CITY FOREST CREDITS

TREASURE VALLEY MUNICIPAL PARKS PLANTING PROJECT
Initial Credit Project Design Document

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INSTRUCTIONS

Project Operators complete and submit this Initial Credit Project Design Document (PDD) after planting has been completed. City Forest Credits then reviews this PDD for validation with all other required project documents. An approved third-party verifier then conducts verification. A separate amendment to the Project Design Document will need to be submitted for future verification at years 4, 6, and after year 25.

Please complete sections starting on page 5 where you find "[Enter text here]" as thoroughly as possible.

PROTOCOL REQUIREMENTS

Below are a list of the eligibility requirements in the City Forest Credits (CFC) Tree Planting Protocol Version 9, dated February 7, 2021. Begin your responses on page 4 under PROJECT OVERVIEW.

Project Operator (Section 1.1)

Identify a Project Operator for the project. This is the person or entity who takes responsibility for the project for the 25-year duration.

Commit to 25-year Project Duration in the Project Implementation Agreement (Section 1.2 and Section 5)

Sign the Project Implementation Agreement – this is the 25-year agreement between the Project Operator and CFC for an urban forest carbon project.

Location Eligibility (Section 1.3)

Project Areas must be located in parcels within or along the boundary of at least one of the following criteria.

A. The Urban Area boundary ("Urban Area"), defined by the most recent publication of the United States Census Bureau
B. The boundary of any incorporated city or town created under the law of its state;
C. The boundary of any unincorporated city, town, or unincorporated urban area created or designated under the law of its state;
D. The boundary of any regional metropolitan planning agency or council established by legislative action or public charter. Examples include the Metropolitan Area Planning Council in Boston and the Chicago Metropolitan Planning Agency;
E. The boundary of land owned, designated, and used by a municipal or quasi-municipal entity such as a utility for source water or watershed protection;
F. A transportation, power transmission, or utility right of way, provided the right of way begins, ends, or passes through some portion of A through E above.

Ownership Eligibility (Section 2)

Project Operator must demonstrate ownership of property and eligibility to receive potential credits by meeting at least one of the following:

A. Own the land, the trees, and potential credits upon which the Project trees are located; or
B. Own an easement or equivalent property interest for a public right of way within which Project trees are located, own the Project trees and credits within that easement, and accept ownership of those Project trees by assuming responsibility for maintenance and liability for them; or

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C. Have a written and signed agreement from the landowner granting ownership to the Project Operator of any credits for carbon storage or other benefits delivered by Project trees on that landowner's land. If Project trees are on private property, this agreement must be recorded in the property records of the county in which the land containing Project trees is located.

Additionality (Section 4.1 and Appendix D)
Legally Required Trees <u>NOT</u> Eligible - Project trees cannot be required by law or ordinance to be planted.

Performance Standard Baseline (Appendix D)
Project trees must be additional based on the performance standard baseline attached.

Multiple planting sites may be aggregated into one project (Section 8)
Planting sites can be on public and private land, in different cities, and aggregated into one project, provided that planting on all properties occurs within a 36-month period and that all properties comply with protocol requirements.

Carbon Quantification (Section 12 and Appendix B)
CFC has developed spreadsheets and methods for quantifying carbon stored and credited. The project design including tree spacing and goals will determine the quantification and monitoring requirements. Project Operators will quantify CO_2 using the method appropriate for the project type. CFC supplies all quantification tools. The three main project designs are:

- Single Tree - trees are scattered and spaced apart more than 10 feet, as in streets, yards, some parks, and schools, individual trees are tracked and randomly sampled
- Clustered Parks - trees are relatively contiguous in park-like settings and change in canopy is tracked
- Canopy – trees are planted very close together, often but not required to be in riparian areas, significant mortality is expected, and change in canopy is tracked. The two main goals are to create a forest ecosystem and generate canopy

Verification by third-party verifiers (Section 13)
All projects must be verified before receiving credits.

Imaging Requirements (based on planting method)
In order to receive credits, additional information is required at Years 4, 6, and 26. Below are the imaging requirements by planting method:

1) Single Tree (spaced 10' or more apart, i.e. street trees or linear plantings)
    a. <u>Initial Credit:</u> The carbon quantification tool for your project contains a worksheet called "Data Collection" for use in tracking each tree. In that file, document the GPS coordinates for each tree planted.
    b. <u>Years 4, 6, and 26:</u> Geocoded photos or imaging of a minimum sample of 20% of the trees is required at Years 4, 6, and 26. The tracking file includes a column where each tree is assigned a unique serial number to help with tracking each coordinate and tree picture or image.
2) Clustered Parks (spaced 10' apart but continuously so to generate canopy over time, i.e. natural areas)

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a. Initial Credit: Projects must document the planting through photos or imaging. Select points and take geo-coded photos that when taken together capture the newly planted trees in the project area. If site is rectilinear, take a photo at each of the corners. If the site is large, take photos at points along the perimeter looking into the project area. If necessary to capture the trees, take photos facing each of the cardinal directions while standing in the middle of the project area. If site is nonrectilinear, identify critical points along property boundaries and take photographs at each point facing in towards the middle of the site. Next, take photographs from the middle of the project area facing out at each cardinal direction.
b. At Years 4, 6, and 26: Project provides images of the Project Area from any telemetry, imaging, remote sensing, i-Tree Canopy, or UAV service, such as Google Earth and estimate the area in tree canopy cover (acres). Imaging from Google Earth with leaf-on may be used. Project operators will calculate the percent of canopy cover from the Google Earth imaging. Projects can use i-Tree Canopy and point sampling to calculate canopy cover. Using i-Tree Canopy, continue adding points until the standard error of the estimate for both the tree and non-tree cover is less than 5%. i-Tree Canopy will supply you with the standard errors. If tree canopy cover is determined using another approach, such as image classification, a short description of the approach should be provided, as well as the QA/QC measures that were used. A tree cover classification accuracy assessment should be conducted, as with randomly placed points, and the percentage tree cover classification accuracy reported.

