Advancing Fort Collins' Climate Goals Through Land Carbon Management

Introduction

As a leader in local climate action, Fort Collins is on a path toward ambitious greenhouse gas (GHG) emission reductions. To meet this aggressive goal, the City will need to assess all potential avenues for reduction—including using Fort Collins lands to absorb and store carbon that would otherwise be emitted into the atmosphere.

The City commissioned a study to evaluate the potential of Fort Collins lands to reduce or offset the City's greenhouse gas emissions. The study looked at both the City's current land management practices and additional actions the City could take to help meet its climate goals. This assessment will allow the City to optimize local land management to minimize these and other environmental impacts.

Recommendations

The study revealed the following recommended steps forward, which collectively contribute about 1.3% of the City's needed emission reductions in 2050—an average of about 25,000 metric tons of additional carbon dioxide equivalent (tCO_2e) in savings per year. In the 2020 timeframe, carbon sequestration could contribute 3.2% or almost 10,000 tCO_2e.

1 Improve soil amendments

Cumulative 2050 carbon savings: 680,000 tCO_2e
Contribution toward 2050 climate goal: 1.1%

In 2015, over 47,000 tons of organic material were generated by Fort Collins businesses and residents and disposed in the landfill. Diverting organic material that is currently being landfilled, composting that material, and applying the compost to soils would reduce potent greenhouse gas emissions from landfills and the manufacturing of synthetic fertilizer.

2 Convert ash trees to other species

Cumulative 2050 carbon savings: 1,000 tCO_2e
Contribution toward 2050 climate goal: <0.01%

The emerald ash borer (EAB) poses a serious threat to future ash survival in Fort Collins. The City is already taking steps to mitigate this threat, including replacement of ash trees (*Fraxinus*) with more resilient and diverse trees. This opportunity involves taking further preventative measures to ensure that important carbon storage is not lost when the ash borer arrives and causes widespread ash tree mortality in Fort Collins.

3 Increase tree planting, focusing on drought tolerant species

Cumulative 2050 carbon savings: 146,000 tCO_2e
Contribution toward 2050 climate goal: 0.17%

The City currently promotes tree planting on residential properties through voluntary programs such as the Neighborhood Tree Planting Project and public education around locally appropriate species. Planting even more new drought-tolerant trees on private lands can increase the city's land carbon storage.

4 Restore riparian forest habitat

Cumulative 2050 carbon savings: 20,000 tCO_2e
Contribution toward 2050 climate goal: 0.05%

The City's Natural Areas Department Restoration Plan (2016-2025) establishes ambitious restoration goals, including initiating restoration of high-priority natural areas along the Poudre River by 2025. This opportunity calls for restoring even more riparian habitat in the city and at a faster pace.

Putting it in Context

Conceptual estimates suggest implementing carbon sequestration initiatives could get the City up to 3.2% (10,000 tCO_2e) closer to its 2020 goal. See below for how this ranks in comparison to other fully-vetted initiatives:

