TOWN OF CARRBORO

NORTH CAROLINA

TRANSMITTAL **PLANNING DEPARTMENT**

DELIVERED VIA: ☒ *HAND* ☐ *MAIL* ☐ *FAX* ☒ *EMAIL*

To: **Board of Aldermen**
David Andrews, Town Manager

From: **Randy Dodd, Environmental Planner**

Thru: **Patricia McGuire, Planning Director**
Christina Moon, Planning Administrator

Date: **November 8, 2016**

Subject: **Draft Community Climate Action Plan Follow Up**

Summary

At the June 21, 2016 meeting, the Board of Aldermen directed staff to assess the benefits of the draft Community Climate Action Plan and report on an implementation schedule; the purpose of this memo is to provide a response. "Benefits" as used herein refers primarily to climate mitigation, or reduction of greenhouse gas emissions. Other "benefits" are briefly presented, including climate adaptation and resilience, a qualitative perspective of the "co-benefits" of climate action, and monetary benefits through a relatively new economic concept, "the social cost of carbon". An appendix with implementation timing considerations has also been prepared.

Information

Community Greenhouse Gas Inventory

The degree of future climate change is dependent on greenhouse gas emissions[1]. Actions taken today to reduce greenhouse gas emissions mean less warming and less severe impacts[2]. In the

[1] Melillo, Jerry, Terese Richmond, and Gary Yohe. "National Climate Assessment". January 1, 2014. Accessed April 16, 2015. http://nca2014.globalchange.gov/highlights#section-5682.

Cities for Climate Protection campaign, the first step to pursue climate mitigation planning and action is to complete an inventory of greenhouse gas emissions. For Carrboro, an inventory was first attempted for Orange County (in collaboration with other local governments) in 2007 (using 2005 data), and was subsequently updated for Carrboro by a UNC Capstone Team (using 2009 data). In 2015, a second UNC Capstone Team worked with the Town to create an updated community greenhouse gas inventory for 2012[3]. This inventory revealed a total greenhouse gas emissions for the community of 112k tons CO_2 equivalent (CO_2e), which equates to 5.5 tons CO_2e per capita. The inventory accounted for emissions for the area within the municipal limits for "direct" GHG emissions (e.g., combustion of natural gas and motor vehicle fuels) along with limited "indirect" GHG emissions, most notably from the use of purchased electricity. As further discussed below, this community scale methodology is not explicitly designed to more holistically or comprehensively account for the full spectrum of emissions from production to consumption from household/personal or business activities.

Subsequent to completion of the greenhouse gas inventory, climate mitigation and adaptation recommendations have been drafted with support from the Energy and Climate Task Force. The draft Community Climate Action Plan (CCAP) recommends a 50% per capita reduction in emissions by 2025. This recommendation is specifically articulated as cutting "the carbon footprint in half over the next 10 years for the entire community, Town operations, the buildings and transportation "sectors", and ultimately each resident and business". The plan includes recommendations organized around themes of community integration, energy efficiency in buildings, transportation, renewable energy, ecosystem protection and restoration, and (following on community input) climate mitigation through food choices. In considering the addition of food related recommendations, some initial thoughts regarding accounting for food (and other) consumption related emissions are included below.

Emissions Estimates Based on Household Consumption

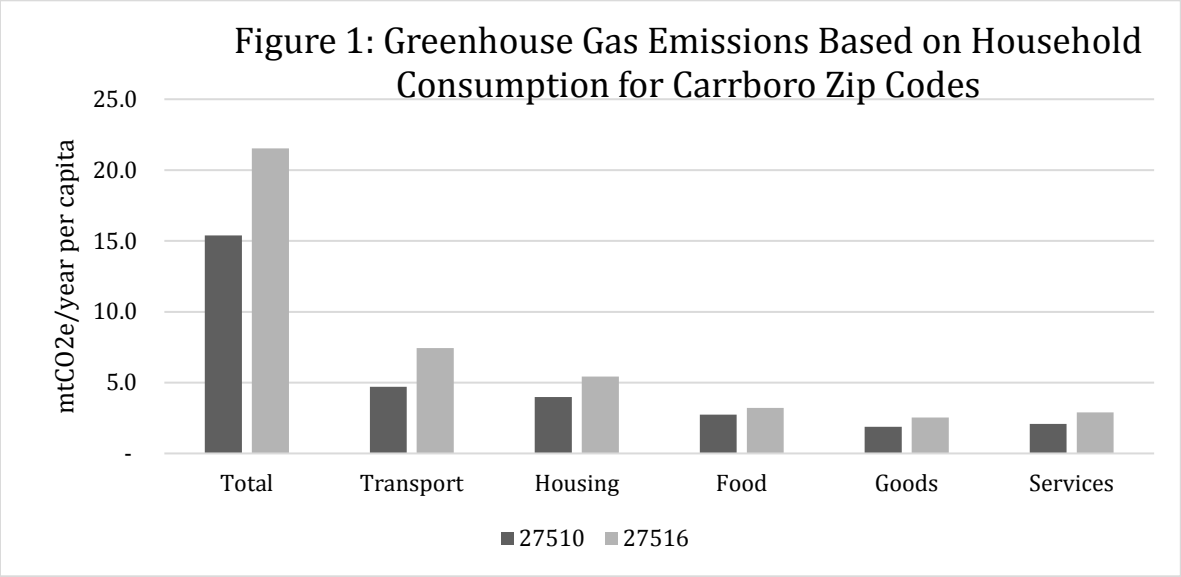
Researchers at UC-Berkeley have developed emissions estimates for the entire U.S., using a different method than in the community inventory that accounts for the entire "lifecycle" ("cradle to grave") of activities that households purse that lead to emissions.[4] These estimates have been completed for five different sectors associated with individual households: transportation, dwellings, food, goods, and services, by zip code (Figures 1 and 2; the emissions shown are for the entire zip code areas across jurisdictional boundaries).

