Climate Action and Sustainability Plan

A Matter of Urgency

for

Mount Auburn Cemetery

Cambridge & Watertown, Massachusetts

June 1, 2021

Second Printing June 21, 2021

Prepared by:

Candace Currie, GardenGIS, LLC *(former Director of Planning & Cemetery Development, Mount Auburn Cemetery)*

Paul Kwiatkowski, Director of Urban Ecology & Sustainability, Mount Auburn Cemetery

David Barnett, President & CEO, Mount Auburn Cemetery

Climate Action and Sustainability Plan

A Matter of Urgency

for

Mount Auburn Cemetery

Cambridge & Watertown, Massachusetts

June 1, 2021

Second Printing June 21, 2021

Prepared by:

Candace Currie, GardenGIS, LLC *(former Director of Planning & Cemetery Development, Mount Auburn Cemetery)*

Paul Kwiatkowski, Director of Urban Ecology & Sustainability, Mount Auburn Cemetery

David Barnett, President & CEO, Mount Auburn Cemetery

Contents

Message from Mount Auburn's President

I am extremely pleased to introduce this organization-wide Climate Action and Sustainability Plan (CASP) that provides the framework and a set of strategies and goals for Mount Auburn Cemetery to achieve 100% carbon neutrality by 2050. If we truly care about the future of our planet for our grandchildren and future generations, **the time to act is now**! The effects of climate change and the damage being done to planet Earth have become crystal clear. As my friend and colleague – Richard Piacentini, CEO at Phipps Conservatory and Botanical Gardens in Pittsburgh – has often said to inspire so many of us in the public horticulture world and beyond, "Being less bad is not good enough." We all need to follow Richard's lead by reducing and even eliminating our carbon footprint. We have seen that it can be done!

This plan culminates a concerted effort by staff over the past twelve years to collect data on Scope 1 and Scope 2 emissions due to mobile combustion from our fleet of vehicles/equipment and all gas and electricity use in our facilities. Using 2010 as our base year, the **"Climate Action Plan"** portion **(Part II)** of the CASP now summarizes and documents the progress we have made over the past twelve years in reducing our greenhouse gas (GHG) emissions by 28%. More importantly, it sets short-term, medium-term, and long-term strategies and goals for achieving the ultimate goal of 100% carbon neutrality by the year 2050. The plan includes broad strategies and some specific goals and actions for each category of GHG emissions that will undoubtedly be revised in future years as Mount Auburn continues to monitor rapidly accelerating technological advances.

With the active support and formal approval by the Board of Trustees in June 2021, this is an exciting and critically important **philosophical** commitment by Mount Auburn's board and staff. I understand, of course, that future actions will be subject to the annual organizational budgeting and project-prioritizing decisions, but to have this document formally approved by the Board is a huge step which ensures that continued discussions about taking steps to achieve carbon neutrality by 2050 will occur.

In addition, the **"Sustainability"** portion **(Part IV)** of the CASP includes several "narratives" summarizing our efforts over the past 25 years to be more environmentally sensitive in all that we do. Strategies for mitigating and adapting to a changing climate are also highlighted. Topics include increasing biodiversity in our plant collections, carbon storage and sequestration by Mount Auburn's 5,000 trees, turf management and alternatives, efforts to improve wildlife habitat, water quality and consumption, recycling/composting, materials management, integrated pest management, and engagement/outreach/education. The Sustainability Index developed by the American Public Gardens Association (see Part I) has provided valuable guidance and inspiration for the development of Mount Auburn's Climate Action and Sustainability Plan.

With my pending retirement as President & CEO in September, Mount Auburn recently completed an 18-month Strategic Bridge Plan to provide a framework for organizational priorities and ensure a smooth transition to new leadership. The Bridge Plan comprises three themes of *Openness and Welcome*, *Beauty and Serenity*, and *Sustainability and Stewardship,* which dovetail beautifully with the APGA's Sustainability Index. One of the stated goals is to "Foster the health, sustainability, and resilience of the landscape and built environment." Completion of our Climate Action & Sustainability Plan was one of the key action steps toward this goal. Now it just has to be implemented!

While I am proud of what the amazing Mount Auburn team has already accomplished, there is so much more that must be done to achieve our ultimate goal of carbon neutrality by 2050. I look forward to following Mount Auburn's progress toward this goal, and I certainly hope that this plan will continue to be widely shared among colleagues and the public and that it will inspire others to act as well.

Acknowledgements

Mount Auburn's Sustainability Working Groups have been important participants, sounding boards, and contributors to this Climate Action and Sustainability Plan. The Energy and Greenhouse Gas Working Group has diligently recorded gas and electricity use for over ten (10) years and has given voice to the greenhouse gas emission targets. We want to particularly acknowledge Gus Fraser, Vice President of Preservation & Facilities, for his active involvement in the Working Group and his leadership in making our facilities more energy efficient. The Education and Engagement Working Group has excelled in finding ways to share Mount Auburn's message, including 'Sustainability Shorts' – videos of great things that are happening at Mount Auburn. To all contributors and writers of Eternally Green articles, your words influenced the narratives included in this plan. The Landscape and Habitat Working Group continues to personify Mount Auburn's extraordinary commitment to sustainable land care, and we make a special shout out to Paul Walker, Superintendent of Grounds, for his ongoing search for energy and performance improvements in the fleet of vehicles and equipment as well as his long-time leadership in making the composting and recycling center a regional model of excellence. Also, many thanks to Dennis Collins, Horticultural Curator, for his long-range understanding and view of the future of Mount Auburn's plants and to the Plant Collections department for contributing iTree research on the carbon storage, sequestration and ecosystem services of Mount Auburn's trees. And thank you to the accounting department for tracking monthly fuel purchases that fill the gas tanks of vehicles and equipment.

Every effort was made to be honest, clear and readable; we take full responsibility for errors, omissions or misconstruing the words of others. Your actions and the data you have compiled are what comprise this Climate Action and Sustainability Plan. Thank you!

We look forward to seeing continued progress and to hearing about future accomplishments by the incredible Mount Auburn team, including actions taken by the newly formed IDEA (Inclusion, Diversity, Equity and Accessibility) staff working group and trustee committee. Finally, a special thank you to the members of Mount Auburn's Board of Trustees who have encouraged and championed the completion of this Climate Action and Sustainability Plan.** Carbon neutrality by 2050 is a matter of urgency for all of us!

In Climate Action,

Candace Currie, Paul Kwiatkowski and David Barnett

June 2021

** On June 10, 2021, the Board of Trustees of Mount Auburn Cemetery voted unanimously to approve the following resolution:

"To endorse the philosophical commitment of the Climate Action and Sustainability Plan document that will guide Mount Auburn for years to come and to express our appreciation for all the early and forward-thinking activities outlined therein."

Organization of this Document

Mount Auburn's Climate Action and Sustainability Plan is divided into five parts to make it easier to single out certain topics, chapters or stories. The intent allowing that Parts I, II, III and IV could each be stand-alone documents.

Part I: Introduction to the Climate Action and Sustainability Plan	Defines Mount Auburn's Climate Action and Sustainability Plan and how it ties into Mount Auburn's Strategic Bridge Plan. It provides an overview of what the future climate could feel like at Mount Auburn and why a plan is important.
Part II: Climate Action Plan	Identifies Mount Auburn's Carbon Footprint. Defines the far-reaching targets for reducing greenhouse gas (GHG) emissions. Demonstrates the trends that twelve (12) years' worth of data may predict and identifies the strategies for reaching net-zero GHG emissions by the year 2050. Outlines the goals and action items to reach targets.
Part III: Summary of Strategies and Goals for Reaching Carbon Neutrality	As a separate pull-out, this part comprises a listing of goals that will bring Mount Auburn to net-zero greenhouse gas emissions by 2050. (The goals are also listed with each category of GHG emissions in Part II: Climate Action Plan).
Part IV: Sustainability Narratives	Mount Auburn has so many great sustainability stories to tell. This section includes short stories about resiliency in the landscape and the value of our diverse plant collections, carbon storage and sequestration of Mount Auburn's trees, alternatives to turf, efforts to improve the wildlife habitat value of the landscape, and our education and outreach programs, just to name a few.
Part V: Appendix	For those who want to take a deeper dive, the appendices include details on GHG emissions and reports by the numbers, a look back over the past 15 years of the analyses of plant collections, sample of the annual weather and water use data, list of vehicles and equipment as of FY2021, and GHG accounting principles.

Part I: Introduction to Climate Action and Sustainability Plan

This Climate Action and Sustainability Plan (CASP) is influenced by over twelve (12) years of data collection and decades of stories about the incredible organization of Mount Auburn Cemetery - the people and the landscape.

What is a Climate Action Plan?

A Climate Action Plan focuses on greenhouse gas emissions and comprises a set of strategies and goals that reduce and ultimately eliminate dependence on fossil fuels. Mount Auburn's Climate Action Plan is Part II of this document, and this plan sets Mount Auburn Cemetery on the path to be carbon-neutral by 2050. Tracking emissions will be an ongoing task to report progress towards attaining goals set in this plan.

What are greenhouse gases? Greenhouse gases have always been part of the earth's ecosystem, and it is why planet earth is a place where humans have thrived. Three major greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Industrialization, with the extraction and use of fossil-fuels over the last 150 years – a source of much pride and innovation – has caused an imbalance in these gases in the atmosphere thereby causing what has become known as 'human enhanced greenhouse effect'. Rather than continuing our extractive methods of living, the climate action and sustainability plan is highlighting ways to give back to the earth and attempt to correct the imbalances in the atmosphere.

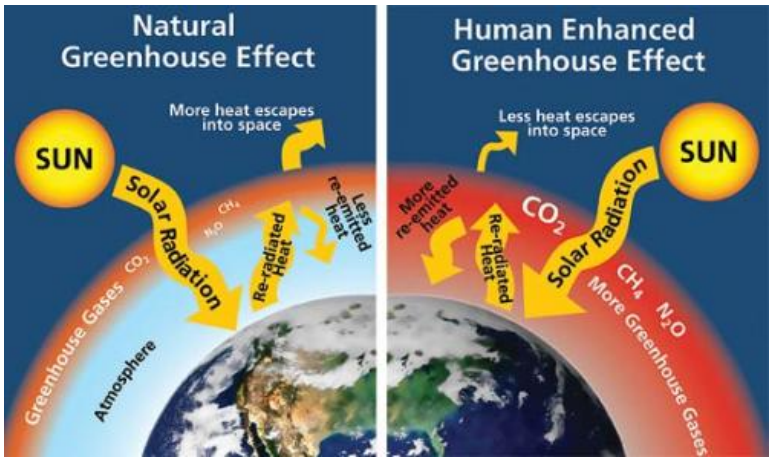


Figure 1 - Source: US National Park Service

Emissions are divided into three scopes: scope 1, 2 and 3.

Scope 1 emissions are based on British Thermal Units (BTUs) and combustion engines. Emissions from stationary combustion equipment used for heating buildings or operating the crematory are calculated based on monthly bills for BTUs. Emissions from the Vehicles and Equipment that burn gasoline, propane and diesel fuels are calculated based on the purchasing records throughout the year. Every time an employee fills a gas tank, it gets reported. Mount Auburn's accounting department maintains this list of daily reporting and aggregates it monthly and balances it against monthly purchases.

Scope 2 emissions are based on the purchase of electricity in kilowatt hours (kWh) that are calculated based on monthly bills.

Scope 3 emissions are harder to quantify, and they are not being identified in this first Climate Action and Sustainability Plan. Scope 3 emissions are a result of employees traveling to and

from work, business travel, vendor deliveries and could also include visitors commuting to and from the cemetery.

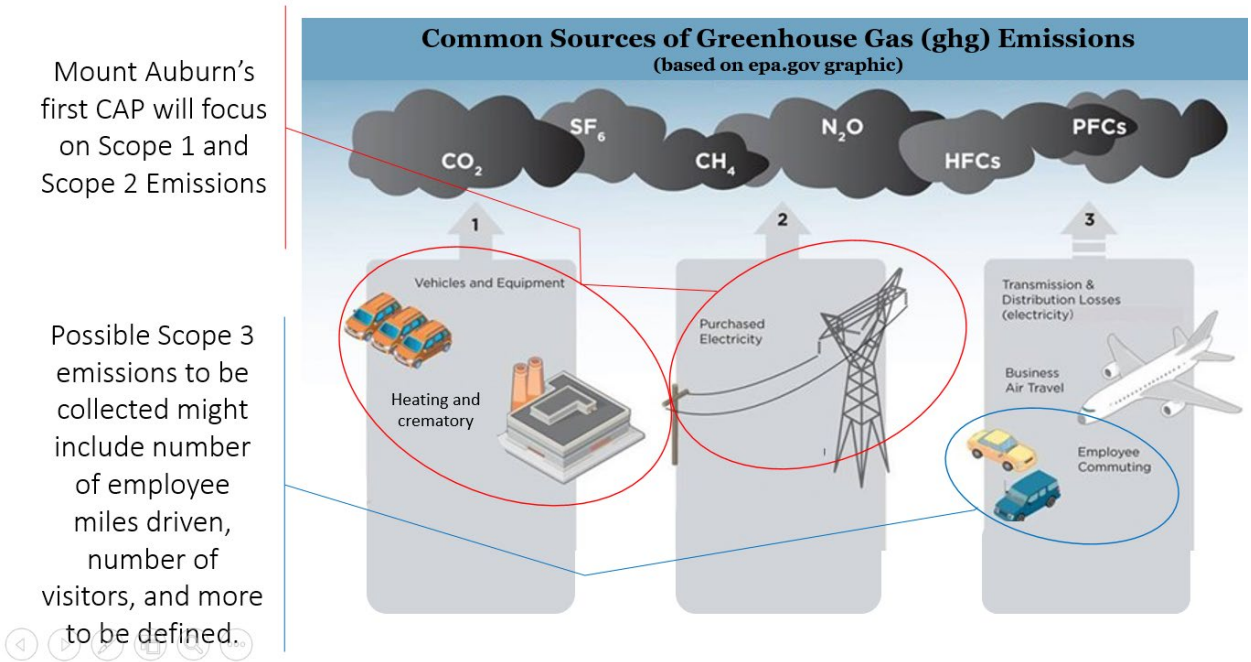


Figure 2 – GHG Emissions are categorized into 3 scopes. This Climate Action and Sustainability Plan focuses on Scopes 1 and 2.

Calculating GHG Emissions

Mount Auburn is using tools provided by the Greenhouse Gas Protocol for calculating greenhouse gas emissions. This tool is free and used by millions of organizations around the globe. It is a spreadsheet that contains conversion factors for scope 1, BTU-related emissions, which means by entering Mount Auburn's BTUs, **the tool calculates the metric tons of carbon dioxide equivalents (mtCO2e), the calculus by which greenhouse gases are reported.**

The conversion factors for scope 2, kWh-related emissions, have been researched and input from the Environmental Protection Agency (EPA) website and are well documented in the spreadsheet where the mtCO2e has been calculated.

What is a Sustainability Plan?

A Sustainability Plan is broader in scope than a climate action plan. This Sustainability Plan focuses on the "triple bottom line" (TBL) of environmental, social and economic concerns. This Sustainability Plan sets in motion ways for Mount Auburn to give back to the ecosystem rather than extract from it; to assess and create a community where all members thrive, are valued, respected, and engaged; and where Mount Auburn's financial investments are in alignment with the environmental and social stances that Mount Auburn promotes.

On Writing a Climate Action and Sustainability Plan

Mount Auburn's leadership position in the local community and in the nation as a national treasure has influence over how and what the public can do to mitigate and adapt to a changing climate. As a cemetery and public garden, open to all, it has a duty to help others be responsive

to the devastating effects of human-caused warming of the planet. Strategies that Mount Auburn implements to reverse the global warming trend can be adapted by staff and visitors as 'take home' messages.

This illustration depicts the heat index (that is, what the temperature *feels* like to us because of humidity and wind) of Massachusetts in higher and lower emission scenarios. Regardless of which emission scenario is followed, the temperature is warming. By mid-century the temperature around the Boston area could feel like that of New Jersey (lower emissions scenario) or Maryland (higher emissions scenario) compared with a baseline c 1970.

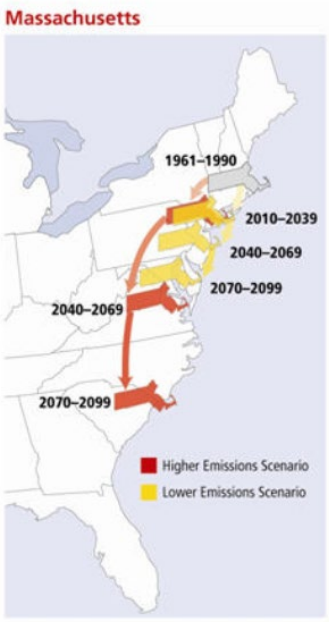


Figure 3 -Source: Northeast Climate Impact Assessment 2006, Union of Concerned Scientists - https://climateshift.com/downloads/northeast/massachuetts_necia.pdf

Therefore, Mount Auburn is concerned about the plant collections and is adding different species where diversity will be key to ensuring there *are* plants at a warmer and wetter Mount Auburn.

Generating electricity through solar panels on the Operations Center and purchasing renewable energy certificates (REC) ensures investments are wisely made in renewable electricity. Mount Auburn has already been a model of sustainable landscape maintenance practices by holding workshops with other organizations such as The Trustees, Mass Audubon Society, and the National Park Service. These workshops have featured our composting and recycling center and various other environmentally sensitive practices that we have been carrying out for many years. In 2014 Mount Auburn was the first cemetery in the metropolitan area to offer natural burial – that is burial without the requirement of a concrete grave liner or vault.

Sharing Mount Auburn's successes and failures can assist others in making educated decisions about what is best for the management of their organizations and/or what actions individuals may implement at their homes.

Planning for Sustainability and Stewardship

Mount Auburn's 18-Month Strategic Bridge Plan, approved by the Board of Trustees in January 2021, contains goals and objectives under the following three themes:

- Openness and Welcome
- Beauty and Serenity
- Stewardship and Sustainability

These three themes evolved from our recently completed Vision and Values process and were defined by the executive leadership team and a trustee task force independently of the American Public Gardens Association (APGA) New Sustainability Index; however, they dovetail beautifully. APGA's Sustainability Index is aligned with the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, which was adopted by world leaders in September 2015 at an historic United Nations Summit.

The APGA Sustainability Index, shown here, comprises twelve attributes under the three main categories of Environmental, Social and Economic.

Figure 4 - APGA's twelve Sustainability Index attributes.

Mount Auburn's goals under the Strategic Bridge Plan's Stewardship and Sustainability theme closely parallel these categories. They are numbered 6, 7 and 8:

6. Foster the health, sustainability, and resilience of the landscape and built environment.
7. Enhance the resilience and strength of our organization and its people.
8. Strive to balance obligations and income sources to achieve organizational priorities, bearing in mind the perpetual nature of our obligations.

Completing this Climate Action and Sustainability Plan (CASP) and beginning implementation of it are the first two objectives under Goal #6 in the Stewardship and Sustainability theme. Several objectives under Goal #7 and Goal #8 are aligned closely with the APGA Sustainability Index attributes in the Social and Economic categories. We look forward to seeing these objectives achieved by the strong and dedicated Mount Auburn team in the coming year under the leadership of the new CEO, and we encourage continued use of APGA's valuable assessment tools to help guide and inspire action.

Within the other themes, specifically 'Openness and Welcome', other goals such as "Embed Inclusion, Diversity, Equity, and Accessibility (IDEA) in all aspects of Mount Auburn" will also be supported by using APGA's assessment tools. The recently formed staff IDEA Working Group and trustee IDEA Committee, working in collaboration with the consultant firm already hired, will undoubtedly play key roles in implementing the action steps under the goal of embedding IDEA in all aspects of Mount Auburn.

Part II: Climate Action Plan

Overview

The staff and Board of Trustees declare Mount Auburn's commitment to achieve carbon neutrality by FY2050 in this document, Mount Auburn's first **Climate Action Plan**. This document reports scope 1 and scope 2 greenhouse gas emissions for fiscal years 2010 through 2021 based on purchasing records related to Mount Auburn's mobile fleet, cremations, building heat and electricity. Understanding the past use is an attempt to predict an unpredictable future. There are things we know. Action is required now, and successes will follow two paths: 1) Making big changes requires capital investments and 2) continuing to perform the smaller upgrades that cost fewer dollars that Mount Auburn has been completing for well over a decade already.

Big Picture Goals for 2030, 2040 and 2050

Mount Auburn has been tracking British thermal units (BTUs), kilowatt hours (kWh) and fuel purchases since 2010; therefore, we know Mount Auburn's total greenhouse gas (GHG) emissions (also known as the carbon footprint) are already on a downward trend.

The ongoing compilation, comparison and reporting of all data towards achieving reduction goals will be based on Mount Auburn's fiscal year (April 1 – March 31) for ease of continued tracking and reporting rather than calendar year. By using the fiscal year, Mount Auburn is tracking GHGs nine (9) months ahead of other businesses that are reporting them based on the calendar year. Annual tracking and reporting are imperative in making future course corrections, or at least in documenting what may have gone awry in a particular year.

Baseline Year:

Fiscal Year 2010 (April 1, 2009 through March 31, 2010)

Accomplished:

Reduced by 20% below 2010 levels by 2020

Greenhouse Gas Emissions Reduction Goals:

Reduce by 50% below 2010 levels by 2030

Reduce by 75% below 2010 levels by 2040

Reduce by 100% below 2010 levels by 2050 for carbon-neutrality

Mount Auburn's Carbon Footprint

The data collected since 2010 comprising Scope 1 and Scope 2 emissions are reported in four categories:

1. Mobile Combustion of Vehicles and Equipment in gallons of fuel purchases
2. Gas Use for Cremations in BTUs of gas purchases
3. Heat in buildings in BTUs of gas purchases
4. Electricity in kWh purchases

About the Graph

The graph on the next page shows 12 years (FY2010 through FY2021) of GHG emissions.

Three (3) axes:

- Fiscal Year along the bottom
- Metric Tonnes of CO2 Equivalents (mtCO2e) along the left side
- Percentage to Carbon Neutrality by FY2050 on the right.

Bars of Stacked Colors – GHG emissions by category (mobile, cremations, heat, electricity)

More about the Legend on the Left (Metric Tonnes of CO2 Equivalents)

- Measuring Mount Auburn's GHG emissions in mtCO2e is the standard of measurement used around the world. Everything that is added to or subtracted from Mount Auburn's carbon footprint uses this scale on the left side of the graph.
- The stacked bars in purple, orange, red and cyan represent totals used during each fiscal year. Each stacked bar equals Mount Auburn's gross carbon footprint for that year.
- These totals are shown in the dashed line called TOTAL GHG Emissions Scope 1 and Scope 2.
- The line for Renewable Energy Certificates (**RECS**) purchases of renewable energy to offset Mount Auburn's electricity use.
- The thicker green line near the top represents **NET GHG Emissions** (Total of the stacked bars minus the RECS).

Legend for the right side of the graph ranges from (100.00) to 0.00 (zero or higher)

- Negative 100, written as (100.00), indicates that 100% of the 2010 carbon-footprint has been 'neutralized'. FY2010 has been selected as the baseline year against which future GHG calculations will be measured. By FY2050, GHG Emissions goal is to reach this (100.00) point, carbon-neutrality.

Calculating the Trend Line (To Carbon Neutrality @ (100.00))

- The dotted navy-blue line shows the year-to-year change of Net GHG Emissions using this scale of (100.00) up to 0 (zero). For 2010, the baseline year, there is no change; therefore, the dotted line starts at zero. It is determined by comparing the change from one year with the previous year. Those changes are summed and then averaged, which produces the linear trend.
- In this chart, the line is trending downward at an average rate of -1.64%. (Note on some charts that follow, there is an upward trend; therefore, the scale goes higher into positive numbers for building heat and cremations).

It would be great to see an accelerated downward trend (a curve rather than a straight line) indicating Mount Auburn is being more aggressive in reducing GHGs early on in this 30-year project. Striving for that accelerated curve now could inspire innovation and provide a longer timeline to achieve the last 10 or 20%, which is often the most difficult to attain.