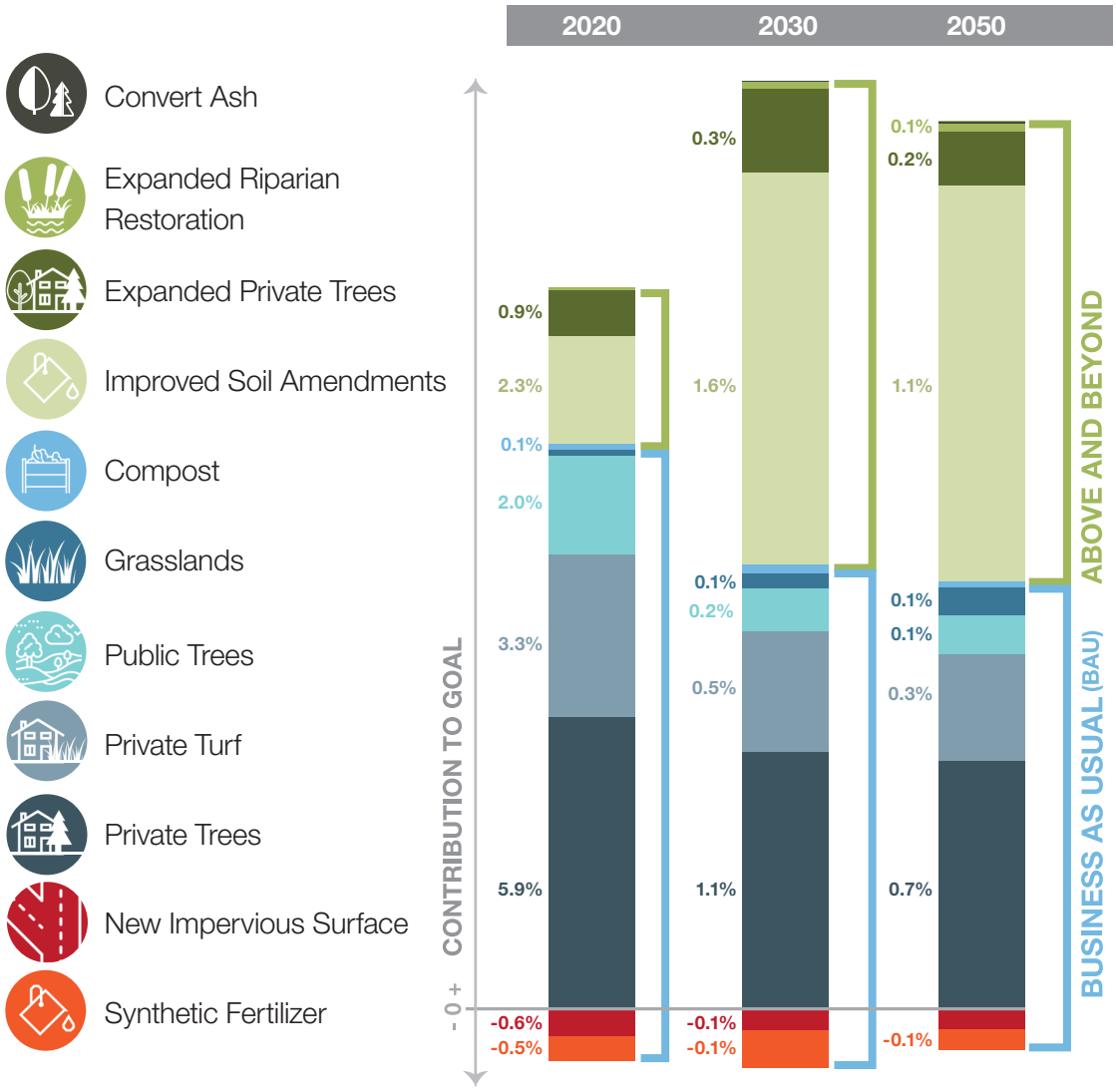
Highest contribution to goal

- Ongoing business and home efficiency (69,000 tCO_2e)
- Enhanced business and home efficiency (26,000 tCO_2e)
- **Carbon sequestration (10,000 tCO_2e)**
- Utilities landscape irrigation incentives (53 tCO_2e)

Lowest contribution to goal

Specific Strategies

How much can Fort Collins lands contribute to the 2020, 2030, and 2050 climate goals? Here's how existing lands and potential opportunities stack up:



	2020	2030	2050
Approx. reduction needed to meet goal (tCO_2e)	300,000	1,500,000	2,250,000
Business as usual (BAU) contribution	31,000 (10%)	24,000 (1.6%)	22,000 (1.0%)
Additional contribution	10,000 (3.2%)	29,000 (2.0%)	29,000 (1.3%)
Total contribution	**41,000 (13.2%)**	**53,000 (3.5%)**	**51,000 (2.3%)**

Other Benefits

In addition to helping meet the City's greenhouse gas reduction goals, recommendations from this study create other public benefits:

DROUGHT RESILIENCE: Compost helps plants retain water and resist drought.
HEAT PROTECTION: Trees provide shade as days get hotter from climate change.
WILDLIFE HABITAT: Restoring natural forests and grasslands creates important habitat for native species.
FLOOD PREVENTION AND WATER QUALITY: Increased vegetation intercepts and absorbs stormwater during heavy rain events and acts as a natural water filter.
WASTE REDUCTION: Composting of organic waste saves landfill space and costs.

From Grasslands to Buildings: The Role of Land Use Change

Past agricultural practices and new urban development will limit soil and tree carbon savings opportunities.

Two centuries ago, the land that is now Fort Collins was predominately native grassland with riparian areas along creeks and the river. Settlers moved in and began tilling the soil to grow crops. Tillage breaks up soil aggregates, releasing nutrients for crops. This practice also increases the amount of carbon released from the soil. The semi-arid climate in Fort Collins makes the carbon stocks in local soils modest in the grassland and low in tilled agricultural areas. This dynamic results in fewer opportunities for carbon savings in the context of new urban development.

When cropland is developed for urban use, some soil carbon is lost through pavement and accompanying soil removal. Some soil carbon is also gained through the introduction of lawns and trees. If lawns and trees are watered, growth is faster and more carbon is transferred to the soil, increasing the soil carbon stock more than would occur without irrigation. With or without irrigation, after several decades, the soil carbon stock reaches a level where ongoing carbon releases approximately match inputs, and the soil carbon stock stops increasing.

Population growth in Fort Collins is projected to continue over the next 50 years, bringing increased demand for housing and urban growth. According to the 2011 City Plan, much of the "greenfield" land within the City's Growth Management Area (GMA) has been developed. As a result, there is increased emphasis on infill and redevelopment opportunities as existing buildings become outdated or underused. To the extent possible, promoting denser development—such as townhouses and multifamily apartments—can minimize additional land conversion to impervious surface and can further enhance carbon savings. Smaller building footprints, taller buildings, and narrower streets can also provide usable built space with less impervious surface. Reduction of driveway and parking lot areas and integration of surfaces that allow for plant growth and soil microbial activity can also limit soil carbon losses.

At the initiation of this analysis, we expected that denser development would reduce greenhouse gas emissions from conversion of soil to impervious surface. In Fort Collins, however, it appears that developable sites tend to have previously degraded soils, so additional carbon losses are small compared to converting native prairie or sites in wetter regions. Also, in dense development there is less room for trees per dwelling unit; in Fort Collins, lots are generally treeless before development, and trees are planted with development. This contrasts with wetter regions, where undeveloped land is typically treed. As a result of these conditions, making development more dense reduces carbon storage in trees, and—per dwelling unit—this foregone storage is several times larger than avoided soil emissions.

