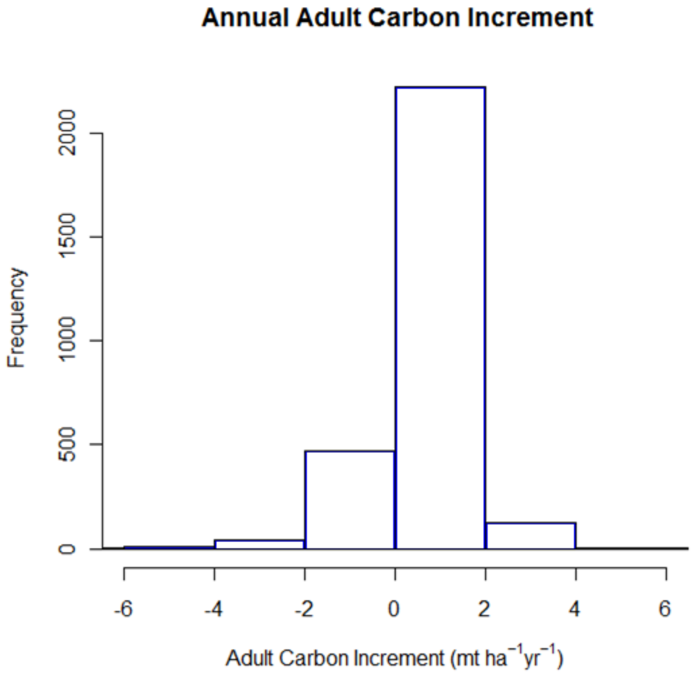


FIGURE 5. Annual Adult Carbon Increment on Unlogged Plots.

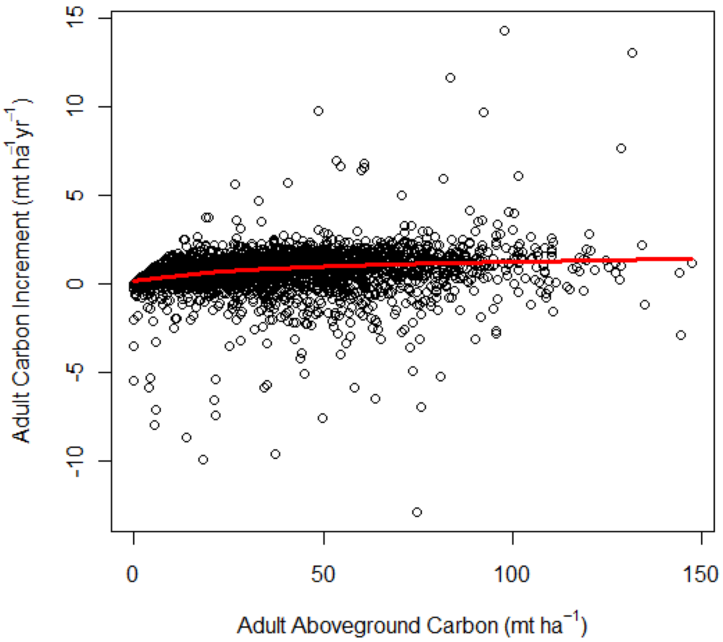


FIGURE 6. Effect of Adult Aboveground Carbon on Annual Carbon Increment on Unlogged Plots with a Lowess Line.