Greenhouse Gas Emissions - View of Mount Auburn's Carbon Footprint

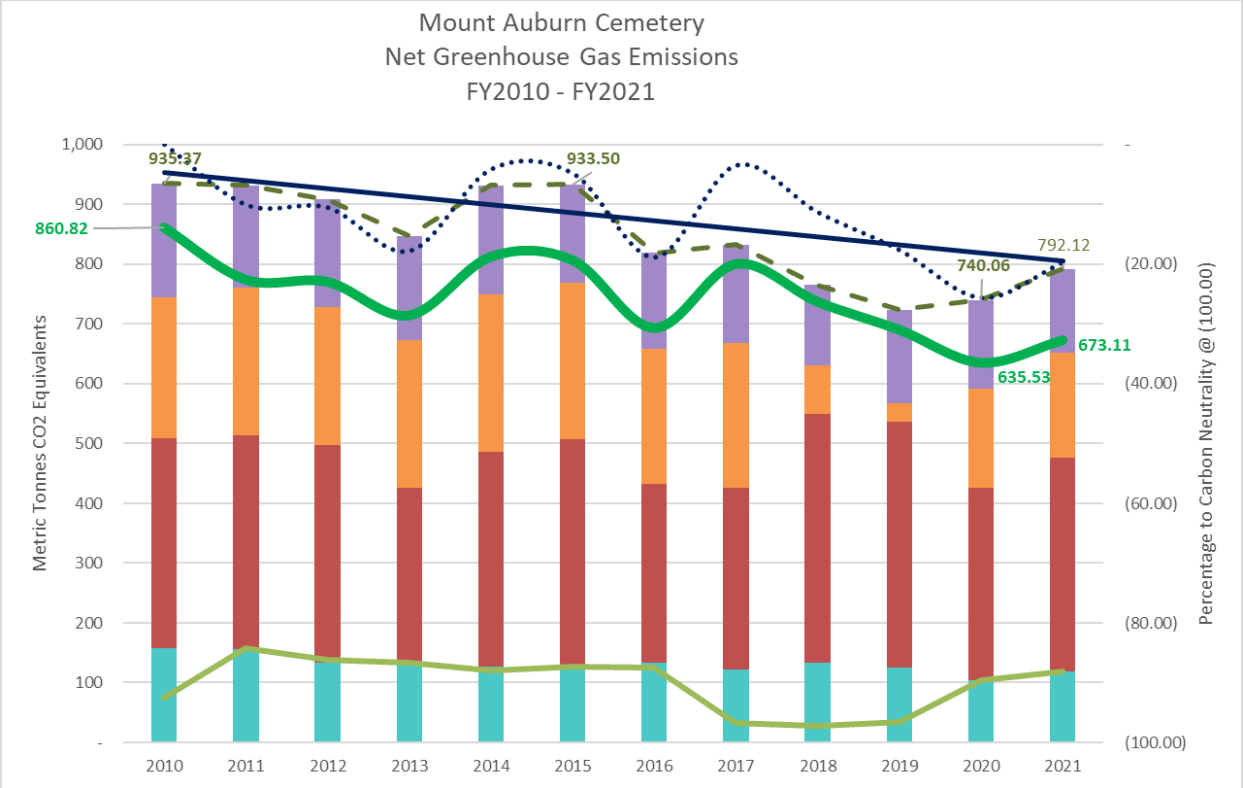
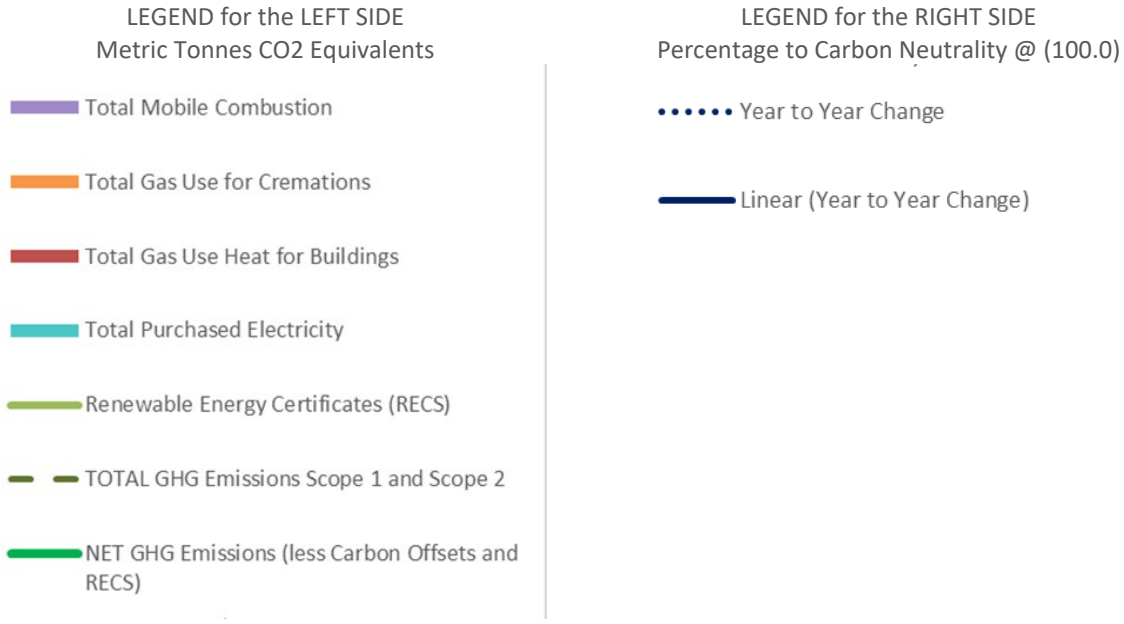


Figure 1 - The overall downward trend of -1.64% is a good thing. This trend line is created by calculating the difference from year to year and then averaging those changes over a period of 12 years (2010 – 2021). Due to an increase in gas use for heating and cremations (due to COVID) in 2021, the trend line is less favorable at the close of 2021 than it was in 2020. It changed from -2.5% to -1.64%.



Comparing FY2010 and FY2021

The GHG emissions are going in the right direction, downward. Mount Auburn's annual carbon footprint (total GHG emissions) was 792 mtCO2e for FY2021. When deducting the amount of renewable energy certificates (RECs), the Net GHG is 673.11 mtCO2e, a 28% reduction compared with the FY2010 gross baseline emissions of 935.37 mtCO2e.

The trend line generated to compare one year to a previous year, shows a negative 1.64% downward trend. This downward trend indicates Mount Auburn's carbon footprint is getting smaller.

These two pie charts compare FY2010 with FY2021. They indicate building heat has increased by 5 percentage points of the overall total GHG emissions even though the actual amount is lower. During the period between 2010 and 2021, Mount Auburn constructed a new greenhouse allowing for some expansion to Mount Auburn's plant propagation program and added square footage associated with the updated crematory at the Bigelow/Crematory complex.

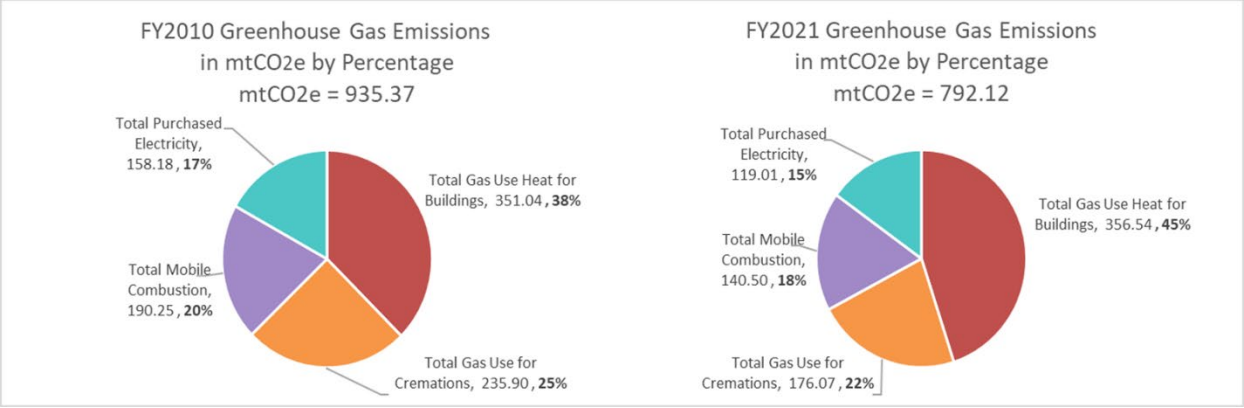


Figure 2 - The overall story is good. Greenhouse gas emissions have gone down over the past twelve (12) years, but we need to do much more. Taking a deeper dive into the data will inform future strategies to achieve greater reductions.

It is helpful to look at each category by itself. The trends for each category help inform future course corrections to ensure the targets are reached. The following sections review the emissions for each piece of the pie: mobile, cremations, heating for buildings and electricity use.

Mobile Fleet (Vehicles & Equipment) Emissions

As of FY2021, Mount Auburn has a fleet of 85 vehicles and specialized equipment – including ten pickup trucks, four dump trucks, eleven vans and SUVs, 31 turf vehicles, eleven riding mowers, two backhoes, two Kubota tractors, an aerial lift truck, and a brush chipper, soil screener, stump grinder and other miscellaneous pieces of equipment. In addition, we have 78 pieces of small power equipment such as chainsaws, leaf blowers and string trimmers. The complete list of vehicles and specialized equipment is included in the Appendix.

Over the past several years we have been actively trialing any and all electric vehicles and other types of equipment when they become available. Finding energy-efficient equipment that functions adequately for our grounds maintenance needs requires at least one season of testing or trialing before an investment can be made to replace gasoline or diesel powered equipment. Persistence has paid off, and we now have two electric/rechargeable battery mowers, three electric turf vehicles, and 16 electric small power equipment items.

As shown in the graph, the downward trend of greenhouse emissions from Vehicles & Equipment shows an average annual percentage change of a negative 2.32%.

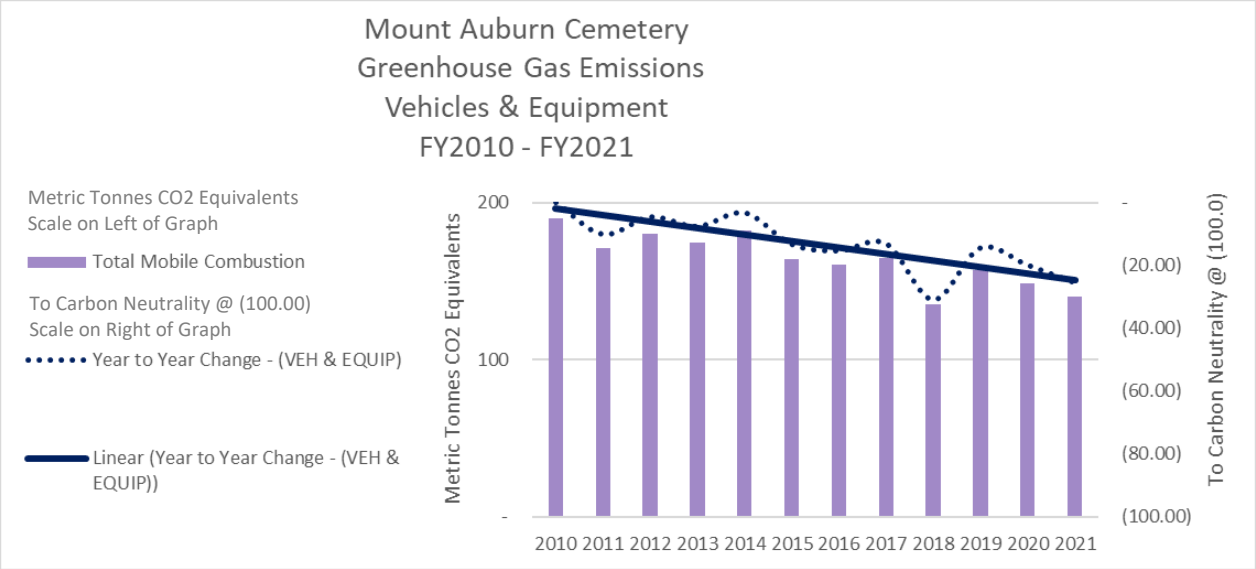


Figure 3 -The downward trend of negative 2.32% shows promise for achieving targets in the future, but is it enough?

As shown in the pie charts below in Figure 4, the total GHG emissions from Vehicles & Equipment of 140.50 mtCO2e in FY2021 is 26% less than those in FY2010 of 190.25 mtCO2e. By far the largest percentage of mobile fleet emissions comes from unleaded gasoline use (85% in FY2010 and 71% in FY2021). We have made significant progress in reducing emissions from unleaded fuel use from 162.06 mtCO2e in FY2010 to 100.25 mtCO2e in FY2021, a reduction of 38%. Plus, the addition of propane as a cleaner alternative to gasoline is now used in five riding mowers that has helped to reduce the GHG fleet emissions. Diesel fuel use has increased however by 8% (15% in FY2010 and 23% in FY2021).

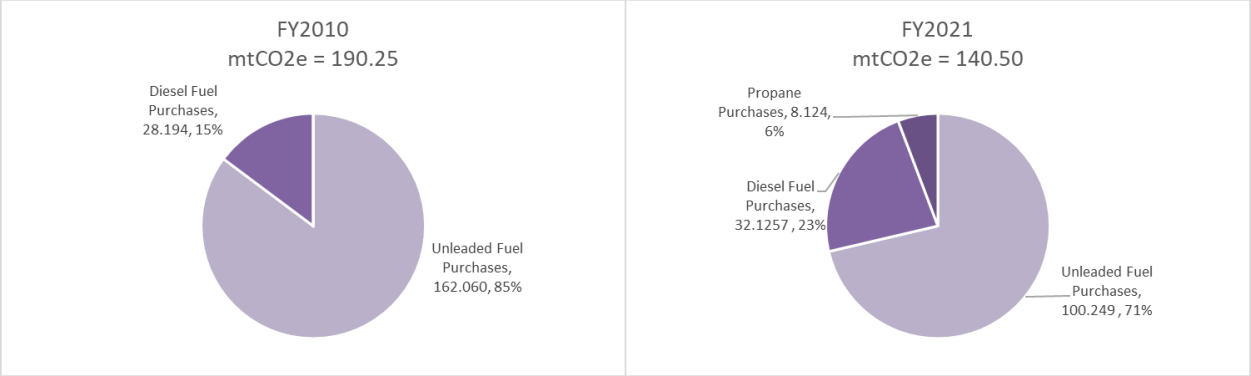


Figure 4 - Overall GHG emissions from our fleet of vehicles and equipment have dropped by 26% between FY2010 and FY2021.

If we use the trend over the past 12 years of 2.32% reduction in GHG emissions per year, Mount Auburn will still fall short of our carbon neutrality goal by FY2050. Therefore, we are making a prediction.

Achieving zero carbon emissions before 2050 is expected given the rapid advances in the types of green power sources becoming available - both in renewable electricity and in 'green hydrogen'. This accelerated trend indicates an improvement of 14% per year. It may require greater financial investment, but prices for electrical vehicles are dropping.

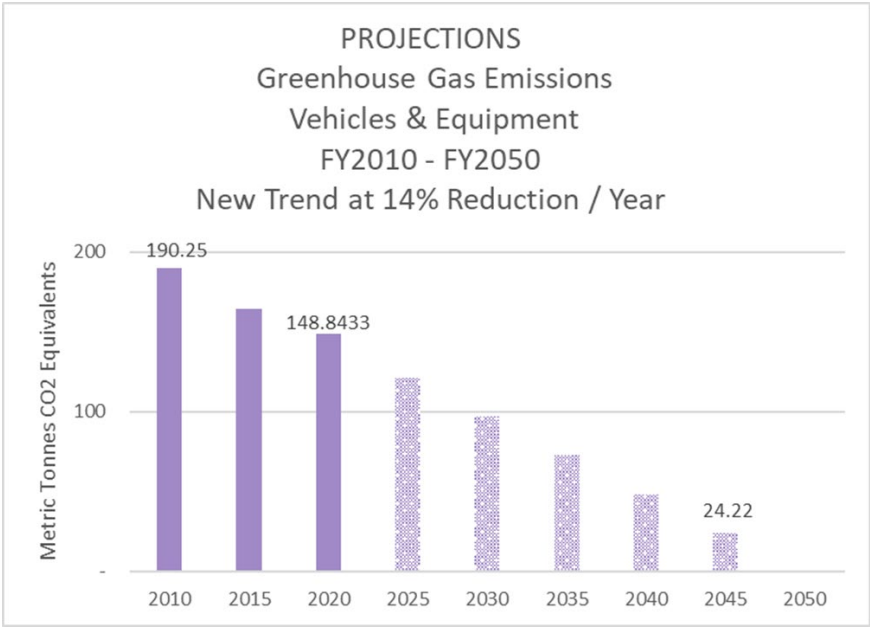


Figure 5 - Achieving zero carbon emissions before 2050 is expected given the rapid advances in the types of green power sources becoming available - both in renewable electricity and in 'green hydrogen'. Zero carbon emissions (in fact, fossil-fuel free) from the mobile fleet is completely do-able by 2050 or before.

Additionally, the rapid improvements in equipment itself are very encouraging; therefore, without hesitation, **zero carbon emissions (in fact, fossil-fuel free) from the mobile fleet is completely do-able by 2050 or before.**

Mount Auburn will continue to closely monitor the changing technology and convert to cleaner equipment as it passes the 'work' test. Making this transition may require an infusion of capital to reach carbon-neutrality. Some of Mount Auburn's vehicles that transport people rather than perform 'hard work' on the grounds could be transitioned first. Those vehicles used by Cemetery and Visitor Services, for example, could be transitioned to electric ones after determining where and when charging stations may be installed.

Reviewing the current inventory of vehicles informs future strategies specifically for the short term. Not all vehicles need to be workhorses. Many of the vehicles are used by Cemetery and Visitor Services and do not require the 'horse-power' of grounds-related vehicles. Even many of the pickup trucks could be successfully transitioned to electric vehicles if the price continues to drop with improved technology.

With the expectation that prices for electric vehicles will become more affordable, Mount Auburn will be able to transition the fleet more rapidly towards clean fuels. As the number of electric vehicles increases however, the number of electric charging stations will also need to increase. Where and how the vehicles are charged needs to be a requirement in the upcoming Facilities Master Plan determining the best locations for charging stations, knowing the types of vehicles, which vehicles, or what equipment needs to be charged.

Mobile Fleet (Vehicles & Equipment) Emissions Goals

a. Short term (FY2022 – FY2024)

i. Continue to capture utility use data and chart to see an accelerated downward trend indicating continued reduction in GHG emissions.
ii. Continue to research and trial new vehicles and large equipment
iii. Continue to transition small equipment to battery-powered as part of cyclical replacement schedule
iv. Identify where electric vehicle charging stations could be installed as part of **Campus-wide Facilities Master Plan**
v. Identify financial incentives offered by State or others to offset cost of charging stations

b. Medium term (FY2025 - FY2034)

i. Install electric charging stations as identified by **Campus-wide Facilities Master Plan**
ii. Track kWh used for new vehicles and equipment to better assess actual costs of going electric
iii. Develop timeline for transitioning all vehicles and equipment to electric or alternatives like propane with fewer GHG emissions.
iv. Budget for and purchase new vehicles and equipment as they pass trials on the Grounds
v. Transition all passenger vehicles to electric in a phased approach
vi. Produce and publish Vehicles and Equipment reports for 2025, 2030, and 2035, and reset reduction targets as needed in light of technology improvements

c. Long term (FY2035 - FY2050)

i. Produce and Publish Vehicles and Equipment Report for FY2040 and FY2050, and reset reduction targets as needed in light of technology improvements
ii. Celebrate achieving goal – hopefully before FY2050!

Cremation-related Emissions

The 1969 crematory was replaced in 2018 – 2019 with a Dutch system, Facultatieve, that is much more energy efficient. Due to that period of construction, the trend is difficult to project for the entire period of FY2010 thru FY2021. However, a trend based on the operations of the new crematory combined with the crematory business plan was used to project the future GHG emissions based on a 2% increase in the number of cremations per year.

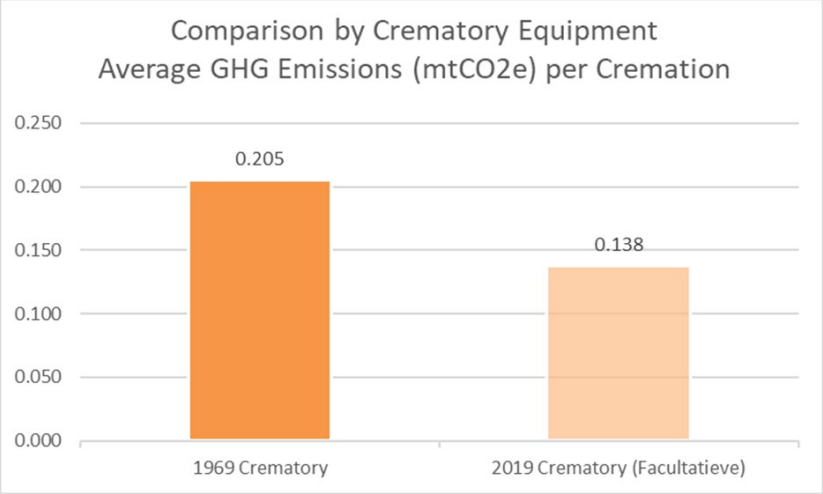


Figure 6 - The 2019 crematory is 33% cleaner per cremation than the 1969 equipment.

When comparing the equipment of the 1969 crematory with that of the 2019 crematory, we see the new crematory is 33% cleaner per cremation.

The GHG emissions have been calculated as if the crematory is using standard combustion equipment. The MA Department of Environment Management uses a different metric based on the two different burners for each cremation chamber. Ultimately, the gas use per cremation is the data driving the trends and the calculated GHG emissions for this report. Biogenic emissions (emissions from a body and casket) have not been studied for this report.

With a 2% increase in the number of cremations per year, there is a steady increase in GHG emissions. These emissions will need to be offset with some type of offset purchase or carbon sink (land and/or forest) to meet net zero GHG emissions by 2050.

Additionally, innovative engineering for capturing the heat from the cremation chambers and using it to heat the chapel could be done in the future.

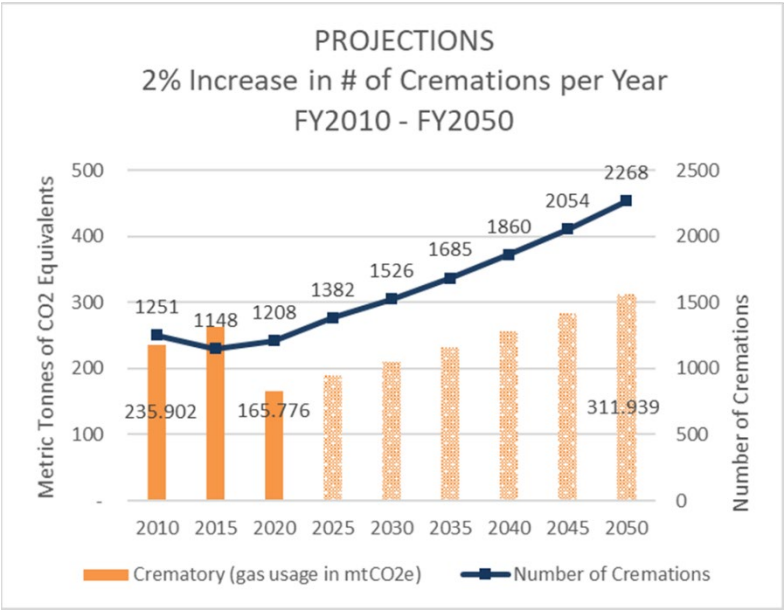


Figure 7 – Regarding cremations, only the purchase of carbon offsets will support a goal of carbon neutrality by 2050.

Currently, only the purchase of carbon offsets will support a goal of carbon neutrality by 2050. The future may hold other options for the disposition of the human body. Keeping an eye on new technologies and determining if they are right for Mount Auburn's business as well as its carbon footprint will require investments of time and money.

Cremation Strategies and Goals

1. **Track, measure and monitor energy consumption, number of cremations and new technologies –** Assuming the cremation rate increases as projected by the crematory business plan, then the number of cremations is likely to increase and the business advantages of maximizing cremations will have to be weighed against the carbon footprint implications.
    a. **SHORT TERM (FY2022 – FY2024)**
        i. Capture gas use data and number of cremations, weight of body and type of casket or container that is burned.
        ii. Consider opportunities for purchasing carbon offsets for cremation activities at Mount Auburn.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Follow new technologies and determine if they are viable options for Mount Auburn. (Specifically, alkaline hydrolysis and natural organic reduction are making headlines across the nation, but not legal in Massachusetts; it is unclear as to who would operate these new technologies; it could be funeral homes, not cemeteries).
        ii. Identify programmatic changes, if appropriate, to support the anticipated increase in cremations

Electricity-related Emissions

Mount Auburn has been purchasing Renewable Energy Certificates or Credits (RECs) since FY2010. Purchasing RECs are a means of investing in renewable energy. From FY2010 through FY2016, Mount Auburn purchased Green-e Certified Clean Source RECs equal to the previous years' kWh through a broker. These RECs were available on a national market, therefore represented renewable energy produced throughout North America. In FY2017 Mount Auburn began purchasing New England-based renewables through municipal aggregation programs at 25%, first through the Cambridge Community Electricity Program, and then through Green Energy Consumers Alliance in Watertown in FY2020. Municipal aggregation programs combine the buying power of the local community of residents and businesses to support regional renewable energy production and offer renewable energy at rates only slightly above the standard utility company's rates. Through these programs Mount Auburn currently purchases New England Class1 renewables each month to cover 100% of its electricity use.

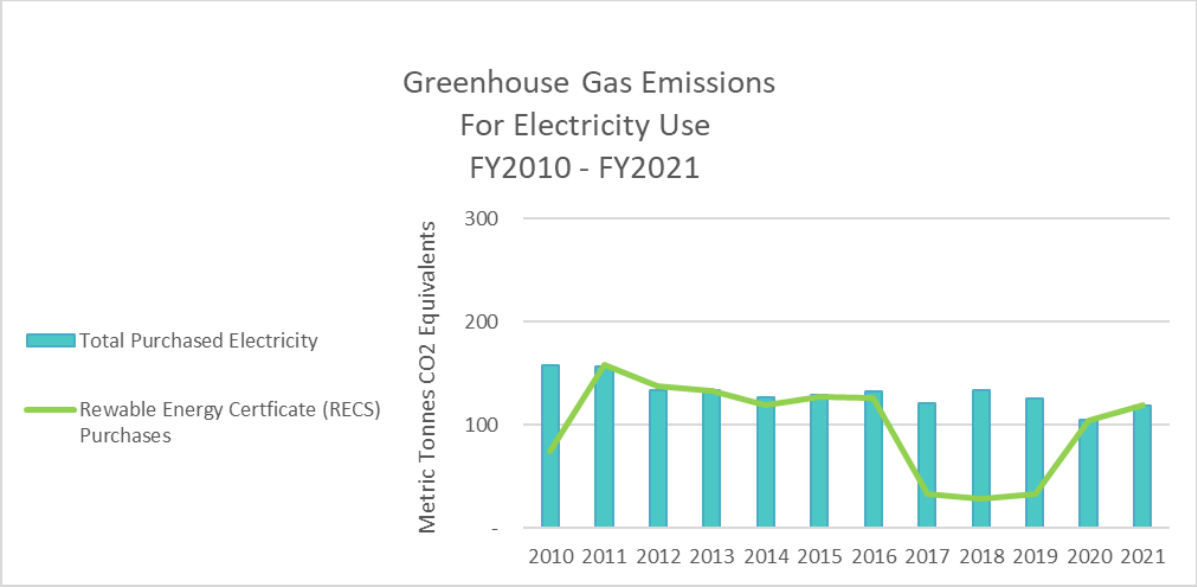


Figure 8 - A downward trend in kWh is a positive sign. The purchase of RECS effectively 'neutralizes' Mount Auburn GHG emissions per kWh. By 2020, Mount Auburn enrolled in 100% New England Class1 renewables through both Cambridge and Watertown municipalities.

The standard protocol for GHG reporting is to report kWh use in both **location-based** and **market-based** emissions. The teal-colored bars represent electricity purchased through a **location-based** electrical grid, which results in GHG emissions based on EPA's Subregion Output Emission Rates for New England (NEWE).

Using **market-based** calculations, zero GHG emissions are represented by the green line due to Mount Auburn's purchase of RECS, which since FY2020 has been 100% through the municipal aggregation program purchases of New England Class1 renewables. These purchases effectively 'neutralize' Mount Auburn kWh GHG emissions. And in the pursuit of saving costs with clean energy, in the spring of 2021 Mount Auburn will begin producing its own electricity from solar panels mounted on the Operations Center buildings. The electricity will be tracked as a new source of clean energy.

Generating clean electricity on-site and purchasing renewable electricity are two ways to reach carbon-neutrality. With the purchases of New England Class1 renewables and the installation of the solar panels at the Operations Center representing about 70% of the Operations Center electricity use, total electricity use at Mount Auburn will easily reach net zero by 2050. Effectively, it already does.