3) Canopy (closely planted with spacing less than 10' apart so to generate canopy and forest ecosystem, high tree mortality expected, i.e. riparian areas)
   a. Initial Credit: Projects must document the planting through photos or imaging. Select points and take geo-coded photos that when taken together capture the newly planted trees in the project area. If site is rectilinear, take a photo at each of the corners. If the site is large, take photos at points along the perimeter looking into the project area. If necessary to capture the trees, take photos facing each of the cardinal directions while standing in the middle of the project area. If site is nonrectilinear, identify critical points along property boundaries and take photographs at each point facing in towards the middle of the site. Next, take photographs from the middle of the project area facing out at each cardinal direction.
   b. At Years 4, 6, and 26: Project provides images of the Project Area from any telemetry, imaging, remote sensing, i-Tree Canopy, or UAV service, such as Google Earth and estimate the area in tree canopy cover (acres). Imaging from Google Earth with leaf-on may be used. Project operators will calculate the percent of canopy cover from the Google Earth imaging. Projects can use i-Tree Canopy and point sampling to calculate canopy cover. Using i-Tree Canopy, continue adding points until the standard error of the estimate for both the tree and non-tree cover is less than 5%. i-Tree Canopy will supply you with the standard errors. If tree canopy cover is determined using another approach, such as image classification, a short description of the approach should be provided, as well as the QA/QC measures that were used. A tree cover classification accuracy assessment should be conducted, as with randomly placed points, and the percentage tree cover classification accuracy reported.

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PROJECT OVERVIEW

Basic Project Details

Project Name: Treasure Valley Municipal Parks Planting
Project Number *(CFC to provide)***:** 004
Project Type: Planting Project (under the Planting Protocol – version 9, dated February 7, 2021)
Project Start Date: June 1, 2016 (refer to attached Park Planting Details spreadsheet)
Project Location *(city, town, or jurisdiction)***:** Boise, ID

Project Operator Name: Treasure Valley Canopy Network
Project Operator Contact Information:
Lance Davisson – 208-994-1135, ldavisson@thekeystoneconcept.com

Project Description
Describe overall project goals, where the project will take place, what method of planting (per Protocol), partners, time period of when the trees have been or will be planted, and any other relevant information. (minimum of 2 paragraphs)

The Treasure Valley Municipal Parks Planting Project is a partnership between the City of Boise and the Treasure Valley Canopy Network (Network). This project will plant approximately 504 trees in 9 municipal parks throughout the Treasure Valley (see vicinity map). Over the course of the next 25 years, these trees will produce over $594,000 in ecosystem services that will benefit our region's environment and its citizens.

The City of Boise is at the heart of Idaho's Treasure Valley, one of the fastest growing metropolitan areas in the United States. As our region grows, its city is committed to building healthy and vibrant public spaces for all citizens to enjoy. The trees planted in these parks will provide residents of various socioeconomic categories with recreational opportunities resulting in healthier environments and people.

This project is the first pilot in the Treasure Valley City Forest Credits Program, administered by the Treasure Valley Canopy Network. As the Network continues to build collaborative partners and planting projects, we anticipate many more opportunities for financial support of our regional City Forest Credits Program. Ultimately, this program will generate funding to significantly increase tree planting efforts throughout the region and raise awareness about the social, environmental, and economic benefits that these trees are providing to our region.

Trees will be planted as scattered single trees throughout the parks as outlined in each municipal park planting plan and planting list.

The Treasure Valley City Forest Credits Program is supported by the diverse public and private member partners of the Treasure Valley Canopy Network (http://www.tvcanopy.net/partners/).

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LOCATION AND OWNERSHIP OF PROJECT AREA (Section 1.3 and Section 2)

Project Area Location

Describe where the Project Area is located and how it meets the location criteria.

The plantings are located in the following urban areas:

- Boise, ID (Urban Area Code: 08785 – Boise City, ID)
  - Franklin Park, 310 S Hilton St, Boise, ID 83705
  - Magnolia Park, 7136 N Bogart Ln, Boise, ID 83714
  - Pine Grove Park, 750 S Maple Grove Rd, Boise, ID 83709
  - Hyatt Hidden Lakes, 5301 N Maple Grove Rd, Boise, ID 83704
  - Sterling Park Pond (Mariposa Park), 9851 W Irving St, Boise, ID 83704
  - Harrison Hollow, 2455 Harrison Hollow Lane, Boise, ID 83702
  - Bernadine Quinn Riverside Park, 3150 W. Pleasanton Ave, Boise, ID 83702
  - Westside Downtown (Cherie Buckner-Webb) Park, 1100 W Bannock St, Boise, ID 83702
  - Bowler Park, 4403 S Surprise Way, Boise, ID 83706

Project Area Ownership and Right to Receive Credits

Describe the property ownership and include relevant documentation including numbered title/filename as an attachment (Ex: 1 - Attestation of Land Ownership, or 1 - Agreement from Owner to Transfer Credits).

Park property ownership, by city:

- Boise, ID
  - Franklin Park – owned by City of Boise
  - Magnolia – owned by City of Boise
  - Pine Grove Park – owned by City of Boise
  - Hyatt Hidden Lakes – owned by City of Boise
  - Mariposa Park (formerly Sterling Park) – owned by City of Boise
  - Harrison Hollow – owned by City of Boise
  - Bernadine Quinn Riverside Park – owned by City of Boise
  - Cherie Buckner-Webb (formerly Westside Downtown) Park – owned by City of Boise
  - Bowler Park – owned by City of Boise

Prior to credit issuance, the property owner and Treasure Valley Canopy Network will sign an agreement outlining the Treasure Valley Canopy Network's right to receive credits from the property owner. Copies will be provided to CFC. – *Refer to attached Agreement to Transfer Credits between TV Canopy Network and City of Boise*

Maps

Provide a detailed map of the Project Area. Also provide a regional-scale map that shows the Project Area within the context of relevant urban/town boundaries. Include numbered title/filename of attachments (Ex: 2 - Regional Scale Map)

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1) **Map of Project Area**
Title/filename of relevant attachment(s): Refer to attached Map TVCN_ParksPlantings_CityForestCredits_MAP

2) **Regional-scale map of Project Area**
Title/filename of relevant attachment(s): Refer to attached Map TVCN_ParksPlantings_CityForestCredits_MAP

Additional Notes

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PROJECT DURATION

Project Operator commits to the 25-year project duration requirement through a signed Project Implementation Agreement with City Forest Credits.

