CITY FOREST CREDITS

Tree Preservation Protocol

Version 13 | February 29, 2024

Appendices

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Appendix A – Forest Composition Report Template for Section 11.1.A

Instructions – Complete the report by providing a thorough description of the forest as outlined below. Include photos (at least four to five for each forest stand) as Exhibit A, a map with points where the photos were taken as Exhibit B, a map showing where the forest stands are located as Exhibit C, and supporting documentation for stand age as Exhibit D.

I am [insert name], the [insert title] for [insert organization name] and created this Forest Composition Report for the [insert Project Name] (Project [insert Project Registry number]) on [insert date]. [Include a short statement describing the background/bio of the person who conducted the site visit and forest assessment, with details relevant to demonstrating their technical forestry knowledge/expertise]

The description below is based upon [insert number] site visit(s) to the property on [insert date(s). [Insert a brief description of how you covered the site in your visit and were able to observe most of the entire site. Include a map (Exhibit B) of the route you took to cover the site. Ideally the map shows where the photos were taken]. Images and other data from the site visit(s) are included as Exhibit A to this document [insert in the report or the Exhibits brief descriptions of any methods of data collection]:

- Where is the Project Area located? How many forest stands are included and where are they located within the Project Area? Include a map (Exhibit C) that clearly shows the stands and associated acreage.
- Is the carbon stock in the Project Area uniform or highly variable?
    - Is the tree density (stems per acre) more uniform or highly variable? Describe.
    - What is the approximate density for each for stand? Estimate the approximate number of stems per acre and include your methods. Include two to three plots per forest stand.
    - Are the sizes of the trees more uniform or highly variable? I.e., does the forest appear more or less the same throughout the Project Area or are there sections that vary in density and tree size from other sections? Describe.
- Which one of the types below best describes the forest? If there are different forest types in different sections of the Project Area, provide a description of the forest types, as well as approximate percentage and acreage of the Project Area each forest type occupies.

  For each stand, include the top three to five trees species most represented in the Project Area.

Tree species	Percentage

- What is the stand age, based on historical documents such as aerial photos, imaging, or core sampling? Provide historical documents (Exhibit D) to show how you determined the stand age. If there are sections that contain stands of varying ages, describe the ages and approximate percentage and acreage of the Project Area occupied by the different forest types
- If known, describe the stage of forest succession of the Project Area or sections of the Project Area
- Describe the overall forest health
- Describe the presence of invasive species
- Provide a short summary of the forest and land use history including evidence of past logging or maintenance (if known)
- Describe current uses (i.e. trails)

If the forest includes multiple parcels, provide the details above for each parcel.

Appendix B – Derivation of Displaced Development Factors

When a project takes land out of the pool of land available for development, that action reduces the supply of land available for development or re-development. Some, but not all of the development that would have occurred on project lands is shifted to other lands.

Deductions for displaced development have two components. One component is estimating the fraction of development that is displaced. The second component is estimating emissions for each unit of development displaced.

The amount of displacement has been modelled econometrically by estimating the effect of a change in supply on price, and then estimating the effect of that change in price on demand, and calculating how much total demand changes.

Calculating the fraction of development displaced requires measurements of the relationships of (a) change in price with change in supply, and (b) change in price with change in demand. Both of these relationships have been estimated empirically.

Reducing the supply increases the price of the remaining available lands, which motivates more landowners to put their land on the market and make it available for sale. Economists call this relationship the price elasticity of supply. Wheaton, Chervachidze and Nechayev (2014) estimated the long run price elasticity of supply of housing in 68 metropolitan areas in the US.

Including outlier cases with unusual situations, the median elasticity found for the 68 metropolitan areas is 0.8715. This means that for a small fractional increase in price, the supply would increase by 0.8715. For example, for a 1% increase in price, 0.87% more properties come onto the market.

At the same time, when price increases, demand decreases. Gyourko and Voith (1999) calculate that the price elasticity of demand for residential land is -1, which means when price increases 1% then demand decreases 1%.

The equilibrium with these two shifts can be calculated. This calculation of displacement uses the equation for quantifying displacement given in Murray, McCarl and Lee (2004). We assume that the amount of land conserved is small relative to the total supply of land in an urban area. This is a conservative assumption because as the fraction of total land conserved increases, less land is available for development elsewhere, and less displacement occurs, so not adjusting for the fraction of total supply conserved has very little effect to a small overestimate of displacement. Using the elasticity of supply of 0.8715 and the elasticity of demand of -1, and the equation for calculating the net displacement as an interaction of supply and demand elasticities, 46.6% of the reduced development is made up elsewhere.