Would it be possible for Mount Auburn to generate all of its own electricity without relying on the grid? In the long run, this change could be a cost-saving measure. For every kWh used for charging a new vehicle, piece of equipment, or even a new heating system, Mount Auburn needs to be cognizant of the source of the electricity that is needed to support the transition to a carbon-neutral future. The combined purchase of New England Class1 renewables and on-site generation is a superb solution.

Building Heat-related Emissions

Heating the buildings comprises the largest percentage of the GHG emissions pie. Tracking and reporting on GHG emissions for buildings in the next few years will provide a view into how small changes can make a difference in the trend direction. Those small changes in the future are energy-efficient enhancements including building assessments and recommissioning of systems.

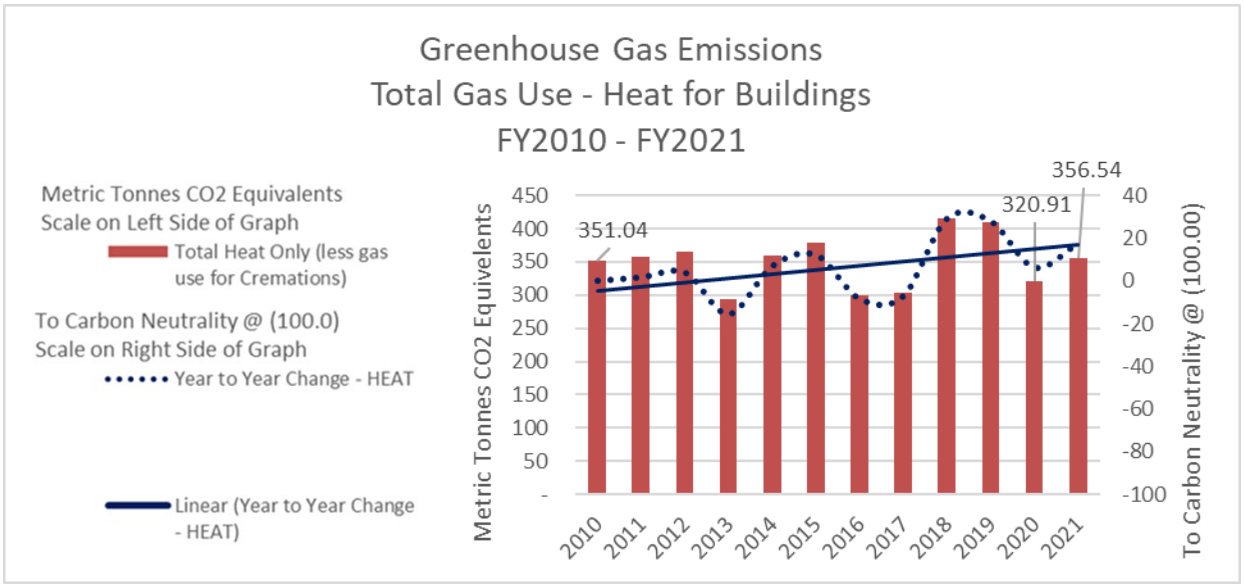


Figure 9 - Mount Auburn expected to see a reduction in GHG Emission during the year of COVID, FY2021. In fact, it shows a greater amount of GHG emissions over FY2020 and even over our baseline year of 2010. The overall trend based on the past 12 years indicates an increase of 1.44% per year.

Mount Auburn expected to see a reduction in GHG emissions during the year of COVID-19, FY2021. In fact, it shows a greater amount of GHG emissions over last year and over our baseline year of 2010. The overall trend based on the past 12 years indicates an increase of 1.44% per year.

While 1.44% is not a huge increase, we recognize efficient insulation, better windows, turning down the thermostats or putting them on timers are not enough to move the GHG emission needle towards carbon-neutrality.

The truth about these projections is that it will never happen like this. Building heat, ventilation and A/C systems (HVAC) are updated about every 20 – 25 years.

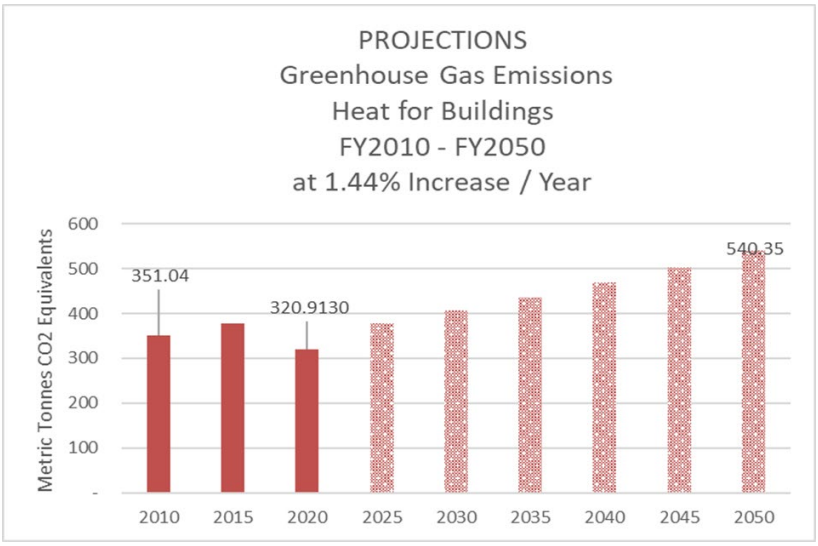


Figure 10 -The truth about these projections is that it will never happen like this. Building heat, ventilation and A/C systems (HVAC) are updated about every 20 – 25 years. We know that heating systems and technologies will be improved.

We know that heating systems will be improved. What is the best course of action in 10 years, 15 years and 25 years from now? Taking a closer look into each building is important for developing a hopeful picture.

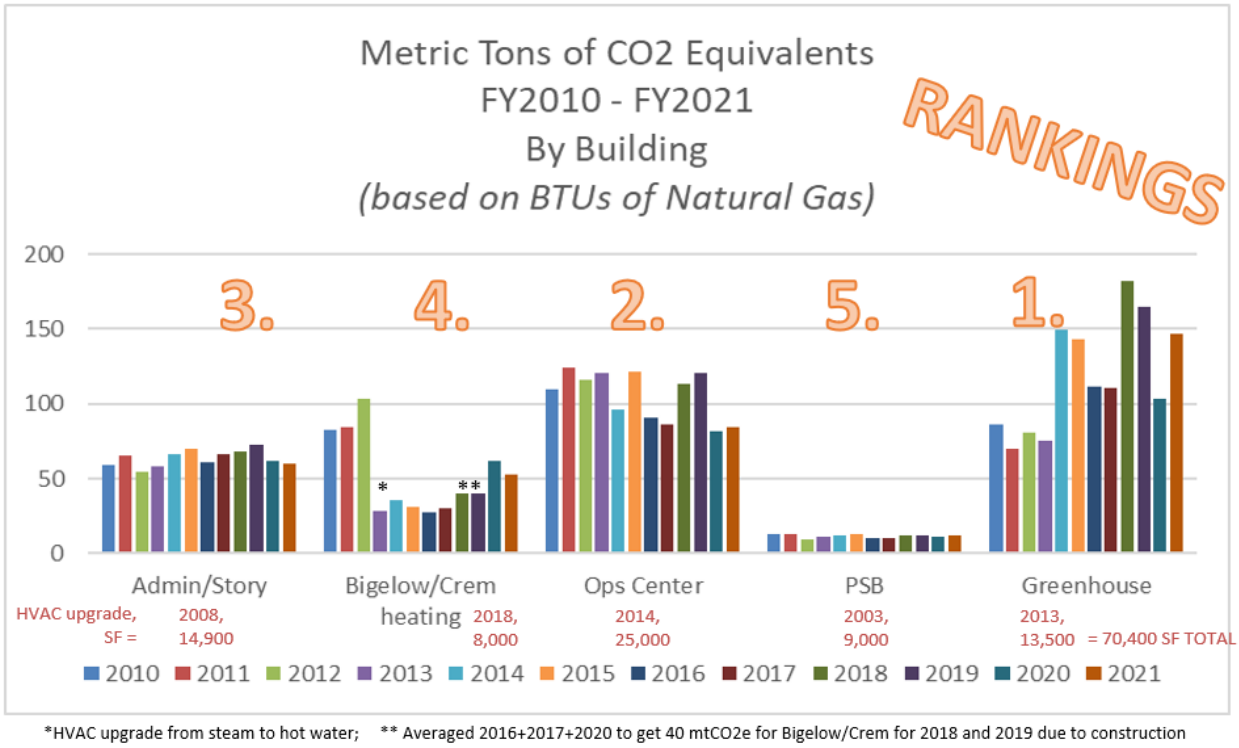


Figure 11 - Knowing which buildings emit the most GHGs and when each heating system was upgraded, two scenarios have been charted: Deep Energy Retrofit and Clean Fuels.

Knowing which buildings emit the most GHGs and when each heating system was upgraded, two scenarios have been charted: Deep Energy Retrofit and Clean Fuels. One scenario reaches to zero emissions, the other gets Mount Auburn close.

One common challenge that comes with the efficiency of each building has been identified by Gus Fraser, *Vice President of Preservation & Facilities*. He says:

> "Despite efforts to upgrade heating systems with more efficient equipment, an increase in intensity of building use has resulted in an increase in heating demand and consequently, GHG emissions. Mount Auburn is using buildings more intensely.
>
> Unless there is financial investment in zero emissions mechanical equipment, Mount Auburn won't see an improvement."

One can barely imagine that we will be heating our buildings with renewably generated electricity by the year 2030 given that just ten (10) years ago designers were recommending installing energy efficient natural gas-fueled boilers as a way towards a cleaner future. Yet, here we are. Doing just that. Imagining!

Given that a major strategy going forward will be converting fossil-fuel heating to renewable electricity, looking at the heat *and* electricity for each building is important.

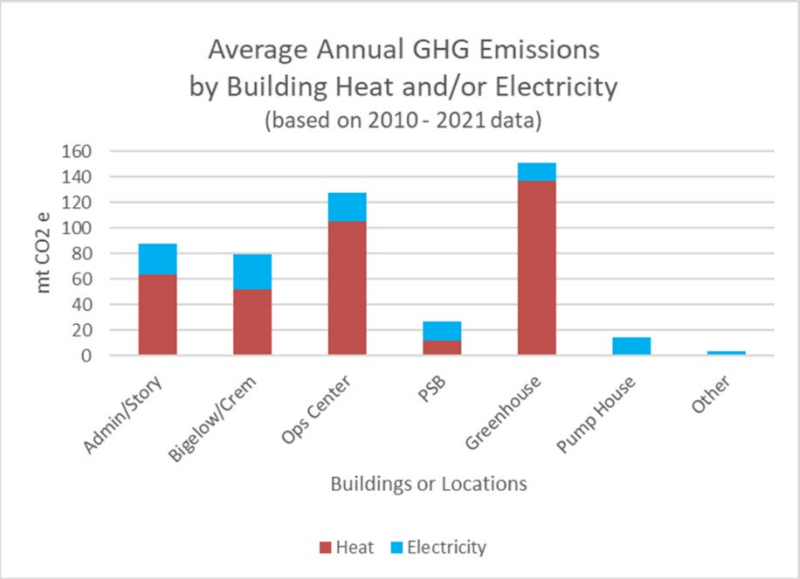


Figure 12 - Given that a major strategy going forward will be converting fossil-fuel heating to renewable electricity, looking at the heat *and* electricity for each building is important.

Anticipating an increase in electricity is likely at this point in time; therefore, ensuring that New England-based Renewables are purchased, or electricity is generated on site will keep the GHG emissions down. The increased likelihood of major advances in technology is encouraging. Those advances include 'green hydrogen' and 'green gas' such that the gas companies can make use of the infrastructure that is already in place for delivering a 'green gas'.

Scenarios for Upgrades to Building HVAC Systems

Both scenarios propose a building HVAC upgrade every five (5) years starting with the greenhouse in FY2025 (only 3 years away), which has the highest GHG emissions. These scenarios also take into account the ages of the HVAC systems. Both scenarios are contingent upon the completion of the **Campus-wide Facilities Master Plan** for which a Request for Proposals (RFP) will be prepared beginning in January 2022 (FY2022) with the support of Mount Auburn's new President.

Scenario 1 – Deep Energy Retrofit

This first scenario assumes at least a 50% reduction in GHG emissions for each building HVAC. The City of Boston calls this scenario a deep energy retrofit. It is not easy to achieve. It is more stringent than what is commonly known as the 'stretch' code that virtually all cities and towns across the state have adopted. The City of Boston says the deep energy retrofit is not good enough to achieve carbon-neutrality without the purchase of offsets. It is a starting place.

In this scenario of 50% reduction in GHG emissions, Mount Auburn gets to around 200 mtCO2e by 2050. **To become carbon neutral, carbon offsets would need to be purchased**. HVAC

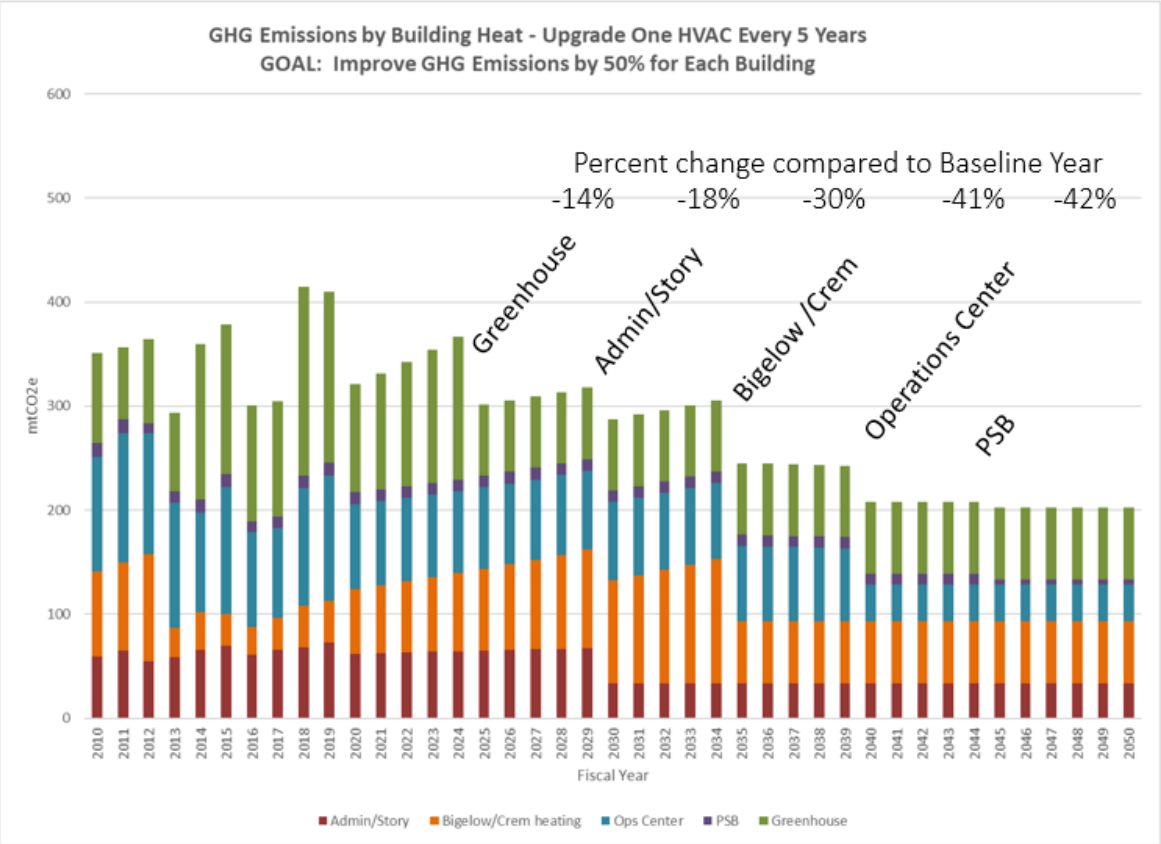


Figure 13 - In this scenario of 50% reduction in GHG emissions, Mount Auburn gets to around 200 mtCO2e by 2050. HVAC upgrades have not been this efficient in part because there has been an increase in building use.

upgrades in the past have not been as effective as predicted because there has been an increase in building use.

Scenario 2 – Clean Fuels, Carbon Free

The second scenario assumes that each HVAC upgrade converts to a clean fuel *except* for the first change at the Greenhouse. There'll be a second greenhouse upgrade in 2045. The first Greenhouse upgrade in 2025 is not fossil fuel free, but it does cut GHG emissions by 50%. This scenario eliminates fossil fuels for heating by FY2050 without the purchase of carbon offsets.

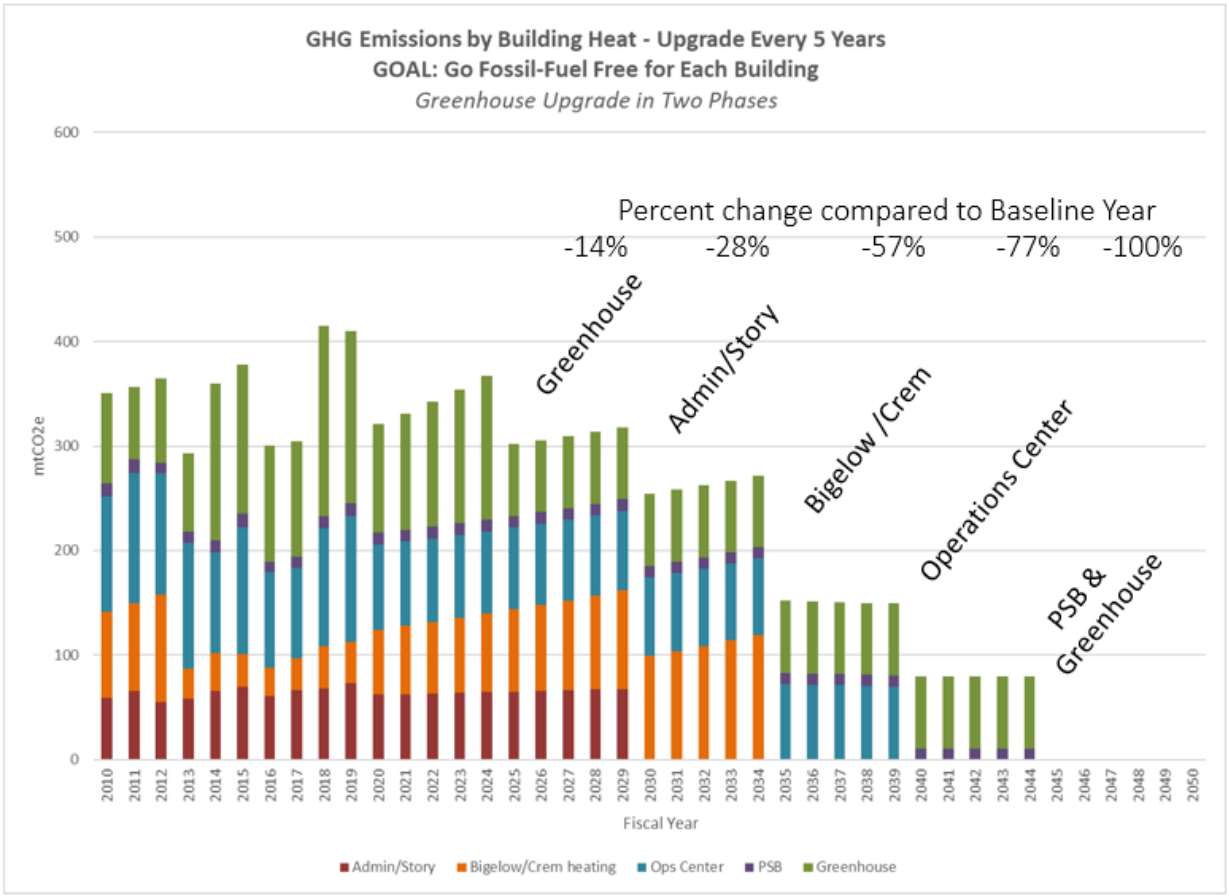


Figure 14 - First Greenhouse upgrade in 2025 is not fossil-fuel free, but it does cut GHG emissions by 50%. All other HVAC upgrades eliminate fossil fuels.

The overall GHG emissions story based on **Clean Fuels, Carbon Free** Scenario 2 is a positive one. Under this most optimistic scenario, only the crematory still emits GHG emissions and even those may be 'neutralized' with the purchase of carbon offsets. The way to achieve carbon-neutrality by FY2050 assumes:

- Heating the buildings will be fossil-fuel free by FY2045
- Mobile GHG emissions will use clean alternatives by FY2050 or before.
- Electricity purchases will be those from clean renewable sources or generated on site
- Crematory will continue to use fossil-fuel for cremation by fire and will be offset.

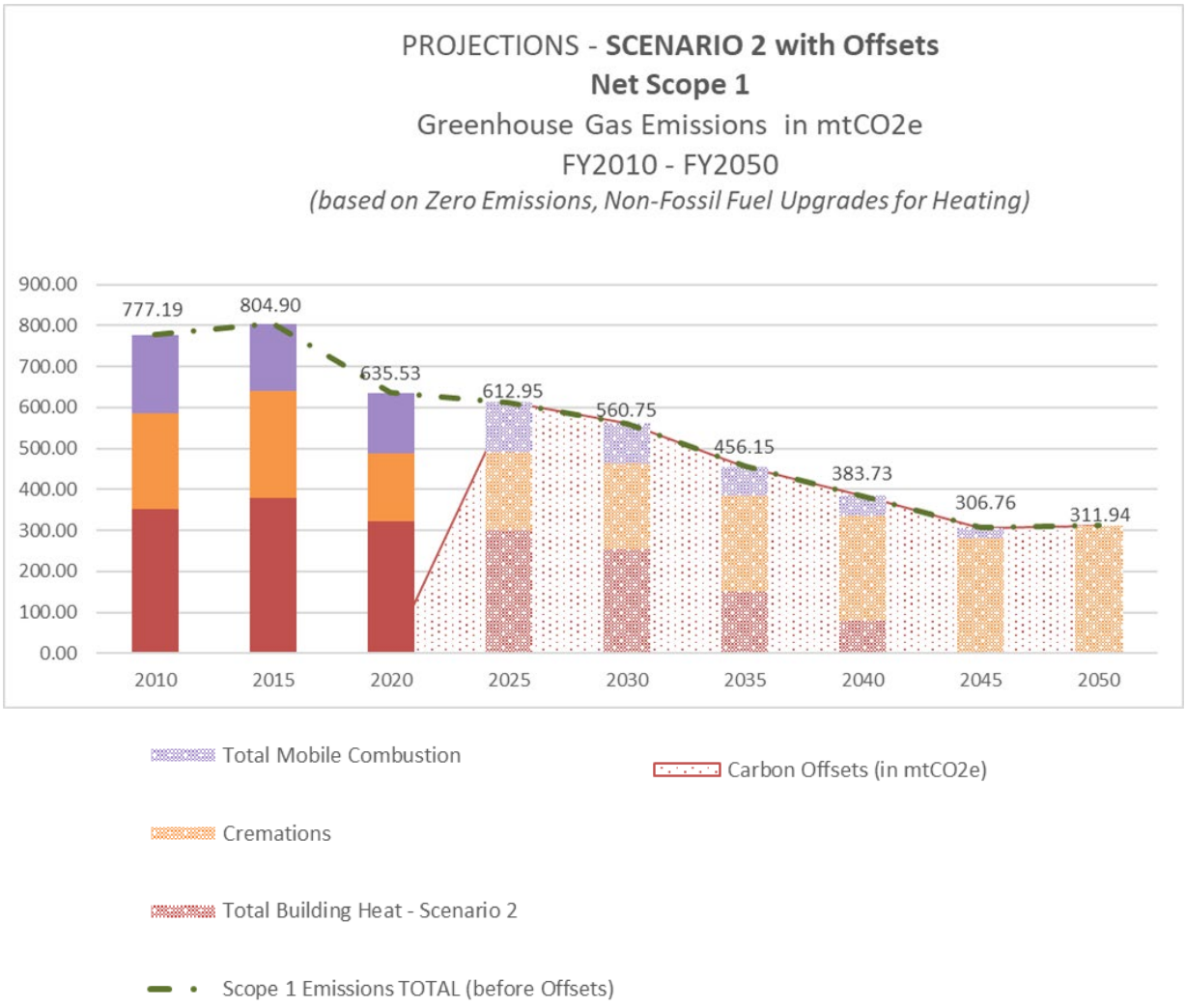


Figure 15 - **Clean Fuels, Carbon Free** Scenario 2 is a positive one. Under this most optimistic scenario, only the crematory still emits GHG emissions and even those may be 'neutralized' with the purchase of carbon offsets.

Facilities Planning for GHG Emissions Reduction

The following four strategies complement, support, and overlap each other. Each strategy includes short-, medium-, and long-term goals. They are a work in progress. Additional specific goals will grow from future **Campus-Wide Facilities Master Planning** effort. Long term capital planning will be required to estimate funds required to achieve target reductions and eventual carbon neutrality.

Building Heat and Electricity Related Strategies and Goals

1. **Track, measure and monitor energy consumption –** Improve efforts to capture energy consumption data to help identify opportunities for improvement and measure the outcomes of our efforts.
    a. **SHORT TERM (FY2022 – FY2024)**
        i. Continue to capture utility use data.
        ii. Benchmark current energy performance against buildings of similar type and age.
        iii. Incorporate smart meters and monitoring technology.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Develop campus wide Building Management System (BMS) to monitor and control systems, and log energy consumption data.
    c. **LONG TERM (FY2035 - FY2050)**
        i. Track progress through data collection and BMS toward target reductions.
2. **Increase energy efficiency in existing buildings –** Regularly assess performance of existing building systems, complete preventive maintenance, and implement improvements to optimize operating efficiencies.
    a. **SHORT TERM GOALS (FY2022 -FY2024)**
        i. Complete preventative maintenance to keep systems running efficiently.
        ii. Assess replacement of Admin HVAC equipment will all electric system. Budget and schedule to coincide with ADA improvements.
        iii. Complete energy audit of all buildings to identify opportunities for energy efficiency improvements.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Incorporate energy audit recommendations and budget estimates into facilities maintenance and capital planning.
        ii. Apply LEED Operations & Maintenance standards to facilities.
3. **Reduce reliance on fossil fuels and increase use of renewable energy sources** – Replace fossil fuel heating/cooling systems with all-electric systems in all Cemetery buildings. Target replacement in one building every five years. Increase on-site generation of clean electricity.
    a. **SHORT TERM (FY2022 - FY2024)**

i. Assess feasibility and costs for **Clean Fuels, Carbon Free Scenario 2** HVAC system replacements over time as part of the **Campus-wide Facilities Master Plan**.
ii. Assess options for on-site electricity generation as part of **Campus-wide Facilities Master Plan.**
iii. Research effective and verifiable carbon offset programs, and prepare costs for review through the budget process.
iv. Continue purchase of 100% green electricity.

b. MEDIUM TERM (FY2025 - FY2034)

i. Replace systems in at least two Cemetery buildings based on the **Campus-wide Facilities Master Plan**.
ii. Prepare for an budget third non-fossil fuel based HVAC replacement system ready for implementation in FY2035.
iii. Adapt plans for systems replacements as new technology develops.
iv. Increase on-site generation capacity per recommendations of **Campus-wide Facilities Master Plan**.
v. Depending on research and budget review, purchase carbon offsets for ongoing Cemetery-wide fossil fuel use.
vi. Continue purchase of 100% green electricity.

c. LONG TERM (FY2035 - FY2050)

i. Replace systems in remaining Cemetery buildings based on the **Campus-wide Facilities Master Plan**
ii. Continue purchase of 100% green electricity.

