# Methods For Estimating Impact Metrics Associated with Working Forest Fund Projects

1. ***Carbon Dioxide Equivalent (CO2e) stored in the following forest pools: above ground live, belowground live, standing dead trees, understory, down & dead woody debris, litter, and soil.***

   Estimates of CO2e stored in each pool are calculated using the "Forest carbon stocks of the contiguous United States (2000-2009)"dataset. This publication contains 8 raster maps; total forest carbon in all stocks, live tree aboveground forest carbon, live tree belowground forest carbon, forest down dead carbon, forest litter carbon, forest standing dead carbon, forest soil organic carbon, and forest understory carbon." [1] Additional information describing the methods for estimating the carbon pools in the USFS dataset, as well as descriptions of the carbon pools represented may be found in "Inputting forest carbon stock estimates from inventory plots to a nationally continuous coverage".[2]

   These raster maps are grids of 250 m x 250 m pixels, with each pixel representing approximately 6.25 hectares. Each pixel contains a per hectare estimate of the carbon stored in the pool represented in Mg (Megagrams). The per pixel values were converted from Mg C per hectare to MT CO2e per acre using the Raster Calculator[3] tool in ArcGIS. The equation to convert C to CO2e and hectares to acres is described below.

   **Where:**

   1 Megagram = 1 Metric Ton

   1 hectare = 2.47105 acres [4]

   1 MT C = 3.667 MT CO2e [5]

$$1\ MT\ CO2e\ per\ acre = \frac{1\ MG\ C\ per\ hectare}{2.47105\ (hectare\ to\ acre)} \times 3.667\ (C\ to\ CO2e)$$

   After the raster maps were converted to MT CO2e / acre, average stocking per acre was calculated for each pool and for each property within the Working Forest Fund portfolio using

[1] Wilson, Barry Tyler; Woodall, Christopher W.; Griffith, Douglas M. 2013. Forest carbon stocks of the contiguous United States (2000-2009). Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. https://doi.org/10.2737/RDS-2013-0004

[2] USFS carbon mapping methods: https://www.nrs.fs.fed.us/pubs/jrnl/2013/nrs_2013_wilson_001.pdf

[3] ESRI Raster Calculator Tool: http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/raster-calculator.htm

[4] Hectare to Acres: https://www.metric-conversions.org/area/hectares-to-acres.htm

[5] C to CO2e: https://ecometrica.com/assets/GHGs-CO2-CO2e-and-Carbon-What-Do-These-Mean-v2.1.pdf

the Zonal Statistics[6] tool in ArcGIS. This tool calculates the average pixel values within each property boundary. Next, the per acre values are multiplied by the total property acres to determine the total amount of CO2e estimated to be stored in each carbon pool for each forested property.

2. ***Estimated Economic Impacts: Total Economic Impact includes the total value of sales generated from forestry, and total estimated spending from travel and tourism***

The estimated economic impact in 3 primary areas related to the working forests are estimated for each Working Forest Fund project. These categories are total jobs sustained the total value of sales, and total value of tourism/travel. Estimates of total timberland acres per state, total public acres of timberland per state, total private acres of timberland per state, total jobs sustained by workings forests, total payroll impact of working forests, and total value of sales and manufacturing from working forests are derived from "The Economic Impacts of Privately-Owned Forests in the 32 Major Forested States"[7].

The estimated impacts of each Working Forest Fund project are calculated using the per acre impact of private and public timberland in each state, then multiplying the per acre impact by the total acres of the project to estimate the total contribution from each WFF project.

The estimated impact per unit area for each category is calculated at the state level for each of the major 32 timber producing states as follows. The example below depicts the calculation for the Sales & Manufacturing category. Each category is calculated in the same fashion.

**Where:**

*TIp* = The total impact to Payroll of privately owned working forests in a given state

*TAp* = The total acres of privately owned timberland in a given state

*IPUAp* = Impact Per Unit Area (private)

$$IPUAp = \frac{TIp}{TAp}$$

The impact of public acres is calculated in the same fashion.

*TIpub* = The impact to Sales & Manufacturing of publicly owned working forests in astate

*TApub* = The total acres of publicly owned timberland in a given state

*IPUApub* = Impact Per Unit Area (public)

$$IPUApup = \frac{TIpub}{TApub}$$

[6] ESRI Zonal Statistics as Table Tool: http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/zonal-statistics-as-table.htm

[7] 2018 NAFO Report: https://nafoalliance.org/wp-content/uploads/2018/11/Forest2Market_Economic_Impact_of_Privately-Owned_Forests_April2019.pdf

After calculating the privately owned impact per acre and the publicly owned impact per acre, these per acre values are multiplied by the total number of project acres located in each state that are projected to enter permanent public ownership or permanent privately conserved ownership respectively to form an estimate of the total average annual contribution from each project.