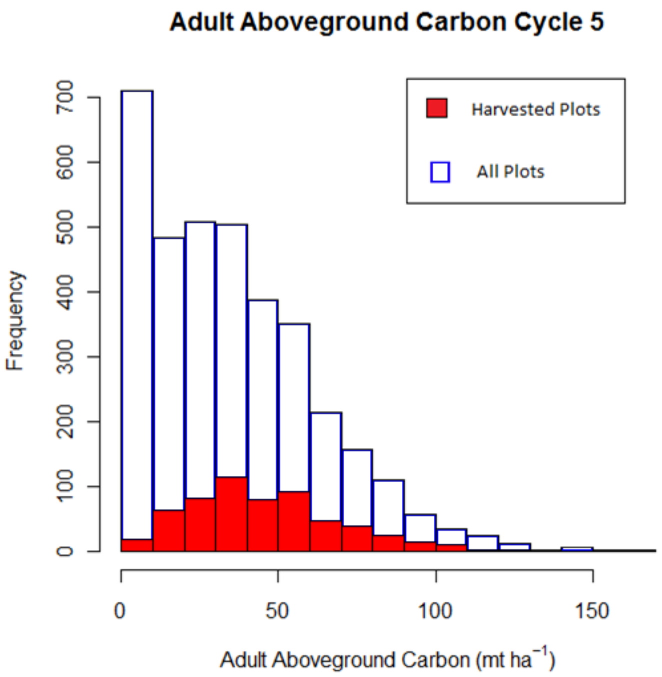


FIGURE 7. Distribution of Adult Aboveground Carbon for Cycle 5 on Harvested Plots within Distribution of Adult Aboveground Carbon Across all Plots in Cycle 5.

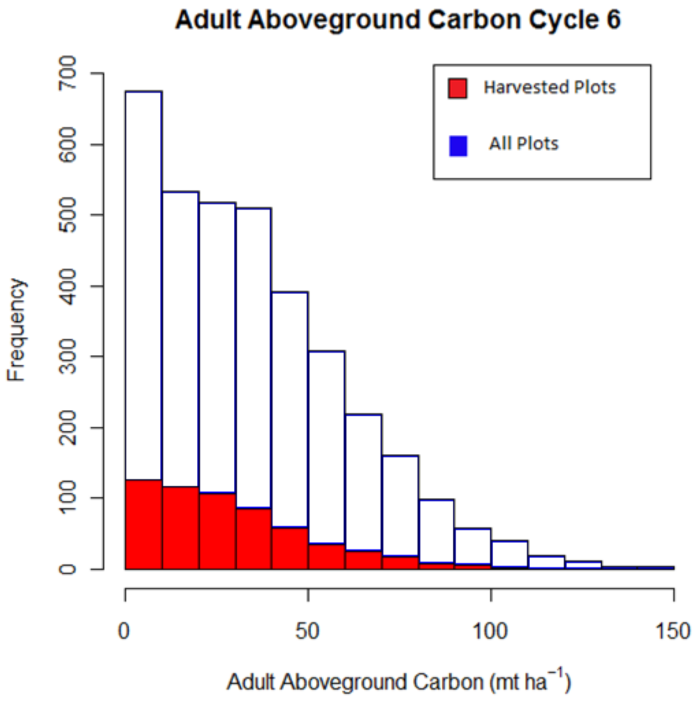


FIGURE 8. Distribution of Adult Aboveground Carbon for Cycle 6 on Harvested Plots within Distribution of Adult Aboveground Carbon Across all Plots in Cycle 6.

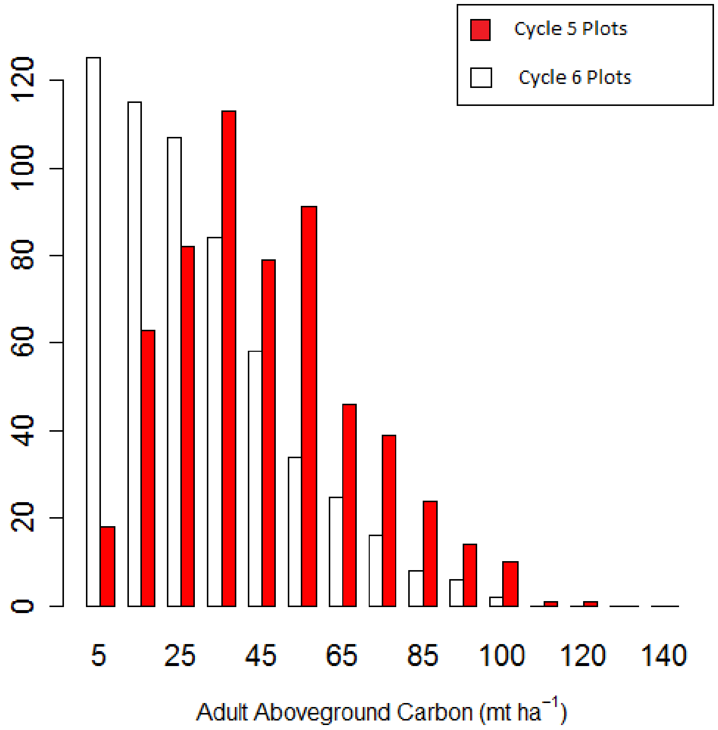


FIGURE 9. Distribution of Adult Aboveground Carbon on Harvested Plots for Cycle 5 and Cycle 6.