4. **Incorporate aggressive GHG reduction goals in all renovation or new construction projects** – The reduction of facilities-related GHG emissions must be a major consideration in a Campus-wide Facilities Master Planning effort.

a. SHORT TERM (FY2022 - FY2024)

i. Incorporate GHG emissions targets and strategies into development of **Campus-wide Facilities Master Planning** effort.

b. MEDIUM TERM (FY2025 - FY2035)

i. Commit to LEED or more stringent standards for all building renovations, additions, or new construction projects resulting from **Campus-wide Facilities Master Plan.**
ii. Assess progress toward GHG reduction targets and reset goals and standards to stay on track for net zero by 2050.

Carbon Offsets

Future research is needed on different carbon offset programs, or when and if the purchase of carbon offsets is prudent for Mount Auburn. There is also the possibility of investing in physical forest or land as a carbon sink. According to https://www.offsetguide.org/understanding-carbon-offsets/carbon-offset-programs/registries-enforcement/, "there are several registries in the voluntary offset market, which have been developed by governments, non-profits, and the private sector. The following voluntary registries are currently operating:

- **American Carbon Registry (ACR)**: https://americancarbonregistry.org
- **APX Inc.** https://apx.com, administers the following offset registries:
    - Gold Standard Registry: https://www.goldstandard.org/resources/impact-registry
    - Climate Action Reserve (CAR): https://www.climateactionreserve.org/
- **Markit**: https://ihsmarkit.com/products/environmental-registry.html, administers the following offset registries:
    - Social Carbon Registry: http://www.socialcarbon.org/developers/registry/
    - Plan Vivo Registry: http://www.planvivo.org/plan-vivo-certificates/markit-registry/
- **Verra**: https://verra.org/, administers the following offset registries:
    - Verified Carbon Standard (VCS) Registry: https://verra.org/project/vcs-program/
    - Climate, Community, & Biodiversity Standards (CCBS) Registry: https://verra.org/project/ccb-program/

This Climate Action Plan is not endorsing any particular registry or plan. The American Public Gardens Association APGA is using Terrapass (https://www.terrapass.com/product/business-carbon-offset) as a vehicle for purchasing carbon offsets.

The registries need to be reviewed for their ability to track and retire RECs and / or offsets to ensure they are not being sold more than once. Ensuring there is verification of the offsets or the projects providing the offsets will provide confidence in the selected registry or program. An NPR story, Do Carbon Offsets Actually Work?, aired on April 30, 2021 can be found in the Appendix. The purchase of carbon offsets needs to be studied carefully. An investment in additional land as a carbon sink may be a more prudent and local approach for Mount Auburn.

Part III: Summary of Strategies and Goals for Reaching Carbon Neutrality

The strategies and goals identified in Part II are repeated here in one place for easy reference.

Mobile Fleet (Vehicles & Equipment) Emissions Goals

a. SHORT TERM (FY2022 – FY2024)

i. Continue to capture utility use data and chart to see an accelerated downward trend indicating continued reduction in GHG emissions.
ii. Continue to research and trial new vehicles and large equipment
iii. Continue to transition small equipment to battery-powered as part of cyclical replacement schedule
iv. Identify where electric vehicle charging stations could be installed as part of **Campus-wide Facilities Master Plan**
v. Identify financial incentives offered by State or others to offset cost of charging stations

b. MEDIUM TERM (FY2025 - FY2034)

i. Install electric charging stations as identified by **Campus-wide Facilities Master Plan**
ii. Track kWh used for new vehicles and equipment to better assess actual costs of going electric
iii. Develop timeline for transitioning all vehicles and equipment to electric or alternatives like propane with fewer GHG emissions.
iv. Budget for and purchase new vehicles and equipment as they pass trials on the Grounds
v. Transition all passenger vehicles to electric in a phased approach
vi. Produce and publish Vehicles and Equipment reports for 2025, 2030, and 2035, and reset reduction targets as needed in light of technology improvements

c. LONG TERM (FY2035 - FY2050)

i. Produce and Publish Vehicles and Equipment Report for FY2040 and FY2050, and reset reduction targets as needed in light of technology improvements
ii. Celebrate achieving goal – hopefully before FY2050!

Cremation Strategies and Goals

1. **Track, measure and monitor energy consumption, number of cremations and new technologies –** Assuming the cremation rate increases as projected by the crematory business plan, then the number of cremations is likely to increase and the business advantages of maximizing cremations will have to be weighed against the carbon footprint implications.
    a. **SHORT TERM (FY2022 – FY2024)**
        i. Capture gas use data and number of cremations, weight of body and type of casket or container that is burned.
        ii. Consider opportunities for purchasing carbon offsets for cremation activities at Mount Auburn.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Follow new technologies and determine if they are viable options for Mount Auburn. (Specifically, alkaline hydrolysis and natural organic reduction are making headlines across the nation, but not legal in Massachusetts; it is unclear as to who would operate these new technologies; it could be funeral homes, not cemeteries).
        ii. Identify programmatic changes, if appropriate, to support the anticipated increase in cremations

Building Heat and Electricity Related Strategies and Goals

1. **Track, measure and monitor energy consumption –** Improve efforts to capture energy consumption data to help identify opportunities for improvement and measure the outcomes of our efforts.
    a. **SHORT TERM (FY2022 – FY2024)**
        i. Continue to capture utility use data.
        ii. Benchmark current energy performance against buildings of similar type and age.
        iii. Incorporate smart meters and monitoring technology.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Develop campus wide Building Management System (BMS) to monitor and control systems, and log energy consumption data.
    c. **LONG TERM (FY2035 - FY2050)**
        i. Track progress through data collection and BMS toward target reductions.
2. **Increase energy efficiency in existing buildings –** Regularly assess performance of existing building systems, complete preventive maintenance, and implement improvements to optimize operating efficiencies.
    a. **SHORT TERM GOALS (FY2022 -FY2024)**
        i. Complete preventative maintenance to keep systems running efficiently.
        ii. Assess replacement of Admin HVAC equipment will all electric system. Budget and schedule to coincide with ADA improvements.
        iii. Complete energy audit of all buildings to identify opportunities for energy efficiency improvements.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Incorporate energy audit recommendations and budget estimates into facilities maintenance and capital planning.
        ii. Apply LEED Operations & Maintenance standards to facilities.
3. **Reduce reliance on fossil fuels and increase use of renewable energy sources** – Replace fossil fuel heating/cooling systems with all-electric systems in all Cemetery buildings. Target replacement in one building every five years. Increase on-site generation of clean electricity.
    a. **SHORT TERM (FY2022 - FY2024)**
        i. Assess feasibility and costs for **Clean Fuels, Carbon Free Scenario 2** HVAC system replacements over time as part of the **Campus-wide Facilities Master Plan**.
        ii. Assess options for on-site electricity generation as part of **Campus-wide Facilities Master Plan.**
        iii. Research effective and verifiable carbon offset programs, and prepare costs for review through the budget process.
        iv. Continue purchase of 100% green electricity.
    b. **MEDIUM TERM (FY2025 - FY2034)**
        i. Replace systems in at least two Cemetery buildings based on the **Campus-wide Facilities Master Plan**.

ii. Prepare for an budget third non-fossil fuel based HVAC replacement system ready for implementation in FY2035.
iii. Adapt plans for systems replacements as new technology develops.
iv. Increase on-site generation capacity per recommendations of **Campus-wide Facilities Master Plan**.
v. Depending on research and budget review, purchase carbon offsets for ongoing Cemetery-wide fossil fuel use.
vi. Continue purchase of 100% green electricity.

c. **LONG TERM (FY2035 - FY2050)**
   i. Replace systems in remaining Cemetery buildings based on the **Campus-wide Facilities Master Plan**
   ii. Continue purchase of 100% green electricity.

4. **Incorporate aggressive GHG reduction goals in all renovation or new construction projects** – The reduction of facilities-related GHG emissions must be a major consideration in a Campus-wide Facilities Master Planning effort.
   a. **SHORT TERM (FY2022 - FY2024)**
      i. Incorporate GHG emissions targets and strategies into development of **Campus-wide Facilities Master Planning** effort.
   b. **MEDIUM TERM (FY2025 - FY2035)**
      i. Commit to LEED or more stringent standards for all building renovations, additions, or new construction projects resulting from **Campus-wide Facilities Master Plan.**
      ii. Assess progress toward GHG reduction targets and reset goals and standards to stay on track for net zero by 2050.

Part IV: Sustainability Narratives

The following ten narratives are intended to share Mount Auburn's commitment to holistic institutional sustainability and the emphasis we place on our role as stewards, advocates and educators to the greater community. Each narrative provides a glimpse into our efforts, from long-term implemented actions to new initiatives. These narratives encompass the activities that may impact the health and wellbeing not only of our flora and fauna, but of staff and visitors alike. Through the narratives, we relay how the Climate Action & Sustainability Plan (CASP) is much more than a Climate Action Plan (CAP) to reduce our carbon footprint – which of course is critically important. It is a living document designed to meet the challenges of today and identify and prepare for those of tomorrow. We hope that these stories provide inspiration to others – individuals, institutions, and communities – to look for ways to be more sustainable in all that they do. The future of the planet depends on it!

Contents

Biodiversity in the Plant Collections

By Dennis Collins

Efforts to increase biodiversity throughout the 175 acres of Mount Auburn began in the 1990s with the completion of the 1993 Master Plan, which noted a clear lack of ground-layer and understory vegetation. In the past 20 years, these efforts have become more focused through a series of horticultural initiatives developed in our strategic planning exercises. The reasons for these efforts include reducing risks from plant pathogens, building resilience to environmental stress, increasing wildlife benefits with vegetation, and eliminating the visual homogeneity in the landscape noted in the Master Plan. The following is a brief summary:

Current Composition

As reported in our most recent Plant Collections Analysis, the statistical data shows a robust botanical collection which has been steadily increasing in numbers and in diversity.

Total Plants/Massed Plantings:	18,748
Total Known Taxa:	2,335
Botanical Families Represented:	120
Genera Represented:	430

Composition Trends

The collections reflect the dynamic nature of Mount Auburn's landscape. Every year we suffer plant losses, due primarily to environmental stresses (e.g., drought and severe storms), and every year we add more new plantings. The net gain/loss of plants tracks our ability to continuously respond to changing conditions and build resilience through diversification. The number of tree removals and of new tree plantings tends to remain relatively static, not only for the most recent five-year period, but over the past 20 years. However, we plant significantly more shrubs and groundcovers in a given year than we remove.

In 2009, our total number of plants and massed plantings was 16,772 and the number of different taxa was 1,754. Over the subsequent 10-year period, the total number of different taxa increased by 33% to 2,335.

In the next few years, we are planning projects that should be able continue this trend toward diversification. Indian Ridge Path Phases 2 and 3, the Alice Fountain landscape renovation, and the proposed shrubland-meadow conversion along Chestnut Avenue all include taxa that will increase our numbers significantly. However, it might be unrealistic to expect another 33% increase in new taxa over the next 10-year period. The more diversified the collections become, the harder it will be to continue diversifying them. It might be more prudent to set goals for noting which of these new additions were successful, and adding significantly more of them.

Horticultural Initiatives

The following initiatives have been driving our diversification efforts for the past several years, and will continue to do so for the foreseeable future.

- Conifer Diversification Initiative: In response to the Hemlock Woolly Adelgid outbreak, which is exacerbated by climate change, since the early 1990s we have reduced our hemlock collection by roughly two thirds down to the current 125 trees. Using our expanded in-house plant production program, we have been adding new conifer taxa to the collection. But the process is slow due to the fact that we have to propagate most of the plants from seed or cuttings. There are currently 250 seedlings in production, though we anticipate using only a portion of these once they reach maturity.

- Underground Tombs, Curb & Fence Lot Plantings: There are 640 lots on the grounds where granite curbing, iron fencing or underground tombs present challenges for the safety of structures and staff from our turf maintenance activities. Our efforts to replace the turf in these lots with more sustainable plantings have been happening since 1993. Currently, we have completed 244 of these conversions (38%), and in recent years have averaged five conversions per year.

- Test and utilize more USDA Hardiness Zone 6 Plantings: This is a long-term initiative, which anticipates further warming and growing conditions that are different from most of what Mount Auburn's landscape has seen in the 190 years since its founding. After testing a fair amount of Zone 6 taxa, we will now focus on adding more of the proven ones into the landscape.

- Expand collections to include more Late Spring – Summer Flowering Plants: This initiative is primarily in response to earlier and earlier flowering times for plants in the spring, a phenomenon being documented by our citizen scientist phenology study. The reduction of flowering during bird migration periods creates insect (food) shortages for birds. Our goal of having 50% of new plantings represent later-flowering plants has been achieved in each of the last two years, and should continue for the foreseeable future.

- Enhancement of Historic Landscape Character Zones: This is by far the broadest of the initiatives, and has been in place since 1993. Among the many different objectives covered under this initiative, the ones for removing high-maintenance hedges and for replacing manicured turf with naturalistic (minimally mowed) turf or groundcover alternatives, are the most relevant for sustainability issues. We are now close to 90% in the effort to replace hedges in "the meadow" area (surrounding the Grove Street Gates) with lower maintenance plantings. The naturalistic turf objective has seen success with landscape renovations at Harvard Hill, the Appleton lot, the North Dell Meadows, the Beech-Central historic zone, the apiary meadow and the slopes along Mountain Ave. These have used fine fescue grasses and a variety of sedges. Looking ahead, Phase-3 of the Indian Ridge project will attempt to replace turf with a sedge-wildflower meadow, and the proposed Chestnut Ave shrubland-meadow project will attempt an even larger conversion (nearly 4 acres).

Carbon Storage, Sequestration and EcoSystem Benefits

By Candace Currie

Carbon storage: "Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation." (*i-Tree 2016*)

Carbon sequestration: "Carbon sequestration is the removal of carbon dioxide from the air by plants." (*i-Tree 2016*)

Mount Auburn's trees provide **ecosystem benefits** or **services.** Those services of air pollution removal, carbon storage and sequestration, oxygen production, runoff avoidance, and structural value[1] are integral to the cultural and natural landscape of Mount Auburn. They can be felt on a hot summer day when one is hidden under the canopy of a European beech (*Fagus sylvatica*), or when one steps off the number 71 bus and walks through the iconic Egyptian Gateway into Mount Auburn's oxygen-producing landscape. These benefits have real value.

As part of her horticultural apprenticeship at Mount Auburn, Alexandra Wolfe calculated the ecosystem benefits provided by 1,047 trees in seven horticultural sections comprising 33 acres of Mount Auburn, utilizing the i-Tree software program. i-Tree is a state-of-the-art, peer-reviewed software suite from the Forest Service, an agency of U.S. Department of Agriculture. It provides urban (and rural) forestry analysis and benefits assessment tools available to anyone via the web: https://www.itreetools.org/. (For more details see *Appendix on Carbon Sequestration and Mount Auburn's Trees*). When extrapolating the services and benefits from the trees in the 33 acres of this study across all of Mount Auburn's 175 acres, the benefits are tree-mendous[2].

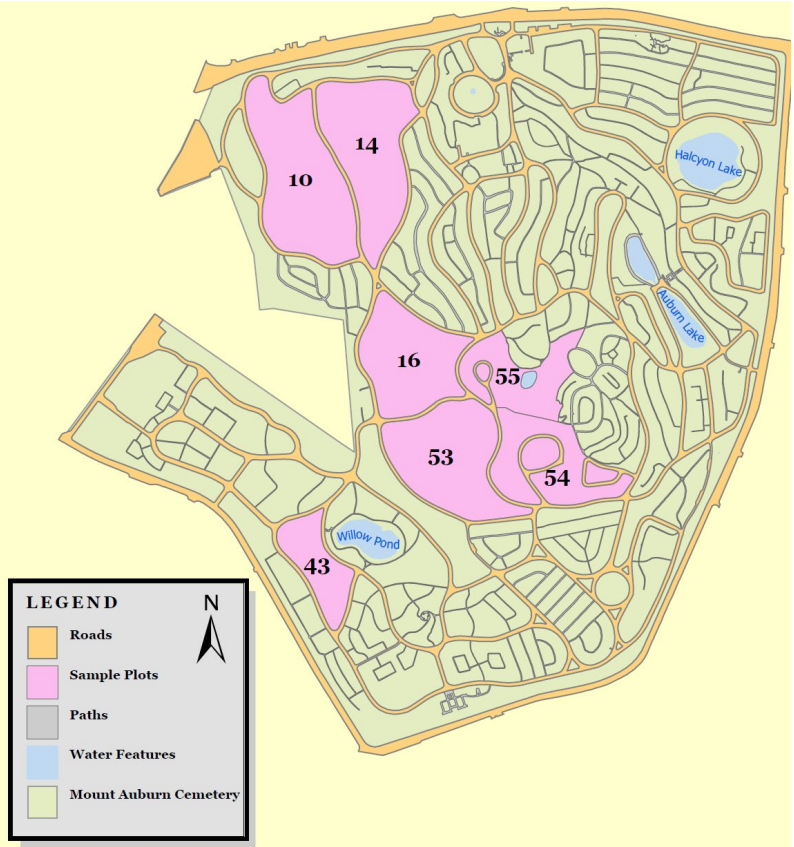


Figure 1 - Map of Sample Plots (in pink) used by i-Tree created by Alexandra Wolfe. November 13, 2020. Map data sourced from Mount Auburn GIS Department.

[1] Based on a species and age compared with the cost of replacement of a similar tree

[2] Sorry, I can't help myself. ccurrie

As for **ecosystem benefits**, imagine a heavy downpour. Tree canopies help slow down the initial rush of water. The understory vegetation reduces storm water sheetflow and its power to overwhelm catch basins, which causes erosion and negatively impacts wildlife habitat. According to iTree, Mount Auburn's trees avoid 94,770ft3 of runoff, which is equivalent to emptying about 24,000 bathtubs each filled with 30 gallons of water. Fortunately, storm water percolates down through the soil and recharges the aquifer. Based on a 2002 study by Emery & Garret Groundwater[3], the perviousness of Mount Auburn's landscape recharges the aquifer at an estimated 92 million gallons in one year of average rainfall. So, the trees slow down the rain, the understory reduces sheetflow, and the ground layer absorbs water. Natural systems are amazing.

Maintaining these natural systems, in this case starting with the trees, requires innovative landscape maintenance and long-term planning ensuring plant health. Adding new plants and diversifying species through wise policies with an eye on the impact of climate change will ensure long-term successful carbon storage and sequestration as well as oxygen-rich air to breath and a beautiful, in fact, priceless landscape.

	SAMPLE USED WITH iTREE				Ecosystem Benefits of Trees Across Mount Auburn's 175 Acres			
iTree Categories Ecosystem Benefits	iTree Sample	units	$		All MAC	units	$	
Number of Trees	1,047				4,968			
Acreage	32.57				175			
Hort Sections	10, 14, 16, 43, 53, 54, 55				1-60			
Tree Cover	42.50%				48.15%			
Most Common Species	*Sugar maple (Acer saccharum), Northern red oak, (Quercus rubra), Eastern white pine (Pinus strobus)*				*Sugar maple (Acer saccharum), Dogwood (Cornus florida), Eastern white pine (Pinus strobus), Northern red oak, (Quercus rubra)*			
Pct of trees less than 6"	41.20%							
Pollution Removal	703.7	lbs/year	$ 17,900	year	3,170.0	lbs/yr	$ 80,600	yr
Oxygen Production	46.82	tons/ year			211	tons/yr		
Avoided Runoff	21,400	ft3	$ 1,410	year	94,770	ft3		
Structural values			$ 3,260,000				$ 14,700,000	
Carbon Storage	816.1	tons	$ 139,000	year	3,680.0	tons	$ 626,000	yr
conversion t to mt	740.6	mt			3,339.4	mt		
C to CO2 conversion	**2,715.4**	**mtCO2e**			**12,244.5**	**mtCO2e**		
Carbon Sequestration	17.56	tons/ year	$ 2,990	year	79.1	tons/ year	$ 13,500	yr
conversion t to mt	**15.9**	**mt / year**			71.8	mt / year		
C to CO2 conversion	**58.4**	**mtCO2e / year**			**263.2**	**mtCO2e / year**		

The total carbon stored in the tree trunks is the 3,339.4 metric tonnes of carbon (mtC). To get a sense of the magnitude of carbon storage when compared with Mount Auburn' net carbon footprint of 614.52 mtCO2e, this carbon(C) storage figure is the equivalent of 12,244.5 mtCO2e. These figures are enormous, however they are a grand total; they have not been annualized. In order to determine the potential carbon offset per year, tree growth between two periods need to be compared, then the yearly offset amount could be calculated, based on new plantings and tree

[3] Consultant to Mount Auburn on permitting and pumping water from the aquifer required by MA DEP.

growth over a period of time, say 10 years. This comparative study between years was not completed in the FY2021 study using iTree. It certainly could be considered as a future project.

It appears the carbon offsets from the carbon storage in the tree trunks to the leafy carbon sequestration of the canopies could offset the GHG emissions of heat for the buildings, all of the mobile fleet, and even the crematory. We do not know those answers yet. What we do know is that the annual ecosystem benefits total $720,100. The total structural value for all of Mount Auburn's trees is almost $15 million. Whatever unit of measurement we use – dollars or carbon offsets – Mount Auburn is a priceless jewel.

Turf Management and Alternatives

By Dave Barnett

The normal "expectations" of clients and visitors to an active cemetery require frequent mowing and substantial use of irrigation, fertilization and pesticide use, and historically this was the case at Mount Auburn for all lawn areas throughout our 175 acres. Beginning in the 1990s with the completion of the 1993 Master Plan, many changes have been made to our turf and landscape maintenance practices to reduce their environmental impact, and following is a brief summary:

Mowing

Following the recommendations of the Master Plan, we began to experiment with different mowing regimes by reducing the frequency of mowing in the "naturalistic" character zones in the historic core of the Cemetery. By the year 2000 we had established a three-tiered mowing cycle that has been used with various modifications ever since. The lawn areas in the front entry precinct and other "active cemetery use" areas are mowed weekly, while the remainder of the grounds in the older, more historic areas are mowed much less frequently. In addition, we are in the process of transitioning our riding mower fleet from gasoline-powered to propane and electric machines. Our fleet currently consists of five gasoline, five propane and one electric. The electric "Mean Green" mower in Figure 2 works really well for mowing turf but it cannot handle the mulching of leaves in the fall due to the engine overheating. We will continue to monitor technological improvements in electric mowers, but at this point we plan to continue replacing all gasoline-powered mowers with propane according to our cyclical replacement schedule.

Figure 1. A "Mean Green" electric mower.

Figure 2. Gas mower that has been converted to propane. Note the tank behind the driver.

Dwarf Fescues and Turf Alternatives

Since the mid-1990s we have been targeting steep slopes, curb and fence lots, and other hard-to-mow areas to replace the existing turf with either dwarf fescues or other more sustainable groundcovers. We experimented with various dwarf fescue seed mixes on slopes in the historic core, and at first found them to be successful in eliminating the need to mow and enhancing the desired 19th-century appearance. Since we generally avoid using any broadleaf weed control, however, weeds became increasingly unsightly before the fescues could become fully established, causing complaints from lot owners. We initially hand-pulled weeds as necessary, but this became too labor intensive. We have more recently installed fescue sod in selected areas, which appears promising so we will continue to experiment with these sods.

We have also used a number of naturalistic meadow-like turf alternatives such as *Liriope spicata, Carex pensylvanica* and *Bouteloua gracilis*, and these plantings are showing increasing promise.

Figure 3. Dwarf fescues at Mountain Avenue

Figure 4. Fescues at North Dell Meadows

Figure 5. *Liriope spicata* on a slope that no longer requires mowing.

Curb/Fence Lots and Underground Tombs: There are a total of 640 burial lots where granite curbing, iron fencing or underground tombs present both safety and maintenance challenges for

our staff. Since 1993 we have eliminated turf in 244 (38%) of these lots and replaced with a variety of sustainable groundcover plantings. Not only has this eliminated the need to mow approximately 75,000 square feet of turf, it has added a great deal of horticultural diversity and improved the visual interest and wildlife habitat value of the landscape.

Figure 6. *Waldsteinia fragarioides* (Barren strawberry) replaces turf within the granite curb lot, eliminating the need to mow.

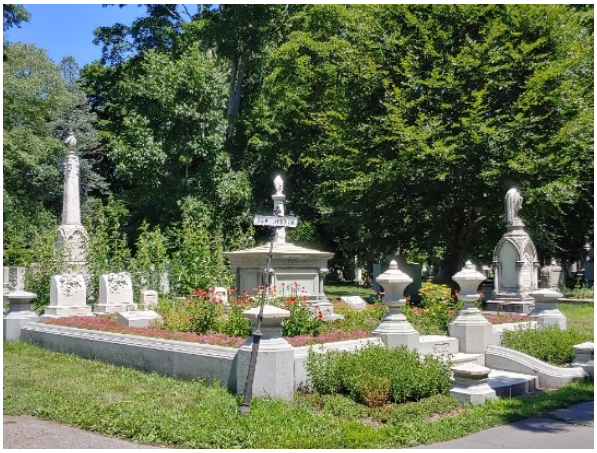


Figure 7. Granite curb lot planted with perennials adding horticultural diversity and visual interest.

A list of the most successful groundcover species and varieties used in these plantings is included in the Appendix.

Leaf Mulching

We started mulching leaves in the fall of 1998, making adaptations to our fleet of rotary mowers to pulverize the leaves in place on the grounds rather than vacuum them up and carry them away. This has reduced the number of manhours required for fall clean-up each year and has also significantly improved the levels of organic matter and nutrients in the soil throughout the grounds. With the exception of a few highly visible areas such as the front entry precinct, we have eliminated the use of fertilizers on turf at Mount Auburn. We continue to vacuum up and stockpile just enough leaves to produce the compost we need for topdressing and other maintenance tasks. We currently collect about 1,200 cubic yards of leaves (an estimated 1-2% of the total leaves that fall to the ground each year), which results in 100 cubic yards of finished compost.

