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Urban Forestry Carbon Offset Protocol 3.0

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**Duke Carbon
Offsets Initiative**
DUKE UNIVERSITY

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Abbreviations and Acronyms

C	Carbon
CH ₄	Methane
CO ₂	Carbon dioxide
CO _{2e}	Carbon dioxide equivalent
DBH	Diameter at breast height (4.5 feet from ground)
DCOI	Duke Carbon Offsets Initiative
GHG	Greenhouse gas
GWP	Global warming potential
ISA	International Society of Arboriculture
KML	Keyhole Markup Language
MtCO _{2e}	Metric ton of carbon dioxide equivalent
N ₂ O	Nitrous oxide

USFS	United States Forest Service
UTP	Urban Tree Planting

Duke Carbon Offsets Initiative Background

In 2007, Duke University signed the American College and University Presidents’ Climate Commitment (ACUPCC) and set a target of achieving climate neutrality by 2024. The Duke Carbon Offsets Initiative (DCOI) was created as a branch of Sustainable Duke to help Duke University reach climate neutrality. Since the DCOI’s inception in 2009, it has developed a number of innovative carbon offset programs in swine waste-to-energy, energy efficiency, residential solar, and now, urban forestry.

Scope

This protocol provides the procedure for determining carbon dioxide equivalent (CO_{2e}) storage associated with urban tree plantings as part of the DCOI Urban Tree Planting Program (“Program”).

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Protocol Overview

This urban forestry carbon offset protocol (“Protocol”) outlines the methodology for measuring the carbon offsets and documenting project co-benefits – the non-GHG related project benefits – generated from an urban tree planting project. This protocol should be used to ensure that the carbon offsets generated from the project meet the basic criteria of a carbon offset:

- **P**ermanent – The reduction must last in perpetuity;
- **A**dditional – The reduction would not have occurred during a business-as-usual scenario;
- **V**erifiable – The reduction must have been monitored and confirmed to have occurred;
- **E**nforceable – The reduction must be counted only once and then retired; and

- **Real** – The reduction must actually have occurred and not be the result of flawed accounting.

Trees sequester carbon by fixation through photosynthesis. Urban trees accumulate and store this carbon throughout the life of the trees, thus serving as a carbon sink. Trees that are healthy and properly managed improve the sequestration rate and lifetime storage of carbon. While urban forests have fewer trees per acre than rural forests, their widespread presence alone makes them an important carbon sink. A 2013 study found urban/community trees in the United States annually sequester 34.3 million metric tons of CO₂ equivalent and store 1.36 billion metric tons of CO₂ equivalent.¹ For comparison, this means that urban/community trees sequestered nearly as much CO₂ as the state of Nevada emitted in 2015.² Carbon sequestration within a city can be enhanced by planting new trees and maintaining the health of those trees.³

In addition to storage of carbon, trees provide many other health, environmental, and economic benefits. Trees reduce air and water pollution, intercept and absorb excess storm water, provide habitat and food for animals and pollinators, offer education and volunteer opportunities to students and community members, improve the health of citizens, and can lower utility bills by providing shade for homes when planted in correct locations. However, it is important to recognize that trees can negatively impact surrounding infrastructure and be costly to maintain. As trees grow, their roots can upend sidewalks and their branches can interfere with powerlines. Local municipalities will likely need to spend more time and money on maintenance of the trees, as well as clean-up from storms and fallen litter.

This protocol adapts various requirements and definitions from the Climate Action Reserve's (CAR) Urban Tree Planting Project Protocol.⁴ However, depending on program needs, these conditions could be adjusted.

Definitions

This protocol uses the following definitions provided by the Climate Action Reserve (CAR) Urban Tree Planting Project Protocol (2.0) and the US Environment Protection Agency (US EPA):

- ***Carbon Dioxide Equivalent (CO₂e) Emissions*** is a metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as metric tons of carbon dioxide equivalents (MtCO₂e). The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP. (US EPA)
- ***Carbon Offset or Carbon Credit*** is equal to one metric ton of carbon dioxide equivalent (MtCO₂e) and can be used to reduce the emissions of an entity by one MtCO₂e or sold to another entity for an agreed upon price.

¹ https://www.fs.fed.us/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf

² <https://www.eia.gov/state/rankings/#/series/226>

³ <https://www.fs.usda.gov/treesearch/pubs/6779>

⁴ http://www.climateactionreserve.org/wp-content/uploads/2014/07/Urban_Tree_Planting_Project_Protocol_V2.0.pdf

- **Carbon Offset Reversal** is “a decrease in the stored carbon stocks associated with the GHG reductions and removals that occurs before the end of the project life.” This can happen when the trees within the project are negatively affected (i.e. tree death, diminished growth rate, loss of crown biomass) due to human activity (avoidable reversal) or unforeseen natural disturbances such as pests or weather (unavoidable reversal). The impact from these types of events should be quantified and subsequently the calculated amount of carbon offsets should be retired from the available buffer pool. (CAR)
- **Greenhouse Gas (GHG)** means any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases includes:
 - carbon dioxide (CO₂)
 - methane (CH₄)
 - nitrous oxide (N₂O)
 - Fluorinated gases (chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) (US EPA)
- **Leakage** is when GHG emissions unintentionally increase outside of the project area due to project activities.
- **Monitoring Events** include full inventories and annual surveys, using valid and rigorous sampling methodologies.
- **Project Duration** means the entire 40-year length of the project, including the 20-year project crediting period and monitoring.
- **Unavoidable Reversal** “is any Reversal not due to the Project Operator’s negligence, gross negligence or willful intent, including, but not limited to, wildfires or disease that are not the result of the Project Operator’s negligence, gross negligence or willful intent.” (CAR)
- **Urban Tree Planting (UTP) Project Definition** is a planned set of activities designed to increase the removals of CO₂ from the atmosphere, or reduce or prevent emissions of CO₂ to the atmosphere, through increasing and/or conserving urban forest carbon stocks. Carbon sequestration benefits from urban tree planting activities occur when the net CO_{2e} (CO_{2e} stored minus CO_{2e} emitted) associated with planted trees exceeds baseline tree planting CO₂. (CAR)
- **Verification** is “the process of reviewing and assessing all of a project’s reported data and information to confirm that the project operator has adhered to the requirements of this protocol.” (CAR). Verification must occur before offsets are generated.
- **Validation** is a the initial project Verification, including a holistic assessment of the Project, a document review and a site visit post planting. This may differ slightly from other offset protocols that conduct formal validations before planting.