On average, lands to which development is displaced have less than 100% forest canopy. Nowak and Greenfield (2018) calculate the average tree canopy cover of US urban areas at 39.4%. We assume that the biomass carbon stock per acre, acres per dwelling unit, and acres of land per square foot of built commercial space are the same. This may be a conservative assumption, because as supply of land is decreased, the density of development increases, with more residences and more square feet of commercial buildings per acre of land. Multiplying the 46.6% of development that occurs elsewhere because of conservation of project lands, times 39.4% tree cover on the lands receiving the displacement means that 18.3% of the conserved tree carbon is lost from displacement of development.

Similarly, there is displacement of impervious surface, which reduces the soil carbon benefit of conserving lands.

The soil displacement factor uses the same displacement rate of 46.6% that is used to calculate the deduction for displacement of biomass emissions.

We have been unable to find measurements of the percent impervious surface in newly developed and re-developed land parcels in US urban areas. Natural Resources Conservation Service (1986) gives the following percent impervious surface by development type:

Use	**Percent Impervious Surface**
Commercial	85
Industrial	72
Residential, 1/8 acre or less per dwelling unit	65
Residential, 1/4 acre per dwelling unit	38
Residential, 1/3 acre per dwelling unit	30
Residential, 1/2 acre per dwelling unit	25
Residential, 1 acre per dwelling unit	20
Residential, 2 acre per dwelling unit	12

Based on discussions with entities considering use of this protocol, it appears that most land that would be conserved is in residential zones. Most of the land zoning would require more than 1/8 acre per dwelling unit. As a conservative but plausible average, we take the impervious cover percentage of the densest residential category, 65%, and assume that a substantial fraction of the residential development is somewhat lower density with a lower fraction impervious surface, and a moderate fraction is commercial development with a higher fraction impervious cover.

Multiplying 65% impervious surface times 46.6% of the development avoided by the project occurring elsewhere equals 30.3% of the soil carbon is lost due to displaced development.

References:

Gyourko, Joseph and Richard Voith. 1999. The Price Elasticity of the Demand for Residential Land: Estimation and Implications of Tax Code-Related Subsidies on Urban Form. Lincoln Institute of Land Policy Working Paper WP99JG1.

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Appendix C – Quantifying Co-Benefits

Introduction

Ecoservices provided by trees to human beneficiaries are classified according to their spatial scale as global and local (Costanza, 2008). Removal of carbon dioxide (CO_2) from the atmosphere by urban forests is global because the atmosphere is so well-mixed it does not matter where the trees are located. The effects of urban forests on building energy use is a local-scale service because it depends on the proximity of trees to buildings.

To quantify these and other ecoservices City Forest Credits (CFC) has relied on peer-reviewed research for quantification of CO_2 storage, and effects of trees on building energy use, rainfall interception, and air quality. CFC's quantification tools provide estimates of co-benefits after 25 years in Resource Units (i.e., kWh of electricity saved) and $ per year. Values for co-benefits are first-order approximations extracted from the i-Tree Streets (i-Tree Eco) datasets for each of the 16 U.S. reference cities/climate zones (https://www.itreetools.org/tools/i-tree-eco) (Maco and McPherson, 2003). Modeling approaches and error estimates associated with co-benefits have been documented in numerous publications (see References below) and are summarized here.

Quantification of Carbon Dioxide Storage

For Tree Preservation Projects, as distinct from Tree Planting or Afforestation/Reforestation Projects, the quantification of CO_2 storage is set forth in Section 11 of the Tree Preservation Protocol. Section 11 describes the methods and source materials, and the Displaced Development (leakage) methodology is set forth in Appendix B to that Tree Preservation Protocol.

Quantification of Co-Benefits

Source Materials

Data on co-benefits are based on the U.S. Forest Service's recently published technical manual and the extensive Urban Tree Database (UTD), which catalogs urban trees with their projected growth tailored to specific geographic regions (McPherson et al. 2016a, b). The products are a culmination of 14 years of work, analyzing more than 14,000 trees across the United States. Whereas prior growth models typically featured only a few species specific to a given city or region, the newly released database features 171 distinct species across 16 U.S. climate zones. The trees studied also spanned a range of ages with data collected from a consistent set of measurements. Advances in statistical modeling have given the projected growth dimensions a level of accuracy never before seen. Moving beyond just calculating a tree's diameter or age to determine expected growth, the research incorporates 365 sets of tree growth equations to project growth.