Figure 8 - Gas and propane powered mowers are adapted with special serrated blades to mulch the leaves in place. This adaptation has reduced the number of manhours required for fall clean-up each year and has also significantly improved the levels of organic matter and nutrients in the soil throughout the grounds.

Goals for Turf Management & Alternatives

SHORT-TERM GOALS (FY2022 – FY2024)

- Continue differential mowing regime throughout the grounds
- Ensure establishment of recent North Dell Meadows planting
- Complete Phase 3 of Indian Ridge Path Renovation by installing meadow planting along the top of the ridge
- Test the "mowed path" concept in proposed Chestnut Avenue meadow area (see below)
- Convert 18 more curb lots from turf to groundcovers

MEDIUM-TERM GOALS (FY2025 – FY2034)

- Convert remaining five riding mowers from gasoline to propane
- Continue converting curb/fence lots from turf to groundcovers at average of six lots per year to reach cumulative total of 320 lots (50% of overall total).
- Complete phased implementation of master plan by Larry Weaner Landscape Associates for the naturalistic meadow plantings on east slope of "mountain" along Chestnut Avenue from North Dell Meadows to Hazel Path, as annual budgeting/goal-setting process and fundraising efforts allow.

LONG-TERM GOALS (FY2035 – FY2050)

- TBD

Wildlife Habitat & Biodiversity

By Paul Kwiatkowski

Mount Auburn Cemetery walks the line between ornamental landscape and natural or wild terrain. Subtlety is required to make this work. The property is a 175-acre urban greenspace that has functioned as an active cemetery and arboretum for nearly 190 years. Very deliberate planning to incorporate desirable plant specimens from across the globe, while not disrupting the functionality of native plantings that support wildlife biodiversity has been part of the cemetery's master plan since it's consecration in 1831. Significant emphasis on combining traditional gardenscapes with more wild areas creates spaces that are beautiful, provide habitat and enhance the visitor experience. In short, Mount Auburn has been heavily manipulated and intensely managed for a very long time, but in recent years we have been driven by a strong desire to find the right balance between ornamental and natural areas.

Small-scale wildflower meadows and butterfly gardens, along with curbed and/or fenced burial lot gardens have been planted with an emphasis on including native plant species to create habitat that provides food, cover and breeding opportunities for pollinators and other native wildlife. These garden spaces are also desirable to beneficial insects. In addition, emergent plant zones have been created that provide much needed habitat for aquatic species in our water bodies. Carefully planned landscape editing and new planting efforts have established corridors connecting water bodies and wild spaces that provide lanes for wildlife movement throughout the Cemetery.

Turf is not a sustainable feature in the landscape. While it may meet the expectations of some lot owners and visitors, it does not provide much by way of habitat value and the constant maintenance requirements make turf very unsustainable. Mount Auburn has implemented strategies to remove turf and replace it with fescue mixes that require less mowing and irrigation. Replacing turf areas with ground covers also provides greater sustainable options. Fescues and ground covers increase cover for wildlife as well.

Figure 1 - The seed heads of many flowering plants provide winter food sources to a variety of wildlife.

Monitoring by staff, academic research collaborators, and citizen scientists has been implemented to evaluate habitat creation efforts, including observing how biodiversity has been

improved through diversification efforts throughout the grounds. Maintenance plans are in place to ensure the integrity and productivity of these diverse ecosystems. An important piece of maintenance is knowing what plant material removal should be delayed at the end of the growing season or left for habitat completely. The seed heads of many flowering plants provide winter food sources to a variety of wildlife. While this may go against the common expectations for crisp and clean grounds, it does provide an opportunity to educate and advocate for wildlife habitat conservation. Hazard trees and branches in most areas must be taken down to ensure public safety. However, Mount Auburn does have designated spaces where fallen branches and trees are allowed to remain in place. An example of this is the steep slopes of Consecration Dell, which is a natural hollow in the center of the cemetery. Here, woody material helps reduce erosion on the hilly slopes and provides habitat for fungi growth as well as cover for invertebrates, amphibians and small mammals. As a log decomposes, it also increases organic matter in the soil.

Mount Auburn has been a long-time destination for birders and more recently has become a living laboratory for biodiversity research in an urban area, with an emphasis on climate studies. The implementation of a citizen science naturalist program has provided the Cemetery an avenue to educate and engage the public with programs for all ages that have not only created a pool of well-trained research assistants, but has established a strong science community that extends outside of Mount Auburn to local elementary and high schools, home school networks and institutions of higher learning.

The Cemetery has been listed as an "Important Bird Area" by the Massachusetts Audubon Society because of its significance as a stop-over point for spring and fall migrants. Mount Auburn is home to many resident bird species as well. Food, hydration, cover and nests sites are available throughout the landscape. Screech owls make use of tree cavities, great blue herons hunt in the shallow emergent zones that we have created in the ponds, and red-tailed hawks captain the sky in-order to snatch up small mammals from the grounds for nourishment.

Figure 2 - Screech owl in tree cavity

A diverse number of mammals reside at Mount Auburn. Eastern cottontails, gray squirrels, chipmunks, groundhogs, raccoons, voles, shrews, skunks, field mice, moles, weasels, muskrats, mink, fishers, flying squirrels, red fox and coyotes have all been observed. Predators and prey are well-represented and the food web follows its dynamic cycle throughout the seasons. An urban bat study has also been implemented. Currently, big brown bats, red bats, hoary bats and little brown myotis have been heard through bio-acoustic studies and/or captured and released during

mist net studies at the cemetery. Bat houses were installed in 2020 and are monitored for activity. Additionally, an urban coyote study is slated for implementation in 2021.

Amphibians, reptiles and fish have less diversity than birds and mammals at Mount Auburn. This is most likely due to the heavy manipulation of the grounds in the Victorian era of the 19th century, followed by heavy pesticide use in the 20th century. Much has been learned about the hazards and impacts of habitat destruction and chemical applications and the cemetery has evolved to become a strong advocate and community leader for sustainable landscape maintenance and habitat conservation. Mount Auburn created a Wildlife Action Plan in 2015 to develop strategies and implement actions to protect and improve habitat through a mini master plan process. Baseline data collection on terrestrial and aquatic species presence and abundance was the first action implemented. This effort has provided the data needed for plant material edits and enhancements to create more and better-quality wildlife habitat and provide a roadmap for native species reintroductions. Since 2015, American toads, spring peepers and gray treefrogs have all been reintroduced at the cemetery. Now all three of these native amphibian species have successful breeding populations. The spring time choruses of trills and peeping have added a previously lacking element to the Mount Auburn visitor experience. With proper management, and following stringent conservation guidelines, additional native species reintroductions may be implemented at Mount Auburn. Some of the amphibians, reptiles and fish that may be considered include: blue-spotted salamander, brown snake, northern redbelly snake, musk turtle, golden shiner and banded sunfish. Currently, it is very common to witness painted turtles basking on fallen limbs in the ponds.

Figure 3 -Since 2015, American toads, spring peepers and gray treefrogs have all been reintroduced at the cemetery. Now all three of these native amphibian species have successful breeding populations. Photo of American Toad by Andrew Rotch.

Invertebrates are also studied at Mount Auburn. Arthropods such as caterpillars and beetles provide food sources for migrant birds every spring when they emerge to feed on leaves and flowers. During the current period of accelerated climate warming, three important citizen science studies are underway to determine if earlier phenophase occurrences in trees and shrubs, along with the associated arthropod activity, still coincides with the timing of bird migration. Temperature is the prime factor impacting the former, while day length is the primary factor to influence bird migration. The first effort is a phenology study which tracks the timing of life cycle stages, or phenophases, of ten deciduous tree and shrub species. Weather conditions are documented and data is collected on the dates of bud burst, leaf emergence, the opening of flowers and the unfolding of leaves of every specimen in the study. This effort helps to determine changes in the phenophases relating to weather in the short-term and may be attributable to climate in the long-term. The

second effort is spring arthropod monitoring. This effort focuses on observing the undersides of leaves of specimens along the phenology trail. Species diversity, numbers and damage are documented. Lastly, a breeding bird survey begins every spring in which all bird species seen or heard at 16 points in the cemetery are documented, along with any nesting behavior, such as transporting nest materials or the feeding of newborns. All three studies collect useful data and when the data is put together, much can be learned about the impact of weather and climate on the success of wildlife and habitat in relation to our warming climate.

A second invertebrate research project underway is a dragonfly study to determine which species are taking advantage of the urban habitat and are successfully breeding at Mount Auburn. A third effort is a pollinator flower visitation survey that has been implemented to document the presence and abundance of primarily insect pollinators, but any pollinator observed is documented. This study provides information on urban pollinators and aids in the evaluation of plant material for habitat value. Finally, Mount Auburn houses a honey bee apiary and a certified beekeeper is on staff. This is particularly important for our efforts to educate the public about the importance of pollinators and in advocating for local conservation efforts.

Goals for Wildlife Habitat & Biodiversity

SHORT-TERM GOALS (FY2022 - FY2024):

1. Continue on-going annual actions:
    a. citizen science biodiversity research studies
    b. landscape monitoring
2. Implement Urban Coyote Study
3. Implement Drift Fence with Funnel Trap Herpetofauna Study (part of Ruggiero Grant)

MEDIUM-TERM GOALS (FY2025 – FY2034):

1. Convert 25% more turf areas to more sustainable fescue mixes or groundcovers. (see Biodiversity in Plant Collections Narrative for other specific goals).

LONG-TERM GOALS (FY2035 - FY2050):

1. Reintroduce recommended native amphibian, reptile and fish species.

Water Quality and Consumption: Landscape

By Paul Kwiatkowski

Water Quality

Mount Auburn Cemetery has four significant water bodies within its 175-acre property. This includes three small ponds and a vernal pool. The ponds are permanently flooded features in the landscape and the vernal pool is a seasonal flooded depression that may completely lack surface water during droughty periods that can last past late summer and into autumn.

Figure 1 – This image of a Great Blue Heron dining on a fish is an indicator that Mount Auburn's long-term plan to monitor water quality and improve the overall health of each pond is working.

All the water bodies are shallow with considerable layers of organic material accumulated at each pond bottom. The three ponds are connected to the underground water catchment system and there are multiple culverts that carry stormflow into the ponds. The vernal pool is not connected to the catchment system and receives storm inputs only through direct rainfall and sheetflow that may contain organic material washed from the slopes of the hollow in which the pool is located.

Organic material does not build up from storm discharge alone. The primary source is the vegetation that surrounds each water body. Leaves and small limbs fall, then sink through the water column and accumulate over time, reducing the depths of the ponds. The storm water and the accumulating sediment impact the waterbodies in negative ways. The stormflow carries harmful, nutrient-laden sediment from the cemetery's roads that is rich in phosphorus and nitrogen. In large enough amounts, each can harm water quality. The loss of pond depth allows the water temperature to warm more quickly which can aid algae growth and impact the amount of available oxygen for fish, amphibians and reptiles.

Mount Auburn has a long-term plan in place to monitor water quality and improve the overall health of each pond. This includes strategies both outside of and inside of the water bodies. The outside efforts include annual street sweeping every spring to remove sands put down during winter storms and cleaning out catch basins throughout the cemetery. These actions reduce sediment entering the ponds. The areas surrounding each waterbody are restricted from fertilizer applications. This also helps reduce excessive nitrogen and phosphorus inputs. The inside efforts include aeration systems to improve oxygenation and the creation of emergent shelves along the shallow pond edges, near storm drainpipes, to allow for sedimentation and for emergent plants to take up and sequester harmful nutrients through their root systems, which protects aquatic habitat for wildlife.

Another issue attributed to the warming climate is stronger storm surge and increased storm water velocity during rain events that can be damaging to habitat and water quality. To address this, Mount Auburn has incorporated solutions such as a rain garden to slow down storm water discharge, capture sediment, and protect habitat before the water enters the pond.

Figure 2 – Newly installed rain garden at Willow Pond, designed to address a warming climate that contributes to stronger storm surges and increased storm water velocity during rain events.

The three ponds were dredged during the late 1990s and early 2000s. Dredging improves overall pond health and water quality by removing accumulated organic material and increasing water depth. Dredging will be an appropriate action to undertake again in the next decade or two. It is on the long-term list for potential cemetery actions. In the meantime, expanding emergent zones within the ponds, creating additional rain gardens outside of the ponds and trialing floating islands are all efforts that can be implemented to improve water quality and protect habitat. All the ponds are wide open at the surface. This limits cover for aquatic species and reduces the ponds' ability to maintain natural system-based water quality. Algae species are present in every pond at non-harmful levels. Conditions are monitored throughout the hot, dry summers to ensure that dangerous algal blooms do not occur that may potentially remove much of the available oxygen from the water column and negatively impact wildlife, particularly fish. Potentially dangerous cyanobacteria blooms are also monitored closely. A maintenance plan is in place to remove sediment, manually pull invasive plants and document the physical integrity of each water body, as well as habitat health. Finally, Mount Auburn collects storm water samples from culverts at each pond annually for water quality analysis and reporting.

Water Consumption

Mount Auburn Cemetery rests atop an underground aquifer. This non-potable water provides all the irrigation water for the plant collections and is recharged through annual precipitation. The underground irrigation infrastructure is quite old and breaks and leaks are common. Significant investment to modernize the irrigation infrastructure will be unavoidable in-order to adequately maintain the plant collections of the cemetery in the future. Mount Auburn has made irrigation improvements that have helped to conserve water throughout the cemetery, such as utilizing smarter sprinkler technology, implementing irrigation timing schedules and choosing the right

plant for the right place: including transitioning to greater drought tolerant plants in garden spaces.

Throughout the year, rainwater is also collected from the greenhouse roof and stored in a 35,000-gallon underground cistern. The collected rainwater is used to irrigate greenhouse crops and eliminates the dependence on city water for irrigation during the winter months when the cemetery's water conveyance system is shut off.

A drought plan has been adopted and is implemented whenever the landscape faces prolonged periods of drought. This includes a breakdown of the grounds and gardens into areas of high demand (such as new, un-established plantings) and areas that can go un-watered (such as well-established specimens and drought tolerant plantings).

Water consumption is monitored at the aquifer pumphouse and weekly readings are taken from April through November. A weather station is also located on the roof of the Operations Center at Mount Auburn. Data is collected and shared with horticulture and arboriculture staff to better inform decision-making regarding planting and maintenance. Drought monitoring is followed through the Massachusetts and United States Drought Monitors and data is also shared to better inform Mount Auburn staff when planning to implement the drought plan.

An example of the Annual Weather & Water Use Record can be found in the appendices.

Goals for Water Quality and Consumption: Landscape

SHORT-TERM GOALS (FY2022 – FY 2024):

1. Continue on-going annual actions:
    a. Storm water sampling, analysis and reporting.
    b. Emergent shelf and rain garden maintenance, including: sediment and invasive species removal, inspection and reporting.
    c. Street sweeping and catch basin cleaning.
2. Complete underground water infrastructure assessment and improvement plan.
3. Incorporate emergent zone expansion and floating island into aquatic habitat. (part of Ruggiero Grant for FY2023)

MEDIUM-TERM GOALS (FY2025 – FY2034):

1. Complete underground water infrastructure improvements.
2. Create additional rain garden.

LONG-TERM GOALS (FY2035 – FY2050)

1. Complete dredging of three ponds.

Reuse, Repurpose & Recycle: Land Care

By Paul Kwiatkowski

Zero waste is the ultimate goal of our sustainable land care efforts. While this may not be achievable now, initiatives are underway to draw Mount Auburn closer to meeting this goal. Reusing, repurposing and recycling of landscape material on site is the backbone of these sustainable efforts.

The plant collections benefit through strategies to improve soil biology and increase organic matter. This is accomplished by mulching grass clippings and fallen leaves in place on 75% of the grounds. Twenty-five percent of grass clippings and fallen leaves are collected and incorporated into feedstock for compost creation and returned to the grounds as turf topdressing, garden soil amendments, and potting mix at the greenhouse. Mount Auburn creates its own woodchips from tree and shrub pruning and removals. This material is used for walking paths and is utilized in mulch creation as well. When combined with collected, aged leaves and run through a tub grinder, the finished product is an aesthetically pleasing mulch that suppresses weeds and increases moisture retention in garden spaces. The creation of these materials on site eliminates the need to purchase and ship bulk amounts, thus reducing carbon emissions from deliveries.

Other elements of Mount Auburn's efforts include asphalt: recycled into new mixtures; stone: crushed and repurposed into new base material; firewood: split and dried from pruning and tree takedowns for staff to use for home heating and recreation; large logs and stumps: chipped and sent to local biomass facilities.

Finally, plant propagation and growing supplies are costly and very problematic when discarded to landfills. The plastics do not breakdown quickly or easily and significantly add to refuse biomass. Mount Auburn reuses all materials when possible, including seed trays, pots, cell pack liners and flats to reduce waste.

Goals for Reuse, Repurpose & Recycle: Land Care

Short-Term Goals (FY2022 - FY2024):

a. Continue on-going annual actions:
    i. reuse, repurpose and recycling efforts
b. Create plan for new recycling area footprint as part of the Campus-wide Facilities Master Plan

Medium-Term Goals (FY 2025 - FY2034):

1. Construct new recycling area

Long-Term Goals (FY 2035- FY 2050):

1. TBD

Recycling Yard Metrics of Mount Auburn's landscape and road materials are on the next two pages.

Integrated Pest Management

By Dave Barnett

Figure 1 - Yellow dandelions in the early spring provide color. While they are considered weeds by many visitors, we do not treat dandelions with any herbicides and have worked to change the perspective of cemetery visitors by discussing the environmental value of not applying chemicals and getting them to accept dandelions in the lawn areas.

Since the mid-1990s we have been implementing an Integrated Pest Management (IPM) program at Mount Auburn Cemetery, which is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques including biological control, cultural practices, physical/mechanical methods, and the use of resistant plant varieties. Pesticides are used only after monitoring indicates they are needed as a last resort, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risk to human health, beneficial and non-target organisms, and the environment. At Mount Auburn, active monitoring for pests and diseases is a key commitment – both out on the grounds and in the greenhouse. Ongoing education through conferences, workshops and trade literature is critical for our horticulturists and arborists to stay up-to-date regarding new potential threats and any possible control techniques.

GROUNDS:

Insect and Disease Pests:

With a collection of 5,000 trees and well over 20,000 plantings of shrubs and groundcovers to care for over 175 acres, we strive to maintain best cultural practices such as mulching, efficient irrigation, and pruning. The implementation of proper tree and shrub pruning practices on the grounds to maintain specimen health is a critical companion piece to IPM monitoring for pests. When insect or other pest damage is found, we continue to monitor and usually do not apply any pesticides. We typically make the decision to accept that a number of trees or shrubs may be damaged but that the damage will likely not be fatal to an individual specimen or to the larger representation of a species. The infestation is allowed to run its course with the knowledge that the tree or shrub most likely will recover. In some cases when an infestation is more widespread, tree or shrubs specimens are removed and replaced with other species resistant to the pest.

One such example is our management plan for the **Hemlock Woolly Adelgid** (HWA), an insect pest that has decimated hemlock forests in the United States and Canada as well as the hemlock collection at Mount Auburn. Over 20 years ago we made the decision to only try to save about 33% of the 300 hemlock trees then present at Mount Auburn. We began removing a number of the most severely damaged hemlocks each year and have taken the opportunity to diversify our

conifer collection with new species and varieties of cedars, firs, spruce and other conifers. For a selection of the healthiest hemlock trees in some of the most prominent locations, we have used a combination of soil drenches and spraying horticultural oil to control HWA. As of the spring of 2021, we have 125 hemlock trees remaining. In place of the 175 hemlocks we have lost, we have added 65 new taxa of conifers to our collection.

For the vast majority of pests, we do not apply any pesticides and instead utilize best cultural practices and/or let nature take its course. Following is a brief explanation of the few insecticides, fungicides and herbicides that we have made the decision to use:

Several years ago, a new insect pest called **Winter Moth** was discovered in eastern Massachusetts and it quickly became a serious problem as the caterpillars completely defoliated a wide range of tree species just after they leafed out in May each year. Many of our newly planted trees were being lost after two consecutive years of being defoliated, so we made the decision to spray a small selection of young trees with a product called Conserve until they became successfully established. Strict environmental guidelines for applications were followed, and our arborists stayed after closing hours in the evening to perform the spraying when no visitors were present. Fortunately, a biological control for the winter moth has now been established in eastern Massachusetts which keeps the winter moth in check, so we have not had to spray for the caterpillar since 2017.

Figure 2 -Photo accessed from: https://ag.umass.edu/landscape/fact-sheets/winter-moth-identification-management shows "feeding injury to a maple caused by the **Winter Moth**. Much of this injury occurred while the leaves were still within the bud. (Photo: R. Childs)

Bronze birch borer continues to pose a serious threat to our **white birch trees**, so for the past ten years we have treated some of our most important specimens of birch trees each year with a total of 120 capsules (each containing 2 ml) of Bidrin insecticide injected directly into the trunks of the birches.

Dutch elm disease continues to be a concern, so over the past five years we have treated a handful of selected mature **American elms** with the systemic fungicide Tebuject each year, injecting a total of 96 capsules (each containing 6 ml) directly into the trunks of the elm trees. In some previous years different fungicide capsules were injected directly into the elm tree trunks, depending on what was recommended and available at the time.

Our magnificent old **European beech** trees, having reached the end of their normal life span and showing increasing signs of decline, have been inflicted with **phytophthora** canker in recent

years. In an effort to do all that we can to prolong the life of these iconic trees, we have experimented with Agri-Fos fungicide applied directly on the bark of the beech trees. It appears to have been effective on at least some of the beech trees.

Weed Control:

By far our biggest challenge related to the use of pesticides is maintaining our turf in the areas of the Cemetery most actively visited by families paying tribute to their loved ones. They have expectations regarding how the grass should look, and in a nutshell they do NOT want to see weeds and they are upset when crabgrass is sprawling over their flat marker. Families are also very vocal with complaints called in to the office, so action must be taken regularly. All season long we have to stay on top of mowing and string-trimming weekly in the "active" areas such as Birch Gardens, Willow Pond, and the "Meadow" near the greenhouse. In order to minimize the amount of time spent reacting to complaints, in recent years we have been forced to be pro-active by applying crabgrass pre-emergent control (Dimension and Lesco Pre-M) each spring in a few of the most actively visited areas. We have also used Lock Up broad-leaf weed control in selected high profile, "active cemetery use" areas. For the rest of the grounds, however, we do not use any chemical herbicides or fertilizers to maintain the turf. As noted in the "Turf Management and Alternatives" chapter, we mulch fallen leaves in place each autumn to return the organic matter and nutrients to the soil.

Figure 3 – Fortunately, the use of black plastic for covering smaller defined areas within curb and fence lots for several months to kill weeds and weed seeds has proven to be successful.

In past years we have used the broad-spectrum herbicide Roundup (glyphosate) in areas where we are converting weed-filled grassy areas into naturalistic fescue or wildflower meadows or other mixed groundcover plantings. Without effective weed control, we could not successfully make these conversions because of the huge investment in labor manhours we would otherwise have to make to physically control the weeds until the new plantings become established. Roundup was always thought to be the safest herbicide because it does not linger in the soil or the environment. Now that it has been listed as a possible carcinogen, we are using up our remaining limited supply and are phasing out its use. Fortunately, the use of black plastic for covering smaller defined areas within curb and fence lots for several months to kill weeds and weed seeds has proven to be successful, but we have not yet found an effective replacement for Roundup for converting larger areas from weedy turf to naturalistic plantings.

We regularly monitor for invasive, non-native plant species in areas that are not regularly mowed such as steep slopes or naturalistic character zones. Whenever possible, mechanical removal

(hand-pulling) is used to remove these invasive species. However, this may not always be practical because of difficult access or the sheer numbers of plants. Effective removal of invasive plants such as **black swallowwort** requires that the entire root system be removed. If the plant roots are broken or not completely removed, the plant is able to multiply faster and spread its invasive range. Thus, in recent years as black swallowwort has dramatically increased, we have selectively used herbicide applications following strict environmental guidelines, as shown in the table below.

The following table shows the complete list of pesticides used on the grounds of the Cemetery over the last ten years:

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Insecticides:										
Conserve (for winter moth)	32 oz	24 oz	15 oz	36 oz	60 oz	90 oz	150 oz	-	-	-
Horticultural Oil (for adelgid)	46 gal	45 gal	31 gal	44 gal	25 gal	37 gal	32 gal	-	23 gal	-
Transtect 70 WSP (soil drench - adelgid)	-	6 oz	-	12 oz	2 oz	-	-	-	-	-
Bandit (soil drench for adelgid)	-	-	-	-	-	-	-	-	33 oz	-
Cross-Check (black vine weevils)	-	16 oz	16 oz	24 oz	-	32 oz	24 oz	18 oz	-	-
Inject-A-Cide (Bidrin for birch borers)	240 ml	240 ml	240 ml	240 ml	240 ml	240 ml	240 ml	240 ml	240 ml	-
Fungicides:										-
Agri-Fos (phytophthora on beech)	-	3.5 gal	-	2.5 gal	5 gal	1 gal	1 gal	1 gal	1 gal	-
Imosol (Dutch elm disease capsules)	-	20 oz	-	20 oz	-	-	-	-	-	-
Tebuject 16 (Dutch elm disease)	-	-	-	-	-	576 ml	576 ml	576 ml	576 ml	576 ml
Herbicides:										
Dimension (crabgrass pre-emergent)	-	-	-	-	2000 lbs	900 lbs	600 lbs	550 lbs	-	800 lbs
Lesco Pre-M 1.5% (crabgrass)	150 lbs	120 lbs	360 lbs	550 lbs	400 lbs	400 lbs	440 lbs	480 lbs	-	-
Roundup Quick Pro Granular	365 oz	216 oz	249 oz	171 oz	198 oz	212 oz	220 oz	166 oz	92 oz	51 oz
Lock-Up (broadleaf weeds)	-	-	-	-	2000 lbs	1000 lbs	950 lbs	900 lbs	775 lbs	-
Garlon 4 Ultra (black swallowwort)	-	-	-	135 oz	36 oz	6 oz	14 oz	20 oz	-	-
Ortho Max - Poison Ivy & Brush Killer	76 oz	60 oz	-	-	-	-	-	-	-	-

GREENHOUSE:

At Mount Auburn's 10,000 square foot greenhouse, effective cultural controls including clean propagation and growing areas are essential for ensuring plant health. High quality compost introduced into soil mixes, along with compost tea and organic fertilizer applications, support strong plant growth. When stress and/or damage to specimens is observed, action is taken. This may be in the form of beneficial insect releases to control pests on greenhouse crops and in the cut flower/trial gardens outside of the glass houses. Host plants that attract beneficial insects are incorporated into planting plans and placed among crops on growing benches in the greenhouse. The establishment of beneficial insect populations on crops and in garden soil helps to limit pest and/or disease outbreaks. Following is a list of beneficial insects released in the greenhouse over the past several years:

- *Neoseiulus cucumeris* is a generalist predator we use on the leaves of our crops. They are a type of mite that feed on whiteflies, thrips, spider mites, aphids, and psyllids.
- *Stratiolaelaps scimitus* is a predatory mite that lives on the soil surface and feeds primarily on the larva of fungus gnats and thrips.
- *Mesoseiulus longpipes* are another mite we use during the hot dry days of summer. They feed primarily on spider mites which grow under the same conditions.