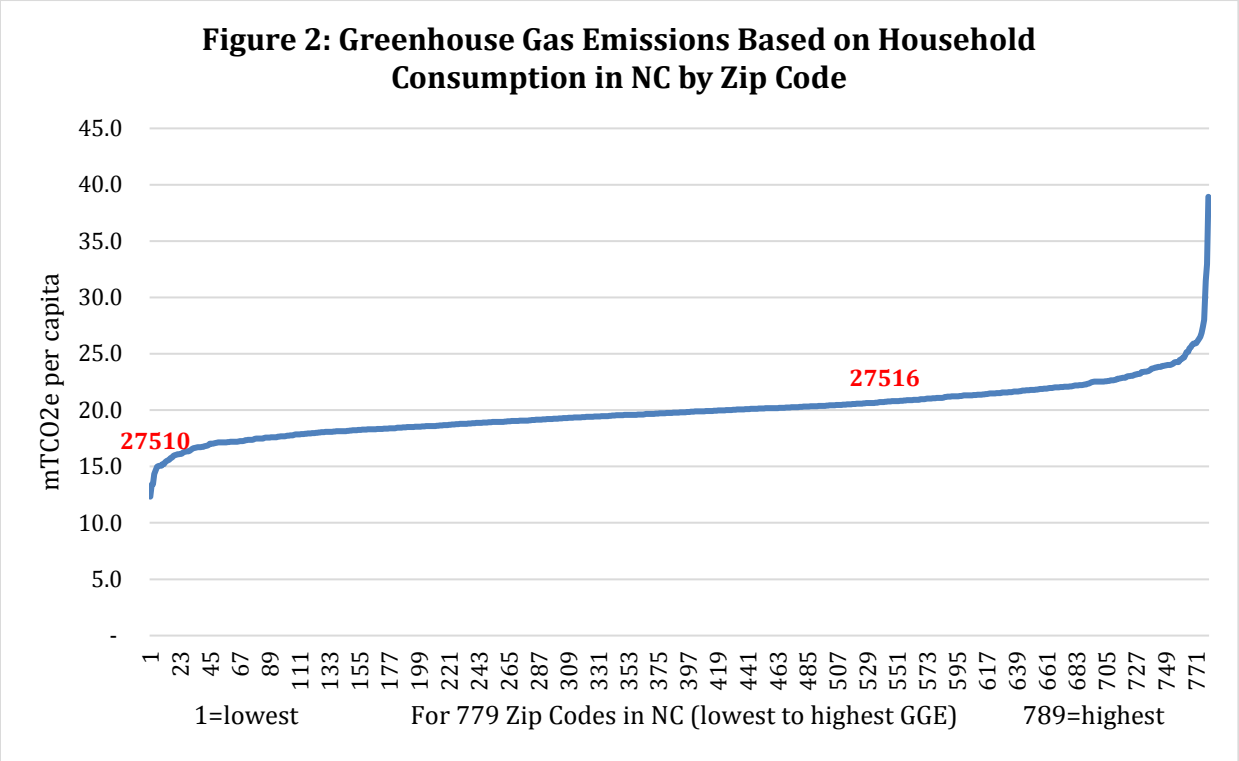
---

[2] "Climate Change Mitigation." United Nations Environment Programme. Accessed March 24, 2015. http://www.unep.org/climatechange/mitigation/ Climate change mitigation is defined as efforts to reduce or prevent emission of greenhouse gases

[3] The inventory is available at http://www.townofcarrboro.org/DocumentCenter/Home/View/2788

[4] Christopher M. Jones and Daniel M. Kammen, Spatial Distribution of U.S. Household Carbon Footprints Reveals Suburbanization Undermines Greenhouse Gas Benefits of Urban Population Density. Environ. Sci. Technol., 2013, dx.doi.org/10.1021/es4034364. Sponsored by UC-Berkeley Renewable and Appropriate Energy Laboratory, California Air Resources Board, National Science Foundation. Online calculator and maps available at http://coolclimate.berkeley.edu/calculator





A few points are worth emphasizing from this work:

1) The total emissions per capita relative to the community based methodology results in about 3 times higher estimates. Conceptually, this is a function of geographically limiting community based emissions estimates to activities within the municipal limits and to direct emissions and a limited portion of the indirect emissions. For example, the

increase in transportation emissions is mostly due to the increase in vehicle miles travelled to account for trips outside of Carrboro. In addition, the food, goods, and services emissions are not accounted for in the community based estimates.

2) There is a notable difference between emissions estimates for the 27510 and 27516 zip codes. The greater emissions in 27516 is due to differences between contributing factors such as vehicle fuel use and economic indicators (e.g., property value, income).

Additional discussion of the potential for emissions reductions as the plan's recommendations are pursued is provided in the following section.

Anticipated Emissions Reductions from the Community Climate Action Plan

This section provides a qualitative/preliminary assessment of the climate mitigation benefits, by sector, associated with implementing the CCAP.

Community Buildings

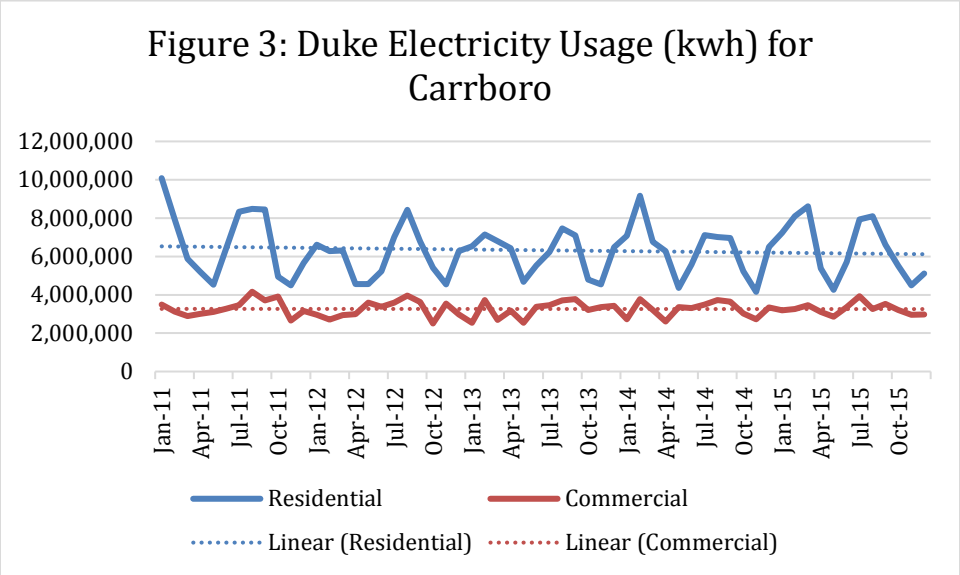
Between 2011 and 2013, with $311k of ARRA federal funding support[5], the Carrboro WISE program was successful in driving energy efficiency retrofits for 113 single-family and multifamily units and providing 5 commercial loans for projects in 3 separate commercial buildings. The projects were estimated to achieve 21% energy savings and a total of almost $40k a year of savings for these homeowners/businesses (Table 1). This resulted in a 0.1% reduction of the total community buildings emissions footprint. This funding also supported an energy efficiency outreach and education program that reached 77 additional Carrboro residents with support from Clean Energy Durham's "Pete Street" program. Although the WISE/Pete Street efforts reached a small percentage of the entire community during this 2+ year window, it nevertheless offers a foundation and lessons learned for looking towards future reductions from energy efficiency improvements for buildings.