Users select their climate zone from the 16 U.S. climate zones (Fig. 1). Calculations of CO_2 stored are for a representative species for each tree-type that was one of the predominant street tree species per reference city (Peper et al., 2001). The "Reference city" refers to the city selected for intensive study within each climate zone (McPherson, 2010). About 20 of the most abundant species were selected for sampling in each reference city. The sample was stratified into nine diameter at breast height (DBH) classes (0 to 7.6, 7.6 to 15.2, 15.2 to 30.5, 30.5 to 45.7, 45.7 to 61.0, 61.0 to 76.2, 76.2 to 91.4, 91.4 to 106.7, and >106.7 cm). Typically, 10 to 15 trees per DBH class were randomly chosen. Data were collected for 16 to 74 trees in total from each species. Measurements included: species name, age, DBH [to the nearest 0.1 cm (0.39 in)], tree height [to the nearest 0.5 m (1.64 ft.)], crown height [to the nearest 0.5 m (1.64 ft.)], and crown diameter in two directions [parallel and perpendicular to nearest street to the nearest 0.5 m (1.64 ft.)]. Tree age was determined from local residents, the city's urban forester, street and home construction dates, historical planting records, and aerial and historical photos.

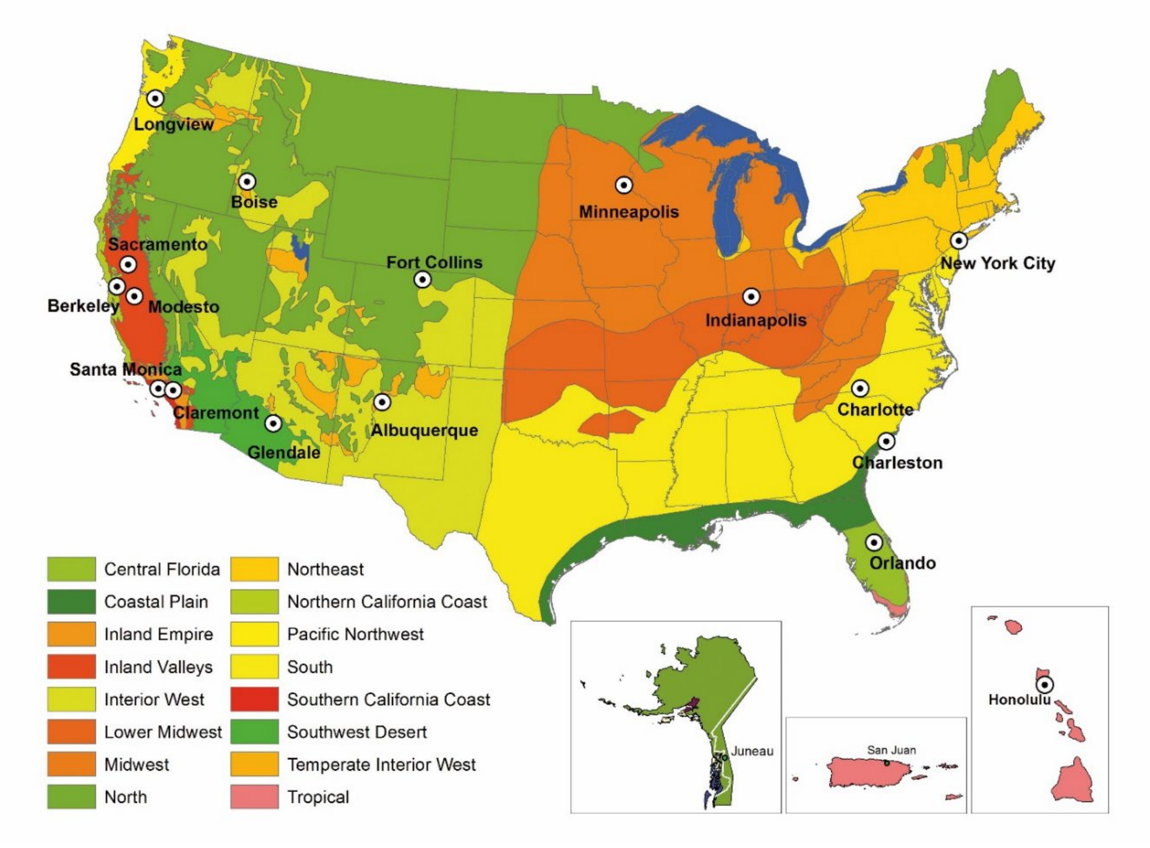

Fig. 1. Climate zones of the United States and Puerto Rico were aggregated from 45 Sunset climate zones into 16 zones. Each zone has a reference city where tree data were collected. Sacramento, California was added as a second reference city (with Modesto) to the Inland Valleys zone. Zones for Alaska, Puerto Rico and Hawaii are shown in the insets (map courtesy of Pacific Southwest Research Station).