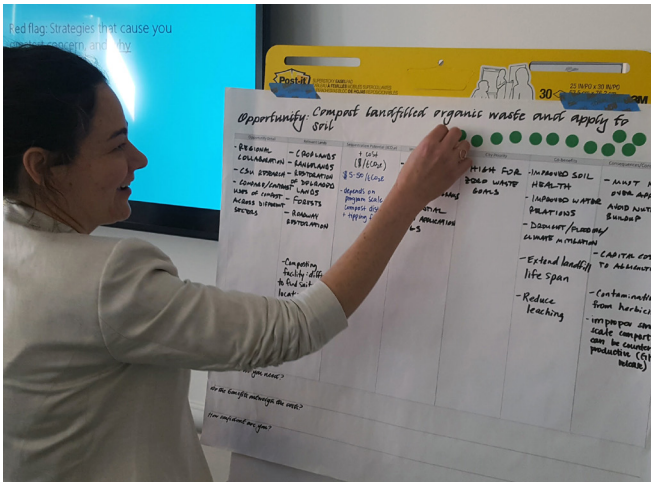
Study Methods

Analysis

The study began with a baseline inventory and analysis of potential options for maximizing carbon storage and accumulation on Fort Collins lands. The study required conducting interviews with City staff and gathering information from City documents and academic literature to develop "business-as-usual" and "above-and-beyond" scenarios. These scenarios considered external factors, such as water scarcity and threats from the emerald ash borer and climate change, to arrive at estimated carbon savings under different future conditions.

Recommendations Development

Findings from the analysis were used to develop initial recommendations to optimize carbon savings. Recommendations were vetted and finalized through a half-day stakeholder charrette that included City staff and subject matter experts from the City Natural Areas, Utilities, Parks, Planning Services, and Building Services departments, members of the City Climate Action Plan (CAP) Water and Land Use Committee, and representatives from Colorado State University (CSU) and its Natural Resource Ecology Laboratory.



Local stakeholders participated in a half-day charrette to refine initial recommendations for land carbon management.

Key Themes and Findings

The baseline inventory and analysis revealed the following key findings:

Current snapshot

- Baseline net carbon accumulation by lands is equivalent to offsetting over 30,000 tons of carbon dioxide equivalent (tCO_2e) of Fort Collins' 2015 non-land GHG emissions.

Expected future

- **Trees** and **turf** account for the majority of expected new carbon storage in the future.
- Although **native grasslands** have substantial underground carbon stores, there are limited opportunities for additional carbon accumulation in the future.
- **New development and redevelopment** emits greenhouse gases in the short term but can result in net carbon savings over the long term due to the growth of planted private and public trees.

Potential future

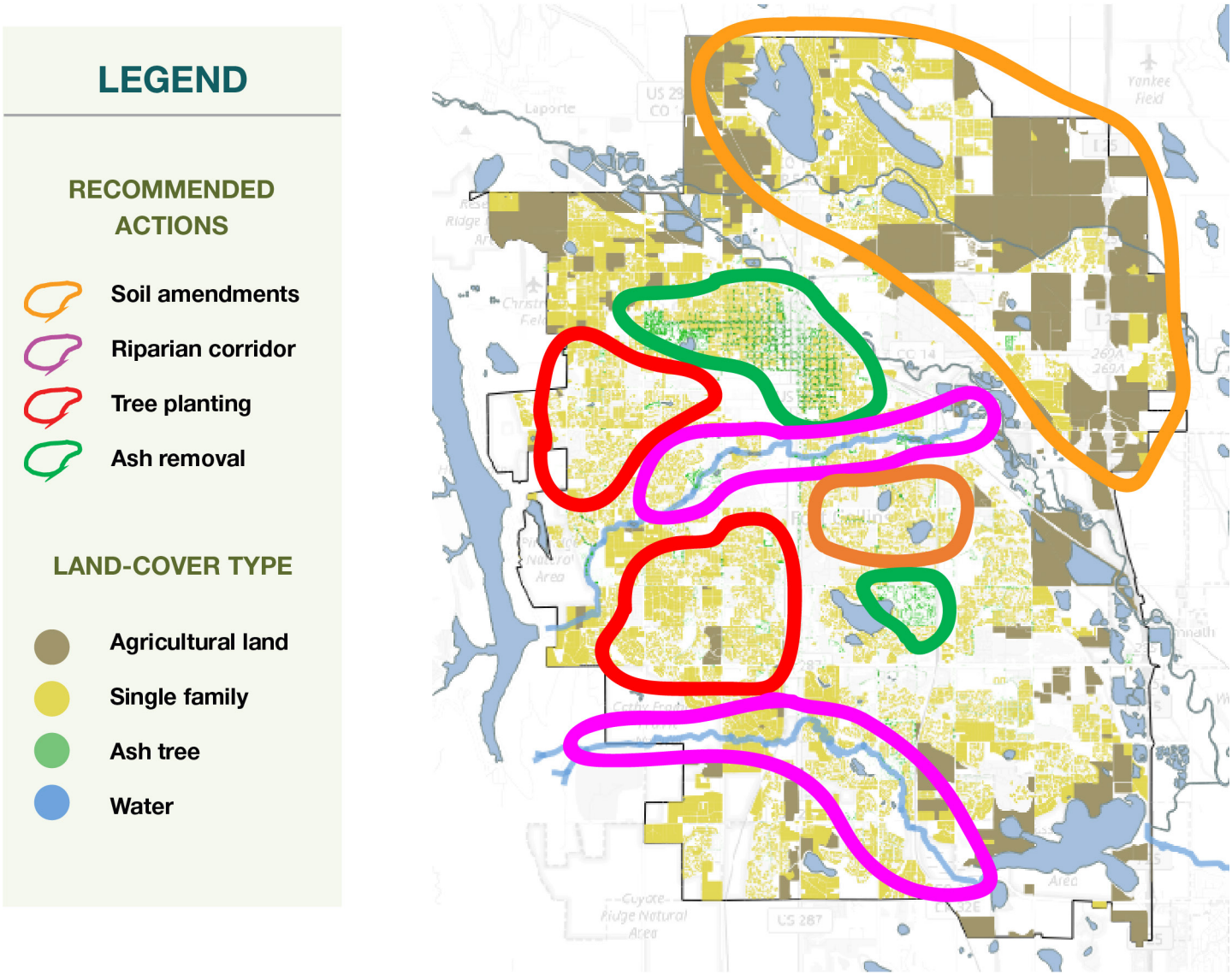
- Fort Collins could undertake additional actions that would contribute up to **3.2%** of the city's needed emission reductions in 2020.
- The largest cumulative identified **carbon-saving opportunities** include applying composted organic material diverted from municipal solid waste to local soils, establishing new trees on private property, and restoring riparian habitat.