Table 1: Benefits from the Carrboro WISE program (single-family, multifamily and commercial)

Total number of units	113
Estimated MMBTU saved/year	1686
Average estimated % saved per unit	21%
Estimated kWh (electricity) saved/year	364373
Estimated Therms (natural gas) saved/year	3372
Estimated cost savings ($)/year	$39,685[6]
Estimated CO_2 reduction/year	89.7 metric tons

[5] This public funding provided administrative, subsidy/incentive, and technical support and leveraged significant private funds from homeowners and businesses as well as additional subsidies from utilities.
[6] These cost savings were estimated using 2013 PSNC ($1.05) and Duke Energy ($0.093) rates.

To obtain a larger perspective beyond what is possible with data from the WISE program alone, it is helpful to look at community wide data and trends in energy usage and therefore greenhouse emissions associated with buildings. Duke Energy has provided monthly electricity use data aggregated for all Duke residential and commercial accounts in Carrboro from January, 2011 through the end of 2015[7]. An analysis of this data (Figure 3) indicates that residential electricity use declined by about 1% per annum during this time, while population increased by about 2% per annum.



This downward trend will need to be approximately doubled to meet the 50% by 2025 per capita emissions reduction goal. Commercial use remained very stable, with essentially no measurable reduction during this period.

How might pursuit of the actions in the CCAP affect the residential and commercial electricity use trends? An important consideration is that only 33% of homes are owner occupied, compared to 59% renter occupied (the remaining 8% of homes are vacant)[8]. The draft CCAP includes several recommendations that consider the low level of owner occupancy. With regard to emissions from commercial buildings, the Town established an Energy Efficiency Revolving Loan Fund for small businesses in 2012 and issued several loans shortly thereafter. As these loans are being repaid, the fund is being replenished so that a growing balance is available for new loans.

Conclusion #1, residential buildings: Achieving a 50% reduction by 2025 is difficult given the ownership (mostly non owner occupied), building stock (a high percentage of multifamily, a

[7] Duke Energy is the electricity provider for about 90% of Carrboro.
[8] "Carrboro, NC Homes and Housing." USA City Facts. Accessed April 9, 2015. http://www.usacityfacts.com/nc/orange/carrboro/homes/ .

sector that is harder to achieve significant reductions in), and potential reduction per building[9]. Furthermore, a more detailed implementation plan associated with the measures included in the draft plan will need to be developed to determine the specific and most effective and cost effective steps for accelerating improvements in energy efficiency.

Conclusion #2, commercial buildings: If the trend observed from 2011-2015 continues, a lower level of reduction in per capita emissions from commercial buildings through efficiency improvements than in residential buildings can be expected in the absence of significant new initiatives. Given the recent trend, it is reasonable to conclude that achieving a 50% reduction by 2025 will be even harder to achieve with commercial buildings than with residential buildings. As with residential buildings, an implementation plan will need to be developed to accelerate improvements in energy efficiency.

Transportation

Appendix A provides a summary of information used in emissions estimates from the 2012 greenhouse gas inventory. There are several important methodological point that are relevant to transportation oriented climate action planning.

1) Using state statistics from federal data as a proxy for the transportation factor set may not capture the unique characteristics for Carrboro and could therefore be introducing a bias into emissions estimates to the degree that vehicle type and fuel economy deviate from these statistics. For example, data and analysis from the USDOE[10] that draws on local vehicle registration data reveals that the community fleet has a higher average fuel economy per vehicle (26.5 mpg versus 23.3 mpg) than assumed for the 2012 community greenhouse gas inventory estimates.
2) Using an aggregated snapshot for VMT at the time of the inventory does not allow for a more robust assessment of trends and patterns to help understand how VMT has changed over time, nor how it varies at different Carrboro locations. It is therefore limited in offering insights into potential emissions reduction strategies and past and future progress towards the 50% reduction goal. Local data indicate that traffic counts at different locations in Carrboro over the past decade demonstrate distinct differences and changes over time[11]. Additional work is needed to insure that these trends and patterns are captured and accounted for in emissions tracking, and inform transportation strategies to reduce emissions.

It is also important to consider the many efforts that the community has been actively involved in for a number of years (e.g., fare free transit, support for bicycle and pedestrian infrastructure and safety, land use planning and transportation demand management that supports mode

[9] Experience from the WISE program suggests that 40% is the maximum expected reduction per home through no cost/low cost efforts and retrofits, i.e., short of redevelopment or extensive rehabilitation
[10] http://apps1.eere.energy.gov/sled/#/
[11] http://citybeautiful21.com/2015/09/03/central-carrboro-traffic-went-down-from-1997-to-2013/

choices) that are relevant to reductions in greenhouse gas emissions from transportation[12]. Examples of relevant initiatives include the Safe Routes to Schools Program and pursuit of Bicycle Friendly Community standards. Key partners include NCDOT, the Durham-Chapel Hill-Carrboro Metropolitan Planning Organization, Triangle Transit, Chapel Hill Transit, UNC, and the Carrboro Bicycle Coalition.

Conclusion #1: At this juncture it is difficult to assess how transportation emissions have changed and could change over time. In addition, the community based method which is limited to trips in Carrboro is not able to capture changes associated with community members' larger transportation behaviors and choices. A helpful step for tracking changes/reductions in transportation emissions for future community inventories could be the development of a new dataset and methodology. Confidence in emissions estimate is less than in the buildings sector where energy use data is more directly measured through metered utility accounts.

Conclusion #2: Carrboro has been involved in important initiatives that have reduced greenhouse gas emissions from transportation for the past 1-2 decades, and has established plans, dedicated resources and partners, and community capacity to continue with these efforts. Vehicle MPG has also steadily increased for several decades. This also is in some contrast to the situation with emissions associated with buildings. All things considered, it seems reasonable that the transportation sector may have a stronger foundation in historical emissions reductions, however, as discussed, additional work is required to more accurately assess historical emissions and assess what might be possible for reductions by 2025.