Co-Benefit: Energy Savings

Trees and forests can offer energy savings in two important ways. In warmer climates or hotter months, trees can reduce air conditioning bills by keeping buildings cooler through reducing regional air temperatures and offering shade. In colder climates or cooler months, trees can confer savings on the fuel needed to heat buildings by reducing the amount of cold winds that can strip away heat.

Energy conservation by trees is important because building energy use is a major contributor to greenhouse gas emissions. Oil or gas furnaces and most forms of electricity generation produce CO_2 and other pollutants as by-products. Reducing the amount of energy consumed by buildings in urban areas is one of the most effective methods of combatting climate change. Energy consumption is also a costly burden on many low-income families, especially during mid-summer or mid-winter. Furthermore, electricity consumption during mid-summer can sometimes over-extend local power grids leading to rolling brownouts and other problems.

Energy savings are calculated through numerical models and simulations built from observational data on proximity of trees to buildings, tree shapes, tree sizes, building age classes, and meteorological data from McPherson et al. (2017) and McPherson and Simpson (2003). The main parameters affecting the overall amount of energy savings are crown shape, building proximity, azimuth, local climate, and season. Shading effects are based on the distribution of street trees with respect to buildings recorded from aerial photographs for each reference city (McPherson and Simpson, 2003). If a sampled tree was located within 18 m of a conditioned building, information on its distance and compass bearing relative to a building, building age class (which influences energy use) and types of heating and cooling equipment were collected and used as inputs to calculate effects of shade on annual heating and cooling energy effects. Because these distributions were unique to each city, energy values are considered first-order approximations.

In addition to localized shade effects, which were assumed to accrue only to trees within 18 m of a building, lowered air temperatures and windspeeds from increased neighborhood tree cover (referred to as climate effects) can produce a net decrease in demand for winter heating and summer cooling (reduced wind speeds by themselves may increase or decrease cooling demand, depending on the circumstances). Climate effects on energy use, air temperature, and wind speed, as a function of neighborhood canopy cover, were estimated from published values for each reference city. The percentages of canopy cover increase were calculated for 20-year-old large, medium, and small trees, based on their crown projection areas and effective lot size (actual lot size plus a portion of adjacent street and other rights-of-way) of 10,000 ft^2 (929 m^2), and one tree on average was assumed per lot. Climate effects were estimated by simulating effects of wind and air-temperature reductions on building energy use.

In the case of urban Tree Preservation Projects, trees may not be close enough to buildings to provide shading effects, but they may influence neighborhood climate. Because these effects are highly site-specific, we conservatively apply an 80% reduction to the energy effects of trees for Preservation Projects.

Energy savings are calculated as a real-dollar amount. This is calculated by applying overall reductions in oil and gas usage or electricity usage to the regional cost of oil and gas or electricity for residential customers. Colder regions tend to see larger savings in heating and warmer regions tend to see larger savings in cooling.

Error Estimates and Limitations

Formulaic errors occur in modeling of energy effects. For example, relations between different levels of tree canopy cover and summertime air temperatures are not well-researched. Another source of error stems from differences between the airport climate data (i.e., Los Angeles International Airport) used to model energy effects and the actual climate of the study area (i.e., Los Angeles urban area). Because of the uncertainty associated with modeling effects of trees on building energy use, energy estimates may be accurate within ± 25 percent (Hildebrandt & Sarkovich, 1998).

Co-Benefit: Rainfall Interception

Forest canopies normally intercept 10-40% of rainfall before it hits the ground, thereby reducing stormwater runoff. The large amount of water that a tree crown can capture during a rainfall event makes tree planting a best management practice for urban stormwater control.