Recommendations

Priority Areas

The map below highlights key areas of the city where implementation of recommended actions could realize carbon benefits. This analysis summarized carbon sequestration potential at the city—not acre or neighborhood—level. We examined general attributes of these highlighted areas, such as predominant land cover or vegetation types, to determine sequestration capacity.

This map highlights areas where the most impact could be achieved based on predominant land use type, however other areas may present additional opportunities. As land use patterns change, high impact areas may shift.



Recommendation #1: Improve soil amendments.

Carbon Savings Potential:

- 680,000 tCO_2e from 2016 to 2050[1]

Overview

- In 2015, over 47,000 tons of organic material generated by Fort Collins businesses and residents and disposed in landfills. Every ton of food waste composted instead of dumped into a landfill not only reduces emissions, but results in a net carbon sink! The City's Road to Zero Waste Plan outlines a plan for shifting from landfilling to composting of organic waste.
- This opportunity would reduce and sequester greenhouse gas emissions by:
  - Applying organic waste-derived compost to soils (est. 553,000 tCO_2e by 2050).
  - Avoiding soil nitrous oxide emissions from synthetic fertilizer (est.124,000 tCO_2e by 2050).
  - Reducing manufacturing and transportation of synthetic fertilizer (est. 48,000 tCO_2e by 2050).

Benefits

- Compost enhances carbon storage in soils, improves **plant drought resilience and nutrient absorption, and reduces erosion and stormwater runoff.**
- Compost, as a soil amendment, could enhance native prairie ecosystems' **resilience to climate change**, though it may also change plant community structure.
- Diversion of waste from the landfill reduces methane emissions, **conserves landfill space,** is aligned with the City's waste reduction goals, improves water quality through reduced nitrate leaching, and could advance the City's goal of **supporting local agriculture** via local compost distribution.

Implementation

1. **Begin diverting organic waste and commercially processing it into compost.** The City could divert organic waste from the landfill through household and business pre-sorting (e.g., curbside collection requirements) or post-disposal waste sorting and commercial-scale composting. The City could pursue grants such as Conservation Innovation Grants (CIG) through the U.S. Department of Agriculture—potentially in partnership with other organizations and municipalities—to address facility and processing costs.

2. **Expand organics diversion and compost application.** Educating and conducting outreach to homeowners, businesses, land-care professionals, and gardeners around land carbon savings and other benefits of organic amendments would encourage organics waste sorting and compost application. The outreach should be based on promoting and enforcing current Soil Amendment Requirements[2] for Fort Collins, and could also emphasize co-benefits such as increased soil holding capacity and plant drought resilience. This step also involves expanding the market for compost application, such as through pilot projects and partnerships with other Front Range municipalities, sustainable farming entities, and organizations such as the Regional Wasteshed Coalition and Compact of Colorado Communities.

3. **Expand compost material sourcing.** If costs of gathering materials are not prohibitive, the City could consider expanding compost production to materials sourced outside Fort Collins. The City would need to carefully examine supplies from these outside sources, as varying compositions can increase operational costs. Further analysis could evaluate regional supplies of materials, especially around the Larimer County and Ault landfills.

   Composting inputs could also be expanded through forest thinning on City-owned natural forest properties outside of town—a practice that also helps avoid greenhouse gas emissions from wildfires. Wood waste alone requires additional nitrogen to make compost, so use of wood waste could be limited by the availability of higher nitrogen materials such as food waste. One solution could be to employ nitrogen-fixing species during the composting process.