Renewable Energy

The North Carolina Sustainable Energy Association (NCSEA) tracks renewable energy installations in North Carolina. Based on the NCSEA estimate of 268 kilowatts (kW) of renewable energy generation (via photovoltaics, or "PV") for 52 installations in Carrboro, the total PV generation as of 2016 is a little under 1% of the total electricity demand. A considerable majority of the solar capacity in Carrboro was installed in 2014 and 2015 as part of back-to-back "Solarize" campaigns[13]. To make significant progress towards the 50% emissions reduction target by 2025, renewable generation will have to ramp up quickly.

What is a reasonable estimate of the maximum amount of solar electricity that can potentially be generated in Carrboro based on physical realities of terrain, solar insolation (available sunshine), and the nature of the built environment? It can be inferred, hypothetically, by extrapolating from an estimate included in the Chapel Hill greenhouse gas inventory[14], that 3% of Carrboro may be suitable for solar installations from rooftops, open land, and parking lots, and a total of 116k megawatt hours (MWh) of potential annual energy generation could mitigate up to 81k

[12] These documents are available at http://www.townofcarrboro.org/719/Transportation
[13] http://solarize-nc.org/locations/
[14] http://ie.unc.edu/files/2016/03/community_carbon_report.pdf (p.21)

mTCO2e. In other words, almost all of the current community electricity demand could conceivably be generated by photovoltaics based on solar access alone, which is equivalent to about 72% of the total community emissions, exceeding the 2025 climate action reduction goal. The Department of Energy has estimated that about 175k square meters of rooftop space is available in Carrboro, which is equivalent to about 34k MWh of potential annual generation, or a little more than 1/3 of the amount extrapolated above.[15] However, economic constraints will drive adoption of new solar capacity more than physical constraints, and it is probably overly optimistic to project that solar generation will approach what is hypothetically/physically possible by 2025 based on either total or rooftop area available.

Achieving more on the order of 5-10% renewable energy generation of total electricity use in Carrboro by 2025 may be more realistic. There are factors working towards an acceleration of adoption of solar electricity. Most notably, the rapid reduction in the cost of hardware has led to market forces being close to a "tipping point" at which solar electricity production could rapidly accelerate. However, there are other factors that will limit new solar uptake, such as the discontinuation of the state renewable energy tax credit, the state-level prohibition of 3rd party sales of solar electricity, the scheduled phased expiration of the federal tax credit between 2019 and 2021, roof/building orientations and constraints, and as with energy efficiency of buildings, the high proportion of homes that are not owner occupied. Solar installations have already declined in 2016 relative to 2014 and 2015 in large part due to the discontinuation of the state tax credit[16]. Finally, there are no opportunities, in all likelihood, in Carrboro for significant utility scale (~1 mW and larger) solar installations because of constraints such as the need for larger open areas, less expensive land access, and proximity to substations with capacity.

There could be a niche for perhaps 20-50 kW systems that can be developed through innovative financing mechanisms and community collaboration[16, 17]. Because of rate structures and the anticipated continued rise in electricity costs, the opportunity is enhanced for sites that can take advantage of net metering, while maintaining electrical generation on an annual basis at or below the onsite electrical demand. Figuring out the financing to create cash flow positive scenarios and making solar installations straight forward and simple for property owners seem to be primary constraints limiting the acceleration of solar installations.

A final note is that community members can also help offset emissions from electric generation through renewable energy programs such as NC Green Power[18], Piedmont Electric's community solar program[19], and other organizations that support renewable energy generation. Accessing

[15] http://apps1.eere.energy.gov/sled/#/results/buildingsandindustry?city=Carrboro&abv=NC&section=electricity&zip=27510&currentState=North%20Carolina&lat=35.9107512&lng=-79.08145230000002

[16] Rob Pinder, personal communication

[17] The 2016-17 operating budget has included resources to initiate this exploration.

[18] https://www.ncgreenpower.org/

[19] https://pemc.coop/save-energy-money/renewable-generation/community-solar/

data and including these types of programs in emissions accounting could result in measurable progress towards the climate action goal.

Conclusion #1, electricity use and generation: Reducing emissions from electricity use can be pursued with a two pronged approach: improved energy efficiency in buildings and accelerated uptake in renewable energy generation. As mentioned in the section on buildings, reductions in per capita emissions from the improved energy efficiency is occurring, but at a rate about half as fast as needed to achieve the 50% reduction goal. Given current constraints, it is unlikely that solar installations in Carrboro can account for a majority or perhaps even a significant percentage of the remaining desired reductions in emissions by 2025. At the same time, at a minimum and with no major intervention, it is likely that small, incremental progress will continue. The success of the Solarize campaigns demonstrates the potential for more rapid progress, especially with new state or federal level policy changes and/or innovations to address current financing challenges.

Food Consumption

The food choices that community members make has an impact on greenhouse gas emissions. Adopting more plant-based, local, and organic diets is a viable means that individuals can choose that has an immediate climate mitigation impact. Based on the limited amount of historical attention to inventorying emissions from food choices and consumption in Carrboro, it is beyond the scope of this memo to attempt to assess emissions reduction potential associated with community scale food choices beyond what is discussed above (in "Emissions Estimates from Household Consumption") and from the input provided in the plan's recommendations.[20]

Conclusion #1. Assessing food related emissions associated with community engagement towards a 50% reduction goal at a community scale will require additional work on the accounting methods and data sources. The latest draft of the plan includes a section that addresses this.

Other Recommendations in the Draft Community Climate Action Plan

Additional recommendations in the draft plan pertain primarily to climate adaptation and resilience through urban forestry, stormwater, and landscape management, but they also relate to climate mitigation by acknowledging the carbon sequestration benefits of the community forest. The recommendation relating to increasing the rate of organic waste collection and composting

[20] e.g., Scarborough P., Appleby P.N., Mizdrak A., et al. "Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK". Climatic Change. 2014;125(2):179-192. This UK study found that the mean GHG emissions (lbs. CO2e/day) ranged from 15.8 for high meat-eaters to 6.4 for vegans, with progressively lower emissions between these two being estimated for medium meat eaters, low meat eaters, fish eaters, and vegetarians. There is some uncertainty in extrapolating a UK study to Carrboro given the different populations and potential for differences in diet.