City Forest Credits uses a numerical interception model to calculate the amount of annual rainfall intercepted by trees, as well as throughfall and stem flow (Xiao et al., 2000). This model uses species-specific leaf surface areas and other parameters from the Urban Tree Database. For example, deciduous trees in climate zones with longer “in-leaf” seasons will tend to intercept more rainfall than similar species in colder areas shorter foliation periods. Model results were compared to observed patterns of rainfall interception and found to be accurate. This method quantifies only the amount of rainfall intercepted by the tree crown, and does not incorporate surface and subsurface effects on overland flow.

The rainfall interception benefit was priced by estimating costs of controlling stormwater runoff. Water quality and/or flood control costs were calculated per unit volume of runoff controlled and this price was multiplied by the amount of rainfall intercepted annually.

Error Estimates and Limitations

Estimates of rainfall interception are sensitive to uncertainties regarding rainfall patterns, tree leaf area and surface storage capacities. Rainfall amount, intensity and duration can vary considerably within a climate zone, a factor not considered by the model. Although tree leaf area estimates were derived from extensive measurements on over 14,000 street trees across the U.S. (McPherson et al., 2016a), actual leaf area may differ because of differences in tree health and management. Leaf surface storage capacity, the depth of water that foliage can capture, was recently found to vary threefold among 20 tree species (Xiao & McPherson, 2016). A shortcoming is that this model used the same value (1 mm) for all species. Given these limitations, interception estimates may have uncertainty as great as ± 20 percent.

Co-Benefit: Air Quality

The uptake of air pollutants by urban forests can lower concentrations and affect human health (Derkzen et al., 2015; Nowak et al., 2014). However, pollutant concentrations can be increased if the tree canopy restricts polluted air from mixing with the surrounding atmosphere (Vos et al., 2013). Urban forests are capable of improving air quality by lowering pollutant concentrations enough to significantly affect human health. Generally, trees are able to reduce ozone, nitric oxides, and particulate matter. Some trees can reduce net volatile organic compounds (VOCs), but others can increase them through natural processes. Regardless of the net VOC production, urban forests usually confer a net positive benefit to air quality. Urban forests reduce pollutants through dry deposition on surfaces and uptake of pollutants into leaf stomata.

A numerical model calculated hourly pollutant dry deposition per tree at the regional scale using deposition velocities, hourly meteorological data and pollutant concentrations from local monitoring stations (Scott et al., 1998). The monetary value of tree effects on air quality reflects the value that society places on clean air, as indicated by willingness to pay for pollutant reductions. The monetary value of air quality effects were derived from models that calculated the marginal damage control costs of different pollutants to meet air quality standards (Wang and Santini 1995). Higher costs were associated with higher pollutant concentrations and larger populations exposed to these contaminants.

Error Estimates and Limitations

Pollutant deposition estimates are sensitive to uncertainties associated with canopy resistance, resuspension rates and the spatial distribution of air pollutants and trees. For example, deposition to urban forests during warm periods may be underestimated if the stomata of well-watered trees remain open. In the model, hourly meteorological data from a single station for each climate zone may not be spatially representative of conditions in local atmospheric surface layers. Estimates of air pollutant uptake may be accurate within ± 25 percent.

Conclusions

Estimates of co-benefits often reflect an incomplete understanding of the processes by which ecoservices are generated and valued (Schulp et al., 2014). Our choice of co-benefits to quantify was limited to those for which numerical models were available. There are many important benefits produced by trees that are not quantified and monetized. These include effects of urban forests on local economies, wildlife, biodiversity, and human health and well-being. For instance, effects of urban trees on increased property values have proven to be substantial (Anderson & Cordell, 1988). Previous analyses modeled these "other" benefits of trees by applying the contribution to residential sales prices of a large front yard tree (0.88%) (McPherson et al., 2005). We have not incorporated this benefit because property values are highly variable. It is likely that co-benefits reported here are conservative estimates of the actual ecoservices resulting from local tree planting and preservation projects.

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Appendix D – Validation and Verification

1. Validation

The Registry shall conduct validation activities at three times. The Registry shall document it validation activities in a written report that shall be posted publicly with other project documents.