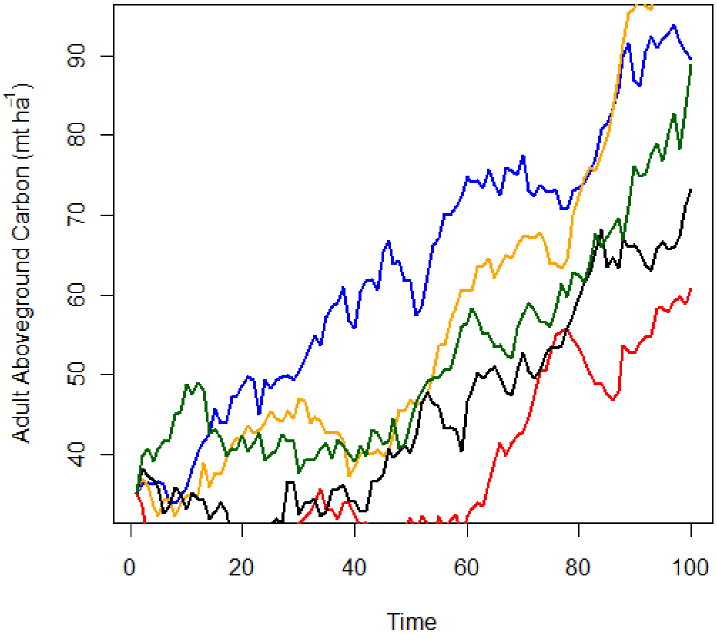


FIGURE 10. Adult Aboveground Carbon Over 100 Years

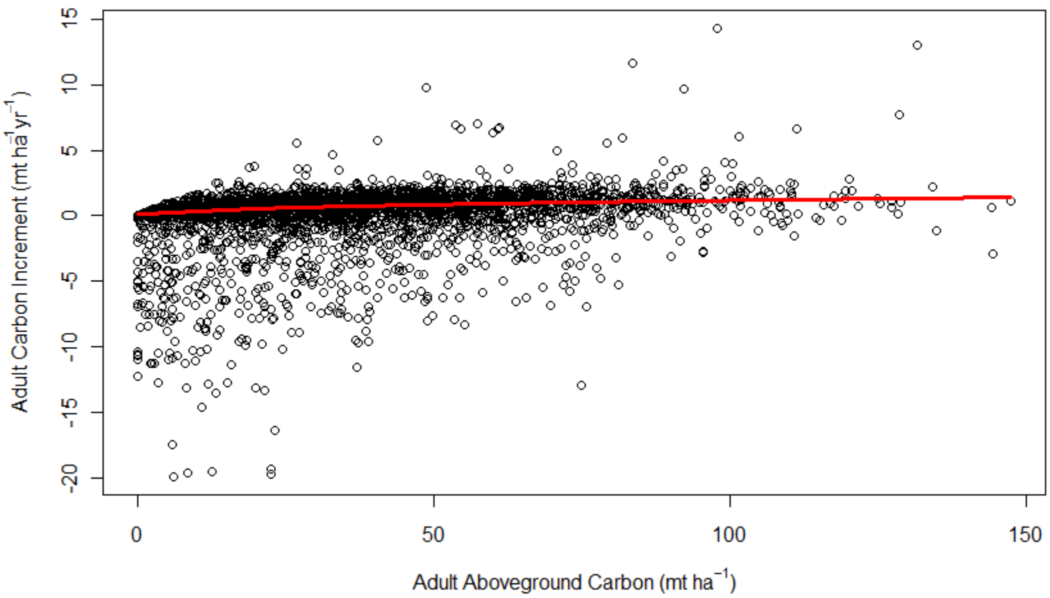


FIGURE 11. Annual carbon increment across all plots.