The average annual impact of each Working Forest Fund project on travel and tourism is calculated by estimating the number of person trips to each project annually, the leisure dollars spent on each trip, the number of jobs supported by each tripp. A person trip is defined as "One person trip of 50 miles or more, one way, away from home or including one or more nights away from home."[8]

Estimated average annual person trips per project were calculated by referencing the 2016 US Forest Service National Recreation Summary Report.[9]This report estimates that there were 148,125,000 visits to the US Forest Service Land (USFSL) over a 4 year period from 2012-2016. Average annual visitation was estimated to be 37,031,250.

$$\frac{148{,}125{,}000\ vists}{4\ years} = 37{,}031{,}250\ average\ annual\ visits$$

The report also provided an estimate of the portion of visits from different distances, ranging from 1 to over 500 miles. 25% of the visits were from 50-199 miles, a distance which was used as a proxy for an overnight person trip. Visits over 200 miles were conservatively excluded as they were assumed to include international travel, as well as travel targeting recreational amenities USFSL provide that the average WFF project may not include. Visits shorter than 50 miles were also excluded as such short visits are unlikely to include the expenses associated with overnight lodging, etc. Estimated annual person trips to USFSL from 50-199 miles was calculated as 25% of the average annual person trips (9,257,812 trips)

$$37{,}031{,}250\ avg.annual\ vists\ \times 25\%(visits\ 50\ to\ 199\ miles) = 9{,}257{,}812\ person\ trips$$

Next, the average number of person trips from 50 to 199 miles per acre was calculated. There are 193,000,000 acres of forestland in USFS ownership.

$$\frac{193{,}000{,}000\ USFSL\ acres}{9{,}257{,}812\ person\ trips\ 50\ to\ 199\ miles} = 0.048\ annual\ trips\ from\ 50\ to\ 199\ miles\ per\ ac$$

The number of visits per acre from 50-199 miles to WFF projects and USFSL was assumed to be equal for the purposes of estimating the average annual impact of leisure spending related to WFF projects.

The estimated leisure spending total leisure spending, leisure jobs supported, and lesuire spending contribution to tax revenue per trip, and number of domestic person trips are referenced from the

[8] Domestic Travel Fact Sheet https://www.ustravel.org/system/files/media_root/document/Research_Fact-Sheet_Domestic-Travel.pdf

[9] USFS National Visitor Use Monitoring Survey Results: National Summary Report https://www.fs.fed.us/recreation/programs/nvum/pdf/5082016NationalSummaryReport062217.pdf

US Travel Association 2018 Domestic Travel Fact Sheet[8] The per trip values associated with leisure spending, leisure jobs supported, and potential contribution to tax revenue is calculated below.

$$\frac{\$649{,}900{,}000{,}000\ annual\ domestic\ leisure\ spending}{2{,}291{,}100{,}000\ annual\ domestic\ leisure\ trips} = \$283.66\ leisure\ spending\ per\ trip$$

$$\frac{5{,}500{,}000\ leisure\ jobs\ supported}{2{,}291{,}100{,}000\ annual\ domestic\ leisure\ trips} = 0.0024\ leisure\ jobs\ supported\ per\ trip$$

$$\frac{\$100{,}400{,}000{,}000\ annual\ potential\ tax\ revenue\ leisure}{2{,}291{,}100{,}000\ annual\ domestic\ leisure\ trips} = \$43.82\ potential\ tax\ rev\ per\ trip$$

Finally, the estimated impact of each WFF project was calculated by multiplying the total project acres by the estimated number of person visits per acre, then multiplying the number of visits per project by the estimated value of each visit. The formula for leisure spending, jobs, and potential tax revenue was the same, with the formula for leisure spending per project shown below.

Where:

PA = total WFF project acres

AAVac = estimated average annual person visits from 50-199 acres per acre

AAV = estimated average annual person visits from 50-199 acres per project

$pertrip = estimate leisure spending per person trip to a WFF project

$spent = total estimated leisure spending per WFF project

$$PA\ \times AAVac = AAV$$

$$\$pervisit\ \times AAV = \$spent$$

***3. Stream & River Miles: Total miles of streams, rivers, located within each WFF project boundary.***

The miles of streams located within each Working Forest Fund project are calculated using the national hydrography database[10] (NHD) provided by the USGS. The extent of the streams located within each property are selected by clipping from the NHD "flowline" layer to the extent of the property boundary using the ESRI clip geometry tool[7]. Next, any water course that is not a natural stream, (such as a manmade ditch) is removed from the clipped layer. Areas that overlap lakes, ponds, and reservoirs are removed from the clipped layer using the ESRI erase[11] feature tool. Finally, the total stream miles are calculated using the ESRI calculate geometry tool[12].

[10] USGS National Hydrography data https://www.usgs.gov/core-science-systems/ngp/national-hydrography/national-hydrography-dataset

[11] ESRI Erase https://pro.arcgis.com/en/pro-app/tool-reference/analysis/erase.htm

[12] ESRI Calculate Geometry ESRI Calculate Geometry Tool: https://pro.arcgis.com/en/pro-app/tool-reference/data-management/calculate-geometry-attributes.htm