ATTESTATIONS

Complete and attach the following attestations: Attestation of No Double Counting of Credits, Attestation of No Net Harm, Attestation of Planting, and Attestation of Planting Affirmation. Provide any additional notes as relevant.

All completed and signed attestations are attached.

ADDITIONALITY

Legally required trees NOT eligible - Project trees are not required by law or ordinance to be planted. See Attestation of Planting.

PERFORMANCE STANDARD BASELINE

Project trees are additional based on the performance standard baseline attached.

PLANTING DESIGN

Describe detailed planting design, including spacing between trees. Will the trees be planted as scattered individual trees, clustered in groups like in natural areas, or tightly clustered to restore a forest ecosystem?

- *Single Tree - trees are scattered and spaced apart more than 10 feet, as in streets, yards, some parks, and schools, individual trees are tracked and randomly sampled*
- *Clustered Parks - trees are relatively contiguous in park-like settings and change in canopy is tracked*
- *Canopy – trees are planted very close together, often but not required to be in riparian areas, significant mortality is expected, and change in canopy is tracked. The two main goals are to create a forest ecosystem and generate canopy*

Describe your data collection on Project Trees and show it in the quantification section below. For example, Project Operator can use the data collection sheet contained in the CFC quantification tool or your own approved method.

This project will plant 504 trees using the single tree method in nine parks in Boise, ID. All trees in all parks will be irrigated and maintained by city parks staff, including pruning and replacement as needed. The expected survival rate for this project is 90%. This is based on a regional average for trees planted in

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new parks. Any tree that dies will be replaced that year over the course of the next 25 years while the project is included in the registry.

All project trees were planted within 2016 - 2021.

CARBON QUANTIFICATION DOCUMENTATION (Section 12 and Appendix B)

Describe which quantification approach you anticipate using, list the project's climate zone, and outline the estimated total number of credits to be issued to the project as well as the amount to be issued upon successful verification. When requesting credits after planting, attach one of the three quantification tool documents below and provide the data you have collected for Project Trees.

- *Single Tree - trees are scattered and spaced apart more than 10 feet, as in streets, yards, some parks, and schools, individual trees are tracked and randomly sampled*
- *Clustered Parks - trees are relatively contiguous in park-like settings and change in canopy is tracked*
- *Canopy – trees are planted very close together, often but not required to be in riparian areas, significant mortality is expected, and change in canopy is tracked. The two main goals are to create a forest ecosystem and generate canopy*

Total number of trees planted	504
Project area (acres), if applicable	N/A
Total number of trees per acre, if applicable	N/A
Credits attributed to the project (tCO2e)	742.4
Credits after mortality deduction (10%)	668.2
Contribution to Registry Reversal Pool (5%) (tCO2e)	33.41
Total credits to be issued to the Project Operator (tCO2e)	634.7
Total credits requested to be issued in Year 1 (10% of above)	64

The single tree quantification approach was used to calculate the estimated carbon credits to be issued and co-benefit information. Each park has its own tool and copies are included in CFC records. Below is a summary of the number of trees, total credits, and co-benefits for all parks. The total number of credits being requested at this first issuance is: **64**.

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Table 2. Summary of Planting Sites

Tree-Type	Tree-Type Abbreviation	No. Sites Planted
Brdlf Decid Large (>50 ft)	**BDL**	204
Brdlf Decid Med (30-50 ft)	**BDM**	73
Brdlf Decid Small (<30 ft)	**BDS**	101
Brdlf Evgrn Large (>50 ft)	**BEL**	0
Brdlf Evgrn Med (30-50 ft)	**BEM**	0
Brdlf Evgrn Small (<30 ft)	**BES**	0
Conif Evgrn Large (>50 ft)	**CEL**	109
Conif Evgrn Med (30-50 ft)	**CEM**	17
Conif Evgrn Small (<30 ft)	**CES**	0
	Total Sites Planted	504

Row Labels	Sum of No. Sites Planted
Amur maple	1
ash	3
Austrian pine	35
black spruce	20
blue spruce	27
common chokecherry	30
crabapple	55
Dawn redwood	11
downy serviceberry	11
eastern redbud	8
English oak	8
European hornbeam	6
European larch	3
hawthorn	7
honeylocust	63
Japanese pagoda tree	21
Kentucky coffeetree	5
littleleaf linden	32
London planetree	10
maple	32
northern hackberry	2
northern red oak	22
Norway spruce	12
river birch	14
Scotch pine	14
silver linden	3
sweetgum	7
tulip tree	28
Vanderwolf pine	3
western white pine	4
willow	7
Grand Total	**504**

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Directions

Using the information you provide and background data, the tool calculates the amount of Credits that could be issued at years 1 (10%), 3 (40%), and 5 (30%) after planting. A mortality deductions (% loss) is applied to account for anticipated tree losses (Cell D6). A 5% buffer pool deduction is applied that will go into a program-wide pool to insure against catastrophic loss of trees. This tool is used to determine credits issued after planting (Intial Crediting). A different tool is used for credit issuance in Years 4 and 6. The tool in those years requires calculation of a sample and collection of data on tree status in the sample sites.

Mortality Deduction (%):	10%

Table 3. Credits are based on 10%, 40%, and 30% at Years 1, 3, and 5 after planting, respectively, of the projected CO_2 stored by live trees 25-years after planting. These values account for anticipated tree losses and the 5% buffer pool deduction.

