Assessing Durham's Climate Impact

Municipal Greenhouse Gas Inventory and
Estimation of Carbon Benefits in Conservation Land

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Executive Summary

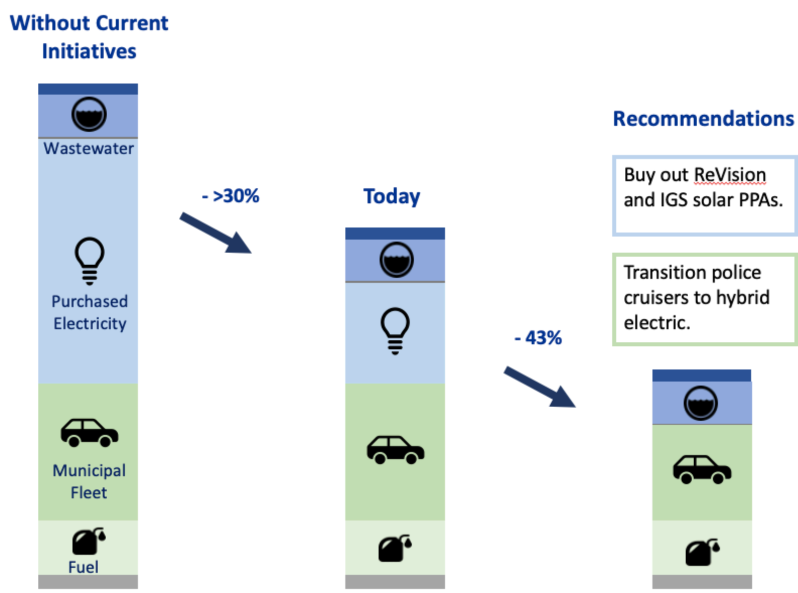
Climate change is a global threat that is already being felt in Seacoast New Hampshire, with sea-level rise, higher winter temperatures, and increased precipitation. These impacts will continue to worsen if global greenhouse gas pollution is not checked. The Town of Durham strives to be a sustainability leader, and as such has taken significant action to lower its climate impact over the past decade (Appendix IV). In summer 2020, the Town partnered with UNH to conduct an analysis of its annual municipal carbon and nitrogen footprints, to inform future efforts.

Annual Emissions

In 2019, Durham had a municipal footprint of 1,195 metric tons carbon dioxide equivalent ($MTCO_2e$) and 7.6 MT nitrogen. The three largest emitting sectors were fleet vehicles (40%), purchased electricity (29%), and stationary fuel (15%) used in facilities.

This footprint is low compared to other municipalities in the state. Breaking it down by sector, Durham has very low emissions per square foot of municipal facilities and average emissions per vehicle in its municipal fleet.

Figure 1. Trajectory of Durham Municipal Emissions ($MTCO_2e$) by Sector with Highlighted Reduction Strategies



Annual Sequestration

Durham has meticulously identified high value conservation land and holds 977 acres in conservation areas or easements. This conservation land sequesters an estimated 2,445 $MTCO_2e$, removes 2.3 tons of particulate matter air pollution, and avoids 1.2 million gallons of surface runoff annually (Appendix III).

Emissions Reduction Strategies

Prioritizing emission reductions in the largest emitting sectors, Durham should consider transitioning its police fleet to hybrid electric vehicles and exercising the buy-out option for its solar power purchase agreements. These strategies would reduce Durham's emissions by 43% and may lead to cost savings in gasoline and electricity purchases within a few years.

Next Steps

In addition to these sector-targeted emissions reduction strategies, the Town should prioritize conducting a community inventory; this would allow for the assessment of potentially high-impact policies such as municipal aggregation, community solar, and weatherization or home energy improvement campaigns (Appendix II).

Introduction

Local Context

Durham is a small town of approximately 16,500 residents located in Seacoast New Hampshire and is home to the University of New Hampshire (UNH). The Town of Durham and its residents have demonstrated consistent leadership in sustainability. The Town has meticulously identified high value conservation areas among its forests, wetlands, and other natural resources; as a result, over 40% of Durham's land is either permanently protected or owned by the Town or UNH. Durham already procures a significant amount of renewable energy, with wind power Renewable Energy Credits for the electricity used at the wastewater treatment plant and solar power purchase agreements for other Town facilities. Other previous sustainability initiatives include renovating public facilities to high energy efficiency standards, and voluntarily adopting a more stringent Climate Zone for its building ordinance (Appendix IV).

This commitment to sustainability is reflected in Durham's Master Plan, which calls for enhancing resilience to climate change, expanding solar access, reducing energy use in the Town's building stock by 30% between 2015-2025, and upgrading stormwater facilities to improve water quality in Great Bay estuary, among other initiatives.

To inform and advance its sustainability work, Durham has taken the initiative to complete a baseline carbon and nitrogen municipal inventory. By quantifying the Town's current emissions sources and volumes, Durham can better prioritize strategies to reduce greenhouse gas emissions going forward. This will increase community resilience in the face of a changing environment and further position the Town as a sustainability leader and model for other towns throughout New England.

Effects of Greenhouse Gas Emissions

A global response is required to manage climate change. In October of 2018, the Intergovernmental Panel on Climate Change (IPCC), a leading nonpartisan group of climate scientists, released its Special Report on the impacts of global warming of 1.5°C (IPCC, 2018). In it, the panel issued its most urgent call to action to date for rapid and fundamental changes in society's energy, land use, urban infrastructure, and transportation. The IPCC emphasizes that droughts, heavy precipitation events, sea level rise, extreme heat, ocean acidification, and reductions in cereal crop yields are all significantly more severe under a 2°C warming scenario compared with 1.5°C warming (IPCC, 2018).

Locally, Durham faces risks from sea-level rise as a coastal community. The region is already experiencing and is expected to continue to see higher winter temperatures, more heat waves, increases in overall precipitation, and increases in the portion of precipitation that falls as rain instead of snow.

In order to limit global warming to 1.5°C, anthropogenic (human-caused) carbon dioxide emissions must be reduced by 45% from 2010 levels by 2030, and net-zero carbon emissions must be achieved globally by 2050 (IPCC, 2018). Cities and towns around the world are responding to this call to action. Over 10,000 cities globally have joined the Global Covenant of Mayors on Climate and Energy. Through policy innovation and diffusion, cities are upgrading to clean energy sources, promoting energy efficiency, and adopting more sustainable land use practices.

Why Include Nitrogen?

Nitrogen footprints are important to measure for a number of reasons. First, nitrous oxide (N_2O) is a potent greenhouse gas. While there is a much lower volume of it emitted than carbon dioxide, it has nearly 300x the global warming potential or potency, so a greenhouse gas inventory is not complete without it (IPCC, 2014).

Nitrogen dioxide (NO_2) is an air pollutant. Exposure to the gas can irritate the respiratory tract, causing coughing, wheezing, and difficulty breathing (EPA). In addition, when nitrogen enters waterways, often via fertilizer runoff, the influx of nutrients enables excessive growth of algae in the water. These algal blooms consume the oxygen in the water, leaving an anoxic environment that cannot support other species, in a process known as eutrophication. UNH research has found high nitrogen levels in the Great Bay Estuary, leading to habitat degradation, eelgrass loss, and fish kills (McDowell et al., 2014). Nitrogen has environmental, public health, and economic impacts and therefore needs to be tracked alongside carbon.

Methodology

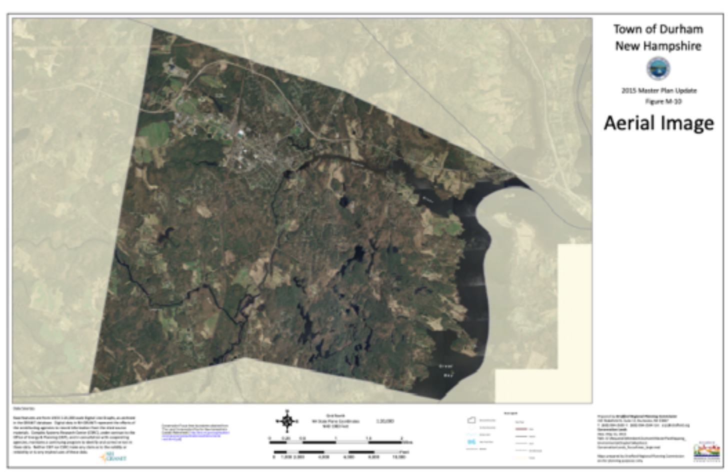
The methodology for data collection in this inventory is informed by the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), a globally recognized standard that facilitates accurate, transparent, and comparable municipal inventories. The analysis is conducted in the UNH Sustainability Indicator Management and Analysis Platform (SIMAP).