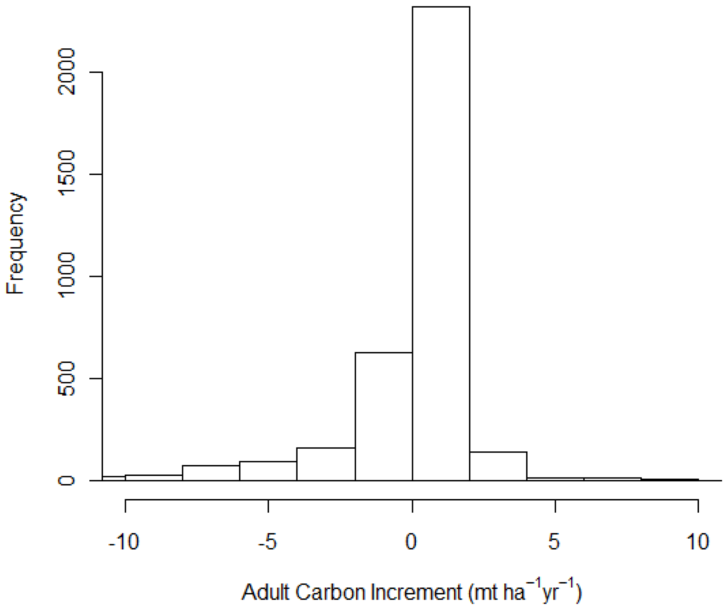


FIGURE 11. Annual carbon increment across all plots.

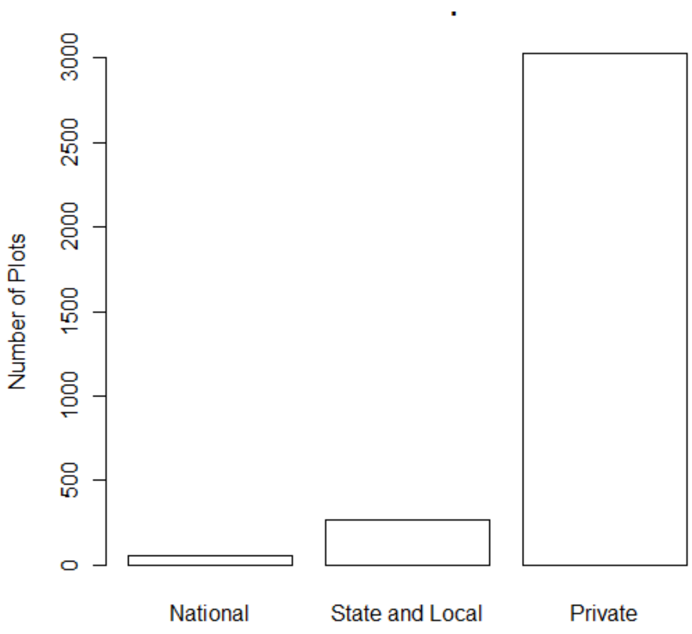


FIGURE 13. Forest ownership groups.

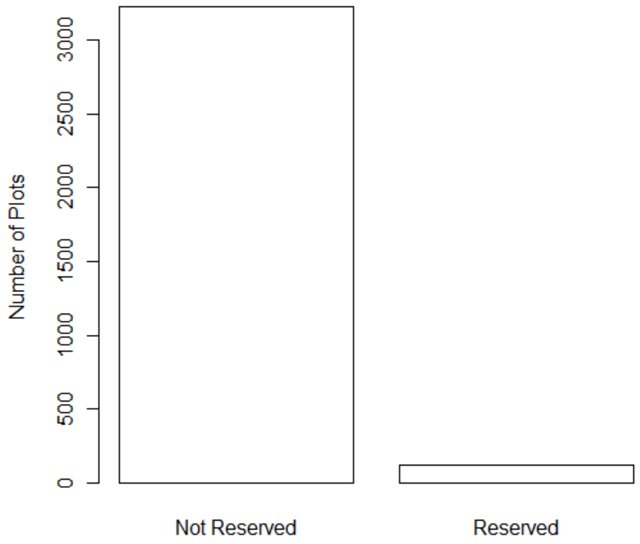


FIGURE 14. Forest reserved land.

TABLE 1. Average Adult Carbon Increment on Unlogged Plots (mt ha^{-1} yr^{-1})

Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
-3.82	.14	0.64	0.62	1.18	4.76

TABLE 2. Annual Carbon Increment Variation with Adult Aboveground Carbon on Unlogged Plots

Range of Adult Aboveground Carbon (mt ha^{-1})	Average Annual Carbon Increment (mt ha^{-1} yr^{-1})
0-25	0.36
>25-50	0.84
>50-75	0.97
>75-100	1.16
>100-150	1.22

TABLE 3. Percentage of Plots Harvested Annually

Number of Plots Harvested	Total Number of Plots	Percentage of Plots with some Level of Harvest
116.48	3374	3.45%