- *Neoseiulus californicus* is a predatory mite used to control spider mites in the leaf canopy.
- *Cryptolaemus montrouzieri* is a type of ladybeetle which feeds on mealy bugs and scale insects.
- Scanmask nematodes. Scanmask is a product that contains a water-soluble mass of *Steinernema feltiae nematodes*. Nematodes are used as either a spray or a dip solution to control fungus gnat and shore fly larva. The nematodes colonize and reproduce within the host larva eventually killing it.
- *Encarsia formosa* is a type of wasp that feeds on honeydew and nectar as an adult and lays eggs on the nymphs of whiteflies.
- *Chrysoperla rufilabris* or green lacewing lay their eggs on leaves where the larva emerge and feed on aphids. Adults feed on nectar and pollen.
- *Orius insidiosus*, the minute pirate bug, is used to prey on western flower thrips. Both adults and nymphs feed on thrips.
- *Aphidoletes aphidimyza* is a midge whose larva feed on aphids.
- *Dalotia coronaria* are rove beetles. Both adult and larva feed on fungus gnat larvae, root aphids, shore fly eggs, and pupating thrips.
- *Aphidius colemani* are native wasps which parasitize aphids. Adults seek out and lay eggs inside aphids which serve as a food host for the developing larva. Adults feed on pollen and nectar.
- *Aphelinus abdominalis* is a wasp which parasitizes aphids for reproduction and will prey on them for food as well.

In addition to beneficial insects, the only pesticides used in the greenhouse for the past twenty-plus years have been biorational products that are all naturally occurring – primarily fungi, bacteria and plant oils – always in small quantities only when absolutely necessary to maintain the health and high quality of the crops. Biorational products that we have used include:

- Actinovate SP (Soluble Powder) is a beneficial bacterium called *Streptomyces lydicus*, which is a naturally occurring soil bacterium. This bacterium colonizes the plants roots and protects against other pathogens such as damping off fungus, root rot, turf brown patch, pythium, rhizoctonia, phytophthora, fusarium, verticillium, and sclerotinia.
- Botaniguard WP (Wettable Powder) Is a beneficial fungus used to control soil dwelling insect larva such as whiteflies, thrips, aphids, psyllids, mealybugs, beetles, plant bugs and weevil. The fungal spores colonize the larva and kill the host before it reaches maturity and leaves the soil.
- Dipel controls caterpillars and borers using the bacteria *Bacillus thuringiensis* v. *kurstaki*. The bacteria produce a crystalline protein, a type of endotoxin, which paralyzes the caterpillar's digestive tract and causes the host to stop feeding, eventually leading to death.
- Greenshield is used once per year to clean and disinfect the greenhouse prior to the new crops arriving in February. It is a biodegradable liquid used to kill algae and fungal spores on the surfaces of tables, glass, and floors. One gallon of Greenshield is equivalent

to 28 gallons of bleach. It lasts four times longer, without the odor, irritation and volatility of bleach.

- Neem oil is a naturally occurring pesticide found in seeds from the neem tree. It is used as a general insecticide for many pests. We use it primarily for aphids. The oil is sprayed on the plants leaves or the pest itself. The pest ingests the oil which causes the insect to stop feeding, disrupts molting, interrupts mating, and suffocates through smothering.
- Rootshield Plus contains two strains of bacteria *Trichoderma harzianum* and *Trichoderma virens*. These bacteria are used as a preventative biological fungicide to control pathogens such as pythium, rhizoctonia, fusarium, cylindrocladium, and thielaviopsis, and phytophthora. Typically, we combine Rootshield, Actinovate, and Botaniguard together and dip newly arrived plants in a liquid solution then reapply as a soil drench several weeks later.
- Ultra-Pure Oil is a mineral oil used as a spray to control adelgids, aphids, fungus gnats, lacebugs, leafminers, leafhoppers, mealybugs, mites, scale, thrips, whiteflies, webworms and powdery mildew on ornamentals.

Looking ahead to the future, we fully expect Mount Auburn Cemetery to maintain the current philosophy and commitment – both out on the grounds and in the greenhouse – to practicing Integrated Pest Management, focusing on long-term prevention of pests or their damage through a combination of techniques including biological control, cultural practices, physical/mechanical methods, and the use of resistant plant varieties. Pesticides will continue to be used only after careful monitoring indicates they are needed as a last resort, and all pest control materials will be selected and applied in a manner that minimizes risk to human health, beneficial and non-target organisms, and the environment.

Sustainable Cemetery

By Candace Currie

Mount Auburn's actions as a cemetery are significant across the nation because it was the *first* rural or garden cemetery in the United States and it has set the standard by which all other garden cemeteries are compared. The more sustainable Mount Auburn becomes, so too, others will follow.

Figure 1 - A natural burial grave, according to Mount Auburn's guidelines, requires the use of the lowering device however, family and friends are encouraged to fill in the grave.

In 2014, it was the first and still the only cemetery in Massachusetts certified by the Green Burial Council (GBC) as a hybrid cemetery. Hybrid means that both conventional burial with grave liners and natural burial with unlined graves are performed. At least 20 other local cemeteries in Massachusetts allow green burial options, but no other cemetery has decided to seek GBC certification.

Natural Burial

There are two ways to integrate green or natural burial into an existing cemetery: adding a 'green section', if land is available; or integrating green burial into the fabric of the landscape. Mount Auburn has done the latter. In fact, integrating natural burial into the landscape has allowed Mount Auburn to use areas that were unavailable for conventional burial.

These GBC standards listed below were revised for clarity in 2020. For hybrid cemeteries, the substance of each standard did not change.

1.	Accurately represent earned level of GBC certification in marketing materials, websites, and conversations with the public, clients, and the media.
2.	Provide clients and families with the opportunity to participate in the burial and ritual process, in keeping with state law and with these standards. (Consider providing multiple sizes of shovels, including ones for children).
3.	Accept for burial only decedents that have not been embalmed or those embalmed only with GBC-approved, nontoxic chemicals.
4.	Prohibit the use of a vault (partial, inverted, or otherwise), a vault lid, concrete box, slab or partitioned liner in the burial plot.
5.	All burial containers, shrouds, and other associated products made only of natural, biodegradable materials.
6.	Develop a Maintenance and Operations Manual to be utilized by all staff members, contractors, and volunteers to implement site goals, policies, and best practices.
7.	Establish an endowment fund to ensure the long-term maintenance of the site by setting aside at least 10% of all burial plot sales.

While Mount Auburn cannot point to *one* Maintenance and Operations Manual as listed in standard number 6, the table of contents of the GBC template identifies topics for which Mount Auburn does have a written policy or procedure:

1. Use and Purpose of Maintenance & Operations Manual
2. Customer Relations
3. Burial Containers
4. Excavation and Burial Techniques
5. Memorial Stones
6. Maintenance
7. Visitation
8. Burial Sites
9. Long-term Maintenance
10. Property

The GBC expects the rules and regulations of a cemetery to explicitly allow green burial. Mount Auburn's rules and regulations, as they exist today in what is known as the 'Green' book were last revised in 1961. A portion (under the heading **Rules and Regulations for Single Graves, Companion Graves and Urn Graves**) were revised December of 1998. There have been no other substantial revisions, but some minor governance revisions have been adopted over the years. Today, they still dictate the use of grave liners or vaults. The deeds, however, for natural burial spaces specify an 'uncontained' burial. Mount Auburn supplied a sample copy of a deed to the GBC as proof of adherence to green burial standard number four (4).

By eliminating the use of grave liners, other benefits are identified. Jim Holman, director of cemetery development says the installation of grave liners:

- Cause disruption by having to carry large concrete boxes/or vaults to the grave in locations where access is limited by built structures and trees,
- Require excavation of a larger footprint that may result in more damage to existing tree roots,
- And the grave liners themselves, are barriers to tree roots.

Natural burial allows for less disruption from heavy equipment and smaller excavations. Is there anything inherently wrong with concrete? No. It is a great product. There is just no need to be buried in it. Concrete comprises materials that come from the earth – limestone and clay – and that requires carbon-intensive processes for extracting minerals, processing them with heating, cooling and pulverizing, and then shipping. While the concrete industry is aware of these carbon-intensive processes and is making improvements, natural burial is simply about placing a biodegradable object (the human body) into a biodegradable container (a plain pine box, for example) and covering both with soil. In its purest form, there is no need for a marker. Over half of Mount Auburn's natural burial spaces are sold without marker provisions. Occasionally, some family members need the physical marker – that touchstone - to honor their parent or brother or husband. The size, type, color, and texture of the actual marker is debated by the team responsible for the development of new burial space guided by the director of cemetery development. And what is wrong the markers? They require concrete foundations!

Requirements for concrete grave liners were added to the Mount Auburn's Rules and Regulations circa 1940 according to a review of Trustee meeting minutes. Grave liners were

added to reduce the costs of lawn maintenance. Over the first 18 months or so when what is below the ground decomposes and the soil over the grave becomes re-compacted with snow, rain and equipment; a little attention is needed. After six years of performing natural burials, Paul Walker notes:

> "We have not seen much difference in subsidence of natural burials versus traditional[4] burials. Natural burials seem to drop a few inches after a couple of months, but we also get that with traditional burials after a heavy rain. We typically just add loam and reseed them as needed. Most of the time we check the newer natural burials for the first few months for settling and all newer graves after a heavy rain to avoid complaints from lot owners. . . . In general, the natural burial graves have not been any more of an issue than the standard burial graves where a grave box is placed in the ground. Choosing a safe[5] location where vehicle and equipment access is limited is most important . . ."

As for the addition of new monuments or markers, the question of safety and access becomes a checkbox on the criteria for additional burial space. It falls under the purview of the director of cemetery development.

Cremation

Part II of the Climate Action Plan about Mount Auburn's greenhouse gas (GHG) emissions projects the crematory's emissions will continue to rise at about 2% per year based on a 2% increase in the number of cremations. The carbon footprint of cremation remains a serious issue, if unresolved. Strategically planning for carbon offsets, carbon sinks, or future alternatives of bodily disposition requires planning, foresight, and innovation. In short, there are opportunities for new business ideas.

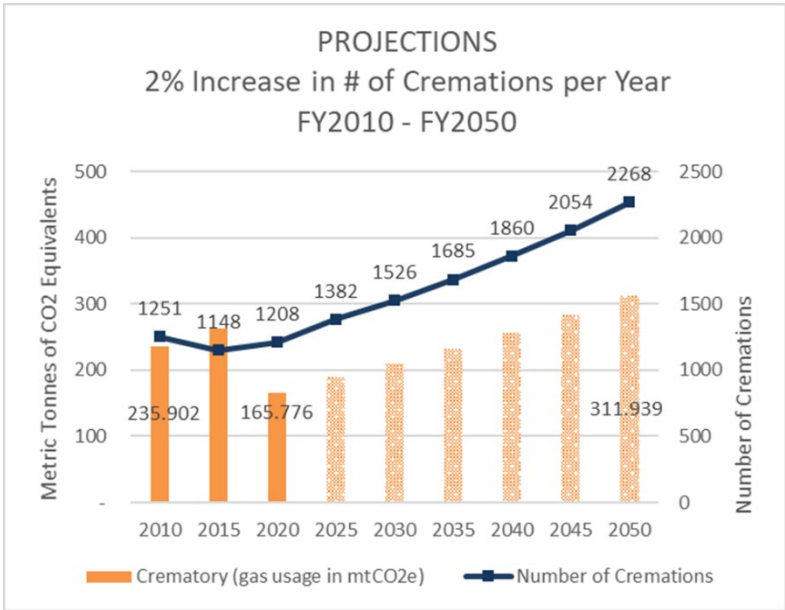


Figure 2 - The future increase in the number of cremations and subsequent GHG emissions will require carbon offset purchases to reach carbon-neutrality. This chart estimates an annual increase of GHG emissions at 2% per year which is based on increasing the number of cremations annually by 2%.

Researching the purchase of carbon offsets or investing in carbon sinks to reach a carbon-neutral goal is possible now. What is the right approach for Mount Auburn?

There are two other options of bodily disposition that are gaining attention across the country. On the surface, they both appear to be *greener* solutions. However, there are complications:

[4] The word 'traditional' is often used instead of 'conventional' – those with vault or grave liner.
[5] 'Safe' location refers to an area where the backhoe or tree truck may place the supporting outriggers or simply drive atop a grave, if necessary, without disturbing the grave. It is crucial that the green burial graves are well marked and numbered especially if there is a lag between when the burial occurs and when the grave shows up on a printed or digital map.

- Funeral directors (or family members) *only* may prepare a body for cremation.
- No employee of a cemetery, not even a crematory operator, is allowed to handle a body.
- Crematories according to Massachusetts General Law Chapter 114 are only allowed inside the bounds of a cemetery.
- Cemeteries may not have funeral homes and vice versa in the state of Massachusetts.

All of this is to say, the two greener alternatives may be sooner approved for funeral homes than cemeteries because it appears both methods require handling the body. Further investigation is required.

Alternatives to Flame Cremation

There are alternatives that are quickly becoming available in other states. The first, **alkaline hydrolysis**, commonly called "water cremation", is legal in twenty states including Maine, Vermont and Connecticut. It is commonly used in all states for pet cremation. The result is something similar to that of cremated remains.

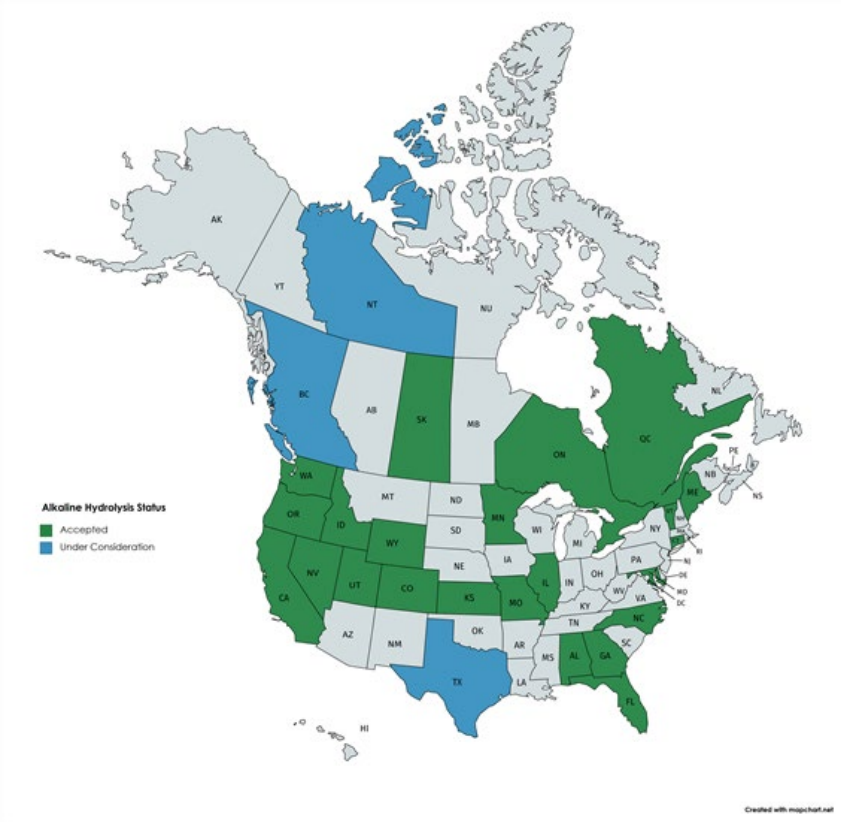


Figure 3 – Alkaline Hydrolysis Accepted and Under consideration. Accessed March 8, 2021: https://cdn.ymaws.com/www.cremationassociation.org/resource/resmgr/consumers/alkaline_hydrolysis_status.png

Natural organic reduction (NOR), the second alternative, evolved from the 'Urban Death Project' which recognized that urban cemeteries are running out of casket burial space. The solution is based on the way farmers dispose of dead livestock. One puts them into the compost pile. Seemingly undignified to city folks, but eminently sustainable. Essentially, NOR is the composting of a human body. After a few years of venture capital funding and scientific study, the state of Washington legalized NOR in 2019. Bills in state legislatures in New York and Colorado may soon legalize NOR.

With NOR, one's body is reduced to compost by placing it in a reusable vessel, covering it with wood chips and supplying oxygen to create an environment for microbes and essential bacteria. Over the course of 30 days, the body is fully transformed into soil.

Figure 4 - Wood chips, alfalfa and straw cover a body which is then aerated to create an environment for microbes and essential bacteria. A body is reduced to compost within 30 days. Accessed March 8, 2021: https://religionnews.com/2021/02/10/recompose-nat

Whether a client chooses cremation, natural burial or some other alternative, keeping an eye on industry forecasts and seeing trends that are specific to Mount Auburn clients will ensure future successes.

Goals for a Sustainable Cemetery

Short-Term Goals (FY2022 – FY2024):

1. Continue on-going annual actions:
    a. Track GHG emissions per cremation
    b. Track body burials, including use of and materials in vaults and grave liners
2. Consider transition of natural burial from single-depth to double-depth. The GBC will allow double-depth burial as long as everything going into the grave is biodegradable (i.e., no concrete or metal, not even to separate the two bodies).
3. Review Rules and Regulations for relevancy and determine the extent of changes, if any, that are required.

Medium-Term Goals (FY2025 – FY2034):

1. Consider adding a section for sustainable cemetery changes in the next iteration of the Cemetery Development Plan
2. Discuss GHG emissions per cremation and identify business case for offering the purchase of carbon offsets by either clients or Mount Auburn.
3. Purchase carbon offsets to balance all cremation activity.
4. Consider supporting alternatives such as alkaline hydrolysis or natural organic reduction (NOR) as legal and safe alternatives in Massachusetts

5. Discuss the idea of eliminating the requirement for grave liners and vaults for all burials, particularly those in the historic core, at Mount Auburn
    a. What is the ripple effect on funeral directors who sell vaults?
    b. Are grave liners needed for safety of double-depth natural burial;
6. Re-use of graves; this topic also requires legislative action, but it could extend Mount Auburn's life as an active burial ground if lot owner permission is granted.
    a. Re-use by a non-relative after 50 years, for example
        i. Would Mount Auburn lift out soil (and bones) and place it back into the grave?
    b. What other solutions might be available when taking the re-use approach?
7. Consider the use of two-tier burials when one grave is in an old lot at a depth that would allow a second, natural burial, on top of the first interment
8. Determine other ways in which natural burial or alternative options could save space, buy time as an active cemetery, or increase income.

LONG-TERM GOALS (FY2035 – FY2050):

1. Identify lots, possibly those sold since 1950 with an implied promise of double-tier burials to ensure that those lots are grandfathered-in, if there is a decision to stop using grave liners.

Engagement, Outreach & Education: Natural History at Mount Auburn Cemetery

By Paul Kwiatkowski & Jessica Bussmann

Summary

The Friends of Mount Auburn Cemetery was established in 1986 to assist in the conservation of the natural beauty and to promote the appreciation of Mount Auburn's cultural, historic and natural resources. Through a wide variety of lectures, walking tours, workshops and special events as well as self-guided educational materials and other publications, Mount Auburn has been able to reach both the local community and visitors from across the globe. Through the influence of the "Sustainability Working Groups" there has been an added emphasis on topics of sustainability in our education and outreach efforts in recent years. The addition of Biodiversity Research and the Citizen Science Naturalist Program has also allowed us to bring greater awareness and education opportunities around the topics of urban ecology, wildlife conservation, and climate change.

Print & Digital Outreach

Mount Auburn seeks to actively engage the local community and visitors on the topic of sustainability. Current avenues of communication and interpretation through print and digital media include the organization website, social media channels, monthly e-newsletter, and biannual *Sweet Auburn* Magazine

The "Eternally Green" website series (also linked to our e-newsletter and shared on social media) includes articles on the following topics: good bugs & bad bugs, composting, tips for beginning birders, water conservation and more. These articles provide information about the steps Mount Auburn is taking to become more sustainable as well as advice for home application. New posts are added to the website each month and are written by members of the Sustainability Working Groups and other staff experts.

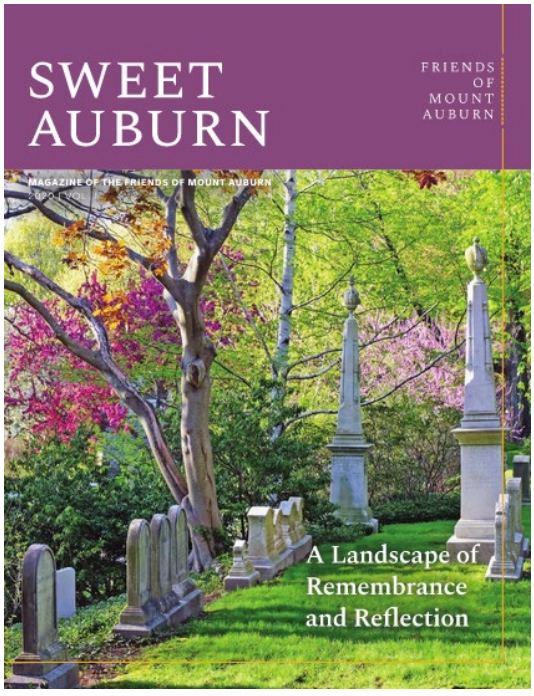


Figure 1 - Sweet Auburn cover for the April 2020 issue.

The Friends of Mount Auburn has a presence on several social media sites: Facebook, Twitter, Instagram, YouTube, Vimeo and Flickr. Through these sites we engage our members, visitors and virtual visitors at home. Some of the favorite posts (most "likes" or comments) are wildlife and horticulture photos. Seeing a preview of what they might see on a visit encourages people to explore the landscape and connect with nature.

Twice a year *Sweet Auburn* Magazine is published and mailed to our members as well as available on the literature racks at the entrance gate, Visitors Center and Administration office.

In some issues topics of sustainability have been feature articles and in every issue there is an article that focuses on a green topic. Recent issues contained the following articles:

2019 Vol. 1: **North Dell Meadows: A Landscape and Habitat Restoration Project, Spring 2019** by Dennis Collins

2020 Vol 1: **A New Vision for Indian Ridge** by Anna Moir & Dennis Collins

Public Programs & Group Tours

About 40 groups elect to visit Mount Auburn each year on a guided tour. Of those the largest type of group is Garden Clubs. Many come year after year. Through these personalized tours with a knowledgeable member of our staff we can exchange ideas about native plants, water conservation, composting and more. The few school groups that come (K – 12 and College classes) also learn from our docents and staff about the Cemetery's efforts to become more sustainable.

In 2019 (pre-Covid-19) the Friends offered approximately 150 public programs, about half of them free of charge. Through these programs we connected with around 4,300 people. Some programs directly highlighted topics of sustainability including our wildlife walks, spring horticulture strolls, and greenhouse workshops. In every program we do, we take the opportunity to share all the facets of Mount Auburn so even on a program celebrating poetry, we may point out a recent planting project, or our Greenhouse and answer questions about trees, wildlife, landscape, etc. During the pandemic when on-site programs were not possible, we pivoted to virtual public programs. Of special note are our Biophilia and Climate Speaker Series, detailed below.

Biophilia Program

E.O. Wilson described biophilia as… "the urge to affiliate with other forms of life." Mount Auburn Cemetery has developed a Biophilia program to encourage public participation in events that celebrate these connections by utilizing Mount Auburn as a backdrop for shared experiences and new discoveries with the natural world.

Previous Biophilia events included:

- A Celebration of the Influence of E.O. Wilson: a storyteller event in which Dr. Wilson's colleagues, students and friends shared stories of the impacts that his biology research and mentorship made on their own lives and careers.
- Mindfulness, Poetry and Sense of Place: a winter landscape walk & meditation session incorporating the poems of prominent Mount Auburn Cemetery "resident," Henry Wadsworth Longfellow.
- Biophilia Book Club: the reading and discussion of Urban Forests by Jill Jonnes.

2021 Biophilia Event:

- #OneWithNature: a crowd-sourced photography and writing program encouraging the community to share what Mount Auburn Cemetery means to them.

Climate Speaker Series

Mount Auburn Cemetery has created a Climate Speaker Series to provide a platform for local researchers, academics, public officials, business and non-profit leaders, and volunteer organizations to share with the public their work to investigate, mitigate and adapt to the threats of our warming climate.

Inaugural Climate Speaker Series Event, Fall 2020:

- Walden Warming: Climate Change Comes to Thoreau's Woods: a zoom presentation by Richard Primack covering the work of his team from Boston University that led to the publication of his acclaimed book about Henry David Thoreau's field observations in the 1850's and the return to these sites by Primack and his students nearly 150 years later. Thoreau's local observations were a precursor to worldwide phenology studies by the end of the 20th century.

Winter 2021 Climate Speaker Series Event:

- The Municipal Vulnerability Preparedness (MVP) Program: a zoom panel discussion covering an overview of the MVP program in Massachusetts and the efforts of Watertown and Cambridge to conduct vulnerability assessments and implement climate change preparedness and resiliency plans. The role of the urban forest and green infrastructure in addressing heat and flood risks was a major component of this discussion. The panelists included: Kara Runsten, MVP Program Manager; John Bolduc, Environmental Planner with Cambridge Community Development; and Laurel Schwab, Senior Environmental Planner & Conservation Agent with Watertown Community Development & Planning.

Biodiversity Research & the Citizen Science Naturalist Program

Cemeteries have become increasingly more popular and important for biodiversity research in urban areas. They are frequently among the largest green spaces in cities and with the continued destruction of habitat to expand urbanization, cemeteries often provide the most desirable habitat for wildlife in an urban area. Trees, shrubs, water features, gardens and flower beds provide opportunities for rest, cover, hydration, food and breeding.

Figure 2 – Image of citizen scientist training program in 2018. The citizen science program was established in 2016. Through the fall of 2020, more than 160 volunteers have participated in citizen science trainings and/or research projects at Mount Auburn.

Mount Auburn Cemetery has collaborated with researchers and faculty from local universities to implement studies to determine species presence and abundance, diversity, and the evaluation of aquatic and terrestrial habitats. Some researchers investigate how species utilize the urban landscape

in contrast to rural areas. These areas of study have provided the information needed to successfully reintroduce several native amphibian species, including American toads, grey treefrogs and spring peepers. The impacts of the warming climate are also studied through projects involving tree and shrub phenology, arthropod emergence and migratory bird arrival and behavior.