						10%	40%	30%	20%
	No. Sites Planted	**No. Live Trees**	**Mortality Deduction (%)**	**25-yr CO_2 stored (kg/tree)**	**Tot. 25-yr CO_2 stored w/ losses and 5% deduction (t)**	**10% CO_2 (t)**	**40% CO_2 (t)**	**30% CO_2 (t)**	**20% CO_2 (t)**
BDL	204	184	0.10	2,587.18	451.3	45.13	180.50	135.38	90.25
BDM	73	66	0.10	1,224.19	76.4	7.64	30.56	22.92	15.28
BDS	101	91	0.10	658.91	56.9	5.69	22.76	17.07	11.38
BEL	0	0	0.10	0.00	0.0	0.00	0.00	0.00	0.00
BEM	0	0	0.10	0.00	0.0	0.00	0.00	0.00	0.00
BES	0	0	0.10	0.00	0.0	0.00	0.00	0.00	0.00
CEL	109	98	0.10	472.49	44.0	4.40	17.61	13.21	8.81
CEM	17	15	0.10	421.75	6.1	0.61	2.45	1.84	1.23
CES	0	0	0.10	0.00	0.0	0.00	0.00	0.00	0.00
	504	454	0.10		634.7	63.47	253.89	190.42	126.95

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In Table 4 the tool infers the amount of CO_2 stored after 25 years from the sample to the population of live trees. Values in column H account for anticipated tree losses and the 5% buffer pool deduction.

Table 4. Grand Total CO_2 Stored after 25 years (all live trees, includes tree losses and buffer pool deduction)

Tree-Type	No. Sites Planted	Mortality Deduction (%)	Total Live Trees After Mortality	25-yr CO_2 stored (kg/tree)	CO_2 Tot. - No Deductions (t)	Grand Total CO_2 w/ Deductions (t)
Brdlf Decid Large (>50 ft)	204	0.10	184	2,587.18	527.8	451.3
Brdlf Decid Med (30-50 ft)	73	0.10	66	1,224.19	89.4	76.4
Brdlf Decid Small (<30 ft)	101	0.10	91	658.91	66.6	56.9
Brdlf Evgrn Large (>50 ft)	0	0.10	0	0.00	0.0	0.0
Brdlf Evgrn Med (30-50 ft)	0	0.10	0	0.00	0.0	0.0
Brdlf Evgrn Small (<30 ft)	0	0.10	0	0.00	0.0	0.0
Conif Evgrn Large (>50 ft)	109	0.10	98	472.49	51.5	44.0
Conif Evgrn Med (30-50 ft)	17	0.10	15	421.75	7.2	6.1
Conif Evgrn Small (<30 ft)	0	0.10	0	0.00	0.0	0.0
	504		454		742.4	634.7

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Directions
In Table 5, enter the low and high price of CO_2 in \$ per tonne (t).

This table incorporates error estimates of ±15% to the high and low estimates of the total CO_2 (t) stored by the live tree population after 25 years. For planning purposes only, it calculates dollar values.

Table 5. CO_2 value

	CO_2 \$ per tonne
Low	\$19.00
High	\$23.00

Table 6. Summary of CO_2 stored after 25 years (all live trees, includes tree losses)

Tree-Type	**Total CO_2 (t) at 25 years**	**Low \$ value**	**High \$ value**
Brdlf Decid	584.6	\$11,106.73	\$13,444.99
Brdlf Evgrn	0.0	\$0.00	\$0.00
Conif Evgrn	50.2	\$953.11	\$1,153.77
Total	634.7	\$12,059.85	\$14,598.76
	CO_2 (t)	**Total \$**	**Total \$**
Grand Total CO_2 (t) at 25 years:	634.7	\$12,059.85	\$14,598.76
High Est. with Error:	729.9	\$13,868.82	\$16,788.58
Low Est. with Error:	539.5	\$10,250.87	\$10,250.87
± 15% error = ± 10% formulaic ± 3% sampling ± 2% measurement			

CARBON CO-BENEFITS QUANTIFICATION DOCUMENTATION (Section 12 and Appendix B)

Summarize co-benefit results based on the project's planting method and provide supporting documentation. CFC can provide co-benefits quantification for Project Operator for rainfall interception, air quality improvements, and energy savings.

- *Single Tree - trees are scattered and spaced apart more than 10 feet, as in streets, yards, some parks, and schools, individual trees are tracked and randomly sampled*
- *Clustered Parks - trees are relatively contiguous in park-like settings and change in canopy is tracked*
- *Canopy – trees are planted very close together, often but not required to be in riparian areas, significant mortality is expected, and change in canopy is tracked. The two main goals are to create a forest ecosystem and generate canopy*

Ecosystem Services	***Resource Units***	***Value***
Rainfall Interception (m3/yr)	2,746.58	$5,659.45
Air Quality (t/yr)	0.0737	$1,675.39
Cooling – Electricity (kWh/yr)	94,345.18	$11,000.65
Heating – Natural Gas (kBtu/yr)	436,062.53	$5,426.52
Grand Total ($/yr)	**533,154.37**	**$23,762.01**

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Using the information you provide and background data, the tool provides estimates of co-benefits after 25 years in Resource Units per year and $ per year.

Table 7. Co-Benefits PER YEAR after 25 years (all live trees, includes tree losses)

Ecosystem Services	Resource Units Totals	Resource Unit/site	Total $	$/site
Rainfall Interception (m3/yr)	2,746.58	5.45	$5,659.45	$11.229
CO_2 Avoided (t, $20/t/yr)	2.65	0.01	$52.92	$0.105
Air Quality (t/yr)				
O3	0.1299	0.0003	$1,432.89	$2.843
NOx	0.0139	0.0000	$391.43	$0.777
PM10	0.0553	0.0001	$1,148.01	$2.278
Net VOCs	-0.1254	-0.0002	-$1,296.94	-$2.573
Air Quality Total	0.0737	0.0001	$1,675.39	$3.32
Energy (kWh/yr & kBtu/yr)				
Cooling - Electricity	94,345.18	187.19	$11,000.65	$21.83
Heating - Natural Gas	436,062.53	865.20	$5,426.52	$10.77
Energy Total ($/yr)			$16,427.17	$32.59
Grand Total ($/yr)			$23,814.93	$47.25

MONITORING AND REPORTING PLANS (Appendix A)

Project Operator is required to submit an annual monitoring report by the anniversary of the first approved verification report. For example, if the verification report is dated January 1, 2021, the first monitoring report will be due by January 1, 2022 and each January 1st thereafter for the duration of the project.