Boundaries

Organizational Boundaries

Durham is starting with a Local Government Operations (LGO) inventory, and as such the organizational boundaries are municipal-owned facilities and operations. These facilities are largely within Durham's geographic boundaries (Figure 2), with the exception of the Five Corners Town Well and the Oyster River Solar Array, both of which are located in the neighboring Town of Lee. The temporal boundaries are calendar year 2019.

Figure 2. Aerial Map of Town of Durham Geographic Boundaries



Source: Town of Durham, Master Plan Update, 2015.

Emissions Scopes
In line with GPC standards, emissions are categorized into three scopes, as follows:

Table 1. GPC Standard Emissions Scopes

Scope	Description	Examples
1	Direct emissions occurring physically within the municipality	Stationary fuel combustion, in-boundary transportation, in-boundary waste and wastewater, agriculture, land use, industry
2	Purchased electricity from the grid	Heating, cooling, electric usage in buildings
3	Indirect emissions occurring outside the municipality	Power transmission and distribution, out-of-boundary transportation, out-of-boundary waste and wastewater

Adapted from: Fong, Wee Kean, et al, 2015.

Emissions Sectors
Within these emissions scopes, GPC identifies the following sectors: Stationary Energy; Transportation; Waste; Industrial Processes and Product Use (IPPU); Agriculture, Forestry, and Other Land Use (AFOLU); and other indirect emissions (GPC, 2015).

Applying this framework to Durham, stationary energy covers the fuel, mainly natural gas and propane, that is burned to heat municipal facilities. It also includes electricity purchased from the grid to power facilities. Transportation emissions are from the combustion of gasoline and diesel fuel to power the municipal fleet. The waste sector includes the wastewater treatment plant as well as waste collection and disposal at Turnkey Landfill.

For this inventory, Industrial Processes and Product Use and Agriculture, Forestry, and Other Land Use were not tracked. As Durham's local government operations do not include industrial production or agriculture, these sectors are not applicable. When expanding to a community inventory, it may be of interest to include emissions from product use, particularly from electronics and refrigerants, to examine consumption-based climate impact in the Town. A summary of information included by sector and scope is provided below.

Table 2. Data Collected by Sector and Scope

Sector	Scope 1	Scope 2	Scope 3
Stationary Energy	Fuel combustion (natural gas, propane, etc.) in municipal buildings	Grid-supplied electricity	Not included.
Transportation	Gasoline and diesel burned in municipal fleet	Grid-supplied electricity used for transportation	Not included.
Waste	Emissions from waste treated inside city, regardless of origin	N/A	Emissions from waste generated by city but treated outside city

Data Collection

Stationary Energy for Town-Owned Facilities

For the majority of municipal buildings, electric and natural gas usage data were collected from Town utility bills with Eversource and Unitil, respectively. A few buildings were billed separately, including the Wastewater Treatment Plant (WWTP) and Fire Station. The WWTP reported its own electricity, fuel oil, and propane usage. The Fire Station occupies part of a service building owned by the University of New Hampshire and thus energy consumption data was reported by the UNH Campus Energy Manager.

Fleet

Durham's municipal fleet uses unleaded gasoline and diesel. The Durham Business Manager reported transportation fuel consumption.

Waste

Municipal solid waste, recycling, and compost tonnage was reported by the Director of Operations in the Public Works Department.

The following table summarizes the sources of data collection.

Table 3. Sources of Data Collection

Sector	Category	Source of Data	Explanation
Stationary Energy	Electricity	Eversource	Grid-supplied electricity to most municipal buildings
		Department of Public Works	WWTP electricity reported directly from Wastewater Superintendent
		UNH	Fire Department energy data reported directly from UNH Campus Energy Manager
		Solrenview	Solar output from arrays on Library, Police Station, and Churchill Rink
		ReVision	Solar output from Oyster River Solar Array
		Chargepoint	Electricity use at EV charging stations
	Natural Gas	Unitil	Grid-supplied natural gas to certain buildings
	Other Fuel	Department of Public Works	Propane and fuel oil use reported directly from Wastewater Superintendent
Transportation	Municipal Fleet	Business Office	Municipal fleet fuel data reported directly from Business Manager
Waste	Municipal Solid Waste	Department of Public Works	Weight of trash, recycling, and compost reported directly from Department of Public Works

SIMAP

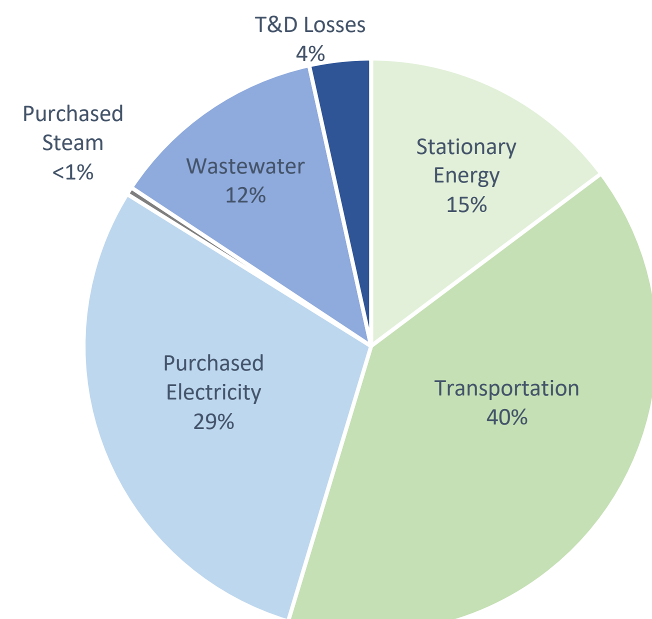
The Sustainability Indicator Management and Analysis Platform (SIMAP) was used to calculate the final carbon and nitrogen footprints, based on the fuel, utility, and waste data collected, as described above. SIMAP converts this activity data to greenhouse gas emissions measured in metric tons of carbon dioxide equivalent using emissions factors. The 2019 standard emissions factors programmed into SIMAP were used. Custom emissions factors were used for the Durham Wastewater Treatment Plant and UNH Cogeneration Plant which services the Fire Station; these were based on previous studies conducted at UNH. In addition, AR5, the latest version of the IPCC global warming potentials guide (a measure of potency of a greenhouse gas relative to carbon dioxide) was used.

Results

Carbon Footprint

Durham's 2019 municipal operations emitted a total of 1194.51 $MTCO_2e$. For context, this volume of emissions is equivalent to approximately 258 passenger vehicles driven for one year or 202 homes' electricity use for one year (EPA Greenhouse Gas Equivalencies Calculator). This is low for a municipal carbon footprint (see Figures 4-5 for comparisons with other municipalities).

Figure 3. 2019 Municipal Carbon Emissions by Sector



Broken down by sectors, the municipal fleet was the largest carbon emitter at 40% of total emissions, followed by purchased electricity at 29%, stationary fuel to heat Town-owned facilities at 15%, fugitive emissions from wastewater at 12%, and electricity transmission and distribution losses at 4%.

These results are tabulated below with the addition of solid waste. Solid waste is reported as negative emissions because Durham's waste is taken to Turnkey Landfill, which recovers methane gas to generate electricity at the UNH Cogen Plant. Since the methane that would have been emitted from the waste is captured and used, the waste is considered to have negative methane emissions. However, the Town should be aware that the Turnkey landfill gas to energy project will reach the end of its useful life around 2030, at which point there will be a spike in emissions from solid waste. Diverting organic waste from the landfill, for example through a municipal compost program, would reduce solid waste emissions at that point.

Table 4. 2019 Carbon Emissions by Sector in Durham

Category	Scope	CO_2 (kg)	CH_4 (kg)	N_2O(kg)	$MTCO_2e$
Stationary Fuel	1	181,477	22	1	194.62
Transportation	1	490,045	13	9	492.81
Wastewater	1	0	0	571	151.18
Purchased Electricity	2	356,952	9	13	360.70
Purchased Steam	2	4,649	2	2	5.34
Solid Waste	3	0	-1,888	0	-52.85
Transmission & Distribution Losses	3	42,273	1	2	42.72

Durham's carbon emissions can be further broken down by source within each category. The results of this breakdown are as follows.

Table 5. 2019 Carbon Emissions by Source

Category	Source	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	$MTCO_2e$
Stationary Fuel	Natural Gas	124,720	12	0	125.13
	Propane	41,328	7	0	41.64
	Distillate Oil (#1-4)	27,672	4	0	27.85
Transportation	Diesel Fleet	254,922	1	1	255.15
	Gasoline Fleet	235,122	13	8	237.66
Purchased Electricity	Electricity	356,952	9	13	360.70
	Steam (Fire Station)	4,639	2	2	5.32
	Other (Fire Station)	10	0	0	0.01
	Transmission and Distribution Losses	42,273	1	2	42.72

Solid Waste	Landfilled Waste (methane capture)	0	-1,888	0	-52.85
Wastewater	Wastewater Treatment Plant (aerobic)	0	0	571	151.18

This level of granularity is useful for prioritizing emissions reduction efforts in each sector. For example, the majority of stationary fuel emissions are from natural gas, so reduction efforts should focus there.