Biodiversity research has allowed for increased community engagement in science. The citizen science program was established in 2016. Through the spring of 2021, more than 180 volunteers have participated in citizen science trainings and/or research projects at Mount Auburn.

The mission of the Citizen Science Naturalist Program is to create a community of well-trained volunteers to support biodiversity research at Mount Auburn, as well as at other sites. The volunteers receive training from a diverse group of local experts that enables each volunteer to become a capable research assistant and informal educator to the public. The naturalist training program includes nine classroom sessions covering flora and fauna, as well as field note taking, nature photography, informal educator training, apps and crowd-sourced science. These sessions establish a foundation on which biodiversity study can be built. Additional learning opportunities are provided throughout the year, including tutorial walks and field trainings for the implementation of research projects.

Figure 3 - Biodiversity Day: Mount Auburn invited the public to participate in aquatic and terrestrial species population surveys.

Biodiversity research projects that have been implemented at Mount Auburn Cemetery include:

- Phenology Study
- Arthropod Monitoring
- Breeding Bird Survey
- Amphibian Monitoring
- Urban Bat Study
- Pollinator Flower Visitation Survey
- Dragonfly Study
- Native Amphibian Reintroductions
- Nocturnal Insect Survey
- Urban-to-Rural Gradient Camera Trap Study

New biodiversity research projects to be implemented in 2021:

- Urban Coyote Study
- Giant Silk Moth Release
- Fungi & Lichens Survey

Goals for Education, Engagement & Outreach

SHORT-TERM GOALS (FY2022 - FY2024):

1. Continue on-going annual actions:
    a. Biophilia programming.
    b. Citizen Science Naturalist Program trainings and research projects.
    c. Climate Speaker Series events.
    d. Offer a variety of public walks, talks, and workshops on general topics of horticulture and wildlife
    e. Regular articles in Sweet Auburn, website, and e-ternally green newsletter and posts on timely topics to social media

Resources:
Sweet Auburn Magazine Archive:
https://mountauburn.org/sweetauburnmagazine/

Mount Auburn on Social Media:
https://www.facebook.com/mountauburncemetery
http://www.flickr.com/photos/mountauburncemetery/
https://twitter.com/MountAuburnCem
http://instagram.com/mountauburncemetery
http://vimeo.com/mountauburncemetery
http://www.youtube.com/mountauburncemetery

Materials Management

By Candace Currie

> "We call our cemeteries parks and lawns and fields and greens. Yet the American graveyard hardly qualifies as a natural environment. For all their landscaping aboveground, our cemeteries function less as verdant resting grounds of the dead than as landfills for the materials that infuse and encase them."
>
> Mark Harris, author of Grave Matters –
> A Journey through the Modern Funeral Industry to a Natural Way of Burial.

It is hard to keep materials out of landfills (or a cemetery) when so many things that are purchased are shrink-wrapped in plastic or shipped inside a recyclable cardboard box, only to be tainted by the desired object being held by Styrofoam on the inside. Many products may arrive safely, but not always in a sustainable fashion.

This narrative will focus on materials and items used by and for Mount Auburn's staff and guests by way of two construction projects and three stories about responsible use of paper products, potable water, and electronics recycling. And whenever possible, Mount Auburn shares successes with staff from other institutions and the community-at-large.

Construction Projects

The two building construction projects that are being highlighted here are the new front entryway on Story Chapel and phase I of the Horticulture Center, the Greenhouse, that was designed to achieve LEED platinum certification.

Story Chapel, a historic 19th-century structure built in 1898, is the setting for lectures, concerts, and special events open to the public, as well as private commemorative services. The noted architect Willard T. Sears' original 1896-1898 design of Story Chapel included an elaborate entrance "…through a large door, protected by a porte-cochere, which extends well over the driveway leading to the building from the main entrance to the cemetery." (Cambridge Chronicle, 1898) Due to structural weakness and its inability to accommodate large hearses and most automobiles, the porte-cochere was removed on July 22, 1971.

Figure 1 - Story Chapel's new front entrance is now more welcoming and accessible. The new entryway was rebuilt with beams purchased from a salvage lumber yard in Connecticut.

As of 2013, the front entryway for Story Chapel to Mount Auburn's Visitors Center became more welcoming and accessible. The new entryway was rebuilt with beams purchased from a salvage lumber yard in Connecticut. This reclaimed wood is large, beautiful and strong. It is impossible to find this quality in virgin timber today. An additional benefit: all the carbon of these old-growth trees is now imbedded in the beams of Story Chapel's porch.

Another project by William Rawn Associates | Reed Hilderbrand comprises a complex of buildings at Mount Auburn's Meadow Extension. Construction was divided into two phases that included a greenhouse (completed in 2013) and a 2-story Horticulture Building with solar film on the roof and a heating system using geothermal technology. The greenhouse and 2-story Horticulture Building has been designed to achieve LEED platinum certification. LEED certification is not given until at least one full year after project completion.

Among the many features of the 9,500 square foot greenhouse are open-roof venting, side-wall and ceiling curtains, high-efficiency boilers for radiant floor heating to create the most energy-efficient climate-controlled environment, and a below-ground 35,000 gallon cistern for collecting rainwater from the greenhouse roofs to irrigate the growing plants inside.

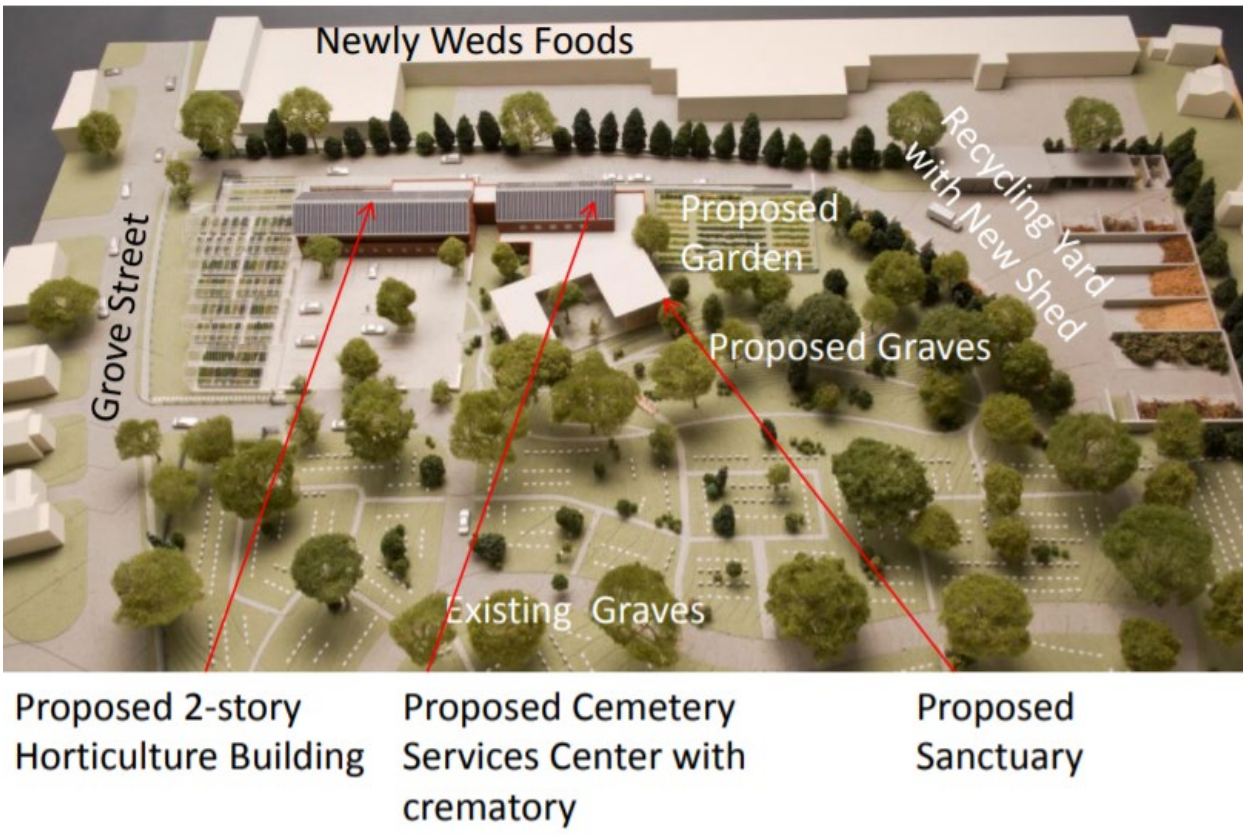


Figure 2 - This William Rawn Associates | Reed Hilderbrand designed complex of buildings at Mount Auburn's Meadow Extension proposes a 2-story Horticulture Building including solar film on the roof and a heating system using geothermal technology. With the greenhouse, the Horticulture Building has been designed to achieve LEED platinum certification. LEED certification is not given until at least one full year after project completion.

With the completion of the new greenhouse, Mount Auburn's horticultural staff expanded its ecological practices, of special note is the use of beneficial insects (rather than chemical pesticides) to combat insect infestations. Good bugs are a significant component of Mount Auburn's plant care program. Classes about using beneficial insects start with identifying damage. According to staff member Kelley Sullivan,

> "pest damage is usually apparent in leaf foliage; leaves appear speckled, spotted, discolored, and distorted (curled), caused by insects that pierce the upper leaf surfaces. Aphids, thrips, mites, and leafhoppers love sucking the juices out of leaves. Leaves with holes and chewed edges are a sign of defoliators, such as caterpillars. Wilted plants may not be a symptom of water deficiency, but of root feeders such as fungus gnat larvae in the soil."

Figure 3 - 'Inspector' Kelley Sullivan

Pests are not eradicated with unhealthy pesticides; instead, they are maintained at a threshold by organic methods that includes spray rotation program in combination with beneficial 'good bug' releases that allows plants to thrive. These releases help sustain healthy good bug populations, and since the greenhouses are pesticide-free, other beneficial bugs from the surrounding environs also visit and stay. Astute observations and scientific methods on how to use good bugs and knowing which host plants support a population of beneficial insects has made this program a model now copied by other growers.

As part of its commitment to the community, Mount Auburn's professional staff shares its expertise in sound ecological practices with other botanical gardens, landscape professionals, and home gardeners.

Indoor Activities

Raise a glass to Water! Mount Auburn eliminated bottled drinking water when tap water is just as good, if not better! Tap water is strictly regulated by the EPA. Bottled water, as a consumer product, is regulated by the FDA, which has significantly lower standards and less frequent testing. The FDA, for example, allows for some degree of *E. coli* and fecal coliform contamination, whereas the EPA allows none in tap water. Unlike tap water, bottled water does not have to be tested for *Cryptosporidium* or *Giardia*. The year of 2020, the year of COVID-19, has been unlike any other that most of us remember. Plastic water bottles made their way back into daily lives as fear of spreading germs increased through personal

Figure 4 - Administrative and building maintenance staff helped make the transition from bottled water to filtered tap water as the main source of drinking water. In 2014, Mount Auburn saved approximately $7,000 by not using big bottles of water and plastic cups.

contact. However, all bottled water was eliminated by Mount Auburn and replaced with tap water in 2014.

Administrative and building maintenance staff helped make the transition from bottled water to filtered tap water as the main source of drinking water. In 2014, Mount Auburn saved approximately $7,000 by not using big bottles of water with coolers and plastic cups. Saving money isn't the only thing good about drinking tap water. It saves other precious resources such as electricity used by the machinery to pump and fill the big bottles, and gas and diesel fuel required for transporting those bottles to customers. The installed filters reduce sediment (though not typical in municipally supplied water) and remove the chlorine taste and odor. Even without the filters however, the water is perfectly safe to drink, but now it tastes better. And **raise a glass of water to everyone** who works on the grounds and is willing to bring in their own reusable bottle instead of using plastic cups!

Paper Use and Recycling: Inside the offices by the mid-2000s, a concerted effort for all Paper Recycling was implemented. A switch from single stream recycling to all recyclables being mixed together allowed for one recycling bin rather than two to be located at convenient locations. Mount Auburn's Green Team, now Sustainability Working Groups, has been responsible for keeping track of the waste and recycling pickups. According to our recycling vendor, Save that Stuff, Mount Auburn's recycling program processed about 6 tons of paper, plastic, glass and metals each year for two years; thereby saving per year about 35 trees, 19 cubic yards of landfill waste, and about 1800 kWh of electricity. A field trip to the recycling facility allowed one to gain new respect for those people and facilities that sift and separate thousands of pieces of plastics from paper so it can be baled and shipped to a manufacturer ready to use it as recycled source material for a new finished product. "Buy 100% recycled products" is the take-away message.

In an effort to **reduce paper use**, a competition between offices was held in 2012 to determine which one could most significantly reduce their paper use compared with 2011 purchases. Much to everyone's amazement, the building that houses the Finance & Administration departments won. How did they do it?

Reasons They Won the Challenge

- ✓ Printing double-sided pages
- ✓ Using white boards for 'thinking' rather than paper
- ✓ Not printing emails that require action. Instead we moved the emails into "@Action" or "@Follow-up" folders
- ✓ Selecting only sections or relevant pages of emails (particularly if it only prints the disclaimer on a separate page)
- ✓ Waiting to print any Trustee or Committee package closer to the mailing deadlines because of last minute changes from the President
- ✓ Viewing spreadsheets on two monitors instead of printing worksheets when verifying numbers
- ✓ Instead of printing and then scanning we print right to a PDF (Adobe)

By changing printing habits, they saved seven cartons of paper – or about 4.2 trees over the previous year.

Recycle Electronics: Today's consumer electronics such as computers, cell phones, radios, and TVs rely on electronic manufacturing technology that utilizes many metals and hazardous chemicals; therefore, it is important to recycle electronic items responsibly. Mount Auburn has hosted an annual electronics recycling program open to staff and the community every January since 2012. Mount Auburn's vendor takes these recycled items, dismantles them and they all gets reused as source materials for other items. It does not go into a landfill. In January 2021, the event was still held with **COVID-19 Safety Precautions**:

"Masks are required. When you arrive on site please observe signs and directions from staff to help us safely and orderly unload your vehicle (walk-ups welcome as well)".

Many arriving to drop off materials say, "I've been hanging onto this thing all year for your recycling event". Thank you.

Figure 5 - Mount Auburn's vendor takes these recycled items, dismantles them and they all gets reused as source materials for other items.

These stories are just of few of the many ways in which Mount Auburn manages materials for use in the buildings and for general consumption. You can read more stories on Mount Auburn website at this link: https://mountauburn.org/tag/eternally-green/.

Goals for Materials Management

SHORT-TERM GOALS (FY2022 - FY2024):

1. Write and Implement a policy to purchase or select materials that are extracted using sustainable practices and contain non-hazardous chemicals and recycled content. Examples are:
    a. Paper products are Forestry Steward Council (FSC) certified or made of 100% post consumer waste
    b. Cleaning supplies are non-toxic yet effective
2. Recycle and reuse materials for construction, renovation, restoration, maintenance, and educational purposes.
    a. Consider salvaged materials for new or renovated paths and roads
3. Reduce toxic and hazardous waste from all landscape management activities and divert, reduce, or eliminate waste to landfills.
    a. Track all dumpster loads that are removed from the site and aim for zero waste
4. Eliminate waste from all office activities
    a. Track materials that cannot be recycled such as Styrofoam and ask the vendor to stop using those materials.

"The elements which have once moved and circulated in living frames do not become extinct or useless after death; they offer themselves as the materials from which other living frames are to be constructed…… the harmonious and ever-changing face of nature reminds us, by its resuscitating influences, that to die is but to live again."

Dr. Jacob Bigelow, Mount Auburn Cemetery Co-founder

Part V: Appendix

These supplementary materials comprise the Appendix of the first edition of Mount Auburn Cemetery's Climate Action and Sustainability Plan.

B) Greenhouse Gas One Page Reports for FY2021, FY2020, FY2015, FY2010

Greenhouse Gas Inventory Report with Carbon Offsets & Renewable Energy Certificates

Name	Mount Auburn Cemetery, 580 Mount Auburn Street, Cambridge, MA 02138
Emission Year	**FY2021** Fiscal Year 4/1/2020 thru 3/31/2021
Geographic Boundary	Buildings and utilities inside the fenced boundary of 175 contiguous acres. Most acreage is in Watertown with a few acres in Cambridge.

Total Greenhouse Gas Emission Before Offsets Applied (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	497.0413
Scope 1 Emissions (gas use for cremations)	176.0686
Scope 2 Emissions (electricity)	119.0084
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
Gross GHG Emissions:	**792.1184**

Carbon Offset Purchases (mtCO2e)

Total offset credits purchased: **0.0000** mtCO2e

Offset Program:

☐	State, Federal regulatory agency in North America		
☐	America Carbon Registry	☐	Gold Standard
☐	Clean Development Mechanism	☐	Join Implementation
☐	Climate Action Reserve	☐	Pacific Carbon Standard
☐	Climate Leaders	☐	Verified Carbon Standard
X	Other NONE PURCHASED		

Carbon Offsets Applied to Inventory by Scope (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	-
Scope 1 Emissions (gas use for cremations)	-
Scope 2 Emissions (electricity)	-
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
Carbon Offset Purchases (mtCO2e) **Total carbon offsets applied:**	**0.0000**

Renewable Energy Certificates (RECS) (mtCO2e)	mtCO2e TOTAL
Scope 2 Emissions (electricity)	119.0084
RECs Purchases (mtCO2e) **Total RECs applied:**	**119.0084**

Net GHG Emissions (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	497.0413
Scope 1 Emissions (gas use for cremations)	176.0686
Scope 2 Emissions (electricity)	-
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
TOTAL Net GHG Emissions (mtCO2e)	**673.1099**

May 28, 2021

Prepared by: Candace Currie, GardenGIS, LLC Date:

Greenhouse Gas Inventory Report with Carbon Offsets & Renewable Energy Certificates

Name	Mount Auburn Cemetery, 580 Mount Auburn Street, Cambridge, MA 02138
Emission Year	**FY2020** Fiscal Year 4/1/2019 thru 3/31/2020
Geographic Boundary	Buildings and utilities inside the fenced boundary of 175 contiguous acres. Most acreage is in Watertown with a few acres in Cambridge.

Total Greenhouse Gas Emission Before Offsets Applied (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	469.7563
Scope 1 Emissions (gas use for cremations)	165.7762
Scope 2 Emissions (electricity)	104.5281
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
Gross GHG Emissions:	**740.0606**

Carbon Offset Purchases (mtCO2e)

Total offset credits purchased: **0.0000** mtCO2e

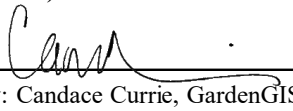
Offset Program:

- [ ] State, Federal regulatory agency in North America
- [ ] America Carbon Registry
- [ ] Clean Development Mechanism
- [ ] Climate Action Reserve
- [ ] Climate Leaders
- [ ] Gold Standard
- [ ] Join Implementation
- [ ] Pacific Carbon Standard
- [ ] Verified Carbon Standard
- [X] Other NONE PURCHASED

Carbon Offsets Applied to Inventory by Scope (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	-
Scope 1 Emissions (gas use for cremations)	-
Scope 2 Emissions (electricity)	-
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
Carbon Offset Purchases (mtCO2e) **Total carbon offsets applied:**	**0.0000**

Renewable Energy Certificates (RECS) (mtCO2e)	mtCO2e TOTAL
Scope 2 Emissions (electricity)	104.5281
RECs Purchases (mtCO2e) **Total RECs applied:**	**104.5281**

Net GHG Emissions (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	469.7563
Scope 1 Emissions (gas use for cremations)	165.7762
Scope 2 Emissions (electricity)	0.0000
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
TOTAL Net GHG Emissions (mtCO2e)	**635.5325**



Prepared by: Candace Currie, GardenGIS, LLC Date: May 28, 2021

Greenhouse Gas Inventory Report with Carbon Offsets & Renewable Energy Certificates

Name	Mount Auburn Cemetery, 580 Mount Auburn Street, Cambridge, MA 02138
Emission Year	**FY2015** Fiscal Year 4/1/2014 thru 3/31/2015
Geographic Boundary	Buildings and utilities inside the fenced boundary of 175 contiguous acres. Most acreage is in Watertown with a few acres in Cambridge.

Total Greenhouse Gas Emission Before Offsets Applied (mtCO2e)	mtCO2e	TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)		542.3900
Scope 1 Emissions (gas use for cremations)		262.1500
Scope 2 Emissions (electricity)		128.6000
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)		-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)		-
	Gross GHG Emissions:	**933.1400**

Carbon Offset Purchases (mtCO2e)

Total offset credits purchased: **0.0000** mtCO2e

Offset Program:

	State, Federal regulatory agency in North America		
	America Carbon Registry		Gold Standard
	Clean Development Mechanism		Join Implementation
	Climate Action Reserve		Pacific Carbon Standard
	Climate Leaders		Verified Carbon Standard
X	Other NONE PURCHASED		

Carbon Offsets Applied to Inventory by Scope (mtCO2e)	mtCO2e	TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)		-
Scope 1 Emissions (gas use for cremations)		-
Scope 2 Emissions (electricity)		-
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)		-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)		-
Carbon Offset Purchases (mtCO2e)	**Total carbon offsets applied:**	**0.0000**

Renewable Energy Certificates (RECS) (mtCO2e)	mtCO2e	TOTAL
Scope 2 Emissions (electricity)		127.0600
RECs Purchases (mtCO2e)	**Total RECs applied:**	**127.0600**

Net GHG Emissions (mtCO2e)	mtCO2e	TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)		542.3900
Scope 1 Emissions (gas use for cremations)		262.1500
Scope 2 Emissions (electricity)		1.5400
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)		-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)		-
TOTAL Net GHG Emissions (mtCO2e)		**806.0800**

Prepared by: Candace Currie, GardenGIS, Inc Date: June 7, 2021 *corrected kWh*

Greenhouse Gas Inventory Report with Carbon Offsets & Renewable Energy Certificates

Name	Mount Auburn Cemetery, 580 Mount Auburn Street, Cambridge, MA 02138
Emission Year	**FY2010** Fiscal Year 4/1/2009 thru 3/31/2010
Geographic Boundary	Buildings and utilities inside the fenced boundary of 175 contiguous acres. Most acreage is in Watertown with a few acres in Cambridge.

Total Greenhouse Gas Emission Before Offsets Applied (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	541.2900
Scope 1 Emissions (gas use for cremations)	235.9000
Scope 2 Emissions (electricity)	158.1800
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
Gross GHG Emissions:	**935.3700**

Carbon Offset Purchases (mtCO2e)

Total offset credits purchased: **0.0000** mtCO2e

Offset Program:

- [ ] State, Federal regulatory agency in North America
- [ ] America Carbon Registry
- [ ] Clean Development Mechanism
- [ ] Climate Action Reserve
- [ ] Climate Leaders
- [ ] Gold Standard
- [ ] Join Implementation
- [ ] Pacific Carbon Standard
- [ ] Verified Carbon Standard
- [X] Other NONE PURCHASED

Carbon Offsets Applied to Inventory by Scope (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	-
Scope 1 Emissions (gas use for cremations)	-
Scope 2 Emissions (electricity)	-
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
Carbon Offset Purchases (mtCO2e) **Total carbon offsets applied:**	**0.0000**

Renewable Energy Certificates (RECS) (mtCO2e)	mtCO2e TOTAL
Scope 2 Emissions (electricity)	74.5600
RECs Purchases (mtCO2e) **Total RECs applied:**	**74.5600**

Net GHG Emissions (mtCO2e)	mtCO2e TOTAL
Scope 1 Emissions (gas use for building heat and mobile fleet of vehicles and equipment)	541.2900
Scope 1 Emissions (gas use for cremations)	235.9000
Scope 2 Emissions (electricity)	83.6200
Biogenic Emissions (not calculated; air emissions at crematory and recycling yard, etc.)	-
Scope 3 Emissions (not calculated; includes travel by staff and visitors, deliveries, etc.)	-
TOTAL Net GHG Emissions (mtCO2e)	**860.8100**

February 26, 2021

Prepared by: Candace Currie, GardenGIS, LLC Date:

C) Groundcovers for Successful Turf Replacement

Botanical Name	Common Name
Achillea tomentosa	Woolly Yarrow
Achillea millefolium (cultivars)	Yarrow (Pink Grapefruit', 'Pomegranate')
Achillea sibirica 'Love Parade'	Siberian Yarrow cultivar
Ajuga reptans (cultivars)	Bugleweed ('Burgundy Glow', Chocolate Chip')
Alchemilla mollis	Lady's Mantle
Allium (cultivars)	Ornamental Onion ('Millenium', 'Summer Beauty')
Amsonia hubrichtii (& cultivars)	Arkansas Bluestar ('Blue Ice', etc.)
Amsonia tabernaemontana 'Short Stack'	Bluestar cultivar
Astilbe simplicifolia (cultivars)	Spirea ('Key West', 'White Sensation')
Athyrium filix-femina (& cultivars)	Lady Fern ('Lady in Red', 'Victoriae')
Athyrium nipponicum (& cultivars)	Japanese Painted Fern ('The Ghost', etc)
Aurinia saxatilis (cultivars)	Basket of Gold ('Gold Dust', etc.)
Calluna vulgaris (cultivars)	Heather ('Reinii', 'H. E. Beale', 'J. H. Hamilton')
Carex morrowii 'Ice Dance'	Japanese Sedge cultivar
Ceratostigma plumbaginoides	Plumbago
Chrysanthemum 'Sheffield Pink'	Hardy Chrysanthemum cultivar
Chrysanthemum weyrichii (cultivars)	Alpine Daisy ('White Bomb', 'Pink Bomb')
Chrysogonum virginianum (cultivars)	Green and Gold ('Superstar', Eco-lacquered Spider')
Euphorbia amygdaloides var. *robbiae*	Wood Spurge
Gaillardia 'Fanfare'	Blanket Flower cultivar
Gallium odoratum	Sweet Woodruff
Geranium macrorrhizum (cultivars)	Bigroot Geranium ('Bevan's Variety', Rozanne', etc.)
Hakonechloa macra	Japanese Forest Grass ('Beni Kazi', 'Naomi', 'Nicholas')
Helianthus salicifolius 'Low Down'	Willowleaf Sunflower cultivar
Heuchera villosa (cultivars)	Coral Bells ('Dale's Variety', 'Bronze Wave', 'Brownies', etc.)
Hosta spp.	Hosta
Hypericum calycinum	Aaron's Beard
Iberis sempervirens (cultivars)	Candytuft ('Tahoe', 'Purity')
Juniperus communis var. *depressa*	Mountain Juniper
Juniperus Sabina (cultivars)	Savin Juniper ('Monna', 'Buffalo')
Lamiastrum galeobdolon	Golden Archangel
Lavandula angustifolia (cultivars)	Lavender ('Dilly Dilly', 'Hidcote', 'Munsted')
Liriope spicata	Creeping Lilyturf
Pachysandra terminalis 'Green Sheen'	Pachysandra
Sedum (cultivars)	Sedum ('Dazzleberry', 'Firecracker')
Sesleria autumnalis	Autumn Moor Grass
Sporobolus heterolepis 'Tara'	Dwarf Prairie Dropseed
Thelypteris decursive-pinnata	Japanese Beech Fern
Thelypteris noveboracensis	New York Fern
Thymus (cultivars)	Thyme ('Pink Chintz')
Trachystemon orientalis	Early Flowering Borage
Veronica 'Waterperry'	Dwarf Veronica cultivar
Vinca minor 'Bowles'	Myrtle
Waldsteinia fragarioides & *W. ternata*	Barren Strawberry

D) Looking Back: Plant Collections and Climate Change at Mount Auburn

By Anna Moir

"The more we are able to manage the process of change, the more likely it will be that this landscape will be passed on to later generations in the best possible condition."