Co-Benefits of Urban Tree Plantings

In addition to the emission reductions, there are many other benefits associated with urban tree plantings. This section highlights the categories that Duke University considers and assess the qualitative co-benefits of this type of program.

⁵ <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>

- **Education**—Urban tree plantings could provide the following educational co-benefits:
 - Offer students an opportunity to develop a carbon offset program
 - Provide volunteering opportunities to coordinate and attend tree planting events
 - Inform community members about the benefits of an urban forest and trees
 - Help develop curriculum about the life and measurements of trees, climate change, and carbon mitigation.
 - Provide opportunities for improved understanding of how climate change will affect potential carbon storage in urban tree plantings
 - Allow for knowledge creation and dissemination regarding tree planting data and subsequent analysis.
- **Social**—Urban tree plantings could provide the following social co-benefits:
 - Foster a connection with local communities and neighborhood through host tree planting events
 - Create a safer walking environment by creating a barrier between cars and sidewalks
 - Reduce crime by fostering community pride and increasing foot traffic
 - Provide emotional and physiological health benefits such as reduced employee sick time and faster recovery for hospital patients.
 - Improve ecological awareness and literacy by providing spaces to interact with nature.
- **Environmental**—Urban tree plantings could provide the following environmental co-benefits:
 - Remove harmful pollutants from car exhaust from the atmosphere
 - Reduce storm water runoff through water evaporation and transpiration
 - Improve resilience to climate change by increasing shade and managing storm water
 - Provide shade to buildings, leading to a reduction in energy use for cooling
 - Offer habitat for local animal populations
- **Economic**—Investments in the urban forest can provide the following economic co-benefits:
 - Increase property values of homes near trees
 - Improve business traffic by encouraging people to use the sidewalks
 - Increase the longevity of roads by reducing heating/cooling fluctuations
 - Reduce building energy bills by reducing heating and cooling needs
 - Provides a high return-on-investment when ecosystem services are aggregated
 - Boosting the local economy, through job creation and use of nurseries and landscapers.
- **Public Relations and Partnerships**—Urban tree plantings are a highly visible community engagement project. This type of project also requires the collaboration of a variety of stakeholders from municipal employees to neighborhood associations to companies looking to engage the community in a lasting, powerful way.

Project Participants

- **Urban Tree Planting Owner** is a corporation, a legally constituted entity (such as a utility or special district), city, county, state agency, educational campus, individual(s), or a combination thereof that has legal control of any amount of urban forest carbon within the Project Area. Control of urban forest carbon means the UTP Owner has the legal authority to effect changes to urban forest carbon quantities (right to plant or remove,

for example). Control of urban forest carbon occurs, for purposes of satisfying this protocol, through fee ownership perpetual contractual agreements, and/or deeded encumbrances. This protocol recognizes the fee owner as the default owner of urban forest carbon where no explicit legal encumbrance exists. Individuals or entities holding mineral, gas, oil, or similar de minimis interests without fee ownership are precluded from the definition of UTP Owner.

- ***Urban Tree Planting Operators*** must contract with the UTP Owner to obtain ownership of the urban forest carbon created from the project. The UTP Operator is thereby responsible for project quantification, monitoring, reporting, and contracting with a third-party to verify the carbon. The Project Operator is responsible for any reversals associated with the project. In all cases where multiple Urban TP Owners participate in a UTP Project, the Project Operator must secure an agreement from all other UTP Owners that assigns ownership of the urban forest carbon to the Project Operator.
- ***Urban Tree Planting Maintainer*** is an entity responsible for maintaining the health of all project trees across the project timeline. Project Maintainers can be the UTP Owner, municipal tree crews, contractors, or volunteers trained in best industry practices of arboriculture. The UTP Maintainer is also responsible for documenting all found tree deaths and submitting them to the UTP Operator for review.

Credit Ownership

The UTP Operator must demonstrate ownership of potential credits 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 and assume responsibility for maintenance and liability for them; 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 carbon credits within that easement, and accept ownership of those Project trees by assuming responsibility for maintenance and liability for them; or
- C. Have a written and signed agreement from the landowner granting ownership to the Project Operator for the Project Duration of any credits for carbon storage or other benefits delivered by Project trees on that landowner's land, and clearly designating tree maintenance responsibility and liability to one of the participating parties.

Eligibility Conditions

This protocol uses the following eligibility conditions provided by the CAR Urban Tree Planting Project Protocol. However, depending on program needs, these conditions could be adjusted as long as they are approved by Offset Network.

Any Planting included in a Project shall meet the following conditions:

- **Project Location:** Projects must be located within at least one of the following:
 - A. The Urban Area or Urban Cluster boundary, as defined by the United States Census Bureau⁶
 - 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;

Project Area: The Project Area is the geographic extent of the UTP Project. The Project Area may be made of aggregated areas. An electronic file must be made available which identifies the project boundaries. There are no size limits for UTP Projects. Areas previously used for commercial lumber products are considered on a case-by-case basis.