A. Pre-Application

Before reviewing an application, the Registry conducts a validation screening:

- Validate eligibility under the Protocol eligibility requirements
- Validate the Project Operator’s understanding of the commitments it must make if it proceeds with the Project:
    - Complying with the Protocol
    - Submitting project documents, including a Project Implementation Agreement with Registry
    - Quantifying carbon dioxide and ecosystem co-benefits according to the appropriate methodology
    - Conducting monitoring and reporting for the Project Duration

B. Before Third-Party Verification

Upon submittal of a final Project Design Document (PDD) and before third-party verification, the Registry will:

- Review the PDD and its supporting documents for:
    - Compliance with Protocol PDD requirements
    - Demonstration that the Project meets the Protocol eligibility requirements

C. After Receiving the Verification Report

When the third-party verifier produces its Verification Report, the Registry then reviews that Report to ensure the following:

- The Verification Report accurately reflects the documentation contained in the PDD and supporting documents.

2. Verification

The Registry will retain a qualified and approved Validation and Verification Body (VVB) to verify compliance with this Tree Preservation Protocol per the requirements set forth herein and per the City Forest Credits Standard Section 5.2 and Appendix C, and International Standards Organization 14064-3. The Registry retains the third-party VVB, rather than allowing projects to do so, in order to avoid conflicts of interest or situations where the financial interests of the VVB are aligned with the Project rather than with the standards body. Specifically, the Registry adopts and utilizes the following standards from ISO 14064-3:

- Upon receiving a completed Project Design Document with data on eligibility, quantification of carbon, and a request for credits, the Registry will retain a VVB to verify the project's compliance with this Protocol. The Registry will be independent of specific project activities. Accreditation requirements for VVBs consistent with Article 6.4 of the UNCCC Paris Agreement are outlined in the City Forest Credits Standard Section 5.2 and Standard Appendix C.
- Verification by a VVB is described in more detail below. Urban forest projects, unlike many other types of carbon offset projects, will be conducted in and around urban areas, by definition. The trees in urban forest projects will be visible to virtually any resident of that urban area, and to anyone who cares to examine project trees.
- The Registry will maintain independence from the activities of projects and will treat all projects equally with regard to verification.
- The Registry requires a reasonable level of assurance in the accuracy the asserted GHG removals.
- The verification items identified in Table 1 and the following sections are all material elements, and any asserted GHG removals must be free of material errors, misstatements, or omissions regarding those elements.
- The Registry will record, store, and track all quantification and verification data and either display it for public review or make it available for public review upon request.
- The Registry will follow a process for follow-up and maintenance for consistency and continuity. This process will consist of a validation by the Registry to ensure that the Verification Report for each Project is consistent with the Project Documents submitted by the Project Operator.

2.1 Verification of Eligibility Requirements

Table 2.1 displays the verification for eligibility requirements.

Table 2.1. Verification Elements for Eligibility

Item	Elements to Verify	Protocol Section	Documentation
1	Project Operator Identity	1.1	State/local records, legal identity documents submitted by Project Operator
2	Project Implementation Agreement	1.2	Signed/received
3	Location	1.3	Geospatial data, maps
4	Project Area	1.4	Geospatial data, maps
5	Right to Receive Credits	1.5	Deed or Recorded Agreement
6	Commencement	2	Recorded Encumbrance recordation date
7	Project Documentation	3	Check documents
8	Project Duration	2.2	Recorded Encumbrance, signed Project Implementation Agreement
9	Preservation Commitment	4	Recorded Encumbrance
10	No Pre-existing Preservation	4	Project Design Document and Supporting Documentation
11	Threat of Tree Loss	4	Project Design Document and Supporting Documentation
12	Attestation of Additionality	6	Attestation
13	Attestation of No Net Harm and No Double Counting	5	Attestation and Project Operator Geospatial Map

2.2 Verification of Project Operator’s Quantification of Carbon

Tables 2.2.1 and 2.2.2 display the verification requirements for carbon quantification for two quantification methods described in Protocol Section 11.1.

Table 2.2.1. Verification Elements for Quantification per Protocol Section 11.1.A

Item	Elements to Verify	Protocol Section	Documentation
1	Quantifying Stored Carbon Stock, Calculating Accounting Stock	11.1	Forest Composition Report, appropriate quantification tool, i-Tree Canopy report and source

			file, historical photos, and other supporting documentation
2	Calculating Avoided Biomass Emissions	11.2	Geospatial data, zoning maps, ordinances, and other supporting documentation
3	Calculating Avoided Soil Carbon Emissions	11.3	Geospatial data, zoning maps, ordinances, and other supporting documentation
4	Calculating Leakage or Displaced Development Adjustments	11.4	CFC Quantification Calculator, Appendix B
5	Quantifying Co-Benefits	11.5	CFC Co-Benefit Quantification Calculator