Nitrogen Footprint

Durham had a nitrogen footprint of 7.61 MT, with 92% of the nitrogen coming from the Wastewater Treatment Plant.

Table 6. 2019 Nitrogen Emissions by Sector

Category	Scope	N_2O (kg)	NOx (kg)	Other N (kg)	$MTCO_2e$
Stationary Fuel	1	1	120	0	0.04
Transportation	1	9	1,486	0	0.46
Wastewater	1	571	0	6,615	6.98
Purchased Electricity	2	13	349	0	0.11
Purchased Steam	2	2	33	0	0.01
Transmission & Distribution Losses	3	2	41	0	0.01

A 2014 UNH study examined nitrogen influent and effluent data for the Durham Wastewater Treatment Plant to calculate a customized nitrogen removal factor. The calculated factor of 0.000049 kg N/gal equates to removal of 74% of nitrogen, already well above the average aerobic wastewater treatment facility (Schiappa and Leach, 2014). Subsequent facility upgrades further improved the nitrogen removal efficiency to 85-95% depending on the time of year and whether UNH is in session. Using an average estimate of 90% nitrogen removal, this equates to an emissions factor of 0.0000189 kg N/gal (Leach, 2020).

This is excellent nitrogen removal performance for a wastewater treatment facility. Durham can benchmark its efforts against another high-performing municipality, the neighboring City of Dover, which has a nitrogen removal efficiency of approximately 80% following extensive system upgrades in 2016 (Kaspari, 2018).

Contextualization of Emissions Results
To understand Durham's emissions in a larger context, it helps to compare to other municipalities in New Hampshire as well as to an earlier estimation of Durham's greenhouse gas emissions.

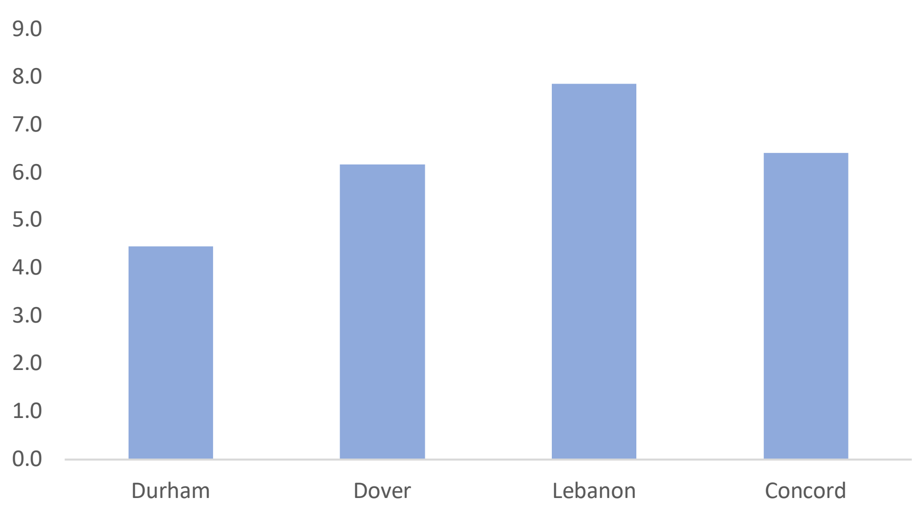
Comparisons with Neighboring Municipalities
The cities and towns of Dover, Exeter, Lebanon, and Concord completed municipal GHG inventories between 2017 and 2019. Below is a comparison of emissions per square foot based on stationary fuel and electricity usage in municipal facilities.

Table 7. Stationary Fuel and Electricity Emissions in Select NH Municipal Facilities

	Stationary Fuel ($MTCO_2e$)	**Electricity ($MTCO_2e$)**	**Gross Square Footage**	**Emissions/GSF ($MTCO_2e/1{,}000ft^2$)**
Durham	194.6	360.7	124,543	4.46
Dover	1,109.7	2,394.5	566,813	6.18
Lebanon	1038	1029	239,467	7.86
Concord	3,265	2,507	898,656	6.42

Normalizing results by square footage of municipal facilities, Durham has the lowest emissions at 4.46 $MTCO_2e/1{,}000ft^2$. Dover has the second lowest emissions at 6.18 $MTCO_2e/1{,}000ft^2$, followed by Concord at 6.42 $MTCO_2e/1{,}000ft^2$ and Lebanon at 7.76 $MTCO_2e/1{,}000ft^2$. This demonstrates the efficacy of Durham's energy efficiency upgrades and maintenance practices in its municipal facilities.

Figure 4. Metric Tons Carbon Emissions Per 1,000 Square Feet



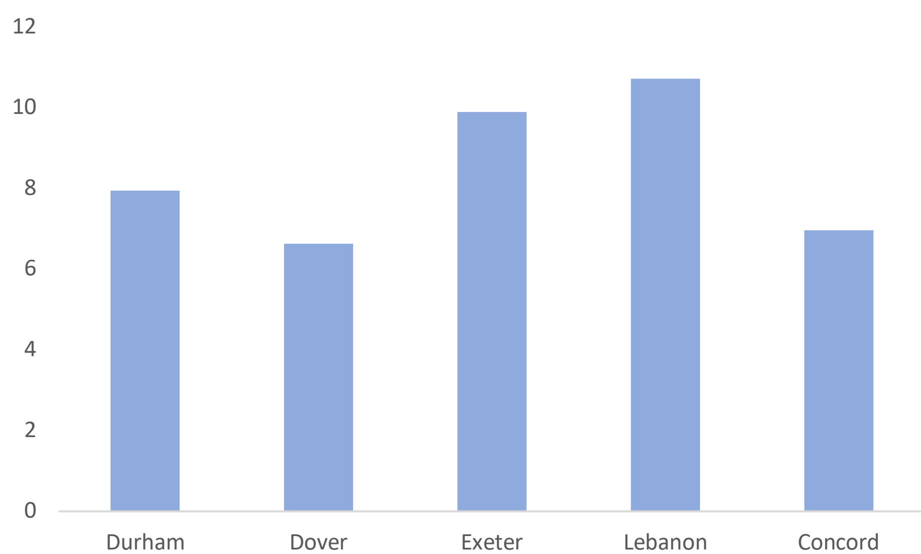
Next, emissions from gasoline and diesel combustion in the municipal fleets were compared, normalizing by number of vehicles in the fleet. For towns which included non-vehicle equipment in their municipal fleet, attempts were made to exclude those entries so that only the number of vehicles were being compared.

Table 8. Gasoline and Diesel Emissions from Select NH Municipal Fleets

	Transportation Emissions ($MTCO_2e$)	Fleet Size (Number of Vehicles)	Emissions/Vehicle ($MTCO_2e$/Vehicle)
Durham	493	62	7.95
Dover	948	143	6.63
Exeter	643	65	9.89
Lebanon	1157	108	10.71
Concord	1546	222	6.96

Durham's municipal fleet has average transportation emissions per vehicle of 7.95 $MTCO_2e$/vehicle. Its emissions are higher than those of Dover and Concord at 6.63 $MTCO_2e$/vehicle and 6.96 $MTCO_2e$/vehicle, respectively. They are lower than Exeter and Lebanon's per vehicle emissions at 9.89 $MTCO_2e$ and 10.71 $MTCO_2e$. While Durham is certainly not underperforming, these results suggest that transportation is an area where efficiency gains may be achieved.

Figure 5. Metric Tons Carbon Emissions Per Fleet Vehicle



Comparisons with Durham 2007 Inventory

A greenhouse gas inventory was completed for Durham in 2007. While the methodologies are not identical, some insights can be drawn from this earlier study.

A table of municipal emissions from the 2007 report is included below. When removing emissions from the Oyster River High School and middle school, which were not included in the scope of this report, Durham's 2007 municipal emissions were estimated at approximately 1,295 $MTCO_2e$.