Written by Horticultural Curator Dennis Collins back in 2006, this strategy continues to guide Mount Auburn today, fourteen years later. And the more you visit Mount Auburn, the more you might spot all the ways that it plays out across our landscape. After all, one of the Cemetery's most important features is that no matter how naturally beautiful we try to keep it, the landscape is never static and does not happen by accident.

Over the years, our staff has worked thoughtfully to maintain and update different areas across the entire Cemetery to create a beautiful landscape, preserve our history, improve sustainability, and showcase our acclaimed plant collection effectively. Sometimes the work we do is obvious, particularly in the larger garden renovations at Asa Gray Garden, along Hazel Path to the Tower, and the most recent plantings in 2020 along Indian Ridge. However, changes are often much more subtle. Every day it can range from what flowers get planted where, to how we preserve older and rare specimens, to what new trees are planted each year, to the ways we respond to any threats to our plants and trees that might arise.

What threats do our plant collections face today?

Our horticulture team has had to address many different issues over time, from **diseases** and **pests** decimating specific species, to stress caused by **extreme weather** like storms or droughts. Factors like insects and diseases have mainly been addressed through diversification – not relying too heavily on specific plant species to increase the odds of more of our collection staying resilient. (For instance, we have addressed Hemlock Woolly Adelgid, an invasive insect which has impacted our hemlock tree collection, by not only preserving as many as we can but also adding other conifers instead of planting more hemlocks to replace those we lose.) Extreme weather, however, points to a threat with many more unknowns that we are tackling for the long-term survival of our landscape: climate change.

Already, **weather and environmental stress are the top reasons why we remove and replace trees** each year (one-third of all removals on average). Climate change has been causing more extreme storms, more droughts, and sharper temperature contrasts, and all of this takes a heavy toll on plants. It also isn't always something that we can spot immediately, because stress from one year can start to weaken plants but take a few more years to have its full impact. Add more years of extreme weather into the equation after that, and the situation gets even more tricky to control.

In the long-term, strong evidence indicates that our climate is warming. It may be hard to see on a day-to-day basis, but the reality is that our growing environment has changed over the course of Mount Auburn's history. We cannot count on it supporting all the same plants moving forward. The USDA has revised its maps of hardiness zones in the past decade, with the Boston area moving into a warmer category than before (from Zone 5 to Zone 6). So, we now face an

uncertain transition – we are dealing with unpredictable winters, but also know that our climate is getting warmer overall.

Addressing the Warming Climate
How far the changes will go in the future is difficult to predict, but we know we have to start addressing our warming climate now. We have started testing plants that we have had little or no experience with at Mount Auburn in the past, to see how more Zone 6 species respond to our environment.

Thanks to phenology data that we've been gathering since 2016, we are also adding plants that flower later in the spring. On average, the timing has shifted earlier for when plants bloom and insects emerge to feed on them, but bird migration has stayed relatively consistent. Since Mount Auburn is a major stopover point for migratory birds, we want to ensure that food is available when they arrive (i.e. the insects feeding on the flowering plants). While not every ecosystem imbalance is in our control, we are optimistic that this is one we can address effectively.

Overall, the situation certainly is daunting, but we have reasons to remain hopeful that Mount Auburn's plant collections will continue to thrive. Climate warming happens slowly – over decades, not years. This gives us more time to diversify our collection and figure out what works best, even amid erratic weather and temperature changes. Our horticulture mission has always given us flexibility to test out a wide variety of plants throughout our history, and we will continue to use this to our advantage.

Will our entire collection remain intact as we know it today? Unfortunately, that has never been a guarantee. Almost any arboretum and botanic garden can attest that sometimes, iconic plants can be vulnerable. **But what we have learned from this is that the less we rely on individual species, the better our long-term success will be.** With more research, testing, and creativity, we are optimistic that our staff will keep Mount Auburn the beautiful, inspiring landscape we know and love, long into the future.

SIDEBAR:
Plant Collections at a Glance
Across its 175 acres, Mount Auburn features a significant collection of almost 19,000 plants.

- 5,000 trees
- 120 different botanical families
- More than 2,300 different taxa*
- During the last 10 years the collections have increased by 1,976 plants or masses of plants (12% increase), and the number of different taxa represented has increased by 581 (33% increase)

** Note: In a botanical context, a "taxon" (pl. taxa) is considered to be a valid name for plants at various classification levels, including species, subspecies, variety, form, hybrid, and cultivar.*

F) Additionality and GHG Accounting Principles

By Candace Currie

***Additionality**: "Additionality is a concept from international Greenhouse Gas (GHG) project accounting principles that requires a project activity is additional to "business as usual" and would not have occurred in the absence of an incentive provided by a GHG offsets market."* (*https://www.climateactionreserve.org/how/projects/)*

Carbon storage: "Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation." (*i-Tree 2016*)

Carbon sequestration: "Carbon sequestration is the removal of carbon dioxide from the air by plants." (*i-Tree 2016*)

Many people believe that the plant collections of Mount Auburn Cemetery should help offset the greenhouse gas (GHG) emissions – that is all use of fossil fuels at Mount Auburn. They do on paper many times over. Unfortunately, using this existing urban forest and calculating the offset requires the understanding of another concept of **additionality**. As a botanic garden, the valued tree collection is 'business as usual' and it does not nudge the climate change needle in an extra positive direction even though the benefits it provides are extraordinary. Hypothetically, the creation of another Mount Auburn in order to expand its landscape footprint and increase ecosystem and carbon storage services would be required to move the needle on climate change.

There seems to be consternation about this topic of **additionality** among professionals in the field of GHG accounting. According to Climate Action Reserve, "Greenhouse gas (GHG) reduction projects must reduce emissions or increase sequestration of GHGs in a manner that is real, permanent, verifiable and **additional**." Papers continue to be written on **additionality** and the proper way to account for a forest like Mount Auburn's. Perhaps in the future, the baseline GHG emissions may be adjusted to account for the carbon storage and leafy sequestration of Mount Auburn's trees, but for now, documenting the many ecosystem services that trees provide: air pollution removal, carbon storage and sequestration, oxygen production, and runoff avoidance as identified in the Carbon Storage, Sequestration and Ecosystem Benefits, and in details with Alex Wolf's iTree Reporting.

G) List of Vehicles and Equipment

Vehicles and Equipment List
as of FY2021

Riding Lawn Mowers *(5 gas, 5 propane, 1 electric)*	11
Turf Vehicles – Toros and JD Progators *27 gas, 1 diesel, 3 electric*	31
Vans & SUVs (all gas)	11
Pickup Trucks (all gas)	10
Dump body Trucks *(3 diesel, 1 gas)*	4
Heavy / Specialized Equipment (all diesel) *2 Case backhoes, 2 Kubota tractors, 2 Bobcat toolcats* *1 JD Wheel loader, 1 Aerial lift truck,* *1 brush chipper, 1 leaf vacuum, 1 soil screener,* *1 air compressor*	12
Miscellaneous Equipment (all gas) *1 tree sprayer, 1 stump grinder, 1 earth mover,* *1 power barrel, 2 walk behind mowers*	6
TOTAL	**85**

Small Power Equipment *(62 gas, 16 battery/electric)* *Including: leaf blowers, string trimmers,* *hedge trimmers, hand-held blowers, chainsaws,* *snowblower, power edger, overseeder, etc.*	78

H) Do Carbon Offsets Actually Work?

https://www.npr.org/2021/04/30/992545255/do-carbon-offsets-actually-work-planet-money-takes-a-look

Do Carbon Offsets Actually Work? 'Planet Money' Takes A Look

April 30, 20214:19 PM ET as heard on All Things Considered, **Transcript**

More and more companies are pledging to cut carbon emissions. Many say they'll buy carbon offsets that save forests, but counting how much carbon is actually saved is fuzzy math.

MARY LOUISE KELLY, HOST:

One-fifth of the world's biggest companies have made some sort of pledge to go carbon neutral, meaning they will pollute less or pay to offset their pollution. One popular type of offset involves saving trees. But as Julia Simon reports for our Planet Money podcast, some critics are finding the tree math doesn't add up.

JULIA SIMON, BYLINE: With so many companies now looking to buy offsets, there is a booming industry of startups looking to sell them, including one called Pachama, which sells offsets from forests.

DIEGO SAEZ GIL: So in a way, we are a marketplace like Airbnb, connecting supply and demand.

SIMON: This is co-founder Diego Saez Gil. On Pachama's website, companies can go to a map and pick a forest to save in Columbia, Peru or this map we're zooming into in Brazil.

Oh, there it goes.

SAEZ GIL: It zooms.

SIMON: Zooming into Brazil.

SAEZ GIL: Yeah.

SIMON: Oh, in the center of Brazil. Woo (ph).

SAEZ GIL: Yeah.

SIMON: Big, big zoom.

SAEZ GIL: Yeah, yeah. And you can see the shape of a triangle.

SIMON: It's a triangle.

SAEZ GIL: Yes. That is the borders of the area that is being conserved. Otherwise it will be deforested.

SIMON: That otherwise it will be deforested is key here because there is a theory behind offsets that save trees. Trees - kind of incredible. They store carbon, suck it out of the air. Some trees get cut down every year for things like ranching or for lumber, so the company pays to stop trees from getting cut down.

Then in theory, those payments prevent carbon emissions. But how is an offset buyer to know what would have happened to the trees without that payment? Maybe no loggers had plans to cut down that forest. Maybe the local government was already protecting it. Or maybe the ranchers just went down the road and cut down a different forest. All these questions are the reason why David Antonioli has a job.

DAVID ANTONIOLI: I'm the chief executive officer of Verra.

SIMON: Verra certifies many of the offsets that Saez Gil and other brokers sell - nearly 70% of all offsets sold to companies. And part of Verra's process involves answering those hypothetical questions about what would have otherwise happened.

ANTONIOLI: You say there's so many hypotheticals. I don't think there are that many, quite frankly. I mean, we know how many trees are on the ground, right? We know how many get cut down. And I think that, you know, absolutely companies can be comfortable and confident that they're reducing emissions.

SIMON: But a study in last year's proceedings of the National Academy of Sciences suggests companies can't be so confident. It looked at forest projects in the Brazilian Amazon, and the researchers concluded the projects were overestimating the deforestation that would have happened had they not been there by almost 60 times. I brought these concerns to Antonioli as Verra issued all the offsets.

Ten out of 12 Brazilian forestry projects that you gave your stamp of approval to didn't stop the deforestation they claim. That's what that study found. So for the corporations that have purchased offsets from these projects, did they offset their emissions?

ANTONIOLI: Yes, I think so. I mean, there are many great studies out there looking at the impacts of projects, and we welcome them. But we shouldn't be throwing the baby out with the bathwater just because there was one study that identified some projects that, according to one methodology, were different than what we say.

SIMON: He says Verra uses studies like this to update their certification process. In fact, earlier this month Verra updated its rules for future forest projects. But there are lots of companies still buying offsets from those projects in Brazil, and they may not be saving as many trees as they thought. For NPR News, I'm Julia Simon.

I1) i-Tree Reporting - Carbon Sequestration and Storage

By Alexandra Wolfe, *Curatorial Associate*, October 18, 2020

INTRODUCTION

At Mount Auburn Cemetery, there resides a diverse living collection of 4,986 trees. These trees bestow many gifts upon us year after year. These gifts are known as ecosystem services. "Ecosystem services are the conditions and processes through which natural ecosystems sustain and fulfill human life." (Daily 1997, p. 3). Some of the ecosystem services that trees provide us are air pollutant removal, storm water run-off mitigation, air temperature reductions, and carbon storage and sequestration (Neylele et al. 2020). The focus of this project is on the ecosystem services of carbon storage and sequestration that the trees of Mount Auburn Cemetery provide.

Trees sequester carbon through the process of photosynthesis when they take in carbon dioxide from the atmosphere (Raven et al. 2012). They use the sequestered carbon for biomass production and release oxygen into the atmosphere as a by-product. The amount of carbon sequestered and stored by each tree varies depending on species and age (Catanzaro & D'amato 2019). The species of tree is important to note because of the variation in wood density amongst different types of trees. Hardwood trees tend to store more carbon than those with softwood (Vermont Dept. Forests, Parks & Recreation 2017). Peak carbon sequestering age is between 30-70 years old (Catanzaro & D'amato 2019). Roughly half of Mount Auburn's trees fall within the peak sequestering age and there is an amalgam of wood densities among them.

METHODS

The first step in estimating Mount Auburn Cemetery's carbon sequestration and storage totals was to consult the plant collections analysis to get an idea of which taxa are most prevalent in the cemetery. According to the plant collections analysis, the highest represented taxa are as follows in order of prevalence*: Acer saccharum*, *Cornus florida*, *Pinus strobus*, *Quercus rubra*, *Tsuga canadensis*, *Pseudotsuga menziesii*, *Chamaecyparis pisifera*, *Picea abies*, *Malus sp., Magnolia sp., Amelanchier sp., Cornus kousa*, *Fagus sylvatica*, *Acer platanoides*, *Quercus alba*, and *Acer palmatum*. The goal was to collect data from sections that when combined would properly reflect the distribution of those taxa throughout the cemetery as a whole. In order to convey the total carbon stored and sequestered in the cemetery without pulling data from every tree, this sampling method was implemented. To select which sections to use as our sample plots, our GIS specialist Stephen Chiavaroli utilized ArcGIS to find which areas contained the highest concentration of the desired taxa. From the information gathered through the GIS, horticulture sections were selected to collect data from based on their collective ratios of the desired taxa. As part of the selecting process, it was also important to look at the ratio of the highest represented taxa to the remaining species composition of each section. Seven sections were settled upon that would most accurately depict this: 10, 14, 16, 43, 53, 54, and 55.

Section 10 is a large section outside of the operations center off of Glen and Vesper avenue. This section has a concentrated amount of *Acer saccharum*, *Tsuga canadensis*, *Cornus florida*, and *Chamaecyparis pisifera*. Section 14 is across the road from section 10, by Fir avenue. This section also has a fair amount of *Acer saccharum*, as well as *Malus* sp., *Cornus florida*, and *Quercus alba*. Section 16 is down the street from 10 and 14, by Spruce avenue. Section 16 has a nice distribution of the medium sized deciduous trees desired. Section 43 is across the street from Willow Pond, along Pond road. An overwhelming amount of *Taxus sp*. can be found here, which is the third most prevalent taxa in Mount Auburn Cemetery. Situated between the Tower and Willow Pond is section 53. Section 53 has a nice hardy amount of both *Acer saccharum* and *Fagus*

sylvatica. The area around the Tower is section 54. Section 54 has an abundance of *Quercus rubra*, as well as *Pinus strobus* and *Cornus florida*. Section 55 encompasses the Dell. The highest amount of *Quercus rubra*, *Pinus strobus*, *Amelanchier sp*., and *Picea abies* out of the seven sections can be found in section 55.

The data necessary for totaling stored and sequestered carbon is the species of tree and the diameter at breast height (4.5 ft. from the base) (Catanzaro & D'amato 2019). Exceptions to the standard are required with trees that branch around the 4.5 feet mark. In those cases, it is typical to take the average measurement of the branches. Most measurement data had previously been recorded in BG-BASE, our plant records database. There were only a handful of trees where missing data was supplemented.

Once the appropriate measurements were gathered for the taxa in question, the i-Tree Eco application was utilized for organizing and analyzing the data. i-Tree Eco is an application software developed collectively by the USDA Forest Service, Davey Tree Expert Company, The Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, Casey Trees, and SUNY College of Environmental Science and Forestry, that is used for urban and rural forestry analysis and benefits assessments. The application has a step by step process on how to properly construct projects that report on ecosystem services provided from the area of study. Step 1 involved planning the project parameters: boundaries of the study, inventory type, and size of sample area. The boundaries of the study are the 175 acres of Mount Auburn Cemetery and the inventory type is a plot based sample. The seven horticulture sections selected are the sample plots. The sample plots are stratified, with the subdivisions within each horticulture section serving as the divider. The average size of each plot was 4.65 acres. The average size of the subdivisions were .518 acres. Totaled together the plots amassed to 32.57 acres which is 18.6% of the cemetery. There were a total of 1,047 trees in the sample, which is 22.2% of the total number of trees in the cemetery. Step 2 involved collecting field data. Since most of the tree measurements from the selected plots are recorded in BG-BASE, querying the system and pulling information from the desired fields constituted most of the field collections legwork. Step 3 entailed entering the collected data into the i-Tree application for analysis. The final step in this project required calculations to convert the sample plot totals into the estimated cemetery totals.

DISCUSSION

After working with i-Tree, it seems that the application is more suited for natural land data collection rather than a botanic setting. An instance that made this apparent to me was the availability of names for input in the data sheets. To enter information for a certain species, you must select from pre-existing names that they have prerecorded information for stored in their system. The list of pre-existing names is largely comprised of straight species with a handful of cultivars present. This proved to be a problem seeing as a third of the specimens in the sample are cultivars. To have the cultivars we are measuring that are missing from their system added to the list, they need to be submitted to the creators for review. The measured data must be assigned to a species listed in the system, otherwise the model will not run. To work around this issue, the straight species was selected for any cultivar not found in the system. This may lead to a less accurate read due to the fact that there is wood density variability even between trees of the same genus (Catanzaro & D'amato 2019). Even though we are speaking of the differences in straight species versus cultivars, the same principles may apply. For the purposes of this project, it did not seem necessary to contact the creators for this matter. It may not have been useful information for them to have in their system seeing as most of their clientele are forest based and therefore concerned with straight species. Perhaps if they plan on widening their scope to botanic institutions, this information may be more useful to them.

Another area that may leave room for inaccuracies in the data stems from the fact that some of the sample plots have not been field checked recently. This means that some of these records are not up to date. The data pertaining to diameter may be slightly different if measured more recently compared to the extant data. It may not be much different since older trees are not actively growing as much and expanding in diameter compared to younger specimens (Johnson et al. 2009). A more concerning situation that may occur with inaccurate records is that a younger tree may have failed without detection and so seems alive in the system and accounted for in sequestration totals. The chances of this happening are low, but are still something to consider.

The most important thing to take into account is that these numbers are an estimate. To get more exact numbers, every tree would need to be measured at the start of the study. This type of surveying would take years to accomplish for 4,698 trees. It would take less time with more aid in measurement, but the more hands involved invites room for error. The method of selecting sample plots as a representative of the cemetery's tree composition was deemed the most efficient way of estimating carbon storage and sequestration totals.

RESULTS & CONCLUSION

In the report generated by i-Tree, the *carbon stored*[1] in the seven sample plots was found to be 816.1 tons. This equates to an estimated 3.68 thousand tons of *carbon stored*[1] in Mount Auburn Cemetery. The annually *sequestered carbon*[2] totals in the sample plots were found to be 17.56 tons. This equates to an estimated 79.1 tons of *carbon sequestered*[2] annually by Mount Auburn's trees. To put these numbers into perspective, Mount Auburn Cemetery's trees sequester about the same amount of carbon per acre as a 100-year-old, mixed hardwood New England forest (Catanzaro & D'amato 2019). Though we match in sequestered totals with local forests, we fall short when comparing storage totals. This discrepancy is due to the fact that the species and age of the trees are not the only factors in determining a carbon pool of an area. There are other things to be considered such as deadwood, leaf litter, and soil disturbance (Vermont Dept. Forests, Parks & Recreation 2017). Even so, it is incredible that Mount Auburn Cemetery's sequestration totals are comparable to those of local natural landscapes. It shows what decades of dedicated horticultural management and planting trees can do for the environment.

Although Mount Auburn Cemetery cannot offset its carbon emissions with its trees alone, the trees still provide many other important ecosystem services. They aid in rain water runoff, removing pollutants from the air, and providing a natural respite for grieving families and those looking for a break from the city. The trees' presence plays a key role in climate change mitigation and are a piece in the working puzzle of climate action planning. Preserving what we have and sustainably planting new each year will continue to move the needle in the right direction.

REFERENCES & DEFINITIONS:

1. Carbon storage: "Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation." (i-Tree 2016)

2. Carbon sequestration: "Carbon sequestration is the removal of carbon dioxide from the air by plants." (i-Tree 2016)

Catanzaro, Paul and D'amato, Anthony. "Forest Carbon: An Essential Natural Solution for Climate Change." Northeast Climate Adaption Science Center. University of Massachusetts Amherst, October 30, 2019. https://www.umass.edu/necsc/news/new-publication-forest-carbon-essential-natural-solution-climate-change.

Sarah E. Johnson, Marc D. Abrams, Age class, longevity and growth rate relationships: protracted growth increases in old trees in the eastern United States, Tree Physiology, Volume 29, Issue 11, November 2009, Pages 1317–1328, https://doi.org/10.1093/treephys/tpp068

Peter Raven, Ray Evert, and Susan Eichhorn. Biology of Plants. 8th ed. Macmillan, 2012.

IUCN. "Forests and Climate Change," November 11, 2017. https://www.iucn.org/resources/issues-briefs/forests-and-climate-change.

Marshall, Michael. "Planting Trees Doesn't Always Help with Climate Change." Accessed November 9, 2020. https://www.bbc.com/future/article/20200521-planting-trees-doesnt-always-help-with-climate-change.

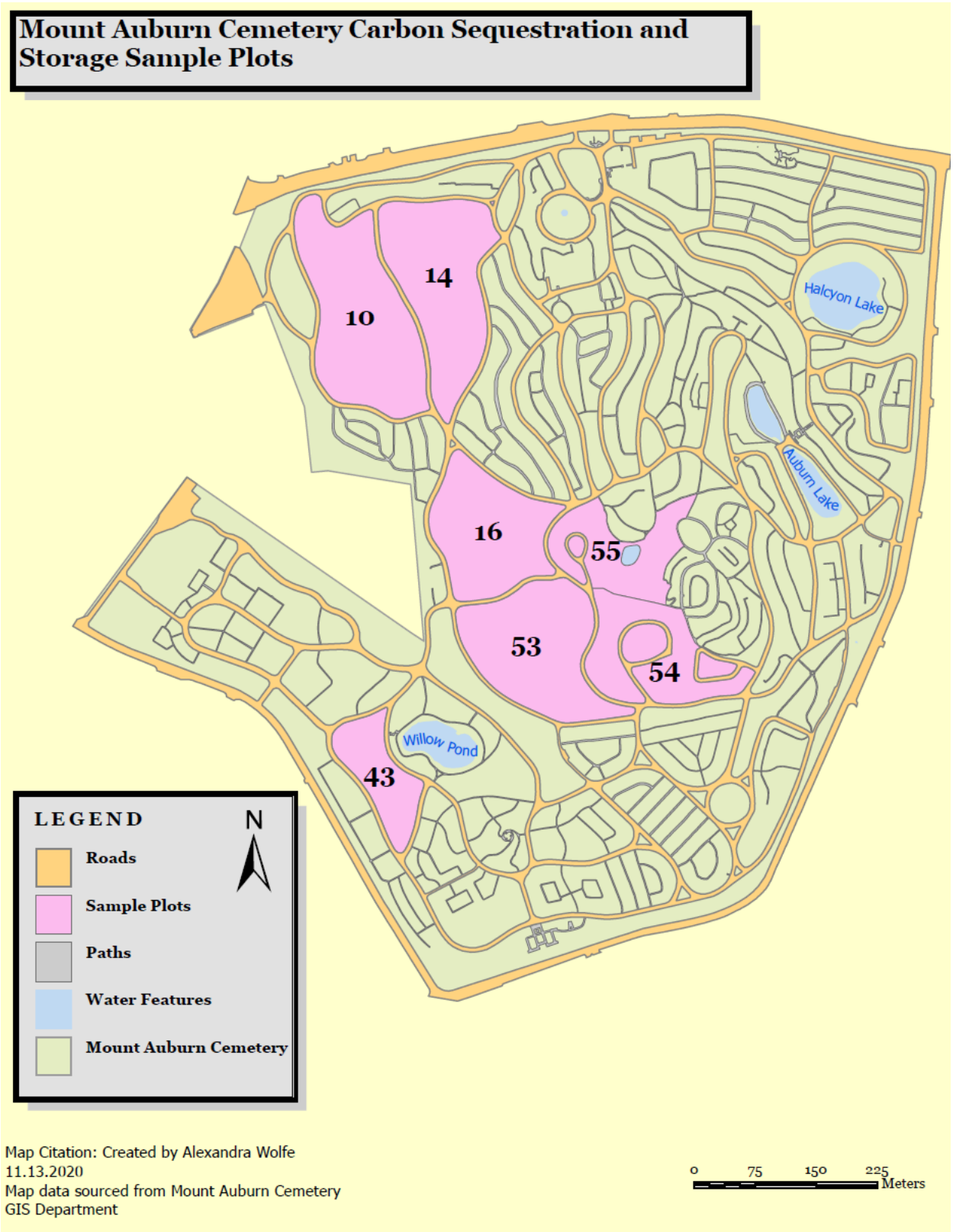
Nyelele, C., & Kroll, C. N. (2020). The equity of urban forest ecosystem services and benefits in the Bronx, NY. Urban Forestry & Urban Greening, 53. https://doi.org/10.1016/j.ufug.2020.126723

Daily, G.C., 1997. Introduction: what are ecosystem services. In: Daily, G.C. (Ed.), Natures Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, DC, pp. 1–10.

"Home Page | Department of Forests, Parks and Recreation." Accessed November 10, 2020. https://fpr.vermont.gov/.

"Learn about i-Tree | i-Tree." Accessed June 26, 2020. https://www.itreetools.org/.

I2) i-Tree Reporting - Map of Sample Plots



I3) i-Tree Reporting - Ecosystem Analysis Report