TABLE 4. Mean Adult Aboveground Carbon per Cycle on Harvested Plots

Cycle	Average Adult Aboveground Carbon (mt ha^{-1})
5	44.99
6	28.71

TABLE 5. Conversion of Annual Amount Harvested to Fossil Fuel Offset

Mt of Biomass	Mt of Fossil Fuel Offset	Current Biomass Harvested (mt ha^{-1} yr^{-1})	Fossil Fuels Offset (mt)
1	.36	7.35	2.65

TABLE 6. Conversion of Annual Harvest to Fossil Fuel Offset with Harvesting Variation

Harvesting Scenario	Mt of Biomass Harvested	Hectares Harvested	Total mt of Biomass Harvested	Mt of Fossil Fuels Offset
Current Harvesting	7.35	282,826	2,078,776	748,359
Double Biomass Harvested	14.70	282,826	4,157,552	1,496,718
Double Number of Hectares Harvested	7.35	565,653	4,157,552	1,496,718
Double Biomass Harvested and Number of Hectares Harvested	14.70	565,653	8,315,105	2,993,437

TABLE 7. Annual Carbon Increment Variation with Adult Aboveground Carbon Across all Plots

Adult Carbon Increment (mt ha^{-1})	Annual Carbon Increment (mt ha^{-1} yr^{-1})
0-<25	.22
25-<50	.72
50-<75	.87
75-<100	1.13
100-150	1.27

TABLE 8. Variations of Carbon Harvesting with Adult Aboveground Carbon

Adult Aboveground Carbon (mt ha^{-1})	Harvested Carbon (mt ha^{-1} yr^{-1})	Standard Deviation
0-25	.97	2.29
>25-50	.48	1.45
>50-75	.26	.95
>75-100	.09	.48
>100-150	.01	.05

TABLE 9. Annual Carbon Increment Across all Plots (mt ha^{-1} yr^{-1})

1st Quartile	Median	Mean	3rd Quartile
-.08	.51	-.03	1.09

TABLE 10. Annual Biomass Harvested on Harvested Plots (mt ha^{-1}- yr^{-1}).

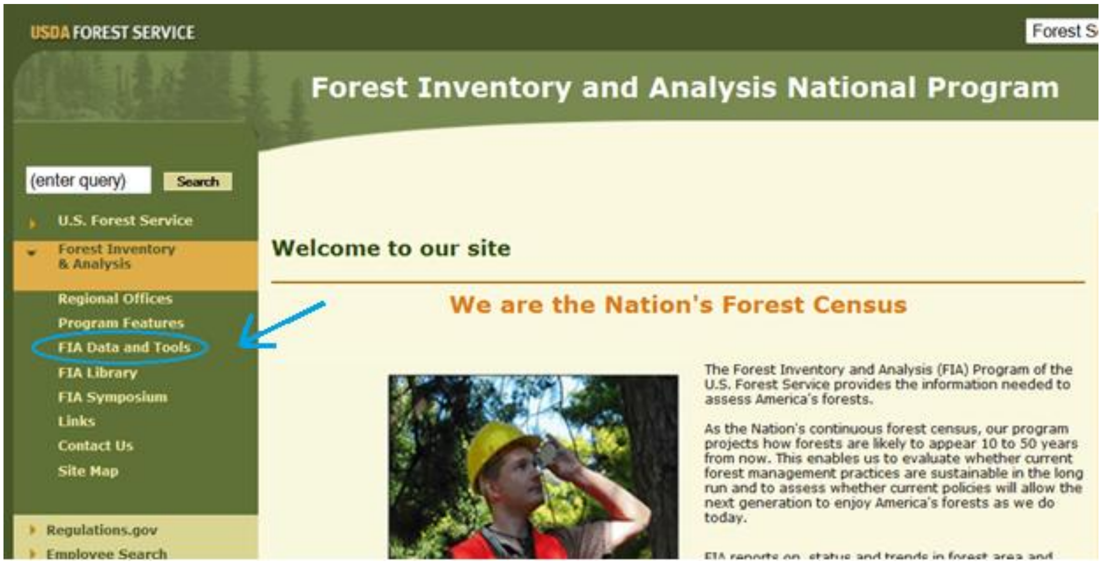
Min	1st Quartile	Median	Mean	3rd Quartile	Max
.18	2.56	5.54	7.39	10.75	26.62

TABLE 11. Biomass harvested between cycles on harvested plots (mt ha-1).