Table 9. 2007 Carbon Emissions by Source

Table 4: MUNICIPAL SECTOR						
Source	2007		CO2	CH4	N2O	CO2eq
	Quantity used	*Unit*	*MT/year*	*MT/year*	*MT/year*	*MT/year*
Electricity	2,116,774	kWh	656	0.02	0.01	660.73
Natural Gas	8,492	scf	0.46	1.14E-06	9.24E-07	0.46
Oil (heat)	8,188	gallon	83	8.35E-04	7.18E-04	83.37
ORHS	1,690,632	kWh	524.10	0.01	0.01	527.71
ORHS (oil)	6,616	gallon	67.17	6.75E-04	5.80E-04	67.36
MS	519,000	kWH	160.89	4.05E-03	3.44E-03	162.00
MS (oil)	31,196	gallons	316.74	3.18E-03	2.73E-03	317.62
DWWTP	1,193,400	kWh	369.95	0.01	0.01	372.51
DWTP	300,000	kWh	93	2.34E-03	1.99E-03	93.64
DWTP (prop.)	14,582	gallons	84	1.74E-04	1.41E-04	83.85
Total Municipal (MT/year)			2,355	0.05	0.04	2,355.55
Total CO2eq (MT/year)			2,355	0.30	3.31	

Sourced from: Cloutier, Scott and Dr. Kevin Gardner. "Town of Durham, New Hampshire Greenhouse Gas Inventory 2007," for Durham Energy Committee.

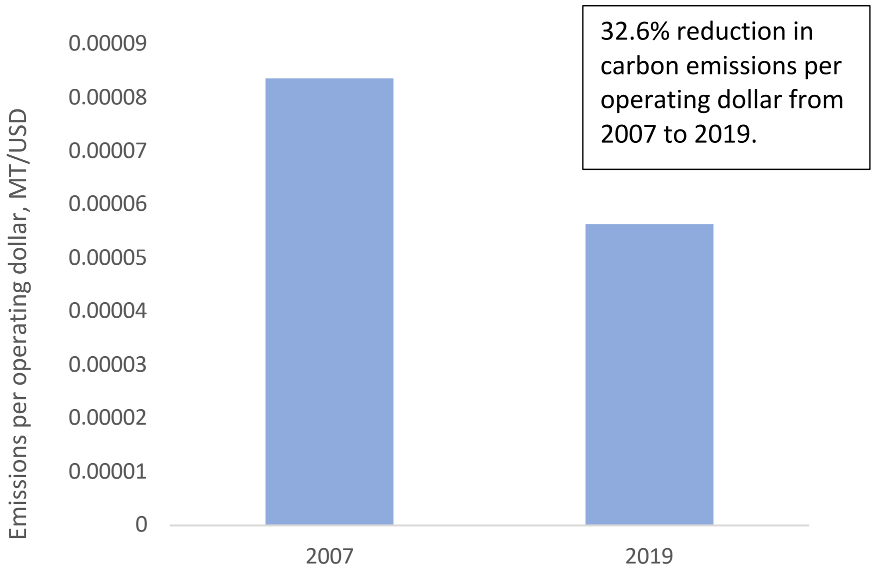
The 2019 estimate of 1,195 $MTCO_2e$ represents an absolute reduction of 100 $MTCO_2e$ or 8% of emissions. During this same time period, Durham's operating budget grew from an inflation-adjusted $15,477,668.76 to $21,192,649.00, an increase of 27%.

Table 10. US Inflation Calculator-Adjusted Comparison of 2007 and 2019 Operating Budgets

	2007 Budget, USD (Raw)	**2007 Budget, USD (Inflation-adjusted)**	**2019 Budget, USD**
General Fund	10,180,964.00	12,553,340.44	16,121,310.00
Water Fund	503,666.00	621,030.66	1,061,430.00
Wastewater Fund	1,656,262.00	2,042,205.51	2,626,824.00
Parking Fund	170,750.00	210,538.30	473,100.00
Depot Road Lot Fund	41,000.00	50,553.85	140,500.00
Library Fund	-	-	514,485.00
Churchill Rink Fund	-	-	255,000.00
Total	12,552,642.00	15,477,668.76	21,192,649.00

Therefore, when factoring in growth in Town operations, emissions per operating dollar declined by 32.6% between 2007 and 2019 (Figure 6).

Figure 6. Durham Metric Tons Carbon Emissions per Operating Dollar, 2007 and 2019



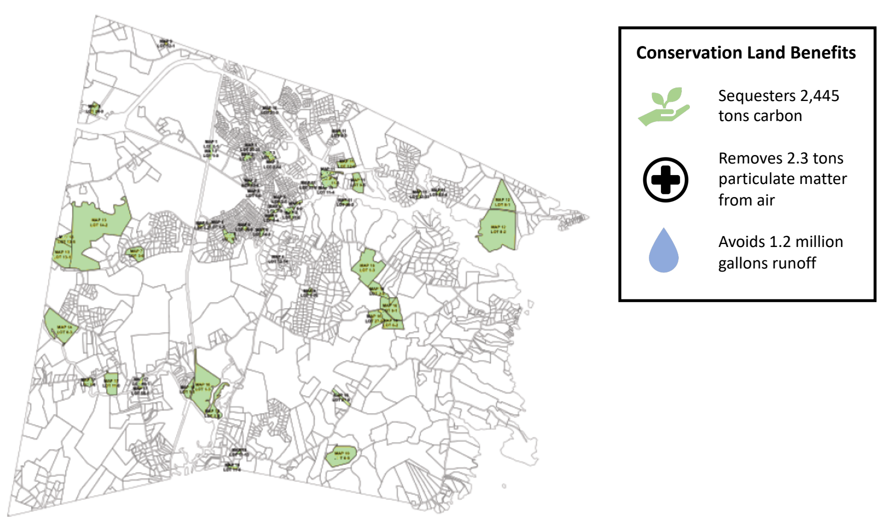
Annual Sequestration

Durham holds a significant amount of conservation land, which among many other benefits, can act as a carbon sink, holding carbon in soil and plant matter and keeping it out of the atmosphere. As part of the effort to understand the Town's carbon and nitrogen impacts, data on Durham's conservation land holdings were entered into the USDA Forest Service's i-Tree Canopy tool to estimate carbon sequestration and other environmental benefits (Appendix III).

Benefits of Conservation Land

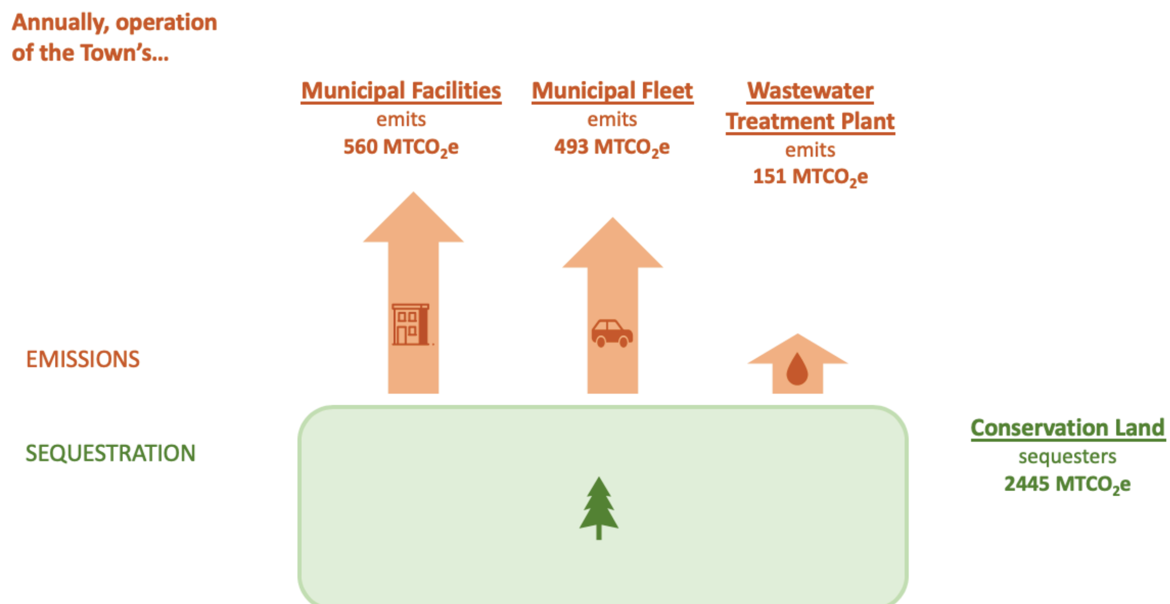
The Town of Durham's 977 acres of land held in conservation areas or easements sequester an estimated 2,445 MTCO$_2$e annually and hold a stock of 61,392 MTCO$_2$e. Conservation land also improves air and water quality, removing an estimated 2.3 tons of small particulate matter (PM) between 2.5 and 10 microns each year and avoiding 1.2 million gallons of surface runoff.

Figure 7. Environmental Benefits of Town-Owned Conservation Land in Durham



The relative scale of emissions and sequestration in Durham is represented below. While not a direct carbon offset, it is clear that conservation land is key for maintaining a sustainable carbon balance. These results demonstrate the significant added environmental and health value of Durham's conservation land (see Appendix III for full discussion).