- **Project Commencement:** A Project commences when the Project Operator submits the project for Registry or GHG Program inclusion, provided the Registry or GHG Program, in this case offsetnetwork.org, approves that application within six months of submittal. Additionally, the date of tree planting or the date that tree inventory data is collected may be selected, provided sufficient timestamped evidence (i.e. email receipt of tree inventory data).
- **Additionality:** The Project must yield surplus GHG emission reductions and removals that are additional to what would have occurred in the absence of funding for the carbon offset project. The additionality checklist and protocol requirements for determining eligibility are listed in the section “Procedure for Determining Additionality.”
- **Legal Requirement:** UTP Projects must achieve GHG reductions or removals above and beyond any GHG reductions or removals that would result from compliance with any federal, state, or local law, statute, rule, regulation, or ordinance. Projects must also achieve GHG reductions and removals above and beyond any GHG reductions or removals that would result from compliance with any court order or other legally binding mandates.
- **Performance Standard Test:** Projects must achieve reductions or removals above and beyond any GHG reductions or removals that would result from engaging in business-as-usual activities. This protocol uses the current business-as-usual within the United States wherein more urban tree canopy cover is lost than gained annually as a national baseline⁷ and recognizes that the use of this baseline would legitimize all newly planted trees as additional, thereby allowing business-as-usual tree planting efforts to pass additionality. Therefore, this protocol goes beyond this national baseline by requiring completion of the additionality checklist as found in the “Procedure for Determining Additionality” to maintain a rigorous project-by-project test for additionality.
- **Project Crediting Period:** The crediting period for a UTP is 20 years. Projects may be renewed but must calculate an updated baseline. The original baseline may be held

⁶ <https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural.html>

⁷ <https://www.sciencedirect.com/science/article/pii/S1618866717307094>

throughout the 20-year crediting period. An updated baseline must ensure that a minimum planting is maintained and no new laws or regulations have been passed changing planting standards. The minimum required Project Duration, which includes this crediting period and a monitoring period, is 40 years long.

- **Minimum Time Commitment:** Projects must monitor, and report project data through to the end of a verification period, at which time the UTP Operator may choose to continue or discontinue the project. The project must maintain quantified standing carbon within the project area and remain in accordance with a signed project contract that provides for appropriate recourse in the event of a project reversal and the release of the project’s stored standing carbon. For more information on discontinuing the project, see Appendix 1.

Procedure for Demonstrating High Quality Offsets

This section discusses the components of a high-quality carbon offset with in-depth descriptions of PAVER requirements and co-benefits.

Offset Criteria and Definition	Required Data and Program Procedures
<p>Permanent The reduction must last in perpetuity and the emission reductions cannot be reversed.</p>	<p>It is important to ensure the longevity and health of trees within the program for them to efficiently store as much carbon as possible. Trees in urban settings are subject to a variety of stressors including minimal rooting zone issues, poor soil quality, drastic temperature fluctuations, lack of water, toxicity, and human interactions. These issues increase the mortality rate of urban trees when compared to non-urban trees and are most pronounced during the first 10 years of growth when trees are adapting to their harsher environments, establishing root systems, and building resilience against these factors.</p> <p>An appropriate management plan for the climate region and species involved should include at a minimum: root zone protection, watering, pruning, monitoring for disease or disorders, and replacement of dead trees. For best practices on tree maintenance, see “Risk Mitigation” section below . Despite a robust management plan, higher mortality rates are still anticipated when compared to non-urban trees. Therefore, it is important to determine a buffer pool to take this into account, or use a carbon offset bundle to mitigate risk. For more information on these options, please read the “Buffer Pool” and “Offset Bundle” sections below.</p>
<p>Additional The reduction would not have occurred during a business-as-usual scenario</p>	<p>To demonstrate additionality, the project must show that there are significant barriers to planting more trees, such as funding or staff limitations. Projects must also show how they remove barriers and result in an increase in tree planting and therefore an increase in carbon storage. For more information about additionality, please read the “Procedure for Determining Additionality” section of this document.</p>

<p>Verifiable The reduction must have been monitored and confirmed to have occurred</p>	<p>At a minimum, the required data for this is the height and trunk diameter at breast height (DBH) of the trees to calculate volume, species information for each tree, and whether or not the tree is alive or dead. This data is needed for each tree (if doing a full inventory) or a random sampling of trees.</p> <p>All offsets generated using this protocol must be verified either by a third-party organization or via peer review. This depends highly on whether the offsets are meant for the voluntary market or internal use. All data and procedures must be transparent and available to the public.</p>
<p>Enforceable The reduction must be counted only once by a single organization and then retired.</p>	<p>After the carbon offsets have been calculated, each individual offset can only be used by a single organization and then retired (i.e. cannot be used again). To properly enforce ownership of offsets, a contract between the UTP Owner and the UTP Operator shall state which organization(s) receives the offsets and how many offsets are to be given to the organization(s). Refer to the “Credit Ownership” section for additional information.</p>
<p>Real The reduction must actually have occurred and not be the result of flawed accounting.</p>	<p>Tree measurement data and the carbon offset calculation methodology should be transparent and made available to the public. The project manager should share the locations and information about the trees in an online mapping database or other similarly accessible and transparent resource that is available to the public and allows for visual verification.</p>

Procedure for Determining Additionality

Additionality is the foundation for trustworthy carbon offset projects. While methods for determining additionality are a topic of debate within the offset professional community, the following offset checklist guides UTP Operators through the task of documenting additionality. This project-by-project approach to additionality requires each project to be assessed within its unique circumstances and relies on UTP Operators to support their findings with instituted policies, supporting documents, and signed agreements to maintain baseline levels of tree planting.⁸

Additionality Checklist:

In order to pass the minimum qualifications for additionality, you must answer YES to all of the following questions. A more comprehensive overview of Additionality is available in the Validation Guidance document on offsetnetwork.org.

- 1) Can you provide baseline planting data such as historical budget information that outlines the number of trees you have planted and the cost of any associated maintenance in the past 5 years? This step is to ensure money provided to support the UTP will be in addition to any budgets already in place. Note: This information must be disaggregated from cost of tree removal.
 - i. If budgetary information is not available, can you provide planting history data, including the number of trees planted in the past 5 years?

⁸ This strategy is slightly different from the Climate Action Reserve’s Urban Forestry Protocol, which employs more standardized but less flexible additionality criteria.