Anticipated Reporting Schedule

Monitoring Report – Year 2	2022	Monitoring Report – Year 15	2035
Monitoring Report – Year 3	2023	Monitoring Report – Year 16	2036
Monitoring Report – Year 4*****	2024	Monitoring Report – Year 17	2037
Monitoring Report – Year 5	2025	Monitoring Report – Year 18	2038
Monitoring Report – Year 6*****	2026	Monitoring Report – Year 19	2039
Monitoring Report – Year 7	2027	Monitoring Report – Year 20	2040
Monitoring Report – Year 8	2028	Monitoring Report – Year 21	2041
Monitoring Report – Year 9	2029	Monitoring Report – Year 22	2042
Monitoring Report – Year 10	2030	Monitoring Report – Year 23	2043
Monitoring Report – Year 11	2031	Monitoring Report – Year 24	2044
Monitoring Report – Year 12	2032	Monitoring Report – Year 25	2045
Monitoring Report – Year 13	2033	Monitoring Report – Year 26*****	2046
Monitoring Report – Year 14	2034		

* Denotes a year where additional information is required in order to receive credits

Monitoring Reports

The report must contain any changes in eligibility status of the Project Operator and any significant tree loss. Monitoring report questions are listed below. The following are questions contained in CFC's annual monitoring report template:

1. Has the contact information for the Project Operator changed? If so, provide new information.
2. Have there been changes in land ownership of the Project Area?
3. Have there been any changes in the Project Design?
4. Have there been any changes in the implementation of management of the Project?
5. Have there been any significant changes to the site (such as flooding or human changes)?
6. Have there been any significant tree or canopy losses?
7. Any other significant elements to report?

Confirm and describe your plans for annual monitoring of this project and specifics on how imaging (see Imaging Requirements in the Protocol Requirements section above) will be conducted based on your project's planting method.

Treasure Valley Canopy Network and City of Boise Parks and Recreation Staff will conduct annual on-site monitoring of the condition of the trees, in addition to the monitoring requirements of the CFC protocols. Monitoring will include photos and condition inspections by an ISA Certified Arborist.

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ADDITIONAL INFORMATION

Include additional noteworthy aspects of the project. Examples include collaborative partnerships, community engagement, or project funders.

This is a highly collaborative project, led by Treasure Valley Canopy Network and City of Boise Parks and Recreation. To learn more about this project, its history and background, visit https://www.tvcanopy.net/city-forest-credits.

PROJECT OPERATOR SIGNATURE

Signed by Lance Davisson, for Treasure Valley Canopy Network.

Lance Davisson
____
Signature

(208) 994-1135
____
Phone

coordinator@tvcanopy.net
____
Email

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ATTACHMENTS

1 - Agreement to Transfer Credits and/or Attestation of Land Ownership
2 - Regional Area Map (in PDD)
3 - Project Area Map (in PDD)
4 - Attestation of No Double Counting of Credits
5 - Attestation of No Net Harm
6 - Attestation of Planting
7 - Attestation of Planting Affirmation
8 - Carbon Quantification Initial Credits Tool (in PDD)
9 - Co-Benefit Quantification Initial Credits Tool (in PDD)
10 - Tree Data (in PDD)

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PERFORMANCE STANDARD BASELINE METHODOLOGY (Appendix D)

There is a second additionality methodology set out in the WRI GHG Protocol guidelines – the Performance Standard methodology. This Performance Standard essentially allows the project developer, or in this case, the developers of the protocol, to create a performance standard baseline using the data from similar activities over geographic and temporal ranges.

A common perception, particularly in the U.S., is that projects must meet a project specific test. Project-specific additionality is easy to grasp conceptually. The 2014 Climate Action Reserve urban forest protocol essentially uses project-specific requirements and methods.

However, the WRI GHG Protocol clearly states that either a project-specific test or a performance standard baseline is acceptable.[1] One key reason for this is that regional or national data can give a more accurate picture of existing activity than a narrow focus on one project or organization.

Narrowing the lens of additionality to one project or one tree-planting entity can give excellent data on that project or entity, which data can also be compared to other projects or entities (common practice). But plucking one project or entity out of its regional or national context ignores all comparable regional or national data. And that regional or national data may give a more accurate standard than data from one project or entity.

By analogy: one pixel on a screen may be dark. If all you look at is the dark pixel, you see darkness. But the rest of screen may consist of white pixels and be white. Similarly, one active tree-planting organization does not mean its trees are additional on a regional basis. If the region is losing trees, the baseline of activity may be negative regardless of what one active project or entity is doing.

Here is the methodology described in the WRI GHG Protocol to determine a Performance Standard baseline, together with the application of each factor to urban forestry:

[1] WRI GHG Protocol, Chapter 2.14 at 16 and Chapter 3.2 at 19.

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Table 2.1 Performance Standard Factors

WRI Performance Standard Factor	As Applied to Urban Forestry
Describe the project activity	Increase in urban trees
Identify the types of candidates	Cities and towns, quasi-governmental entities like utilities, watersheds, and educational institutions, and private property owners
Set the geographic scope (a national scope is explicitly approved as the starting point)	Could use national data for urban forestry, or regional data
Set the temporal scope (start with 5-7 years and justify longer or shorter)	Use 4-7 years for urban forestry
Identify a list of multiple baseline candidates	Many urban areas, which could be blended mathematically to produce a performance standard baseline

The Performance Standard methodology approves of the use of data from many different baseline candidates. In the case of urban forestry, those baseline candidates are other urban areas.[2]

As stated above, the project activity defined is obtaining an increase in urban trees. The best data to show the increase in urban trees via urban forest project activities is national or regional data on tree canopy in urban areas. National or regional data will give a more comprehensive picture of the relevant activity (increase in urban trees) than data from one city, in the same way that a satellite photo of a city shows a more accurate picture of tree canopy in a city than an aerial photo of one neighborhood. Tree canopy data measures the tree cover in urban areas, so it includes multiple baseline candidates such as city governments and private property owners. Tree canopy data, over time, would show the increase or decrease in tree cover.