Figure 8. Visualizing the Carbon Balance in Durham



Recommendations
Durham has done a tremendous amount to limit its carbon and nitrogen footprints, as seen from its solar power purchase agreements, the wind power-sourced Renewable Energy Credits it purchases for its Wastewater Treatment Plant, and the large amount of land it holds in conservation. To further advance Durham's work as a sustainability leader, the following next steps are recommended.

Immediate Opportunities
I. Join the Global Covenant of Mayors
To affirm its commitment to climate goals, Durham could formally sign onto the Global Covenant of Mayors for Energy and Climate (GCoM). GCoM is an alliance of over 10,000 cities worldwide taking on voluntary climate action. A number of Durham's New England neighbors participate, including Kennebunk, York, Burlington, and Northampton. GCoM provides a variety of resources to participating cities, including measurement guidelines and a common reporting platform, and technical assistance from regional chapters.

There are five primary requirements for joining GCoM and Durham is well on its way towards meeting them. First, the Town must conduct a community-scale GHG inventory within two years of joining. This local government operations inventory is a starting point for the community inventory, and further recommendations are included in Appendix II for expanding the inventory. Second, Durham needs a Climate Risk and Vulnerability Assessment, which the 2019 Sustainability Fellow, Justin Klingler, already completed. Third, Durham needs to set a formal GHG reduction target, likely in the form of a percent reduction in emissions based on the community inventory. Fourth, the Town needs to develop a Climate Action Plan within three years of joining. The following recommendations in this report serve as a starting point for such a plan. Finally, GCoM requires an Energy Access Assessment, which can be a part of the Climate Action Plan document, though precise guidance on this requirement is still in progress.

II. Transition the Municipal Fleet to Hybrid-Electric Vehicles

Transportation emissions from the municipal fleet are the largest source of carbon emissions for Durham, representing 40% of municipal emissions. While Durham has identified legitimate cost and power constraints that have prevented the Town from electrifying its fleet in the past, the electric vehicle industry is rapidly evolving. The Town should continue to monitor the market. As a way to formalize this in decision-making, a volunteer member of the Energy Committee or staff member within each municipal department could be designated to give an annual update on the availability and cost of electric vehicle technologies relevant to their departments.

Currently, there is a hybrid electric police cruiser option on the market available at a $4,500 upcharge compared to Durham's current Ford Explorer police vehicles. Traditional police vehicles must keep their engines running in idle for extended periods of time to power radios, electric equipment, and lighting, consuming a great deal of gas. Hybrid vehicles allow the lithium ion battery to power the vehicle's electrical load, only turning the gas engine on periodically to charge the battery. Based on preliminary analysis using a $2.75 average gasoline price, this upcharge would pay itself off from reduced gasoline purchases within two years (Ford, 2020).

Using national averages for gasoline consumption and time spent in idle for police cruisers, the manufacturer estimates that the 2021 hybrid vehicle model saves roughly 12 MT in carbon emissions per year compared to their 2018 standard gas-powered model (Ford, 2020). If all 13 police cruisers in Durham were transitioned to hybrid vehicles, this could amount to over 150 MT carbon savings, or about 12.5% of Durham's total municipal emissions. It would be the equivalent of removing 32 passenger vehicles driven for one year off the road (EPA Greenhouse Gas Equivalencies Calculator).

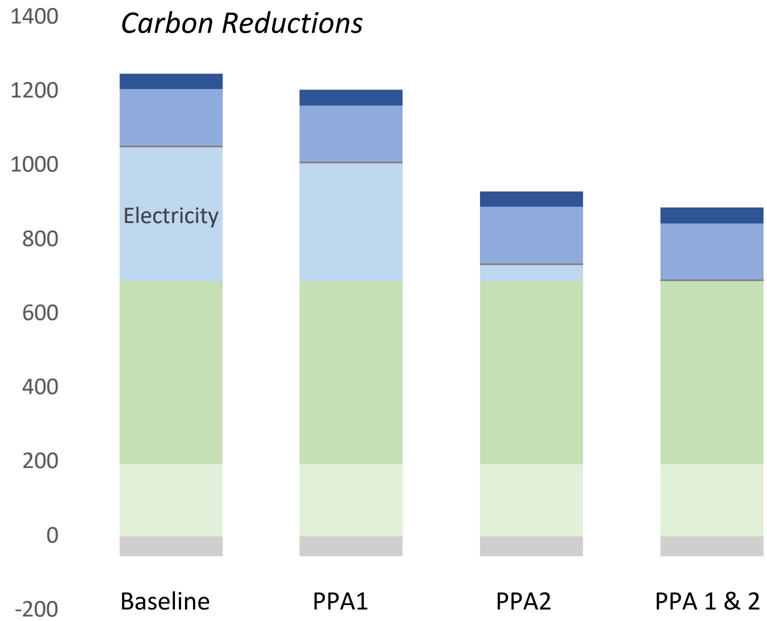
For vehicles that do not currently have technologically feasible or cost-effective electric options, the current model of downgrading the usage of each vehicle until the end of its usable life should be continued. When such vehicles do need to be replaced, the Town should implement a green procurement policy to favor best-in-class fuel efficiency for its vehicles. The California Low Emission Vehicle Standards is a possible third-party certification to use to guide this policy.

III. Buy Out Solar Power Purchase Agreements

The next largest emissions sector is purchased electricity at 29% of total emissions. Durham participates in two power purchase agreements (PPAs). PPA 1 with ReVision Energy covers the solar arrays on the library, police station, and Churchill Rink, and PPA 2 with IGS Solar covers the Oyster River Solar Array at Packers Falls Road in Lee. PPA 1 was established in 2013 and is already available for buying out, while PPA 2 will be available for purchase in 2022.

Purchasing PPA 1 lowers the purchased electricity emissions total from 360 MT to 317, resulting in 43 MT of emissions savings. This lowers Durham's overall carbon footprint by 3.5%. Purchasing PPA 2 lowers electric emissions by 317 MT from 360 MT to 43 MT. This represents a 26.5% reduction in Durham's overall carbon emissions. Finally, buying out both PPAs eliminates purchased electricity emissions. This 360 MT abatement is a 30% reduction of Durham's total carbon footprint (Figure 8).

Figure 9. Solar Buy-Out Scenarios with Associated Carbon Reductions



The financials of buying out PPA 1 are compelling. The current fair market value for all three solar systems on the library, police station, and Churchill Rink is $90,000. ReVision has agreed to donate the system on the police station if the other systems are purchased, so the Town would pay $86,000 for the three systems.

ReVision's models indicate that the solar arrays will generate an additional 3,633,556 kWh electricity over the next 32 years. Using an estimated $0.11/kWh price of electricity, the future value of the arrays is estimated at close to $400,000. Modeled future value includes an inverter replacement in year 20, estimated at $26,000. It also includes operation and management (OM) expenses using ReVision's Bronze OM package at a flat fee of $450/system/year plus an additional $4.00/kW generation (ReVision, 2018).

It is also worth noting that due to pest interference with the solar array at the library, the solar panels were replaced in 2018 and squirrel guards were installed. As such, the Town would be paying for an 8-year-old system, while actually receiving a 2-year-old array at the library.

IV. Maintain High Energy Efficiency
Stationary energy is the third largest emitting sector at 15% of total emissions. Stationary energy use in Durham is primarily combustion of natural gas for heating, as well as some propane and distillate oil.

In conjunction with this inventory, energy benchmarking of municipal facilities was completed using the EPA Portfolio Manager tool. The study revealed that Durham's buildings as a whole score highly on energy efficiency when compared to a national median, with nine of the twelve buildings examined scoring well above average (Appendix I). The high energy efficiency performance of Durham's buildings is indicative of the Town's consistent adherence to energy efficiency best practices, with advanced building controls, LED streetlights, and regular inspection and maintenance of air distribution, heating, and cooling systems. The WWTP main building is heated with electric heat pumps, which are a particularly efficient option that can reduce electric demand for heating by half and may be considered for other facilities moving forward (DOE).

One strategy that Durham could employ to ensure improved energy performance over time is adopting a procurement policy, or Environmentally Preferable Purchasing (EPP) policy. A simple procurement policy could be adding language in contracts to prefer products with certain approved third-party environmental certifications, whenever available (EPA, 2008).

The State of New Hampshire adopted its first EPP policy in 2006, which is managed by the NH Bureau of Purchase and Property (NERC, 2015). New Hampshire recognizes the following certifications under this policy: ASTM, Energy Star, EPEAT, R2, and e-Stewards (NERC, 2015). There are a variety of other certifications that neighboring states in the Northeast use and Durham could consider incorporating, such as the EPA Comprehensive Procurement Guidelines, EPA Design for the Environment, Forest Stewardship Council, Green Seal, LEED, NSF/ANSI, and WaterSense (NERC, 2015).