[1]Assumes no net change in landfill emissions (i.e., avoided methane emissions are approximately equivalent to loss of carbon storage).
[2]https://www.fcgov.com/utilities/business/builders-and-developers/development-forms-guidelines-regulations/soil-amendment-requirements

Challenges and Solutions

Challenges	Solutions	Next Steps
Compost processing (cost, facility siting)	Pre-sorting requirements to minimize contamination	• Explore voluntary and mandatory policy options
Household participation and sorting	Marketing, outreach and education, incremental implementation	• Develop behavior change strategy
Compost market development and agricultural application restrictions	Private/public partnerships, evidence-based policy development	• Identify market development projects • Conduct pilot projects • Target small-scale, sustainable farmers • Build partnerships to pursue grant opportunities
Correct compost application	Share application details provided in Soil Amendment Requirements for Fort Collins through community education/ code compliance.	• Review soil amendment requirements ordinance periodically for opportunities to revise based on new information.

Implementation Assumptions and Details

Realizing the estimated carbon savings potential of this opportunity would require the following:

- Doubling of organic waste diversion by 2050.
- Increase in waste availability proportional to population growth.
- Consistent watering and fertilization rates over time.
- Application of all available compost to soils at the modest rate of 2.8 tons per acre (0.14 lbs per square foot), which is equivalent to the current rate of biosolid application at Meadow Springs Ranch.

High-Potential Areas

Compost can be applied to both currently fertilized and unfertilized agricultural croplands, rangelands, lawns, and gardens. High priority areas include those that current receive synthetic fertilizers, such as the following:

- Lawns
- Large landscaped areas
- Agricultural areas

Recommendation #2: Convert ash trees to other species.

Carbon Savings Potential:

- 590 tCO_2e from 2016 to 2050

Overview

- Emerald ash borer (EAB) presents a significant threat to existing ash trees in Fort Collins. The City estimates that 15% of city trees (and nearly 24% of biomass) could be impacted within 15 years of EAB arrival in Fort Collins.[3] EAB is currently present in Boulder County, but it is unknown when it will arrive in Fort Collins.
- The City is already taking steps to mitigate this threat on City owned property, including replacement of ash with diverse types of shade trees that are well-adapted to the current climate.
- Expansion of these efforts on public and private lands could prevent up to 47,000 tCO_2e from being released into the atmosphere from mortality and decomposition of existing ash trees. Diverting dead trees from the landfill to create usable compost also brings carbon benefits.

Benefits

- Maintenance (and possible expansion) **of tree shade**, reducing urban heat island effect and **cooling costs**.
- **Water savings** as drought-tolerant species continue to be planted.
- Enhanced **public safety** from avoided ash tree fall.

Implementation

1. **Continue expanding the City's preferred tree list.** When considering ash tree replacement, the City should focus on planting species to optimize carbon savings, pest and drought resistance and co-benefits of replacement trees. Emphasis on lower water use tree species for new plantings would ensure that carbon savings benefits are realized without increasing water demand. Fort Collins is already a leader in tree selection, and should continue to evaluate additional trees through the lens of a changing climate. Further discussion of the City's preferred tree list is provided on page 10.

2. **Monitor and mitigate emerald ash borer arrival.** The recent arrival of EAB to Boulder County heightened concern of its spread to Fort Collins. The City should continue to closely monitor EAB spread and implement management strategies as found in the EAB Management Plan, including regulating transport of woody material from infected areas.

3. **Expand ash tree replacement on public lands.** For City-owned public lands, a cost-effective option for ash replacement may be to use "shadow plantings," in which replacement trees are planted near currently established ash trees in anticipation of ash borer arrival. This approach—detailed in the City's EAB plan—calls for taking out some trees and treating those over 12 inches DBH and in fair or better condition. However, due to spacing and growth requirements, this option may have limited applicability to public street trees. The City could also simultaneously remove and replace ash trees that will not be proactively treated with a non-ash species, but this approach would cause a delay between planting and full tree development and result in temporary loss of canopy cover. In any case, the City should prioritize tree replacement based on tree size and risk indicators such as tree health to maximize resource efficiency and efficacy of the replacement program. The City and private landowners will treat some high-value ash trees to protect them against the borer, but these treatments would have to be maintained for decades to keep the trees.

4. **Provide education and incentives for private ash tree replacement.** The City has limited direct control over ash trees on private property, so ash replacement on private lands must be mandated or incentivized through promotional programs. To maximize program effectiveness, the City should identify lessons learned and best practices from other public incentive or behavior change programs. The City is pursuing potential partnerships with organizations such as property management companies, homeowners associations, and tree-removal companies to educate land and business owners and to possibly negotiate reduced costs.

[3] Source: Davey Resource Group Tree Resource Assessment, 2016.

Challenges and Solutions

Challenges	Solutions	Next Steps
Tree replacement	Shadow plantings, targeted or tiered replacement, selective ash replacement for trees less than 12" and in poor condition	• Increase shadow plantings • Prioritize tree replacement based on sized risk indicators • Continue to expand budget for ash replacement and shadow planting on City land
Water limitations	Collaboration with water conservation department and relevant departments to identify additional well-adapted drought-tolerant species	• Coordinate with water utility
Anticipated EAB arrival	Monitoring regional EAB presence	• Where possible to enforce and maintain regulations on woody material transport • Maintain effective monitoring • Maintain inventory and ash tree treatment prioritization

Implementation Assumptions and Details

Realizing the estimated carbon savings potential of this opportunity would require the following:

- Reducing the carbon released by mortality of public and privately owned ash trees (excluding natural areas).
- Successful ash tree replacement that results in an equivalent or greater carbon stock over time as that of the replaced ash trees.
- Carbon stock at risk of emission is calculated from the ash biomass estimated in the Community Tree Resource Assessment (2016), assuming that 20% of the biomass would be protected from loss because the trees have ongoing treatment to protect them from borers, and that 20% of the biomass would still be undecomposed by the time that replacement trees grow, assuming that replacement trees are not planted until after ash trees die.