- 2) If you or your organization is bound by any law, regulation, statute, or court orders to plant trees in the same manner as the UTP project: Is your UTP offsetting project resulting in a greater number of planted trees than legally mandated? Note: Only such “additional” trees may be considered for offsetting purposes.
 - i. Provide explanation of any relevant mandated actions.
 - ii. Attest via signature to the validity of your response.
- 3) Do implementation barriers, such as budget, staffing, capacity, knowledge gaps, local resistance, or other factors exist to limit your ability to plant trees beyond current business-as-usual levels?
 - i. Provide detailed explanation of existing barriers and include backup documentation and evidence where available (emails, signed attestations, etc).
 - ii. Refer to “Procedure for Determining a Baseline” for guidance in establishing the business-as-usual scenario.
- 4) Can you demonstrate that the reductions and removals of carbon from your offset project are above the business-as-usual scenario?
 - i. Provide explanation of the business-as-usual scenario.
 - ii. Provide proof of the offset planting program.
- 5) Is your organization willing to sign an agreement that states you will minimize project leakage by maintaining efforts to pursue and obtain baseline tree planting funding and the funding for the UTP will not displace any current operational budget?
 - i. NOTE: Leakage can also diminish the staff capacity to maintain established trees due to the increase of trees planted. To account for this, it is important to establish a leakage buffer to account for any losses.
 - ii. Refer to the section titled “Risk Mitigation” for additional info about leakage.

Procedure for Determining a Baseline

This protocol will determine the project baseline, and the business-as-usual scenario for UTP Projects based upon a national baseline coupled with the fulfillment of the Additionality Checklist. The combination of these two components assures the project’s tree planting efforts are beyond the business-as-usual scenario at a national level and that the UTP is truly additional at the zoomed-in, unique organizational perspective as well.

Apply a National Baseline: Urban tree cover is declining nationally. This protocol therefore permits the use of a national baseline of declining tree cover as the business-as-usual scenario for use by the UTP Operator in determining the project impact. Therefore, it can be assumed that qualifying trees planted through the use of this protocol are beyond this national baseline and do not require assessment of the UTP Project Site’s standing carbon before implementation of the UTP Project occurs. While the national trend in forest cover is accepted by this protocol, if regional or local data on the urban forest near the project is available it will more accurately assess the baseline.

Provide a Planting Program: As stated in the Additionality Checklist, the UTP Owner/Maintainer should provide currently active planting programs, if available. This tree planting plan offers the most accurate assessment of future tree planting efforts in establishing the business-as-usual and baseline scenario. If no formal plan exists, provide budget information combining both tree planting funds as well as tree maintenance funds to act as a financial baseline of urban forestry effort within a given jurisdiction.

Additional Options to Determine a Baseline: Further options for determining the project baseline may be found in Appendix 2 and represent approaches applied by CAR's Urban Forestry Protocol. These options involve a greater time commitment from the UTP Operator but may make sense to pursue if the baseline represents a scenario in which tree cover is decreasing at a rate faster than the nationally applied baseline.

Risk Mitigation

There is a risk that the planted trees do not capture the anticipated amounts of carbon due to tree death or slow growth rates. Trees are more likely to thrive if they are properly selected for the site, well maintained, and UTP Maintainers care for trees following best management practices for urban tree care. Nevertheless, some level of unavoidable risk will remain due to leakage, human error, and natural disasters or pests. To mitigate against this risk, the protocol requires the use of a conservative buffer pool.

Best Practices for Urban Tree Care

Caring properly for trees may reduce mortality, improve growth, and ultimately reduce the risks associated with a UTP. Regular tree maintenance should be completed by a Certified Arborist⁹ who understands the intricacies of tree care in the local ecosystem. The following broad categories of tree maintenance should be completed in the long term, with considerations for each particular planting project. It is important to consult with an expert to determine best care practices:

- **Tree Selection:** The survival and health of a tree depends on how well the species is matched to a particular site. See 'Other Considerations' for more details regarding tree selection.
- **Planting:** Best practices in planting are also highly site-specific. However, the trees should be planted in an area with enough room for the tree to grow unimpeded (including root growth) for the foreseeable future. The UTP Owner may need to work with the City's Forestry manager to determine where trees can be planted on public land. Trees should be planted carefully by well-trained individuals that follow best management practices for the tree type and region.¹⁰ Depending on the planting site, trunk guards, staking, and guying may be necessary to protect trees from vandalism and/or injury.
- **Pruning:** Regular pruning is necessary for the structural development and long-term health of most species and may be necessary to remove diseased or damaged branches or for more practical applications like keeping signage, roadways and powerlines clear. Regardless of the purpose, pruning must be done carefully and intentionally¹¹; any pruning is technically

⁹ <https://www.treesaregood.org/findanarborist>

¹⁰ <https://www.fs.usda.gov/naspf/publications/tree-owners-manual-national-edition>

¹¹ A Certified Arborist may provide location and tree-specific expertise on pruning. Basic guides are also available; for North Carolina, consider: <http://www.ncufc.org/pruning.php>

wounding the tree and may have long-term consequences if done improperly. Topping, which is indiscriminate cutting of tree branches leading to stubs or lateral branches that are not large enough to assume the terminal role, is widely discouraged among arborists¹².

- **Mulching:** Mulching can provide a suite of benefits to the trees, including but not limited to: moisture control, weed prevention, and soil quality improvement. Only a thin layer (~2-3 inches) of mulch is necessary; ideally, it should extend from 3 inches away from the base of the tree to the width of the canopy.¹³ If the mulch ring cannot extend to the edge of the canopy, extending it as far as possible will still be beneficial. It is important that the mulch does not cover the tree trunk (i.e. volcano mulch) to prevent tree bark from rotting.
- **Pest Management:** Pest infestation can severely harm trees and can be difficult to control. Pest control will vary drastically depending on the type of pest, and can range from little to no damage to requiring the complete removal of a tree. Selecting diverse and resilient trees and regularly monitoring for pests can help mitigate the damage of pests. Application of pesticides should be undertaken only by licensed/trained applicators.
- **End of Life:** End-of-life use of fallen, damaged or management directed tree removals is accepted and encouraged through this protocol. End-of-life use of trees must adhere to management principles and removals must remain within anticipated mortality rates, but these trees should be used to reduce the purchase of new wood products provided that doing so does not increase CO₂ emissions relative to the BAU purchase of new wood products.