Min	1st Quartile	Median	Mean	3rd Quartile	Max
.89	12.65	28.12	36.64	52.28	140.50

TABLE 12. Mortality between cycles and annually on all plots.

Measurement Period	Basal Area lost to Mortality
Between Cycles	14.28
Annually	2.86



Welcome to our site

We are the Nation's Forest Census

The Forest Inventory and Analysis (FIA) Program of the U.S. Forest Service provides the information needed to assess America's forests.

As the Nation's continuous forest census, our program projects how forests are likely to appear 10 to 50 years from now. This enables us to evaluate whether current forest management practices are sustainable in the long run and to assess whether current policies will allow the next generation to enjoy America's forests as we do today.

FIA reports on status and trends in forest area and

IMAGE 1. U.S. Forest Service Forest Inventory Analysis Home Page - Data Collection Step 1.

Data and Tools

User Alerts:

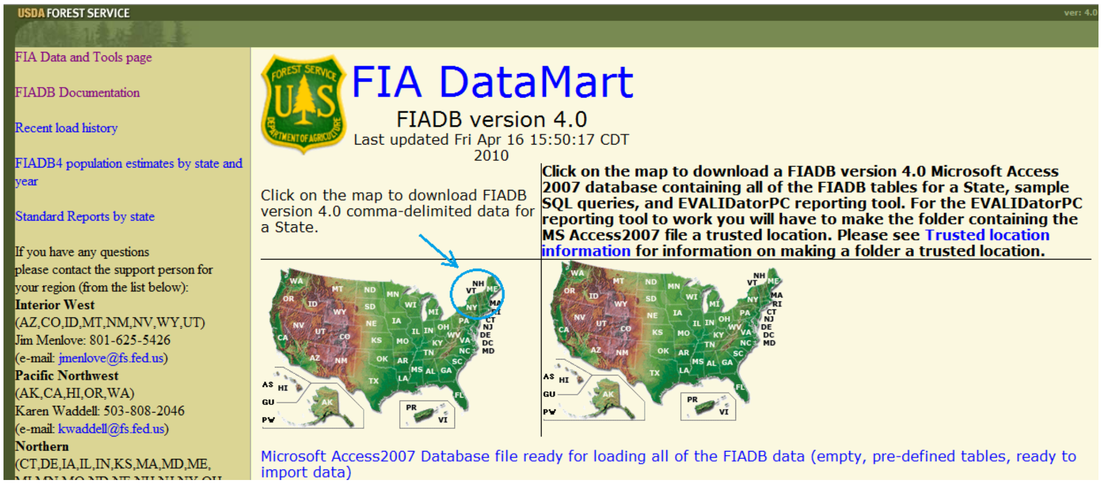
User alert regarding Forest Type changes in FIADB 4.0

User Alert Regarding Biomass and Carbon Estimates

Sign up to be notified of upcoming FIA training opportunities!

Surf forest inventory data using the FIDO on-line tool!! Create your own forest inventory tables and maps.

IMAGE 2. U.S. Forest Service Forest Inventory Analysis Data and Tools Page - Data Collection Step 2.



FIA DataMart

FIADB version 4.0

Last updated Fri Apr 16 15:50:17 CDT 2010

Click on the map to download FIADB version 4.0 comma-delimited data for a State.

Click on the map to download a FIADB version 4.0 Microsoft Access 2007 database containing all of the FIADB tables for a State, sample SQL queries, and EVALIDatorPC reporting tool. For the EVALIDatorPC reporting tool to work you will have to make the folder containing the MS Access2007 file a trusted location. Please see Trusted location information for information on making a folder a trusted location.