High-Potential Areas

High-priority areas for converting ash trees to other species include:

- **Park, street, and private trees.** The emerald ash borer poses a low threat in natural or restored riparian areas.
- Ash trees less than 12" DBH and ash in poor condition.

Recommendation #3: Increase tree planting, focusing on drought-tolerant species.

Carbon Savings Potential:

- 146,000 tCO_2e from 2016 to 2050

Overview

- The growth and anticipated expansion of tree canopy cover on privately owned lands—especially yards—makes up over half of anticipated land carbon savings in Fort Collins. An initial estimate suggests that up to 15% of physically suitable plantable space could be converted to trees; however, more research is needed to refine this estimation.
- Past City programs such as the Neighborhood Tree Canopy Project have encouraged residential tree planting.
- Expanding such programs to encourage additional plantings of drought-tolerant trees on private lands would accumulate up to an additional 146,000 tCO_2e over the next 30 years.

Benefits

- **Expanded shade** and reduction in urban heat island effect and **cooling costs.**
- **Water savings** as drought-tolerant species continue to be planted, although water demands for tree establishment must be considered.
- Alignment with public health goals of **reducing heat-related illness and death.**
- **Increases in ecosystem services** such as food sources for pollinators, wildlife habitat, and aesthetic value.

Implementation

1. **Continue expanding the City's preferred tree list.** To address water scarcity challenges associated with new tree establishment, the City should continue to promote tree species that require lower irrigation after establishment. The City is continuously evaluating new trees for suitability to the Fort Collins climate, and, moving forward, it should increasingly look at new species through a climate change and adaptation lens. Currently recommended drought-tolerant trees include hackberry (*Celtis occidentalis*), Honey locust (*Gleditsia triancanthos inermis*),[4] Kentucky coffeetree (*Gymnocladus dioica*), several oaks *(Quercus),* and many other species. The list should also be continuously updated, leveraging the research of CSU and the information generated for the Front-Range Tree Recommendation List published by the Colorado Nursery & Greenhouse Growers Association. In order to make existing information more impactful, the City should also prioritize the tree list according to drought tolerance/water requirements and improve the accessibility and user-friendliness of the list. Note that planting only drought-resistant trees carries the risk of increasing monocultures within the community; care should be taken to strike a proper balance between drought resiliency and diversity. Public education and incentives should be explored as primary options to increase and improve species selection on private property. Local nurseries should be part of this program.

2. **Develop promotional programs.** Due to its limited direct control over private lands, the City will need to develop education and incentive programs to encourage tree plantings on private property. Current programs such as the Neighborhood Tree Canopy Project, despite being small in scale, have successfully leveraged external funding from the state and nonprofit sources to promote tree planting. Providing landowners with relatively small tree seedlings at wholesale cost could make a program accessible to landowners while keeping City costs low; for example, the City could partner with developers and tree nurseries to allow homeowners associations to purchase trees at wholesale prices. The City could also explore other successful local incentive programs, such as energy and water efficiency programs, to glean best practices for maximizing participation and effectiveness. For example, charging a modest price for the seedlings, as opposed to offering them for free, may foster better tree care and survival.

[4]Honey locust and some types of pine, while drought tolerant, may not be encouraged as the species is already near saturation point in the area and further planting could increase vulnerability to pests and diseases.

3. **Deploy promotional programs.** Once funding and best practices are identified, the City should implement promotional programs—such as tree planting education and training—through the City's existing outreach venues and expansion of the Neighborhood Tree Canopy Project. It will be especially important to reach historically underserved communities that currently have minimal canopy cover to realize shade benefits. Areas with high potential for additional tree cover include single-family residential areas with larger lots such as south of Prospect, the Taft Canyon neighborhood, and southeast Fort Collins.

Challenges and Solutions

Challenges	Solutions	Next Steps
Expanding the current planting options to include more low-water-use species	Continue evaluating new species for the tree list with added emphasis on drought tolerance	• Apply information gained from Fort Collins Forestry evaluations • Coordinate with regional experts • Continue to run pilot plantings • Research trees from nearby regions with hotter, drier climates and assess feasibility for Fort Collins • Prioritize tree list according to drought tolerance and improve user friendliness and access
Maintaining and enhancing participation	Addressing barriers and enhancing understanding of benefits	• Identify program best practices • Education and outreach
Cost of trees for planting	Coordination and funding diversification	• Plant smaller trees (note: could be more prone to vandalism) • Continue to acquire external and internal funding • Coordinate with nurseries and other partners to explore new funding models

Implementation Assumptions and Details

Realizing the estimated carbon savings potential of this opportunity would require the following:

- Planting typical shade tree species (including drought-tolerant trees) on residential and commercial properties.
- Planting 15% of the city's total "plantable space," equivalent to 280 acres of canopy cover per year for 10 years (starting in 2018). More research is needed to refine this assumption.