Table 2.2.2. Verification Elements for Quantification per Protocol Section 11.1.B

Item	Elements to Verify	Protocol Section	Documentation
1	Quantifying Stored Carbon Stock, Calculating Accounting Stock	11.1	Plot sample or full inventory tree sampling data, geospatial data, relevant i-Tree Eco report sections and source file, appropriate quantification tool, and other supporting documentation.
2	Calculating Avoided Biomass Emissions	11.2	Geospatial data, zoning maps, ordinances, and other supporting documentation
3	Calculating Avoided Soil Carbon Emissions	11.3	Geospatial data, zoning maps, ordinances, and other supporting documentation
4	Calculating Leakage or Displaced Development Adjustments	11.4	CFC Quantification Calculator, Appendix B
5	Quantifying Co-Benefits	11.5	CFC Co-Benefit Quantification Calculator

The Project Operator may elect to account for additional growth of trees within the Project Area and seek credits after the Initial Crediting Period (Protocol Section 11.6).

The appropriate verification requirements for carbon quantification under Protocol Section 11.1.C will be determined by the Registry according to the specific details of the method submitted by the Project Operator.

2.3 Verification Report

The VVB retained by the Registry shall submit its Verification Report in compliance with the requirements of Section 13 of this Protocol and of ISO 14064-3.

The Verification Report shall contain at a minimum reporting on

- Verification process, data reviewed, standards applied
- The Verifier's verification of compliance with Protocol requirements and of the Project Operator's GHG reduction assertion in its Completed Project Design Document
- Verification of the Project Area
- Total Credits Attributed to that Project and allocation of credits by sub-area or property if requested by the Project Operator in the Completed Project Design Document
- Deductions for the program-wide Reversal Pool Account of credits
- Schedule for Issuance of Credits

Appendix E – Activity Penetration Analysis of Urban and Peri-Urban Forest Conservation

Version 1.0

3/11/2024

Purpose

This document outlines the use of an activity penetration analysis to demonstrate that urban and peri-urban forest conservation project activities are not common practice, as required under Section 6 on Additionality of the City Forest Credits (CFC) Preservation Protocol (Version 13). The full list of requirements for project additionality is provided in the CFC Preservation Protocol.

Introduction

The preservation of urban and peri-urban forests provides a host of nature-based benefits to people and wildlife, including improvements to air quality, watershed health, urban heat mitigation, carbon sequestration, habitat connectivity, and human health and well-being (O'Brien et al., 2022; Wolf et al., 2020). But forests in and around metropolitan areas of the US are at risk of conversion to developed uses, with urban growth projected to add close to 100 million acres of urban land to the United States by 2060 (Nowak & Greenfield, 2018). Between 2001 to 2015, more than two thirds of global, urbanization-related forest loss took place in the eastern US alone (Curtis et al., 2018).

This analysis determined that conservation of forestland in urban and metropolitan areas of the US is at 4.3% – a low level of penetration relative to its maximum adoption capacity and below the 5% threshold set in CFC Standard Section 4.9.1 for common practice demonstrations[1].

Analysis

Activity penetration is determined for a certain time frame (*t*) by calculating the level of measured project activity as a percentage of its maximum adoption capacity, or:

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[1] The Clean Development Mechanism's *Methodological Tool for Common Practice* *(TOOL24; Version 03.1)* recommends a 20% threshold to demonstrate that an activity is not common practice. The 5% threshold used here is more conservative and consistent with commonly used additionality thresholds listed in the Clean Development Mechanism Concept Note CDM-MP83-A09 *Consistent use of market penetration metrics for additionality, common practice, and FOIK*, as well as Verra's VMD0052 *Demonstration of Additionality of Tidal Wetland Restoration and Conservation Project Activities*.

Activity Penetration(*t*) = Measured Activity(*t*) / Maximum Adoption Capacity(*t*) * 100

= Protected Urban and Peri-urban Forestland(*t*) / Total Urban and Peri-urban Forestland(*t*) * 100

The time frame for this analysis was selected as the period between 2001 to 2021. The bounding date of 2021 was selected based on data availability for forest land cover and protection status. A wide period of analysis spanning two decades was chosen conservatively to reflect the pace of land use change and the length of time required to fund land acquisition and protection.

Maximum Adoption Capacity Calculation

To determine the Maximum Adoption Capacity for urban and peri-urban forest conservation, the total amount of forestland within CFC's service area of urban and peri-urban lands was calculated.