Adopting existing third-party standards for equipment, office supply, and transportation purchases is a relatively simple and standardized way to implement an environmentally favorable procurement policy.

V. Update Land Acquisition Policy
Based on results from the preliminary carbon sequestration study, Durham's conservation land provides significant benefits beyond the conservation and recreation services typically considered in land acquisition decisions. The Town should therefore revisit its Guidelines for Acquiring Legal Interest in Conservation/Open Space Land document. In section 7, "Criteria to Evaluate Real Estate Interests for Conservation/Open Space," additional criteria should be added that factor in the benefits of carbon sequestration and air pollution reduction.

Follow-up Work and Future Opportunities

I. Community Inventory

Having now developed a baseline for municipal operations emissions, expanding to a community GHG inventory should be a follow-up goal. Municipal emissions are a small subset of a Town's total community emissions. A community inventory would provide a fuller picture of sustainability in Durham and would provide the information necessary to assess other potentially high-impact policies such as municipal aggregation, community solar, and weatherization or home energy improvement campaigns. Since a community inventory requires a variety of additional data beyond what applies to local government operations, an overview of next steps and recommended data sources can be found in Appendix II.

II. Municipal Aggregation

As of October 1, 2019, Senate Bill 286 came into effect, granting New Hampshire communities the opportunity to pursue municipal aggregation, or community power (Clean Energy New Hampshire, 2019). Municipal aggregation combines and leverages the purchasing power across a community. The Town purchases electricity in bulk from a competitive supplier, allowing more choice in power source and potentially better prices (Clean Energy New Hampshire, 2019). While purchasing the solar arrays in the Town's existing power purchase agreements would completely offset municipal electricity usage, this strategy could be considered for the wider community.

To inform decision making around municipal aggregation, a community-wide inventory is important to conduct in addition to this municipal government inventory. Understanding the aggregate electricity usage of residents, as well as trends in this usage over the past few years, would help to design an appropriate community power program.

When considering municipal aggregation, it is important to integrate diversity, equity, and inclusion principles. Aggregating the Town's power source should allow for competitive energy prices as well as more direct choice in the source of power. The Town should strive to ensure that electric rates are affordable to low and moderate-income residents, making the program accessible to all. Additionally, the siting of the power source selected for a community power program and what communities are in proximity to it is an important consideration.

Community power could offer a way for Durham to enhance social justice in the broader region. There are social implications embedded in the energy system. Examining the New England Electric Grid, the sources feeding the grid may have greater negative impacts on low-income populations. For example, the Seabrook nuclear power plant is sited in a lower-income Seacoast town. Hydro Quebec, which supplies the New England grid, has created controversy building dams in First Nations' lands. Therefore, in addition to lowering its greenhouse gas emissions, renewable community power could give Durham local control over socially responsible energy source and siting.

III. Hire Sustainability Coordinator
Reaffirming the recommendation from Durham's 2019 Climate Resilience Assessment and Planning report, Durham would benefit from hiring a Sustainability Coordinator (Klingler, 2019). Sustainability is by nature multisectoral work and Durham's many sustainability initiatives are spread across a variety of departments and committees. Developing a staff position dedicated to managing Durham's sustainability efforts and communicating across departments would greatly facilitate this work, while freeing up time for other staff members to focus on their many other responsibilities.

Conclusion
Durham has demonstrated a consistent commitment to sustainability work, from its solar investments to its significant holdings of conservation land. The Town has already reduced its carbon footprint greatly with energy efficiency retrofits in its facilities and offsetting the WWTP's electricity usage with wind power. These efforts are reflected in this already low baseline carbon and nitrogen municipal inventory.

Going forward, Durham may consider the following strategies:

- Affirm its commitment to climate action and tap into a common reporting framework and technical assistance by joining the Global Covenant of Mayors for Climate and Energy.
- Transition its police fleet to hybrid electric vehicles, lowering emissions and saving money in reduced gasoline purchases in as little as two years.
- Maintain best-in-class fuel efficiency for all other vehicles.
- Save money on electricity and supply all municipal electric needs by exercising buy-out options of its solar power purchase agreements.
- Continue to maintain best operational practices for energy efficiency in facilities and adopt environmentally conscious procurement policy going forward to purchase best-in-class appliances and supplies.
- Add carbon sequestration and air pollution reduction benefits to land acquisition policy.
- Divert organic waste from landfills via a community composting program to prevent a spike in methane emissions when the Turnkey landfill gas to energy project ends.
- Hire Sustainability Coordinator to oversee these efforts and identify others.

These strategies have potential to reduce greenhouse gas emissions, reduce fleet and facility operating costs, increase community resilience to climate change, and keep the air and water clean for the residents of Durham.

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Appendix

I. Energy Benchmarking Results

Building	Energy Star Score
Town Hall	80
Wastewater Treatment Plant	44

The Energy Star score is a single number between 1 and 100 and represents the relative energy efficiency of a building compared to buildings of the same type nationwide. A score of 50 means the building operates at median efficiency. A score of 75 or higher is considered very efficient and may be eligible for Energy Star Certification. The calculation is based on source energy, which includes all fuel required to operate the building, both burned on site and purchased from the grid, as compared to site energy which only includes the former.

Durham's LEED Silver certified Town Hall could qualify for additional Energy Star certification. In order to get the building certified, Durham would need to get its application certified by a Professional Engineer or Registered Architect who conducted a site visit. The building may then be audited by the EPA at any point, in which case utility bills and documentation of building attributes would need to be provided.

The Wastewater Treatment Plant had an Energy Star score of 44, slightly below the national median of 50. While wastewater plants are challenging to compare because they are constrained with site-specific challenges, the 2017 WWTP energy audit provides a list of possible energy conservation approaches for the plant. It should also be noted that the energy efficiency score does not factor in the source of energy and the Town purchases wind power Renewable Energy Credits for the WWTP's electricity use.

Property Name	Property GFA - Calculated (Buildings) (ft^2)	Source EUI ($kBtu/ft^2$)	Weather Normalized Source EUI ($kBtu/ft^2$)	National Median Source EUI ($kBtu/ft^2$)	% Difference from National Median Source EUI
Durham Public Library	21,000	51	51.1	143.6	-64.5
Durham Police Department	9,186	127.7	127.8	124.9	2.2
Town Hall	14,396	74	74.1	120.2	-38.4
Wastewater Treatment Plant	15,360	814.4	817.3	765.5	6.4
Churchill Rink	23,676	24.6	24.5	112	-78
Courthouse/Old Brick Town Hall	5,138	32.7	32.3	89.3	-63.4

Transfer Station	2,500	80	81.1	89.3	-10.4
Fire Station	8,222	130.6	130.8	124.9	4.6
Public Works	10,500	50.7	50.8	89.3	-43.2
Old Concord Road Pump Station	968	329.6	330.2	491.9	-33
Oyster River Road Pump Station	330	107.8	108.3	387.2	-72.2
Dover Road Pump Station	2,040	565.1	567.4	2383.7	-76.3

Building types that are not eligible for Energy Star scores instead receive an Energy Use Intensity (EUI) score. The EUI measures the building's energy use as a function of its size and activity and is reported in energy per square foot. In addition to the EUI calculation, Portfolio Manager provides the percentage higher or lower the score is compared to the national median for that building type. Nine buildings scored well above the national average, with between 10 and 78% less energy use compared to similar building types nationwide. Three buildings scored slightly (2-6%) below the national average in energy efficiency.

When interpreting the percent difference in energy performance from the national median, note that the Portfolio Manager offers a limited number of building types for comparison. There were direct building type matches for the library, police station, fire station, wastewater treatment plant, and ice rink. The town hall and courthouse were assigned "Office." The transfer station and Public Works building were assigned "Public Services - Other." All pump stations were assigned "Drinking Water Treatment and Distribution." For the buildings assigned to more general categories, the national median may be a less accurate point of comparison.

II. Community Inventory Guidelines

The following are the data categories recommended for a community inventory, organized by order of data entry in SIMAP.

Scope 1

Stationary Energy

- Contact natural gas and heating oil providers in the region to inquire about their ability to release aggregate data of fuel sold in Durham.
- If it is not possible to obtain aggregate fuel data, use regional fuel consumption data and scale down to Durham's population. Household averages in the Northeast from 2015 can be found here: https://www.eia.gov/consumption/residential/data/2015/c&e/pdf/ce2.2.pdf
- Work with facilities at Oyster River Cooperative School District or obtain numbers from their published report, if applicable.