Data on Tree Canopy Change over Time in Urban Areas

The CFC quantitative team determined that there were data on urban tree canopy cover with a temporal range of four to six years available from four geographic regions. The data are set forth below:

[2] See Nowak, et al. *"Tree and Impervious Cover Change in U.S. Cities,"* Urban Forestry and Urban Greening, 11 (2012), 21-30

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Table 2.2 Changes in Urban Tree Canopy (UTC) by region (Nowak and Greenfield, 2012)

City	Abs Change UTC (%)	Relative Change UTC (%)	Ann. Rate (ha UTC/yr)	Ann. Rate (m2 UTC/cap/yr)	Data Years
EAST					
Baltimore, MD	-1.9	-6.3	-100	-1.5	(2001–2005)
Boston, MA	-0.9	-3.2	-20	-0.3	(2003–2008)
New York, NY	-1.2	-5.5	-180	-0.2	(2004–2009)
Pittsburgh, PA	-0.3	-0.8	-10	-0.3	(2004–2008)
Syracuse, NY	1.0	4.0	10	0.7	(2003–2009)
Mean changes	-0.7	-2.4	-60.0	-0.3	
Std Error	0.5	1.9	35.4	0.3	
SOUTH					
Atlanta, GA	-1.8	-3.4	-150	-3.1	(2005–2009)
Houston, TX	-3.0	-9.8	−890	-4.3	(2004–2009)
Miami, FL	-1.7	-7.1	-30	-0.8	(2003–2009)
Nashville, TN	-1.2	-2.4	-300	-5.3	(2003–2008)
New Orleans, LA	-9.6	-29.2	−1120	-24.6	(2005-2009)
Mean changes	-3.5	-10.4	-160.0	-7.6	
Std Error	1.6	4.9	60.5	4.3	
MIDWEST					
Chicago, IL	-0.5	-2.7	-70	-0.2	(2005–2009)
Detroit, MI	-0.7	-3.0	-60	-0.7	(2005–2009)
Kansas City, MO	-1.2	-4.2	-160	-3.5	(2003–2009)
Minneapolis, MN	-1.1	-3.1	-30	-0.8	(2003–2008)
Mean changes	-0.9	-3.3	-80.0	-1.3	
Std Error	0.2	0.3	28.0	0.7	
WEST					
Albuquerque, NM	-2.7	-6.6	-420	-8.3	(2006–2009)
Denver, CO	-0.3	-3.1	-30	-0.5	(2005–2009)
Los Angeles, CA	-0.9	-4.2	-270	-0.7	(2005–2009)
Portland, OR	-0.6	-1.9	-50	-0.9	(2005–2009)
Spokane, WA	-0.6	-2.5	-20	-1.0	(2002–2007)
Tacoma, WA	-1.4	-5.8	-50	-2.6	(2001–2005)
Mean changes	-1.1	-4.0	-140.0	-2.3	
Std Error	0.4	0.8	67.8	1.2	

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These data have been updated by Nowak and Greenfield.[3] The 2012 data show that urban tree canopy is experiencing negative growth in all four regions. The 2018 data document continued loss of urban tree cover. Table 3 of the 2018 article shows data for all states, with a national loss of urban and community tree cover of 175,000 acres per year during the study years of 2009-2014.

To put this loss in perspective, the total land area of urban and community tree cover loss during the study years totals 1,367 square miles – equal to the combined land area of New York City, Atlanta, Philadelphia, Miami, Boston, Cleveland, Pittsburgh, St. Louis, Portland (Oregon), San Francisco, Seattle, and Boise.

Even though there may be individual tree planting activities that increase the number of urban trees within small geographic locations, the performance of activities to increase tree cover shows a negative baseline. The Drafting Group did not use negative baselines for the Tree Planting Protocol, but determined to use baselines of zero.

Deployment of the Performance Standard baseline methodology for a City Forest Tree Planting Protocol is supported by conclusions that make sense and are anchored in the real world:

- With the data showing that tree loss exceeds gains from planting, new plantings are justified as additional to that decreasing canopy baseline. In fact, the negative baseline would justify as additional any trees that are protected from removal.

- Because almost no urban trees are planted now with carbon as a decisive factor, urban tree planting done to sequester carbon is additional;

- Almost no urban trees are currently planted with a contractual commitment for monitoring. Maintenance of trees is universally an intention, one that is frequently reached when budgets are cut, as in the Covid-19 era. The 25-year commitment required by this Protocol is entirely additional to any practice in place in the U.S. and will result in substantial additional trees surviving to maturity;

- Because the urban forest is a public resource, and because public funding falls far short of maintaining tree cover and stocking, carbon revenues will result in additional trees planted or in maintenance that will result in additional trees surviving to maturity;

- Because virtually all new large-scale urban tree planting is conducted by governmental entities or non-profits, or by private property developers complying with governmental regulations (which would not be eligible for carbon credits under our protocol), and because any carbon revenues will defray only a portion of the costs of tree planting, there is little danger of unjust enrichment to developers of city forest carbon projects.

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[3] Nowak et al. 2018. "Declining Urban and Community Tree Cover in the United States," *Urban Forestry and Urban Greening,* 32, 32-55

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Last, the WRI GHG Protocol recognizes explicitly that the principles underlying carbon protocols need to be adapted to different types of projects. The WRI Protocol further approves of balancing the stringency of requirements with the need to encourage participation in desirable carbon projects:

Setting the stringency of additionality rules involves a balancing act. Additionality criteria that are too lenient and grant recognition for "non-additional" GHG reductions will undermine the GHG program's effectiveness. On the other hand, making the criteria for additionality too stringent could unnecessarily limit the number of recognized GHG reductions, in some cases excluding project activities that are truly additional and highly desirable. In practice, no approach to additionality can completely avoid these kinds of errors. Generally, reducing one type of error will result in an increase of the other. Ultimately, there is no technically correct level of stringency for additionality rules. GHG programs may decide based on their policy objectives that it is better to avoid one type of error than the other.[4]

The policy considerations weigh heavily in favor of "highly desirable" planting projects to reverse tree loss for the public resource of city forests.

[4] WRI GHG Protocol, Chapter 3.1 at 19.