First, CFC's service area was estimated as the non-overlapping union between US Census-designated 2020 Urban Areas (US Census Bureau, 2023) and federal Metropolitan Planning Organization boundaries (USDOT, 2024), with exclusions as described in the CFC Preservation Protocol Section 1.3.

Forest distribution was determined using the US Geological Survey's National Land Cover Database (NLCD). Developed in collaboration with the Multi-Resolution Land Characteristics Consortium, the NLCD has been, per the USGS, "one of the most widely used geospatial datasets in the US, serving as a basis for understanding the Nation's landscapes in thousands of studies and applications, trusted by scientists, land managers, students, city planners, and many more as a definitive source of U.S. land cover" (EROS, 2018). The latest suite of 2021 NLCD products for the conterminous US was used for this analysis; it includes 16 land use classes at 30-m spatial resolution (MRLC, 2023). The amount of land cover classified as forest (Deciduous Forest – 41, Evergreen Forest – 42, Mixed Forest – 43) in 2021 was calculated for areas lying within the CFC service area.

The total national extent of urban and peri-urban forests (as determined by the CFC service area) in 2021 was 273,917 km^2.

Measured Activity Calculation

To determine the Measured Activity for urban forest conservation, the total amount of protected forestland within CFC's service area of urban and peri-urban lands was calculated.

First, protected areas were determined using the US Geological Survey's Protected Areas Database (PAD-US; USGS GAP, 2022). This dataset is "America's official national inventory of US terrestrial and marine protected areas" (Gap Analysis Project, 2022) and includes lands owned and managed by federal and state agencies, regional, county, and local agencies, nonprofits and land trusts, and private landowners (PAD US, 2016). Conservation easement data included in PAD-US is taken from the National Conservation Easement Database. Although the PAD-US dataset has gaps, given the voluntary nature of reporting and the ongoing development of the database, it has been described as the “most comprehensive” publicly available dataset of US protected areas (Healey et al., 2023) and has been used in multiple peer-reviewed publications for national analyses of vegetation, land use, and land protection trends (for example, see Healey et al., 2023; McKerrow et al., 2021; Jackson et al., 2021; Browning et al., 2022).

This analysis uses the latest version of the dataset, PAD-US 3.0, which was released in 2022 and includes protected lands established in 2021. Only lands classified as GAP Status Code 1 and 2 were considered “fully protected”, as these lands are permanently protected from conversion, have a mandated management plan, and are not subject to extractive uses such as mining and logging (USGS GAP, 2022). Lands classified as GAP Status Code 3 and 4 were excluded because they are subject to extractive uses (Status 3) or lack mandated or legally recognized protection (Status 4; USGS GAP, 2022).

The time period was established by excluding fully protected lands whose Date of Establishment was older than 2001. However, about 42% of Status 1 and Status 2 lands do not have a Date of Establishment; to be conservative, these properties were included in the analysis, even if they likely represent lands protected prior to 2001.

To analyze only urban and peri-urban forests, protected lands that fell outside of the CFC service area were excluded. The amount of land cover classified as forest (Deciduous Forest – 41, Evergreen Forest – 42, Mixed Forest – 43) by the 2021 NLCD within urban and peri-urban Protected Areas of Status 1 and 2 was then calculated.

The total national extent of protected urban and peri-urban forests (as determined by the CFC service area) from 2001 to 2021 is 11,808 km^2.

Activity Penetration Calculation

Activity Penetration(*t*) = Measured Activity(*t*) / Maximum Adoption Capacity(*t*) * 100

= Protected Urban and Peri-urban Forestland(*t*) / Total Urban and Peri-urban Forestland(*t*) * 100

$$= 11{,}808 \text{ km}^2 / 273{,}917 \text{ km}^2 * 100$$

$$= 4.3\%$$

The activity penetration for urban and peri-urban forest conservation between 2001 to 2021 is 4.3%, which is less than the 5% threshold set in the CFC Standard to demonstrate that an activity is not common practice.

Additional Notes

Activity penetration of urban forest conservation across all time periods was also analyzed by repeating the steps above, but including Protected Areas where the Date Established was older than 2001. The activity penetration for all urban and peri-urban forest conservation from 1800 to 2021 was calculated at 5.94%, just above the 5% threshold set in the CFC Standard for common practice analysis.

All analyses were conducted using ArcGIS Pro 3.2.1. This analysis will be updated as new versions of the NLCD and PAD-US datasets become available.

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