Microsoft Access2007 Database file ready for loading all of the FIADB data (empty, pre-defined tables, ready to import data)

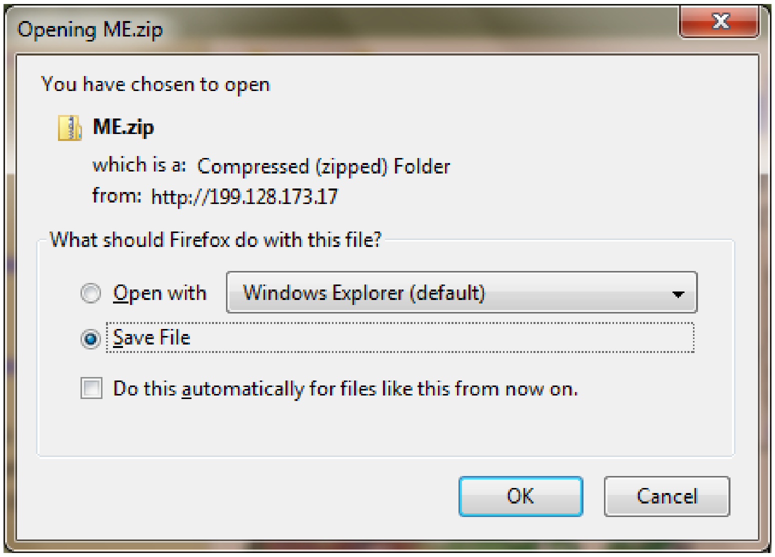
If you have any questions please contact the support person for your region (from the list below):

Interior West
(AZ,CO,ID,MT,NM,NV,WY,UT)
Jim Menlove: 801-625-5426
(e-mail: jmenlove@fs.fed.us)

Pacific Northwest
(AK,CA,HI,OR,WA)
Karen Waddell: 503-808-2046
(e-mail: kwaddell@fs.fed.us)

Northern
(CT,DE,IA,IL,IN,KS,MA,MD,ME,

IMAGE 3. U.S. Forest Service Forest Inventory Analysis DataMart Page – Data Collection Step 3.



Opening ME.zip

You have chosen to open

ME.zip

which is a: Compressed (zipped) Folder

from: http://199.128.173.17

What should Firefox do with this file?

○ Open with Windows Explorer (default)

● Save File

☐ Do this automatically for files like this from now on.

IMAGE 4. U.S. Forest Service Forest Inventory Analysis Zip File Popup Box – Data Collection Step 4.

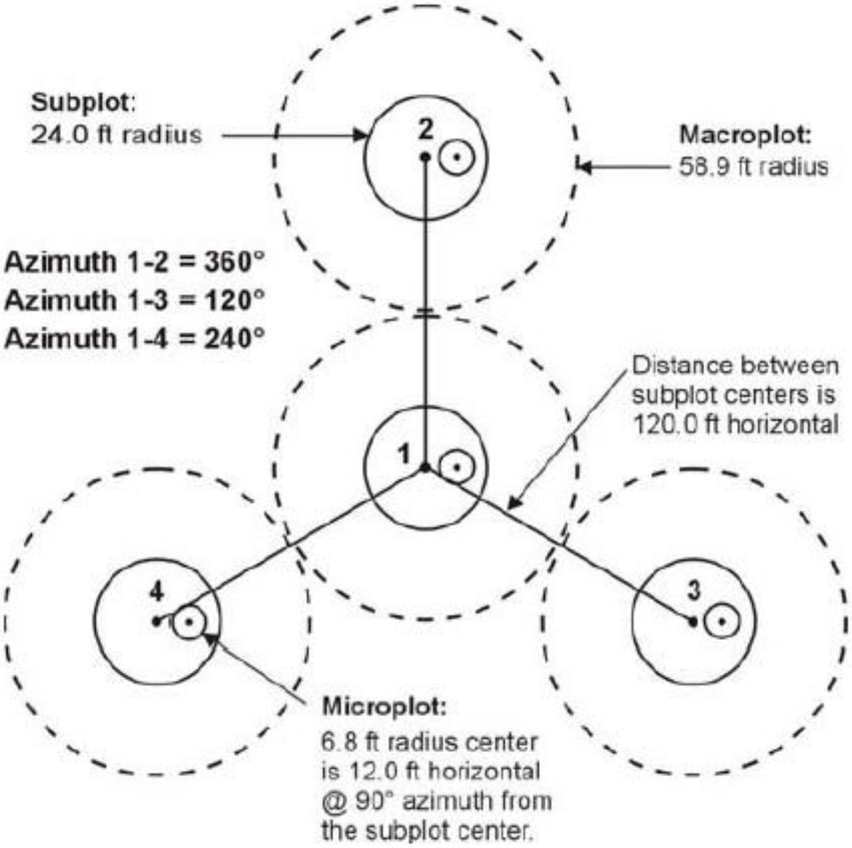


IMAGE 5. U.S. Forest Service Forest Inventory Analysis National