High-Potential Areas

- Single-family residential areas with larger lots (e.g., south of Prospect, the Taft Canyon neighborhood, southeast Fort Collins).
- Homeowners association lands that are currently only grass or turf, especially if the HOA is already irrigating the land.
- Priority areas include depressions and drainage areas where soil water levels may be higher than adjacent yards. Care should be taken to ensure that new trees will not impede flow in these areas.

Recommendation #4: Restore riparian habitat.

Carbon Savings Potential:

- 20,000 tCO_2e from 2016 to 2050

Overview

- The City's Natural Areas Department Restoration Plan (2016-2025) establishes ambitious restoration goals, including initiating restoration of high-priority natural areas along the Poudre River by 2025. Implementation of this current plan will result in a net capture of approximately 4,000 tCO_2e from the atmosphere.
- This opportunity calls for restoring even more riparian habitat in the city and at a faster pace. For example, the City could increase tree area and carbon density in natural areas along the Lower Poudre River corridor, as well as many of the creeks that traverse through Fort Collins. There may be an additional opportunity to restore private lands that are within the floodplain and where building is not permitted, possibly including lands surrounding former gravel mines.

Benefits

- Improved **natural habitat** for species and **natural aesthetic** for community enjoyment.
- Enhanced stream **water quality**, flow attenuation, and **flood control.**

Implementation

1. **Explore and optimize available funding for expanded riparian restoration.** The costs of riparian restoration can range from inexpensive preparation of soil that facilitates natural regeneration of trees to expensive use of heavy earth-moving machinery. To address cost limitations, the City could explore new funding opportunities such as a mitigation fund for new development, utilization of Keep Fort Collins Great funding, or fundraising. Right-sizing restoration activities to individual site needs will ensure that more costly options like earth moving are only implemented when necessary.

2. **Identify and implement additional restoration projects.** Due to limited land availability and high costs of land acquisition, the City should pursue integration of riparian restoration into other projects and planning processes. The City will need to plan early and, where possible, cluster projects with other departmental and capital improvement projects and plans (e.g., projects under the current Stormwater Master Plan) or on expanded areas of current projects where land transactions have already occurred. The recent State of Poudre River Health Assessment may provide a starting point for project identification. Explicitly acknowledging riparian restoration climate benefits in the City's Climate Action Plan could also bolster financial and political support for this work and ease implementation. Also, riparian restoration projects should be designed to maximize successful tree establishment. Water diversion reduces flooding and bank scouring that promotes cottonwood regeneration, and armoring of banks and channel incision limits the ability of streams to routinely flood. Without flooding, it may not be possible to restore riparian tree species. Reconnecting the channel to the floodplain and removing non-critical bank armoring can address this issue, but is also costly.

Challenges and Solutions

Challenges	Solutions	Next Steps
Restoration costs	Exploration of new funding and fewer hard flood control structures	• Establish collaborative partnerships • Explore new sources
Time-intensive permitting process and limited land availability	Early planning and piggybacking on existing projects	• Identify existing project opportunities (e.g., within CIP)
Successful tree establishment	Reconnecting the floodplain and removing non-critical bank armoring	• Design projects to allow for water flows • Manage heavy recreational use

Implementation Assumptions and Details

Realizing the estimated carbon savings potential of this opportunity would require the following:

- Restoration of 120 additional acres of Lower Poudre River natural areas per year (compared to 20 acres under the baseline scenario) until 2027.
- Planting trees that grow at least as quickly as mixed hardwood tree species (note: cottonwoods grow more quickly).

High-Potential Areas

The City has already completed numerous riparian restoration projects in natural areas along the Poudre River.

Other high-potential areas include:

- Spring Creek corridor, including various ephemeral tributaries and managed ponds (e.g., near the Gardens on Spring Creek or north of Lilac Park), as well as Fossil and Mail creeks.
- Areas of smooth brome and reed canary grass can be converted to a mosaic of trees and shrublands.

Other Opportunities

The study considered a variety of opportunities for further land-based carbon savings. Some identified opportunities were not quantified due to limited data availability, implementation feasibility, or perceived carbon potential. In addition to the primary recommendations presented in this report, the following other opportunities were also recommended:

1. **Reestablish trees on burned portions of natural areas.**
   Carbon Savings Potential: 12,000 tons CO_2e from 2016 to 2050
   A stated priority in the City's natural areas restoration plans, reestablishment of ponderosa pine trees on burned areas would reintroduce important natural habitat for native species and could realize approximately 12,000 tCO_2e in cumulative carbon savings by 2050. Feasibility will depend on the ability to establish trees under hotter and drier climate conditions.

2. **Treat forests to make them more resistant to stand-replacing fire.**
   Carbon Savings Potential: 0 to 200,000 tons CO_2e from 2016 to 2050
   Thinning forests to remove ingrowth helps avoid stand-replacing losses from fire. Although forests may lose carbon from thinning, this loss would be offset through growth of remaining trees and avoidance of large fire-induced emissions. This opportunity also builds resilience of surrounding forests to climate change-induced increases in wildfire risk.

3. **Maintain pervious surfaces.**
   Carbon Savings Potential: 16 tons CO_2e per acre-year for 10 years
   The conversion of land area that is currently absorbing carbon, such as parks, private open space, and natural areas, to new impervious surfaces such as roads and buildings can lower carbon accumulation in soils. Keeping pervious area porous when it is developed, such as through the use of permeable pavers that allow for vegetation and by building up instead of out, can avoid an estimated 16 tCO_2e per acre of emissions from conversion of soils to impervious surface.