Buffer Pool

A conservative buffer pool is used to protect against unavoidable reversals in the project. This buffer pool addresses three primary concerns: leakage, anticipated mortality of project trees, and crediting of offsets at project initiation. Each of these concerns are addressed within the buffer pool in the following manner:

- Leakage
 - Leakage occurs when the maintenance burden on the UTP Maintainer increases to the point where tree health across the UTP Owner's sites (project & non-project trees) suffers, or when offset project funding causes a reduction in the baseline budget for urban forest management. Unmitigated leakage can increase the likelihood of tree mortality or cause a reduction in long-term funding.
 - A 5% contribution of credits to the buffer pool accounts for this burden.
 - Adjustments can be made to Leakage's contribution 10 years after project initiation. At that point, if Leakage contribution is found to be too high, offsets can be reconciled and returned to the UTP Owner.
- Anticipated Mortality
 - While tree mortality rates vary based on species and location, it is necessary to create a standard expected mortality to establish a robust buffer pool contribution.
 - Urban foresters anticipate a 2-7% annual median mortality rate on transplanted trees

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¹² <http://www.treesaregood.org/portals/0/docs/treecare/WhyToppingHurts.pdf>

¹³ <http://www.ncufc.org/mulches.php>

¹⁴ <https://www.fs.usda.gov/treearch/pubs/58772>

- In lieu of 3rd party verification, buffer pool contributions related to anticipated mortality will be a conservative 10%⁰¹⁵.
- Crediting
 - Once the project is initiated, the offsets must be verified to have occurred before they may be retired and used to counter emissions.
 - Once the offsets have been verified (see verification schedule below), 85% of the verified offsets can be purchased, leaving 15% in the buffer pool in case of future mortality and leakage.

Offset Network reserves the right to review the scale and scope of all buffer pool contributions during project lifetime.

This 15% buffer pool was compared to similar protocols, such as the [ACR Tool for Risk Analysis and Buffer Determination V1.0¹⁶](#). Unintentional risk factors included in this determination of project risks are outlined below and align closely with the 15% total buffer pool required above.

Financial 4%
 Project Management 4%
 Social/Policy 2%
 Disease and Pests (no epidemic disease or infestation in area) 4%
 Other natural disaster events 2%

TOTAL DEFAULT RISK FACTOR = 16%

Other Considerations

Tree Species Selection

Tree species should be selected based on the specific site to ensure short-term survivability and long-term longevity. However, past climate conditions are not a good predictor of future climate conditions. Precipitation and temperature patterns are changing with rising atmospheric carbon concentrations. As a consequence, local populations of insects, fungi, and other organisms that form the ecosystem within which urban trees exist, whether in mutualistic or antagonistic relationships, will also be changing. The effects of these systemic changes on trees' carbon storage capacity are very likely to vary substantially by tree species. Therefore, this protocol encourages experimental variety in the tree species planted even if the result is that the species planted are not those that would maximize carbon storage under current climate and climate-related conditions. Such experimentation will not require an increase in the size of the buffer pool. It is recommended that a Project Developer work with a local nursery and/or tree planting partner when making tree species selections.

Tree Planting Locations

¹⁵ https://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs158.pdf

¹⁶ <https://americancarbonregistry.org/carbon-accounting/guidance-tools-templates/acr-risk-tool-v1-0.pdf>

While this protocol only requires that trees are planted in an urban area, it is recommended that project developers and their partners take into account several factors when deciding where to plant Project Trees:

- **Equity:** Does the tree cover in an urban area differ based on the socioeconomic and racial characteristics of neighborhoods? The urban tree canopy in cities across the United States has been positively correlated with median household income, demonstrating an environmental justice concern¹⁷. When possible, plant trees to correct this injustice and ensure that all citizens benefit from tree cover.
- **Shade Provision:** Plant trees where shade provision on buildings and hardscape will be maximized. This placement of trees can lead to reduced energy use in buildings and lessen the urban heat island effect, further reducing the amount of carbon that is ultimately released into the atmosphere.

Quantifying Tree Carbon Sequestration

Estimates of tree carbon sequestration are based on the i-Tree Eco tool. This tool incorporates age or diameter at breast height, regional climate data, and tree species to estimate aboveground biomass and rates of carbon sequestration. i-Tree is a USDA Forest Service tool that derives its models from data from nearly 1000 urban trees. Project developers can opt to use software packages that integrate this tool into a user-friendly interface. See Appendix 5 for more information.

Project Monitoring

The purpose of project monitoring is to ensure the project trees are achieving their goals of generating offsets, sequestering atmospheric CO₂, and providing co-benefits as projected for the full project period. Additionally, this monitoring may lead to valuable information about the trees, such as their sensitivity to climate change and carbon storage capacity.

Project monitoring is conducted in two phases, full inventory and annual surveys, also known as Monitoring Events. The full inventory is repeated every 5 years and the annual surveys are conducted every year in between each full inventory event. Project monitoring is usually completed by the UTP Maintainer according to the following schedule:

Time Since Planting	Monitoring Event Type
Within 4 weeks	Full inventory*
Years 1-4	Annual surveys
Year 5	Full inventory
Years 6-9	Annual surveys
Year 10	Full inventory
Years 11-14	Annual surveys

¹⁷ <https://www.vibrantcitieslab.com/resources/trees-grow-on-money-urban-forests-signal-environmental-injustice/>

Time Since Planting	Monitoring Event Type
Year 15	Full inventory
Years 16-19	Annual surveys
Year 20	Full inventory
Years 21-24	Annual surveys
Year 25	Full inventory
Years 26-29	Annual surveys
Year 30	Full inventory
Years 31-34	Annual surveys
Year 35	Full inventory
Years 36-39	Annual surveys
Year 40	Full inventory

Full Inventories

Full Inventories are used to measure the growth and health of project trees. Project verifiers compare their measurements with full inventories at each verification period (see Verification Timeline) to ensure project expectations and buffer pool contributions are aligned.

The following data must be collected during each Full Inventory for every tree planted, or in accordance with representative sampling practices as detailed in the section below titled “Sampling”:

- Location (must be uniquely identifiable such as GPS coordinates)¹⁸
- Species of tree
- Diameter at Breast Height (DBH)
- Height or height estimate
- Health and vigor

For quality assurance of these inventories, it is recommended that ISA Best Management Practices for Tree Inventories be used. However, since this is not a publicly available document, it is not required.

Additional data, such as maintenance needs & site conditions, can be captured during Full Inventories depending on the availability of each city. It is recommended to receive direct feedback on tree health by having maintenance workers perform site visits with the verifier, and by ensuring that maintenance staff includes a trained arborist/forester or that maintenance staff have access to the services of a trained arborist/forester.