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QUANTIFYING CARBON DIOXIDE STORAGE AND CO-BENEFITS FOR URBAN TREE PLANTING PROJECTS (Appendix B)

Introduction

Ecoservices provided by trees to human beneficiaries are classified according to their spatial scale as global and local (Costanza 2008) (citations in Part 1 are listed in References at page 16). 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 that has combined measurements and modeling of urban tree biomass, and effects of trees on building energy use, rainfall interception, and air quality. CFC has used the most current science available on urban tree growth in its estimates of CO_2 storage (McPherson et al., 2016a). CFC's quantification tools provide estimates of co-benefits after 25 years in Resource Units (i.e., kWh of electricity saved) and dollars 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 quantification of CO_2 storage and co-benefits have been documented in numerous publications (see References below) and are summarized here.

Carbon Dioxide Storage

There are three different methods for quantifying carbon dioxide (CO_2) storage in urban forest carbon projects:

- Single Tree Method - planted trees are scattered among many existing trees, as in street, yard, some parks, and school plantings, individual trees are tracked and randomly sampled
- Clustered Parks Planting Method - planted trees are relatively contiguous in park-like settings and change in canopy is tracked
- Canopy Method – trees are planted very close together, often but not required to be in riparian areas, significant mortality is expected, and change in canopy is tracked. The two main goals are to create a forest ecosystem and generate canopy
- Area Reforestation Method – large areas are planted to generate a forest ecosystem, for example converting from agriculture and in upland areas. This quantification method is under development

In all cases, the estimated amount of CO_2 stored 25-years after planting is calculated. The forecasted amount of CO_2 stored during this time is the value from which the Registry issues credits in the amounts of 10%, 40% and 30% at Years 1, 4, and 6 after planting, respectively. A 20% mortality deduction is applied before calculation of Year 1 Credits in the Single Tree and Clustered Parks Planting Methods. A 5% buffer pool deduction is applied in all three methods before calculation of any crediting, with these funds going into a program-wide pool to insure against catastrophic loss of trees. At the end of the project, in year 25, Operators will receive credits for all CO_2 stored, minus credits already issued.

In the Single Tree Method, the amount of CO_2 stored in project trees 25-years after planting is calculated as the product of tree numbers and the 25-year CO_2 index (kg/tree) for each tree-type (e.g., Broadleaf Deciduous Large = BDL). The Registry requires the user to apply a 20% tree mortality deduction before

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calculation of Year 1 Credits. Year 4 and Year 6 Credits depend on sampling and mortality data. A 5% buffer pool deduction is applied as well before calculation at any stage.

In the Clustered Parks Planting Method, the amount of CO_2 stored after 25-years by planted project trees is based on the anticipated amount of tree canopy area (TC). Because different tree-types store different amounts of CO_2 based on their size and wood density, TC is weighted based on species mix. The estimated amount of TC area occupied by each tree-type is the product of the total TC and each tree-type's percentage TC. This calculation distributes the TC area among tree-types based on the percentage of trees planted and each tree-type's crown projection area. Subsequent calculations reduce the amount of CO_2 estimated to be stored after 25 years based on the 20% anticipated mortality rate and the 5% buffer pool deduction.

In the Canopy Method, the forecasted amount of CO_2 stored at 25-years is the product of the amount of TC and the CO_2 Index (CI, t CO_2 per acre). This approach recognizes that forest dynamics for riparian projects are different than for park projects. In many cases, native species are planted close together and early competition results in high mortality and rapid canopy closure. Unlike urban park plantings, substantial amounts of carbon can be stored in the riparian understory vegetation and forest floor. To provide an accurate and complete accounting, we use the USDA Forest Service General Technical Report NE-343, with biometric data for 51 forest ecosystems derived from U.S. Forest Inventory and Assessment plots (Smith et al., 2006). The tables provide carbon stored per hectare for each of six carbon pools as a function of stand age. We use values for 25-year old stands that account for carbon in down dead wood and forest floor material, as well as the understory vegetation and soil. If local plot data are provided, values for live wood, dead standing and dead down wood are adjusted following guidance in GTR NE-343. More information on methods used to prepare the tables and make adjustments can be found in Smith et al., 2006. See Attachment A at the end of this Appendix for more information on the Canopy Method.

<u>Source Materials for Single Tree Method and Clustered Parks Planting Methods</u>

Estimates of stored (amount accumulated over many years) and sequestered CO_2 (i.e., net amount stored by tree growth over one year) 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

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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.

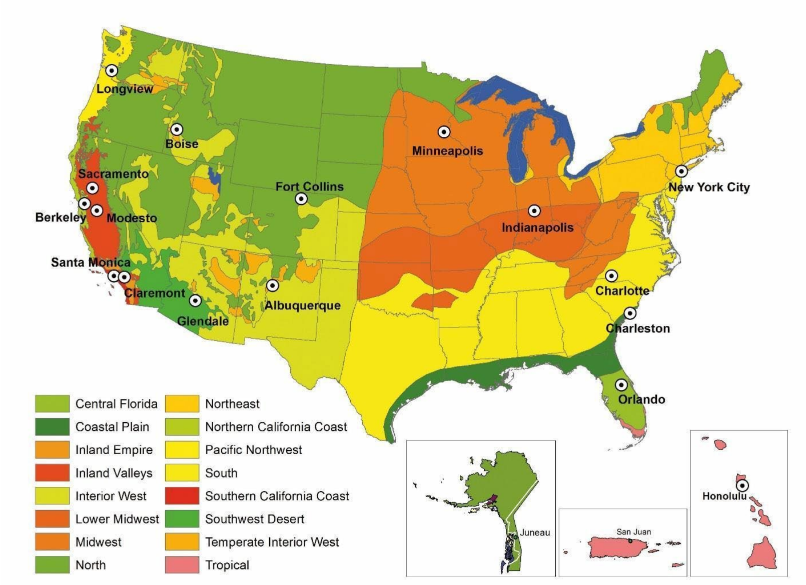

Fig. 1. Climate zones of the United States and Puerto Rico were aggregated from 45 Sunset climate zones into 16 zones. Each zone has a reference city where tree data were collected. Sacramento, California was added as a second reference city (with Modesto) to the Inland Valleys zone. Zones for Alaska,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

Species Assignment by Tree-Type

Representative species for each tree-type in the South climate zone (reference city is Charlotte, NC) are shown in Table 1. They were chosen because extensive measurements were taken on them to generate growth equations, and their mature size and form was deemed typical of other trees in that tree-type. Representative species were not available for some tree-types because none were measured. In that case, a species of similar mature size and form from the same climate zone was selected, or one from another climate zone was selected. For example, no Broadleaf Evergreen Large (BEL) species was measured in the South reference city. Because of its large mature size, *Quercus nigra* was selected to represent the BEL tree-type, although it is deciduous for a short time. *Pinus contorta*, which was measured in the PNW climate zone, was selected for the CES tree-type, because no CES species was measured in the South.