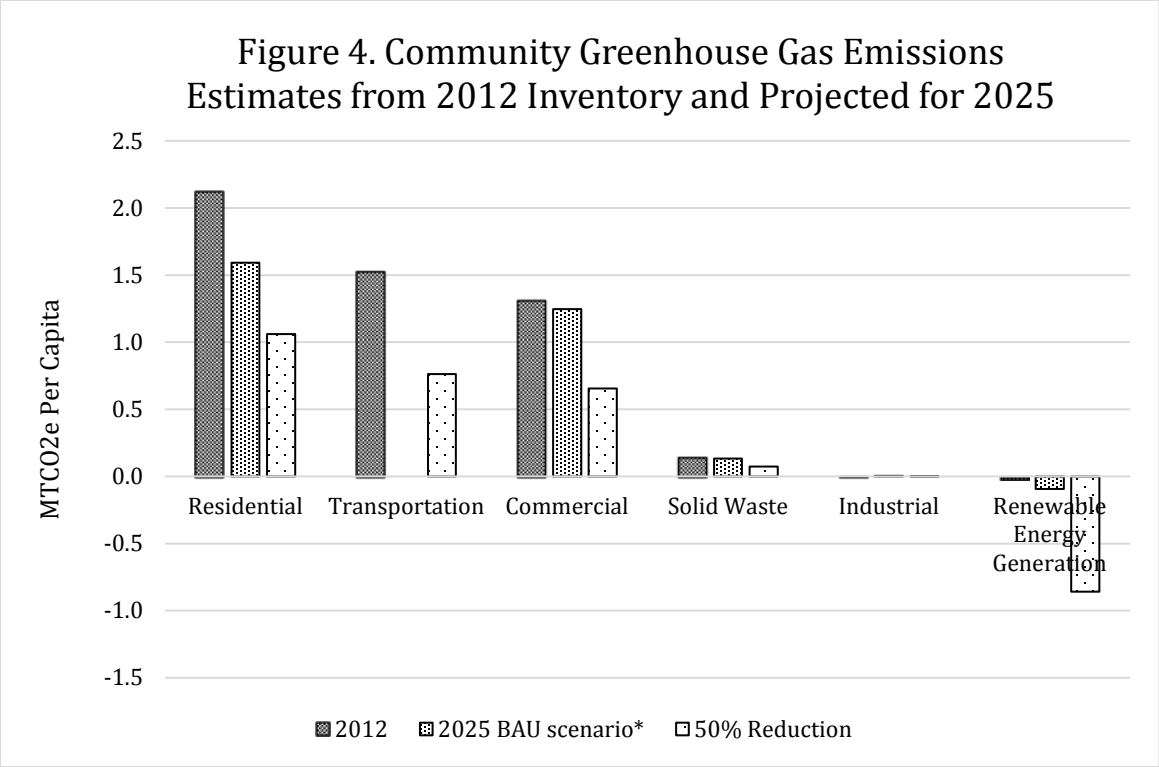
is also relevant to mitigation by reducing emissions associated with waste hauling and methane emissions from the landfill. Methane is 21 times more potent as a greenhouse gas than CO_2; reducing the amount of organics that end up in a landfill is therefore an important step for reducing community GHG emissions[21,22], and at the same time captures the carbon for use in improving local soils. Further reductions in waste generated will also be helpful since Carrboro's solid waste now has to travel to Durham, resulting in a higher transportation footprint. Carrboro is currently pursuing a solid waste study[23] and Orange County is exploring expanded organics collections through a proposed drop off site at Eubanks Road and a pilot program at the Carrboro Farmers Market.[24] Both of these efforts should result in further reductions in emissions.

Conclusion #1: Since solid waste related emissions are small relative to the total community emissions, the expected/potential reductions resulting from future changes in solid waste services will contribute incrementally but not substantially to the 50% reduction goal.

Summarizing Potential Reductions

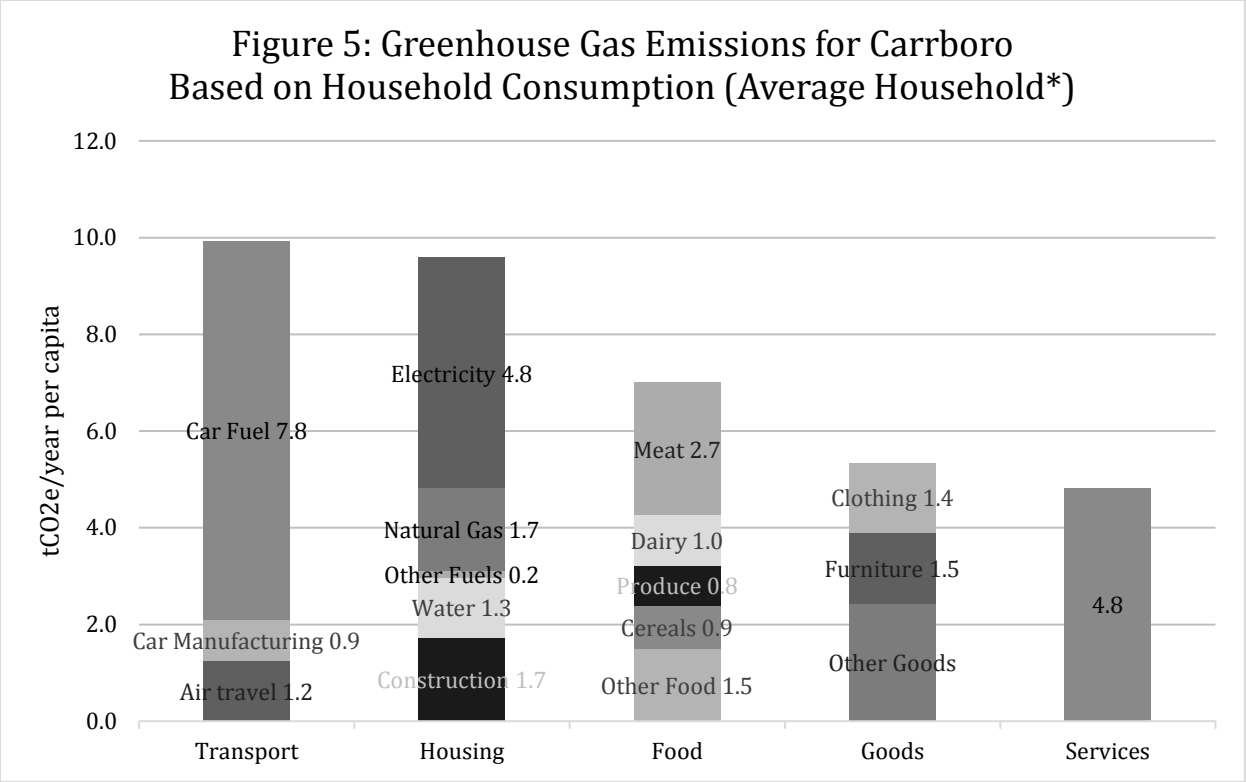
Current and potential emissions from the above discussion are summarized in Figures 4 and 5. Figure 4 presents emissions for the 2012 baseline from the community inventory along with future "business as usual" and 50% reduction scenarios. A "business as usual" transportation estimate is not included given the difficulty in completing this estimate with currently available data. Figure 4 graphically depicts the magnitude of changes expected and needed to approach the CCAP reduction goal for the different sectors and within the context provided by the 2012 inventory data and methodology.