Full Inventories should ensure representative project data to reduce the risk of potential future reversals. The initial full inventory, after planting, requires that all trees are inventoried. For future full inventories, if fewer than 100% of trees are to be inventoried, please follow the guidance

¹⁸ Sometimes GPS may not function optimally on site due to various reasons such as inclement weather and/or device limitations. Under such situation, the GPS tool should allow users to manually plot the planted trees on the map in a manner such that the relative positions of the trees are consistent and allow easy tracking of trees on site.

provided in Appendix 3 – Sampling Methodology to fulfill representative sampling guidelines and complete the Full Inventory.

Annual Surveys

Annual Surveys are intended to identify anomalies in the growth and health of project trees and act as preventative ‘check-ups’ that allow UTP Operators to identify issues in between Full Inventories. Annual surveys reduce overall maintenance costs and further reduce project risk. The following data must be confirmed by surveying, in accordance with the sampling recommendations, the same number of trees as in a Full Inventory year during each Annual Survey:

- Does the tree still exist?
 - a. It is There/Not There
 - b. It is Alive/Dead

If a tree is Not There and/or Dead (a partial project reversal) the UTP Maintainer or Operator must determine the cause of the reversal, and if biologically caused, consult a trained forester either on the maintenance staff or through an established relationship to identify the cause of the reversal and ensure additional project trees will not be affected (in the case of pests/diseases, etc.). The UTP Operator and Maintainer must then assess the carbon cost of the reversal, the appropriate action needed to recover project assets from the buffer pool, and estimate the future impact on the project’s estimated carbon sequestration.

Additional data, such as health & vigor, maintenance needs, and site conditions, are also recommended to be gathered during Annual Surveys to ensure consistency of management practices.

Sampling

Depending on the total population (the # of trees) of the Urban Forestry project, inventorying the entire population may not be financially feasible, or might itself produce a carbon footprint that cannot be justified on the basis of the increment to knowledge relative to strategic sampling. To simplify the process and reduce the total amount of work associated with inventorying large populations, this protocol recommends sampling. Assuming the sample is representative of the entire population and limited in overall bias, sampling can be a cost and time effective method of inventorying without sacrificing data quality. This protocol utilizes simple random sampling (as explained in **Appendix 3 – Sampling Methodology**) to generate a sample that is large enough *and* representative of the population, so that the data collected from the sample can be extrapolated to the entire population with statistical significance.

As mentioned in the [California Air Resources Board \(CARB\) Urban Forestry Protocol](#)¹⁹, the goal of sampling is to reduce the number of samples taken as much as possible, while avoiding biased estimates. In their protocol, CARB offers explanations of several different sampling processes. The Climate Action Reserve (CAR) also offers a [guidance document](#) regarding a distinct sampling method known as “sequential sampling.” This methodology samples a small portion of the population, and if the attained values fall within a range of expected values, the sampling stops. Should any values fall outside that range or bias in the sampling is detected, sampling must continue.

¹⁹ See pages 25-34.

Monitoring Report

Monitoring Reports must be generated following all Annual Surveys and Full Inventories, also known as Monitoring Events. During each monitoring event, the data will be collected and entered into a computer-based spreadsheet or using software designed for urban forest inventory data collection. The template of a monitoring report is provided in Appendix 6 below. The data collected in the monitoring report will be used to estimate carbon sequestration within the project, and it must be stored to a secure server and made available to project verifiers upon request in coordination with the Verification Timeline.

In addition to data collection, the method should produce monitoring reports after each monitoring event that include the following:

- Date(s) of monitoring event: when data was collected in the field
- Names of data collectors with contact information (both phone number and email address)
- Type of monitoring event (Full Inventory or Annual Survey)
- Methods of tree inspection (Drive-by or visual inspection, in-person or online (ie using recent Google Street View images or drone surveys), what percentage of trees are sampled?)
- Estimated number of hours spent on monitoring event
- Summary of data collected
- Identification of any and all reversals (tree deaths/missing trees), any and all potential near-future reversals (evidence of tree decline or disease)
- A comparison of actual and projected carbon stocks for each Full Inventory
 - If actual carbon stocks differ from projected stocks by more than 5%, the monitoring report should also include steps for adjustment (replanting of tree, reduction in available buffer, etc.)

Data, surveys and reports from every completed Monitoring Event must be made available to project verifiers during verification periods.

Verification

Verification supports the project by confirming the validity and existence of carbon offsets generated by an offset project. This section identifies the different levels of verification that are accepted under this protocol, the requirements of each verification, and the required verification timeline.

Verification Methods

There are two accepted verification methods for projects using this protocol. Below is a description of each method.

- 3rd Party Verification
 - An organization external to project operator, UTP Owner, and UTP Maintainer that is accredited to ISO standards 14065 and 14064-3 and has working knowledge of this protocol.
- Educational Institution Peer Verification
 - A peer educational institution with an individual or department possessing working knowledge of this protocol, comprehensive knowledge of PAVER requirement

- fulfillment, and demonstrable ability to exercise a Verification.
- Follow guidance document provided by the Peer Review Committee (forthcoming on offsetnetwork.org) for executing Full Verifications.
- Credits issued through Educational Institution Peer Verification are expected to be eligible for internal carbon commitments through programs such as AASHE Stars and Second Nature. Credits are not anticipated to be marketable.

The following sections describe the purpose of each verification method, the steps involved, and the resulting Buffer Pool contributions.