- School district serves Durham, Lee, Madbury—determine metric for allocating emissions, perhaps by percentage of total students who come from Durham.

Transport Fuels

- Look into availability of vehicle registration data and fuel sales from gas stations in Town.
- Work with school district for school bus fuel use.

Fertilizer

- Reported fertilizer use by farms.

Animals

- Contact farms to estimate number of livestock by animal type.
    - 2015 Master Plan Agricultural Chapter, Agricultural Commission identified at least 48 parcels of land with agriculture or gardening activity, covering 1,288 acres. Contact Agricultural Commission to obtain this list.

Refrigerants & Chemicals

- Estimate refrigeration and air conditioning equipment in Town using EIA 2015 Residential Energy Consumption report: https://www.eia.gov/consumption/residential/data/2015/.

Scope 2

Utility Consumption

- Work with Eversource to get aggregate residential electricity consumption in Durham.
- If it is not possible to obtain aggregate data from Eversource, use Northeast average electricity consumption numbers found here: https://www.eia.gov/consumption/residential/data/2015/c&e/pdf/ce1.2.pdf

Renewable Energy

- Contact ReVision and other local solar providers for aggregate data.

Scope 3

Food

- Food consumption by residents can be approximated using reported behavior from the 2018 Consumer Expenditure Report. Average food consumption for New England can be found here: https://www.bls.gov/cex/2018/division/division.pdf
    - Food consumption data is provided by category at the bottom of page 1 going on to page 2. Use the New England column and copy the data over to Excel. This is household expenditure data, so multiply by number of households in Durham.
    - Convert this expenditure data into weight by using average price per kilogram datasets for each food product. See the following paper for methodology: https://iopscience.iop.org/article/10.1088/1748-9326/ab76dc/meta

- Enter the food weight data in SIMAP. SIMAP has 18 food categories, which align well but not identically with the 19 CE food categories. Below is a recommended way to line up the categories.

Consumer Expenditure Category	SIMAP Category
Cereals and cereal products	Grains
Bakery products	Grains
Beef	Beef
Pork	Pork
Other meats	Chicken
Poultry	Chicken
Fish and seafood	Fish
Eggs	Eggs
Fresh milk and cream	Milk
Other dairy products	Cheese
Fresh fruits	Fruits
Fresh vegetables	Vegetables
Processed fruits	Fruits
Processed vegetables	Vegetables
Sugar and other sweets	Sugars
Fats and oils	Oils
Miscellaneous foods	Grains
Nonalcoholic beverages	Liquids
Alcoholic beverages	Liquids

- Note: Consumer Expenditure Report data is collected via two-week surveys of a sample population. There is a high degree of uncertainty in this self-reported data, with many respondents underestimating daily food consumption.

- Depending on status of Oyster River Cooperative School District GHG inventory, request school lunch invoices to include in community report.

Paper

- Request invoice of paper purchases from schools.

Waste & Wastewater

- Same as LGO inventory; WWTP serves community at large and Town collects waste.

Sinks

Compost

- Contact Mr. Fox Composting, Agri-cycle energy, and other compost providers in the area for quantity of residential compost collected.
- For residents who compost in their yards without a compost provider, survey on compost practices.

Non-Additional Sequestration

- See Appendix III—estimation of carbon sequestration in all of Durham is included there.

III. Land-based Carbon Sequestration

Carbon Sequestration and Carbon Stock

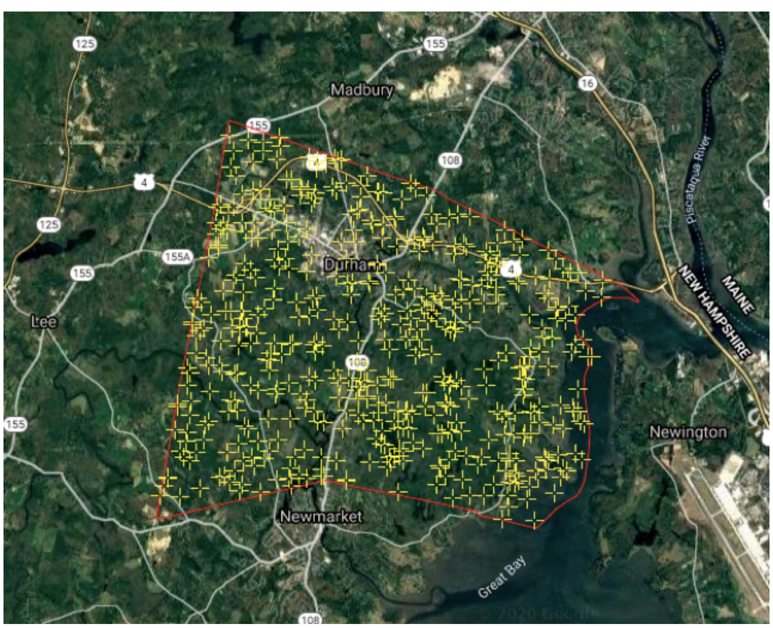
One of the many benefits of conservation land is that it can act as a carbon sink, holding carbon in soil and plant matter and keeping it out of the atmosphere.

Carbon sequestration is the uptake of carbon dioxide by soil and vegetation, thereby storing the carbon in the organic matter and taking it out of the atmosphere (Cascadia Consulting Group, 2017). Carbon stock is the total amount of carbon stored in the soil and vegetation. It can be thought of as "the sum of all past sequestration, minus emissions of stored carbon" (Cascadia Consulting Group, 2017). In other words, sequestration is the flow of carbon into the total carbon stock or reserve held in the land.

Methodology

The i-Tree Canopy tool, put out by the USDA Forest Service and collaborators, was used to estimate carbon sequestration and stock in Durham's land. After selecting Durham's geographic boundaries, the program utilizes random sampling, highlighting a point on an aerial image that the user then classifies into one of several land-cover classes: Trees/shrubs, Grass/herbaceous, Impervious buildings, Impervious road, Impervious other, Soil/bare ground, and Water. For this study, 500 points were selected, shown in the figure below.

Figure 1. Random sampling of points in Durham



Based on the land class chosen, i-Tree provides an estimate of carbon sequestration in the study area. The program uses average carbon sequestration for urban and community areas based on 28 cities and 6 states in the US. Average carbon storage is estimated at 7.69 kilograms carbon per meter squared (kg C m^{-2}) +/- 1.36 kg C m^{-2}, and average net carbon sequestration is 0.205 kg C m^{-2} $year^{-1}$ +/- 0.041 (Nowak, 2013).

Results

Forested land in Durham

Durham has 8,283 acres of forested land, comprising approximately 52% of the Town's total land area. The following table shows the estimated carbon benefits when sampling the entirety of the Town.

Figure 2. i-Tree Reported Estimate of Carbon Benefits

Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (mi^2) ± SE
H	Grass/Herbaceous		38	19.00 ± 2.77	4.71 ± 0.69
IB	Impervious Buildings		5	2.50 ± 1.12	0.62 ± 0.28
IO	Impervious Other		5	2.50 ± 1.12	0.62 ± 0.28
IR	Impervious Road		12	6.00 ± 1.68	1.49 ± 0.42
S	Soil/Bare Ground		7	3.50 ± 1.32	0.87 ± 0.33
T	Tree/Shrub		107	53.50 ± 3.53	13.27 ± 0.87
W	Water		26	13.00 ± 2.38	3.22 ± 0.59
Total			**200**	**100.00**	**24.80**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (kT)	±SE	CO_2 Equiv. (kT)	±SE	Value (USD)	±SE
Sequestered annually in trees	11.59	±0.76	42.50	±2.80	$988,349	±65,155
Stored in trees (Note: this benefit is not an annual rate)	291.07	±19.19	1,067.26	±70.36	$24,821,157	±1,636,276

Currency is in USD. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Carbon sequestered is based on 0.874 kT/mi^2/yr. Carbon stored is based on 21.940 kT/mi^2. Carbon is valued at $23,256.92/kT. (English units: kT = kilotons (1,000 tons), mi^2 = square miles)

Forested land in Durham sequesters an estimated 39,720 $MTCO_2e$ (+/- 1,780) annually. The estimated carbon stock in its land is 997,440 $MTCO_2e$ (+/- 44,610).

Town-owned conservation land

Scaling down to municipal-owned lands, the Town of Durham holds 977 acres of land in conservation areas or easements. This is equivalent to 1.53 square miles or 6.2% of the total study area of 24.80 square miles.

Durham's municipal conservation lands therefore sequester an estimated 2,445 $MTCO_2e$ annually and hold a stock of 61,392 $MTCO_2e$. This is a conservative estimate as the study in all of Durham includes developed land, leading to a higher proportion of impervious, non-vegetated areas than is the case in conservation land.