[21] "USCC Position Statement: Keeping Organics Out of Landfills." US Composting Council. Accessed April 15, 2015. http://compostingcouncil.org/admin/wp-content/uploads/2011/11/Keeping-Organics-Out-of-Landfills-Position-Paper.pdf
[22] Daigneau, Elizabeth. "Curbside Composting Added to a Major City: Is It Yours?" Curbside Composting Added to a Major City: Is It Yours? February 1, 2012. Accessed April 15, 2015. http://www.governing.com/topics/energy-env/gov-curbside-composting-added-to-major-city.html .
[23] The bid documents are available at http://www.townofcarrboro.org/bids.aspx?bidid=15
[24] A presentation to the Solid Waste Advisory Group by HDR on longer range options is available at http://www.orangecountync.gov/departments/solid_waste_management/SWAG/HDR_OrganicsPresentation_Nov4.pdf



* "business as usual" inferring no major changes to status quo.

Figure 5 is based on the household consumption approach from UC-Berkeley researchers and available data for an "average" Carrboro household. No attempt has been made to forecast these lifecycle based emissions estimates forward. The estimates and related information do suggest potential alternative strategies that can be considered with finer resolution than is possible with data from the community inventory. For example, household emissions can be calculated for Carrboro that indicate that the lowest (<$10k) annual income households have about one half of the footprint of the highest (>$110k) annual income households. The data and methods have sufficient detail to offer fairly granular assessments to help an individual household understand specific elements of their footprint and create a climate action strategy that fits that household.



* 2.3 persons/household with average gross annual household income ($50k) for Carrboro.
\+ From http://coolclimate.berkeley.edu/calculator

The online resources (calculators, maps, research) available from the Berkeley researchers[+] also offer potentially helpful support with outreach and education.

In summary, this household based data and analysis emphasizes the complexity and many elements that contribute to greenhouse gas emissions footprints from personal to household to community scales, and the importance of thinking holistically.

Other Benefits of Climate Action

The previous sections have been focused on the magnitude of emissions and factors around realizing reduction goals. Appendix B discusses the "co-benefits" of climate action and the potential for synergies with other community goals and values such as environmental quality, affordability, social equity, the local economy, and public health. Appendix C presents the relatively new concept of the "social cost of carbon" which indicates that pursuing the scale of greenhouse gas reductions recommended in the CCAP in Carrboro has a multimillion dollar annual implication when linked to global economic consequences.

Recommendation

It is recommended that the Board of Aldermen receive this staff memorandum.

Appendix A
2012 Greenhouse Gas Inventory Summary and Data Tables

In 2015, a UNC Capstone Team worked with the Town to create an updated greenhouse gas inventory for 2012[25]. This inventory, as with the previous inventories, was pursued using the methods and software developed by ICLEI USA-Local Governments for Sustainability to support community scale emissions estimates. This included reporting for the area within the municipal limits for "direct" GHG emissions (e.g., combustion of natural gas and motor vehicle fuels) along with limited "indirect" GHG emissions, most notably from the use of purchased electricity. According to the UNC Capstone Team, the 5.5 tons CO_2e per capita emissions estimate is amount is relatively low compared to state and national estimates and estimates from neighboring jurisdictions. Chapel Hill's 2012 inventory, which includes emissions from UNC, estimated 21.9 tons of CO_2e per person. The State of North Carolina as a whole emitted 12.7 tons of CO_2e per person in 2011[26] and in 2012 the United States emitted 16.4 tons CO_2e per capita[27]. The world as a whole also had higher per capita emissions (7.65 tons CO_2e) than Carrboro[28]. Carrboro's per capita emissions from this inventory are lower than these other estimates because Carrboro has almost no emissions from industry, and also because some components (e.g., food consumption, goods and services, upstream processes, interjurisdictional transportation, water and wastewater) that may be included in others estimates were not included in the Carrboro inventory.

In looking at emissions from the 2012 inventory, the community sector contributes 93% to Carrboro's greenhouse gas emissions, and local government operations make up 7%. Residential buildings have the largest emissions. Energy use from this sector in 2012 generated 43.4k $mtCO_2e$. Transportation contributed 31,183 tons of CO_2e. Commercial buildings generated roughly a quarter of the total emissions at 26,8k $mtCO_2e$. The solid waste and the industrial sectors contributed much lower levels of emissions.

For the transportation sector, it is important to understand the methodology used and data available to measure emissions to inform steps needed to track changes in emissions over time. The 2012 inventory accounted for vehicle miles travelled (VMT) within the municipal limits. Data were obtained from modeling performed by the NC Capital Area Metropolitan Planning Organization. Mileage from all trips taken within Carrboro, whether it be by a resident or nonresident of Carrboro, were counted, and trips taken outside of Carrboro's city limits were not counted. In addition to VMT, emissions estimate require a "transportation factor set" (provided below). For Carrboro's inventory, the factor set was obtained from statistics produced by the U.S. Department of Transportation (USDOT), and required a breakdown of vehicle type and an average fuel economy for each vehicle type. The USDOT provided a breakdown of vehicle type and fuel economy by vehicle type for North Carolina, which was used as a proxy for Carrboro[29,30,31].

---

[25] The complete inventory is available at http://www.townofcarrboro.org/DocumentCenter/Home/View/2788

[26] "Table 5. Per Capita Energy-related Carbon Dioxide Emissions by State (2000–2011)." U.S. Energy Information Administration. Accessed April 16, 2015. http://www.eia.gov/environment/emissions/state/analysis/pdf/table5.pdf .