Verification Requirements

- Project Validation: This initial process provides a holistic assessment of the Project, including a document review and site visit. It is only performed once, at the beginning of the project. More information is available in the Urban Forestry Validation Guidance document²⁰.
 - During this validation event, the verifier(s) are required to do the following:
 - a site visit to ensure existence of project
 - count all planted trees (per species) to ensure it matches project operators' purchase/planting list
 - verify that all necessary contracts between the project operator and the UTP Owner(s) are set, to ensure that offset ownership is enforceable
 - review monitoring reports to verify that data collection was properly documented
 - review offset projection spreadsheet for accurate accounting
 - interview data collector(s) about their data collection process
- Project Verification
 - After each Full Inventory event, the verifier is required to perform either an Onsite Verification or a Virtual-Onsite Verification as detailed below before the project can generate credits.
 - Onsite Verification:
 - Conduct a site visit to ensure existence of project
 - Count project trees to verify project operators' count
 - Verify project trees lost to removals or tree mortality
 - Review monitoring reports to verify that data collection was properly documented
 - Interview data collector(s) about their data collection process
 - Interview tree maintainers about any tree removals or major disorders
 - Review offset generation spreadsheet for accurate accounting
 - Compare calculated number of generated offsets to projected number of generated offsets to determine if they fall within 5% of each other and if not propose adjustments to the growth model requirements
 - Ensure all offsets have been given an individual ID and that the appropriate amount of offsets have been placed within the buffer pool.

²⁰ <https://offsetnetwork.org/guidance-templates>

- Virtual-Onsite Verification (fulfill all of the Onsite Verification objectives with the below adjustments):
 - This pilot-phase initiative is intended to create easier and lower-carbon options (eliminating the carbon from traveling to the project site) for full verifications.
 - A site visit may take the form of a real-time live streamed video feed (through Skype, FaceTime, Google Hangouts, or other live video streaming tool). Record your virtual site visits if possible and maintain with other verification documentation.
 - The video quality must be sufficient to verify:
 - The number of trees
 - Data collection methods
 - For large projects, the UTP Operator may purchase high-spatial-temporal resolution aerial photographs and give them to the verifier to verify the trees exist and are thriving.
- Verification Deferral
 - After the Project Validation, the UTP Operator may choose to defer the second verification (‘year 5’ below in the timeline*) until the end of the crediting period, emulating deferral options offered in the CAR Forestry Project 4.0 Protocol, Section 8.3.2.1.
 - This may occur if planted trees are small and are therefore not expected to sequester carbon rapidly until they have reached maturity.
 - No credits shall be issued during the deferral period.
 - The UTP Operator shall continue to follow all monitoring requirements during the deferral period.

Verification Timeline

Time Since Planting	Verification Event
6-12 months	Project Initial Validation
Year 5	Full Verification*
Year 10	Full Verification
Year 15	Full Verification
Year 20	Full Verification
Year 25	Full Verification
Year 30	Full Verification
Year 35	Full Verification
Year 40	Full Verification

**Second verification may be deferred until the end of the crediting period. See “Verification Deferral”*

Verification Report

Verification reports must be produced following a validation or onsite verification event. The verification report should follow the guidance provided by The Offset Network²¹ including findings from field visits, interviews with maintainers, review of documents, provision of supporting documents, and calculation of projected carbon storage and comparison between projected and actual carbon storage. The detailed list of information required for inclusion within the verification report can be found within the Validation Report and forthcoming Verification Report instructions documents and templates. The verification report must be sent to the administrator of the Offset Network to be uploaded and included within the project profile page to be publicly accessible and to allow for review of the verification report. While the verification will assess the impact of the project, this secondary level of review will assess the success of the validation/verification and therefore confirm or revise the determination of project impact established by the report.

Acknowledgments

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²¹ <https://offsetnetwork.org/resources-and-tools>

Appendix 1 – Process for Discontinuing UTP Project

If UTP Owner cannot continue their project throughout the entire 40 years commitment, they may choose to discontinue their project before the end of the 40 year period. In these circumstances, the UTP Owner is expected to purchase third-party verified offsets that are equivalent to the estimated carbon accumulated over the lifetime of the trees. For example, if a project is discontinued at Year 20, the UTP Owner must cover both the offsets already generated by the 20 years of tree growth, and offsets that would have been generated in years 21-40.

If the UTP Owners feel they have reasonable proof to assume their plantings will remain in perpetuity in the absence of continued monitoring and verification, they may petition to the GHG Program coordinator for a maximum of 25% of their offset purchase requirements to be waived.

Appendix 2 – Additional Options to Determine the Baseline Scenario

The CAR Protocol performance standard: The CAR performance standard statistic is the CO_{2e} associated with the average of tree planting data between the 50th and 100th percentiles over the past 5 years from entities similar to the project. The data are based on the following:

- Municipalities/Counties: Trees Per Capita.
- Educational Institutions: Trees Per Acre of maintained landscaping
- Utilities: Trees per ratepayer

Project Operators must include the performance standard level of planting, supplied by CAR²², as their baseline calculation as described in the Quantification Guidance:

Establishing a Baseline for a Tailored Project: This is a scenario in which Project Operators and UTP Owners freely share data and program objectives. Thus, a baseline can be calculated from the UTP Owners previous five years of planting data. Determine the baseline using the following steps (2 options):

Option 1:

- Obtain quantity and species of trees planted in the previous five years.
- Use iTree Planting²³ to calculate the projected carbon from trees planted annually as an average of the previous five years.²⁴
 - Should include necessary reductions for verified mortality²⁵.

Option 2:

- Obtain average annual number of trees planted over last five years.
- Use the average as a baseline. (CAR's way)

²² “Urban Forest Project Data” <http://www.climateactionreserve.org/how/protocols/urban-forest/>

²³ <https://planting.itreetools.org/>

²⁴ Note that not all trees planted in the urban environment will be available on the US Forest Service’s carbon calculator. When a different tree is selected, please consult with the UTP Owner, urban tree expert or reference peer reviewed literature to determine if any tree on the US Forest Service list is similar to selected tree.

²⁵ Verified Mortality Rate: the rate at which planted trees experience mortality through first years of life.

Appendix 3 – Sampling Methodology

Simple random sampling is this protocol’s primary sampling methodology; however, Project Developers can use any sampling methodology as long as it is robust and accepted in the scientific community. It is required that Project Developers thoroughly document the sampling methodology they utilize.

As an example, simple random sampling involves assigning each unit within the project population a unique number. Then, using statistical equation or online sample size calculation tools, sample sizes can be derived (NOTE: identify the source of the sample size statistical equation or online calculator used). To reduce the potential for biased estimates, this protocol requires minimum sampling at or beyond the below parameters:

Table A-1 displays example sample size based on population ranges.