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Table 1. Nine tree-types and abbreviations. Representative species assigned to each tree-type in the South climate zone are listed. The biomass equations (species, urban general broadleaf [UGB], urban general conifer [UGC]) and dry weight density (kg/m^3) used to calculate biomass are listed for each tree-type.

Tree-Type	Tree-Type Abbreviation	Species Assigned	DW Density	Biomass Equations
Brdlf Decid Large (>50 ft)	BDL	*Quercus phellos*	600	*Quercus macrocarpa* [1.]
Brdlf Decid Med (30-50 ft)	BDM	*Pyrus calleryana*	600	UGB [2.]
Brdlf Decid Small (<30 ft)	BDS	*Cornus florida*	545	UGB [2.]
Brdlf Evgrn Large (>50 ft)	BEL	*Quercus nigra*	797	UGB [2.]
Brdlf Evgrn Med (30-50 ft)	BEM	*Magnolia grandiflora*	523	UGB [2.]
Brdlf Evgrn Small (<30 ft)	BES	*Ilex opaca*	580	UGB [2.]
Conif Evgrn Large (>50 ft)	CEL	*Pinus taeda*	389	UGC [2.]
Conif Evgrn Med (30-50 ft)	CEM	*Juniperus virginiana*	393	UGC [2.]
Conif Evgrn Small (<30 ft)	CES	*Pinus contorta*	397	UGC [2.]
[1.] from Lefsky, M., & McHale, M.,2008. [2] from Aguaron, E., & McPherson, E. G., 2012				

Calculating Biomass and Carbon Dioxide Stored

To estimate CO_2 stored, the biomass for each tree-type was calculated using urban-based allometric equations because open-growing city trees partition carbon differently than forest trees (McPherson et al., 2017a). Input variables included climate zone, species, and DBH. To project tree size at 25-years after planting, we used DBH obtained from UTD growth curves for each representative species.

Biomass equations were compiled for 26 open-grown urban trees species from literature sources (Aguaron and McPherson, 2012). General equations (Urban Gen Broadleaf and Urban Gen Conifer) were developed from the 26 urban-based equations that were species specific (McPherson et al., 2016a). These equations were used if the species of interest could not be matched taxonomically or through wood form to one of the urban species with a biomass equation. Hence, urban general equations were an alternative to applying species-specific equations because many species did not have an equation.

These allometric equations yielded aboveground wood volume. Species-specific dry weight (DW) density factors (Table 1) were used to convert green volume into dry weight (7a). The urban general equations required looking up a dry weight density factor (in Jenkins et al. 2004 first, but if not available then the Global Wood Density Database). The amount of belowground biomass in roots of urban trees is not well researched. This work assumed that root biomass was 28% of total tree biomass (Cairns et al., 1997; Husch et al., 2003; Wenger, 1984). Wood volume (dry weight) was converted to C by multiplying by the constant 0.50 (Leith, 1975), and C was converted to CO_2 by multiplying by 3.667.

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Error Estimates and Limitations

The lack of biometric data from the field remains a serious limitation to our ability to calibrate biomass equations and assign error estimates for urban trees. Differences between modeled and actual tree growth adds uncertainty to CO_2 sequestration estimates. Species assignment errors result from matching species planted with the tree-type used for biomass and growth calculations. The magnitude of this error depends on the goodness of fit in terms of matching size and growth rate. In previous urban studies the prediction bias for estimates of CO_2 storage ranged from -9% to +15%, with inaccuracies as much as 51% RMSE (Timilsina et al., 2014). Hence, a conservative estimate of error of ± 20% can be applied to estimates of total CO_2 stored as an indicator of precision.

It should be noted that estimates of CO_2 stored using the Tree Canopy Approach have several limitations that may reduce their accuracy. They rely on allometric relationships for open-growing trees, so storage estimates may not be as accurate when trees are closely spaced. Also, they assume that the distribution of tree canopy cover among tree-types remains constant, when in fact mortality may afflict certain species more than others. For these reasons, periodic "truing-up" of estimates by field sampling is suggested.

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

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(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: CO_2 Avoided

Energy savings result in reduced emissions of CO_2 and criteria air pollutants (volatile organic hydrocarbons [VOCs], NO_2, SO_2, PM_{10}) from power plants and space-heating equipment. Cooling savings reduce emissions from power plants that produce electricity, the amount depending on the fuel mix. Electricity emissions reductions were based on the fuel mixes and emission factors for each utility in the 16 reference cities/climate zones across the U.S. The dollar values of electrical energy and natural gas were based on retail residential electricity and natural gas prices obtained from each utility. Utility-specific emission factors, fuel prices and other data are available in the Community Tree Guides for each region (https://www.fs.fed.us/psw/topics/urban_forestry/products/tree_guides.shtml). To convert the amount of CO_2 avoided to a dollar amount in the spreadsheet tools, City Forest Credits uses the price of $20 per metric ton of CO_2.

Error Estimates and Limitations

Estimates of avoided CO_2 emissions have the same uncertainties that are associated with modeling effects of trees on building energy use. Also, utility-specific emission factors are changing as many utilities incorporate renewable fuels sources into their portfolios. Values reported in CFC tools may overestimate actual benefits in areas where emission factors have become lower.

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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

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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

Our estimates of carbon dioxide storage and co-benefits 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 projects.

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