[27] Olivier, Jos, Greet Janssens-Maenhout, Marilena Muntean, and Jeroen Peters. "Trends in Global CO2 Emissions 2013 Report." European Commission. January 1, 2013. http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf .

[28] "GHG (CO2, CH4, N2O, F-gases) Emission Time Series 1990-2012 per Region/country." European Commission. Accessed April 16, 2015. http://edgar.jrc.ec.europa.eu/overview.php?v=GHGts1990-2012 .

[29] The Chapel Hill greenhouse gas inventory reports that including the entire range of trips, at the scale of the national average of almost 14k miles driven per vehicle per year, would increase transportation emissions by a factor of almost 3. (This would also extend the geographic scope of the inventory.) However, due to the extensive free bus system, the proportion of the population (including students) that either cannot or choose to not

Data tables from the inventory are provided below.

Source	Fuel	CO2 (MT)	CH4 (MT)	N2O (MT)	CO2e (MT)	Energy Equivalent (MMBtu)	Electricity Used (kWh)	Fuel Use (Therms)
Residential Buildings								
PSNC	Natural Gas	6219	0.5865	0.01173	6237	117300		1173000
PEMC	Electricity	1897	0.038319	0.031164	1907	13293	3894809	
Duke Energy	Electricity	35073	0.70854	0.57624	35262	245795	72017858	
Commercial Buildings								
PSNC	Natural Gas	3165	0.2985	0.00597	3175	59700		597000
PEMC	Electricity	4714	0.095239	0.077456	4740	33039	9680331	
Duke Energy	Electricity	18820	0.3802	0.30921	18921	131892	38644446	

Solid Waste

Source	Tons	CO2 (MT)	Per Capita lbs/day	Per Capita CO2 (MT)/day
OCSW	8,047	3,034	2.24 lbs	.15 CO2 tons

Industrial Energy

Source	CO2 (MT)	CH4 (MT)	N2O (MT)	CO2e (MT)	Electricity Energy Equivalent (MMBtu)	Electricity Used (kWh)
Ready Mix Concrete Plant	54	0.00108	0.00088	54	377	110598
Duke Energy	58	0.00117	0.00095	59	409	119740

Transportation

	DVMT	AVMT	CO_2e (tons)
Orange County	4,335,000	1,575,068,000	-
Carrboro	190,780	69,317,524	31,183

own vehicle, and a vehicle mix that probably has a higher percentage of efficient vehicles, a tripling of transportation emissions to account for the entire extent of trips may be an overestimate.

[30] "Highway Statistics Series." Table VM-4 – Office of Highway Policy Information (OHPI) – FHWA. November 1, 2014. Accessed April 16, 2015. http://www.fhwa.dot.gov/policyinformation/statistics/2013/vm4.cfm .

[31] "National Transportation Statistics." Bureau of Transportation Statistics. Accessed April 16, 2015. http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html .

Factor Set for Community Transportation

Type of Vehicle	**Percentage**	**Fuel Economy (miles/gallon)**
Passenger Vehicles	71.73%	23.3
Light Trucks	20.49%	17.1
Heavy Trucks	6.04%	7.3
Motorcycles	0.85%	43.5

Factor Set for Community Solid Waste

ClearPath Factor Set	**2012 Percentage**	**Waste Composition Category**
Percentage Newspaper	2.1%	“newspaper/print” under “paper”
Percentage Office Paper	2.2%	“mixed office paper” under “paper”
Percentage Corrugated Cardboard	1.5%	“recyclable cardboard” under “paper”
Percentage Magazines/Third Class Mail	0.9%	“glossy magazines” under “paper”
Percentage Food Scraps	21.2%	“food waste” category under “organics”
Percentage Grass	0.6%	⅓ of “yard waste”
Percentage Leaves	0.6%	⅓ of “yard waste”
Percentage Branches	0.6%	⅓ of “yard waste”
Percentage Dimensional Lumber	1.4%	“lumber” under “wood”
Mixed Solid Waste	68.9%	100% minus all previous categories

Factor Set for Grid Electricity

	2007	**2010**
CO2 lbs/MWh	1134.88	1073.65
CH4 lbs/GWh	23.77	21.69
N2O lbs/GWh	19.79	17.64

Appendix B
Co-benefits of Mitigating Greenhouse Gas Emissions.

While mitigation is essential to prevent the most devastating impacts of climate change, pursuing mitigation can also improve quality of life and have monetary benefits. Combustion of fossil fuels produce not only greenhouse gases that contribute to climate change but also pollutants such as fine particulates and nitrous oxides, a precursor to ground-level ozone. Limiting greenhouse gas emissions from combustion typically limits these dangerous pollutants and reduces health impacts which will especially benefit populations most susceptible to respiratory illness such as the poor, elderly and children[32]. Investments in renewable energy and building energy efficiency will reduce emissions through less fossil fuel combustion, improve indoor air quality and comfort, reduce utility bills, and result in a higher degree of energy independence. Emission reduction strategies that increase walking, biking and using transit should also reduce fuel use (and expense) and traffic congestion and improve air quality and public health[33]. Eating less meat, dairy, and eggs and more plants than in a typical American diet is arguably better for people while reducing the environmental impacts of food production. With more tree canopy, not only will more CO_2 be captured, but citizens will enjoy a greener community and cooler temperatures in the summer. Improving stormwater management in response to the risk imposed by shifting rainfall patterns will not only improve water quality and stream health, but will also help create green infrastructure that improves quality of life and decreases the cost of grey infrastructure maintenance and replacement and property damage. Waste reduction and increased composting will not only reduce methane emissions[34], but will also reduce fuel use (and CO_2 emissions) and the costs of collection and hauling. Jobs will be created to support the transition to renewable energy, making buildings more efficient, and creating green infrastructure. The "greening" of the local economy and environment attracts investment and new residents and businesses. Some recommendations in the draft CCAP focus on, or at least recognize, the need for addressing social and economic equity and community cohesion and collaboration which are different types of community benefits.

Co-benefits mean those benefits discussed above that derive from mitigation efforts, but are not the primary intent of mitigation (greenhouse gas emissions reduction). There is merit in the plan's climate mitigation and adaptation recommendations for their co-benefits alone. From this perspective, reductions in greenhouse gas emissions can be seen as an ancillary benefit to interests already being pursued with motivations besides addressing climate change. Transitioning to a lower carbon future involves maximizing the synergies in these many and varied interests and opportunities.