Discussion

Demonstrated value of conservation land

These results demonstrate significant added value of Durham's conservation land. In addition to recreational and community value, conservation land provides a host of ecosystem services, including carbon sequestration, flood mitigation, and water and air purification. Durham's municipal-owned land sequesters approximately 2,445 $MTCO_2e$ annually, more than the Town's government operations emit. Of course, municipal operations emissions are a small subset of the Town's overall emissions, but this clearly shows how critical conservation land is for maintaining a balance of carbon emissions and uptake. If this land were developed in the future, that would represent a large new source of emissions that would make it challenging to meet climate goals.

The i-Tree program also estimates air pollution and avoided runoff benefits. Forested land in all of Durham removes 36.73 +/- 1.64 tons of particulate matter (PM) between 2.5 and 10 microns each year. Of this, 2.28 tons of PM removal can be attributed to Town-owned conservation land. These small particles can enter the lungs and bloodstream, contributing to health impacts from asthma and decreased lung function to irregular heartbeat and heart attacks (EPA). These air purification benefits keep Durham residents healthier and lower healthcare expenditures.

Figure 3. i-Tree Reported Estimate of Air Pollution Benefits

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (T)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	3.52	±0.16	$679	±30
NO2	Nitrogen Dioxide removed annually	23.52	±1.05	$596	±27
O3	Ozone removed annually	200.10	±8.93	$62,632	±2,795
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	36.73	±1.64	$33,078	±1,476
PM2.5	Particulate Matter less than 2.5 microns removed annually	10.33	±0.46	$133,545	±5,960
SO2	Sulfur Dioxide removed annually	18.42	±0.82	$274	±12
Total		**292.62**	**±13.06**	**$230,804**	**±10,301**

Currency is in USD. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in T/mi²/yr @ $/T/yr:
CO 0.283 @ $193.17 | NO2 1.889 @ $25.36 | O3 16.074 @ $313.00 | PM10* 2.951 @ $900.53 | PM2.5 0.830 @ $12,928.05 | SO2 1.480 @ $14.85 (English units: T = tons (2,000 pounds), mi² = square miles)

Finally, the i-Tree program estimated that Durham's forested land is responsible for 18.9 million gallons (MG) of avoided runoff, or about 1.2 MG avoided runoff from municipal conservation land. Surface runoff can harm water quality, picking up pollutants, sediment, nutrients from fertilizer, and pesticides from lawns as it flows overland towards a water source. Therefore, maintaining conservation land that prevents runoff by allowing precipitation to infiltrate into the soil helps keep Durham's water bodies clean.

While it is difficult to quantify the benefit of ecosystem services in terms of dollars, a recent study in Downeast Maine attempted to do just that, finding that conservation land in the study area produced an estimated benefit of $653/acre/year (Lichko, 2019).

Limitations

It is important to note that this carbon sequestration estimate is not a formal carbon offset and is therefore not directly subtracted from emissions in the main greenhouse gas inventory for the Town. It is entered in SIMAP as non-additional carbon sequestration for tracking purposes.

Durham would need to seek formal offset verification in order to subtract this carbon sequestration estimate from the Town's emissions. There are a variety of offset certification programs, with one of the most common being the Verified Carbon Standard. These official offsets, or "transferrable emissions units," would be included in the inventory in a separate offsets section to ensure transparency and prevent double counting of emissions reductions. Similarly, if Durham purchased offset credits from projects outside the town, these offsets would be separately reported in the inventory and not directly deducted from the reported inventory results. These standards help ensure high environmental integrity of all emissions reductions reported.

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IV. Previous Initiatives

Durham has undertaken an impressive array of sustainability initiatives in the past. A highlighted selection of these efforts is included below, drawn from a presentation by Town Administrator Todd Selig to the Environmental Business Council of New England in 2019 (Selig, 2019).

- Durham has significant wetlands, forested land, and conservation land that helps filter and control stormwater runoff during periods of high rainfall. Durham has meticulously identified high value conservation land and the Town and UNH now permanently protect or own 44.7% of land area in town.
- Durham is working to acquire a 40-acre parcel along the Oyster River that would directly link the downtown to 2,000 acres of conservation land.
- Durham has nearly 300 feet of new living shoreline at Wagon Hill Farm. The shoreline is being restored, re-graded, armored with natural hard and soft-scape materials, and planted to restore the salt marsh and tidal buffer that has eroded over time.

- Durham’s Public Works Department tracked twelve unusually significant storm events between 2006-2018. As a result, the Town proactively worked with Eversource to improve local electrical grid infrastructure and has identified 6 critical facilities and 11 bridges within the 100-year flood plain.
- The Town has developed an energy checklist to encourage developers, applicants for Site Plan or Subdivision review, and applicants for building permits to systematically consider the energy efficiency of Durham’s new or renovated buildings and sites that are being developed or subdivided. Completion of this checklist and a meeting with the Building Inspector and a representative of the Durham Energy Committee is required prior to any Planning Board site plan or subdivision approval.
- Durham’s building ordinance automatically adopts the International Energy Conservation Code upon publication of the code updates every three years. Although Durham is located in one of four NH Counties identified as Zone 5, for conservation purposes Durham by local option self-aligns with Climate Zone 6, which includes more northern counties and more stringent insulation standards.
- Durham has replaced its street lighting with highly energy efficient LED fixtures.
- Durham has installed a total 120 kW of solar capacity at the police station, public library, and Churchill Rink, and an additional 640 kW solar array at Packers Falls Road in Lee, NH under two power purchase agreements.

V. Social Sustainability

Another key element of sustainability, as well as a goal in Durham’s 2015 Master Plan, is building a diverse and welcoming community. Residents noted in the 2011 Visioning Forum that Durham’s population is ‘too homogenous’ (Master Plan, 2015). The 2018 American Community Survey, put out by the US Census Bureau, revealed that Durham is approximately 90% White, 6% Asian, 3% two or more races, and 1% Black or African American (US Census Bureau, 2018).

A lack of affordable housing options prevents working class populations, young people, and seniors or fixed-income populations from living there. Durham consistently has higher median home prices than the larger Strafford Region, with the gap reaching higher than a $100,000 difference in 2004 (Master Plan, 2015). Only 12.5% of owner-occupied housing units in Durham are classified as affordable to a four-person household making the median income of $84,300, the standard set by the New Hampshire Revised Statutes Annotated (RSA) 674:59: Workforce Housing Opportunities. Of those, 3.5% of housing units were affordable to people earning 60% or less of median income (Master Plan, 2015). Increasing the affordable housing stock with smart environmental planning and design principles can both encourage a more diverse population and meet climate goals.

The Town of Durham has recently established a Housing Subcommittee to the Economic Development Committee, which is a great resource for encouraging a balanced and diverse housing stock, while understanding limiting factors in Durham such as conservation land restricting the amount of land available for housing, thereby driving prices up, and a desire to limit student housing downtown. With deference to the expertise and local knowledge of the

Committee, the following approaches are offered for consideration, based primarily on the Strafford Regional Planning Commission's 2015 Regional Housing Assessment and New Hampshire Housing Finance Authority.

1. Consider increased development density in downtown areas with high walkability and access to public transit, thereby avoiding sprawl.
    a. Offering density bonuses to developers could incentivize the construction of affordable housing in these areas (New Hampshire Housing Finance Authority, 2014).
    b. Zoning to allow mixed-use districts could take advantage of existing space, with commercial uses on the first floor of buildings and apartments or condos on the upper floors (BCM Planning LLC, 2015).
2. Allow retrofits and subdivision of existing single-family homes into smaller duplexes and triplexes (BCM Planning LLC, 2015).
    a. When retrofitting existing building stock, integrate climate solutions by prioritizing energy efficiency. Energy bills can represent a high portion of expenses for low and moderate-income tenants; therefore, efficiency serves the dual purpose of lowering energy use and bills.
3. Support the development of accessory dwelling units alongside existing single-family homes, diversifying the housing stock and creating a new stream of income for homeowners (Gray, 2019).
    a. Revisit acreage needed per unit and limits on number of units per structure or number of structures per lot (BCM Planning LLC, 2015).
4. Explore manufactured housing cooperatives and multifamily housing cooperatives (BCM Planning LLC, 2015).
5. Partner with the New Hampshire Housing Finance Authority, Workforce Housing Coalition of the Greater Seacoast, Strafford Regional Planning Commission, and other relevant stakeholders to identify and implement new affordable housing opportunities.

Not only could these steps increase accessibility in the community, prioritizing the addition of efficient, affordable housing will support older residents' desire to age in place and will attract young professionals and families needed for the economy and local school system (New Hampshire Housing Finance Authority, 2014).