Table A-1

Population Size	Calculated Sample Size using Confidence Level \geq 95%	Protocol Recommendation
1-100	86	100%
101-500*	273	70%
501-1000*	375	50%
1001-2000*	462	30%
2000+*	463+	500 Trees

*The second column, “Calculated Sample Size,” is calculated based on the upper bound population value.

After the sample size is determined and the random numbers have been assigned to each tree, a random number generator (as are available online, or through Excel), should be used to draw numbers of individual trees within the population, through the pre-determined sample size. Then, these trees would be inventoried and represent the urban forest population.

For example, if a project manager controlled a population of 200 urban trees and needed to sample 70% of them, they would assign each of the trees a unique number between 1-200 and record, using GPS or other similar technology, which tree is associated with each number. Then, using applicable software, like Excel, the project manager would request 140 numbers drawn at random between the values of 1 and 200. The 140 numbers drawn would reflect the sample of trees to be inventoried. Using the GPS data, verifiers would then measure each randomly selected tree and use the compiled data to represent the population.

Appendix 4 – Inventory Methodology

Below outlines information that would be useful to collect for each tree in the program.

Attribute	Description	
Site Information		
Date of Site Visit	Day/Month/Year	
Inventory Personnel	Enter the name of the inventory technicians responsible for measuring and recording data for the project trees. Also include contact info.	
Individual Tree Information		
Location of Tree	Latitude/Longitude from GPS*	
Tree Species	Select the genus and species (including specific varietal information) or species code for the tree. The species code can be found for each species using the U.S. Forest Service's UTP Owner RE database ²⁶ or within the approved data collection method.	
Diameter at Breast Height (DBH) or Tree Diameter	Measure and record diameter of all trees to the nearest inch using a diameter tape and wrapping the tree at a height of 4.5 feet from the base of the tree on the uphill side.	
Vigor	Provide a rating of the tree's apparent vigor. Determination of vigor based on consideration of color foliage, crown proportion and appearance, retention of leaves/needles, appearance of apical growth, length between growth whorls, and presence of cavities and fungal growth. The code is assigned base on the following classes.	
	1	Excellent - tree exhibits high level of vigor and no barriers (soil, light, etc.) to continued vigor. No decay or broken branches are observed.
	2	Good - tree exhibits high level of vigor and some minor barriers (soil, light, etc.) to continued vigor
	3	Fair - tree appears generally health. Barriers (soil, light, etc.) affect the trees vigor. Tree's crown may be smaller proportionally than in healthier areas. Decay and/or broken branches, if observed, are not likely to have negative impacts in the short term
	4	Poor - Tree appears notably unhealthy, as determined by reduced crown, presence of decay and/or broken branches and/or significant barriers to future growth. Observed problems have high likelihood of being rectified through management of said tree and trees surrounding it.

²⁶ https://www.nrs.fs.fed.us/tools/ufore/local-resources/downloads/PDF_UDORE_SPECIES_LIST.pdf

	5	Dead - No live material is observed in the tree area.
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**When GPS location is inaccurate and does not allow effective tracking, the validators should have the option to plot the trees on map manually in a manner where relative position of trees are consistent and allow easy tracking of trees for future verification.*

Appendix 5 – Quantification of Carbon Offsets

Trees sequester carbon in its leaves, branches, trunk, and roots throughout its life. To have an exact estimate of carbon sequestered by a single tree, you would have to remove the tree and all of its roots, dry them, and calculate the weight of the tree. However, this is not practical or desirable for a carbon offsetting system. Instead, there are less arduous estimation methods that are recommended to be employed for this protocol.

First, to identify the potential amount of carbon that can be sequestered throughout the lifetime of a project, it is recommended to use a carbon calculator. For example, a tool from the United States Forest Service (USFS) called i-Tree may be used to estimate the lifetime carbon sequestration of a variety of tree species around the United States.²⁷ i-Tree offers basic estimates through the i-Tree Planting tool, or can produce more comprehensive results with the i-Tree Eco tool.

After the potential growth and carbon sequestration rates have been identified, the actual measurement of trees will need to be conducted to verify the accuracy of the growth estimates.

As a base requirement, a tree's diameter at breast height (DBH), species type and general condition (excellent, good, fair, poor, dead) will need to be measured and tracked. Depending on other program or municipal needs, additional data can be collected such as maintenance needs, presence of diseases or fungus, or proximity to other utilities. Long-term health and carbon storage capacity can be tracked using applications like Fulcrum, which allows users to track tree health and maintenance needs using photographs.²⁸

Using the i-Tree tool, you can compare the height, DBH, and age that you measured/estimated to calculate the amount of carbon sequestered and stored.

²⁷ i-Tree Eco and i-Tree planting tools can be found on their website: <https://www.itreetools.org/>

²⁸ Fulcrum application information may be found on their website: <http://www.fulcrumapp.com/apps/tree-inventory-north-america/>

Appendix 6 – Template of Monitoring Reports

Date		Time (Start) Time (End)	
Name of Collector(s) & Contact Details (email & phone)			
Location			
Type of monitoring events: <input type="checkbox"/> Annual Survey <input type="checkbox"/> Full Inventory			
Sampling method & intensity			
Total number of trees surveyed			
Tree inspection methods (drive-by, visual inspection, etc)			
Number of dead trees			
Number of missing trees			
Number of unhealthy trees			
Comments Please indicate: What is the proportion of dead, missing and unhealthy trees of the population? Where such trees exist, what are the causes? Are there any follow-up actions intended? Are there any unforeseen risks to tree health such as new development works or weather damages?			

Attachments:

Please attach spreadsheet or other documents including at minimum information on:

- (i) Annual Survey: list of GPS locations, Genus, Species, Tree Presence, Tree Vigor
- (ii) Full Inventory: list of GPS locations, Genus, Species, Tree Presence, Tree Vigor, DBH, Height

Appendix 7 – Related Documents

Several documents have been published alongside this Protocol to assist project developers, validators and verifiers complete their reporting. These documents are listed below and could be found on the Offset Network – Resources and Guidance section²⁹.

1. Project Plan Instruction and template
2. Project Description Document (PDD) instructions and template
3. Validation Instruction and template
4. Additional guidance documents will be released as they are available

²⁹ <https://offsetnetwork.org/resources-guidance/>