---

[32] "Society Impacts." United States Environmental Protection Agency. September 9, 2013. Accessed March 24, 2015. http://www.epa.gov/climatechange/impacts-adaptation/society.html

[33] Hosking, Jamie, Pierpaolo Mudu, and Carlos Dora. "Health Co-benefits of Climate Change Mitigation." World Health Organization. January 1, 2011. Accessed March 24, 2015. http://www.who.int/hia/green_economy/transport_sector_health_co-benefits_climate_change_mitigation/en/

[34] Smith, Alison. "The Big Picture: Climate Policies & Co-benefits." In *The Climate Bonus: Co-benefits of Climate Policy*, 8. Abingdon, Oxford: Routledge, 2013.

Appendix C
The "Social Cost of Carbon"

Globally, climate change is leading to negative social and economic consequences such as the spread of disease, decreased food production, coastal destruction, and many more. The social cost of carbon pollution index calculates the economic cost of these problems and estimates the damage done by each metric ton of carbon dioxide equivalent. It compares the costs of limiting pollution to the costs of climate change mitigation. In benefit-cost analyses, agencies use social cost of carbon pollution to measure the monetary benefits of regulations that reduce carbon emissions, and weigh them against the costs of the regulation. The current estimate adopted by the U.S. government for regulatory/policy analysis varies based on different factors but can be generalized at around $40/mTCO2e. Those performing studies of the social cost of carbon acknowledge that many impacts have not yet been monetized. Some researchers believe the number used for regulatory analysis should be considerably higher. Using the current federal general estimate, a 50% reduction in emissions for Carrboro equates to a benefit of $2.25M/year when looking at the community based estimates, and about 3 times as much when looking at consumption based/lifecycle estimates. OWASA approved including the social cost of carbon (based on the methodology used by Federal agencies) in the evaluation of clean energy projects at its September 8th, 2016 Board of Directors meeting, and Orange County is also looking at this concept.

More information on the social cost of carbon is available at:
http://costofcarbon.org/
https://www3.epa.gov/climatechange/EPAactivities/economics/scc.html
https://www3.epa.gov/climatechange/Downloads/EPAactivities/social-cost-carbon.pdf
http://www.orangecountync.gov/document_center/DEAPR/Att_16___The_social_cost_of_carbon_due_to_climate_change__E_E_Publishing___1_13_15_.pdf
https://www.owasa.org/Data/Sites/1/media/about/meeting%20summaries/2016/2016-09-08_board_summary.pdf

Appendix D
Implementation Timing Considerations

Recommendation	Time Frame (from Plan)	Type	Notes
Community Integration			
Create Grass Roots Partnerships to Engage Community	This can move forward as soon as leadership is identified.	New	
Expand Public Partnerships to More Explicitly Consider Climate Action	Exploration can begin immediately. Some partnerships will take longer to develop.	Ongoing	
Create Green Neighborhood Program	Will depend on identification of leadership	New	
Integrate Climate Action with Local Living Economy	Some steps can be pursued immediately, others will take longer	New	
Expand Capacity	As soon as possible	New	Sustainability Coordinator position recommended in plan.
Facilitate Low Cost Financing for Energy Efficiency and Renewable Energy Projects	Exploration could begin immediately.	New	Next Climate and staff are currently exploring potential for pilot project
Integrate Climate Action and Social/Equity Initiatives	Coordination with affordable housing focused efforts can be explored immediately. Significant traction is a long term proposition.	New	
Buildings			
50% Challenge	Exploration could begin immediately. For a higher probability of moving forward, a champion will likely be needed.	New	
Demonstrate/Pursue Energy Performance Beyond Minimum Requirements for New Development	Exploration could begin immediately. Identifying a champion will likely be needed.	New. statutory authority if regulatory	
Create Rental Property Task Force and Process	Depends on Board priority and staff/community capacity. Operating the resulting program would be a long term endeavor.	New	
Create Rental Property Registry/Certification	Time frame to set up depends on Board priority and staff/community capacity. Operating it would be a long term endeavor.	New. statutory authority if regulatory	
Transportation			
50% Challenge	It is recommended that local leaders do this immediately.	New	
Improve Bicycle and Pedestrian Infrastructure	Some elements have begun, and could be accelerated depending on the priority. Infrastructure improvement is a long term undertaking.	Ongoing	
Enhance Transit Service	Transit improvement is an ongoing and long term	Ongoing	

	undertaking.		
Improve Vanpool/Carpool Options	The main timing consideration is determining who can champion this.	Ongoing	
Further Promote Walking, Biking, Transit	This is ongoing. The main consideration for accelerating is identifying people with capacity.	Ongoing	
Limit Idling in School Loading Zones	This could be pursued immediately.	New	
Renewable Energy			
Pursue Community Solar Projects	Projects could take months or more to develop with benefits for decades.	Ongoing	Next Climate and staff are currently exploring potential for pilot project.
Pursue Downtown Geothermal Heating and Cooling	An initial assessment could be pursued quickly. Project development would several years, with benefits for decades	New	
Create Rental Property Task Force and Process	Depends on Board priority and staff/ community capacity. Operating would be a long term endeavor.	New	
Ecosystem Protection and Enhancement			
Pursue Stormwater Utility	Deciding to look into a stormwater utility could happen immediately. Forming a utility or joining Chapel Hill's utility would likely take 1-2 years	Ongoing	This process has been initiated.
Evaluate Extent to Which the Deer Population and Climate Change affect Native Plant Ecosystems.	Further study could be pursued immediately.	New	
Accelerate/Expand Organic Waste Collection/Composting	Carrboro has initiated a solid waste study. Current trajectory for Solid Waste Advisory Group (SWAG) to consider a residential composting program is three to four years.	Ongoing	Solid waste study has been initiated
Tree Preservation, Protection and Conservation	Depends on identifying leadership and ability to mobilize community	Ongoing/ New	
Improve Regulations and Community Capacity to Discourage Invasive Plants and Encourage Native Plants	Town staff are currently looking at the LUO. An outreach campaign is a long term undertaking.	Ongoing/ New	A neighborhood initiative is being pursued at Bolin Forest and Quarterpath Trace
Pursue Watershed Restoration Actions to Protect Local Streams from Changes in Rainfall Due to Climate Change	TBD	Ongoing/ New	Watershed restoration plan has been created.
Food Measures			
50% Challenge	It is recommended that local leaders do this immediately.	New	
Develop Local Dietary Consumption and Associated GHG Profile	Maybe a year to begin to collect data with approach that could be replicated every 3 years.	New	