City staff also expressed a desire to evaluate carbon savings potential of other lands outside the scope of this study, including the city's source water supply watershed and surrounding wildfire-prone forested areas. We recommend the City pursue additional research to evaluate the carbon savings potential of these areas.

The following table summarizes all examined opportunities:

Category	Opportunity	Quantified?	Why Not?
Trees	Establish new trees on public property within the GMA		Small impact[5]
	Establish new trees on private property within the GMA	√	
	Plant larger or more dense trees on public and private property within GMA		Likely negligible
	Restore trees in burned areas outside GMA	√	
	Reduce wildfire emissions	√ (large uncertainty)	
	Restore riparian areas	√	
	Convert green ash to other species	√	
Impervious Surface	Shift to denser development	√	
Grasslands	Restore additional grassland in urban natural areas	√	
	Restore additional grassland in natural areas outside GMA		Already scheduled
	Use rotational grazing on grasslands		Widely practiced
Soils	Reduce irrigation saturation		Limited data
	Reduce over-fertilization		Limited data
	Subsidize soil compost amendment	√	
	Replace synthetic fertilizer with compost	√	
	Compost landfilled organic waste and apply to soil	√	
	Reduce soil tillage		Widely practiced; few acres
	Produce and apply biochar		Cost-prohibitive
Urban Agriculture	Expand garden area on public property		Likely negligible
	Expand garden area on private property		Likely negligible

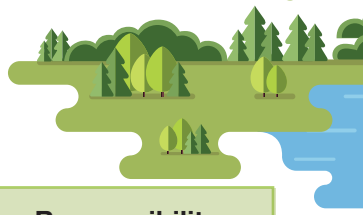
[5]An initial assessment suggests that planting new or restoring existing public street and park trees would result in few carbon sequestration benefits due to limited available land area.

Next Steps

This study yielded the following recommended next steps for the City:

Short-term Actions

Rec#	Action	Steps	Related Policies	Responsibility
All	Quantify implementation costs	• Conduct cost analysis	• N/A	• Environmental Services
1	Begin diverting organic waste from landfill and processing into compost	• Introduce regulatory requirements • Support development of local/regional organics recycling infrastructure	• City Plan: ENV 15.1 • Road to Zero Waste Plan: 6	• Environmental Services (Waste Reduction & Recycling)
2, 3	Identify priority drought-tolerant species and research new species for a changing climate	• Partner with agricultural extensions to identify suitable species adapted to hotter, drier climates in nearby regions • Perform pilot study of tree survivability	Nature in the City Strategic Plan: • LU 2 • CP 3 West Central Area Plan: OS 3.11	• Forestry • Gardens on Spring Creek • Natural Areas • Parks • Utilities
2, 3	Continue developing tree species list	• Further identify drought tolerance of tree species from City Forestry Evaluation, including suitable species under climate change • Apply information from City Forestry Divison tree evaluations • Utilize information in Front Range Recommended Tree List	Nature in the City Plan: LU2	• Forestry • Gardens on Spring Creek • Natural Areas • Water Utility
4	Explore and optimize funding for riparian restoration	• Explore new funding mechanisms (e.g., mitigation fund) • Use current funding opportunities (e.g., Keep Fort Collins Great)	• City Plan: ENV 24.4 • Nature in the City Strategic Plan: C6	• Natural Areas



Medium-term Actions

Rec#	Action	Steps	Related Policies	Responsibility
1	Expand community organics diversion and compost application	• Pilot projects • Partner with CSU on application research • Private/public partnerships for market development	• Nature in the City Strategic Plan: CP1 • City Plan: ENV 22.2	• Environmental Services • Forestry • Gardens on Spring Creek • Natural Areas
3	Develop tree planting incentive programs	• Identify available plantable areas • Explore funding • Identify target communities and program best practices	• Old Town Neighborhoods Plan: S2 • West Central Area Plan: OS 3.11	• Forestry • Natural Areas • Utilities • Social Sustainability • Neighborhood Srvcs.
3	Deploy tree planting incentive programs	• Provide training and education • Implement programs	Northside Neighborhoods Plan: OL4	• Forestry • Natural Areas • Utilities • Social Sustainability • Neighborhood Srvcs.
4	Identify and implement additional riparian restoration projects	• Identify existing projects and opportunities • Incorporate into CAP	Neighborhood Tree Canopy Project	• Natural Areas • Utilities • Forestry
2	Expand public ash tree replacement	• Increase shadow plantings	• City Plan: ENV 24.4 • Nature in the City Strategic Plan: C6	• Forestry

Long-term Actions

Rec#	Action	Steps	Related Policies	Responsibility
1	Expand compost material sourcing	• Evaluate regional supplies • Compost wood waste from forest enhancement projects	City Plan: ENV 15.1, 15.3	• Environmental Services (Waste Reduction and Recycling) • Natural Areas
2	Continue to monitor and mitigate EAB arrival	• Continue monitoring regulations and enforce where feasible	City Plan: ENV 2.5	• Forestry
2	Encourage private ash tree replacement	• Design effective programs • Expand program implementation	Neighborhood and Subarea Plans (e.g., West Central Area Plan: OS 3.11)	• Forestry • Neighborhood Services • Planning