Vermont Greenhouse Gas Emissions Inventory Update *1990 - 2009*

Vermont Agency of Natural Resources
Department of Environmental Conservation
Air Pollution Control Division

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INTRODUCTION

Results from analyses conducted as part of this *Vermont Greenhouse Gas Emissions Inventory Update (1990-2009)* indicate that 2009 statewide greenhouse gas (GHG) emissions increased slightly (~1%) from 2008 levels to 8.43 million metric tons CO_2 equivalent (MMTCO_2e) (see Table 1). This level is approximately 4% higher than 1990 levels, and ends the steady decline in GHG emissions since 2004. Emissions from most sectors declined slightly or remained nearly constant except for a slight increase in fuel consumed in the Residential / Commercial / Industrial sector (due at least in part to a higher heating demand in 2009 vs. 2008), and an uptick in emissions from electricity consumption. Total electricity consumption for 2009 was somewhat less than 2008, but emissions were higher due to a greater percentage of electricity coming from higher emissions regional market power.

These emissions estimates were developed using methodologies consistent with the *Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030*[1] developed by the Center for Climate Strategies (CCS), the most current State Inventory Tool modules from the U.S. Environmental Protection Agency (containing data through calendar year 2009), and data available from a variety of in-state and national sources. Historical and updated GHG emissions data are summarized by sector in the tables and graphs that follow.[2]

At present, calendar year 2009 is the most current year for which activity data is available for *all* inventory sectors. As a result, this inventory provides a comprehensive GHG emissions update through calendar year 2009. However, data for two important sectors that were responsible for nearly 79% of the total statewide GHG emissions in 2009 (Transportation Gasoline & Diesel, and Residential / Commercial / Industrial Fuel Use), have become available recently for calendar year 2010 and in some cases 2011. These data have not yet been analyzed thoroughly to produce a comprehensive estimate of GHG emissions for 2010 and 2011; however, they indicate that emissions from these major sectors remained relatively constant through 2011 (see Figure 8).

This update also provides new estimates of carbon stocks and fluxes from Vermont forests. Over the past several years, as forests recovered from ice storm damage, increases in tree growth and age have maintained forests as a carbon sink, with carbon flux at approximately -1.61 million metric tons per year (uptake), and carbon storage increasing to over 370 million metric tons of stored carbon.

[1] See http://www.anr.state.vt.us/anr/climatechange/Vermont_Emissions.html

[2] Primary author – J. Merrell VT Air Pollution Control Division (APCD) – jeff.merrell@state.vt.us

Table 1. Vermont Historic GHG Emissions by Sector
(Million Metric Tons CO2 equivalent (MMTCO2e).

Sector	*Year*					
	1990	***1995***	***2000***	***2005***	***2008***	***2009***
Electricity Supply & Demand (consumption-based)	**1.09**	**0.77**	**0.44**	**0.64**	**0.34**	**0.39**
Coal	0	0	0	0	0	0
Natural Gas	0.047	0.01	0.018	0.003	0.004	0.004
Oil	0.014	0.013	0.058	0.011	0.01	0.03
Wood (CH4 & N2O)	0.003	0.005	0.009	0.009	0.01	0.018
System Purchases & Net Imported Electricity	1.03	0.75	0.35	0.62	0.32	0.34
Residential / Commercial / Industrial (RCI) Fuel Use	**2.43**	**2.43**	**2.88**	**2.98**	**2.63**	**2.71**
Coal	0.02	0.008	0.003	0.0003	0.0003	0
Natural Gas	0.31	0.37	0.50	0.44	0.45	0.45
Oil, Propane	2.06	2.00	2.34	2.49	2.13	2.20
Wood (CH4 & N2O)	0.05	0.05	0.04	0.04	0.05	0.05
Transportation	**3.22**	**3.77**	**3.99**	**4.20**	**3.93**	**3.91**
Onroad Gasoline	2.64	2.82	3.20	3.29	3.04	3.04
Onroad Diesel	0.41	0.84	0.66	0.69	0.65	0.61
Rail / Ships / Boats	0.06	0.03	0.04	0.02	0.02	0.02
Jet Fuel & Aviation Gasoline	0.08	0.06	0.07	0.17	0.19	0.21
Other	0.02	0.03	0.02	0.02	0.03	0.03
Fossil Fuel Industry	**0.012**	**0.012**	**0.012**	**0.014**	**0.015**	**0.015**
Natural Gas Distribution	0.011	0.011	0.011	0.013	0.014	0.014
Natural Gas Transmission	0.0007	0.0008	0.0008	0.0009	0.001	0.001
Industrial Processes	**0.12**	**0.25**	**0.27**	**0.30**	**0.30**	**0.29**
ODS Substitutes	0	0.06	0.15	0.21	0.24	0.24
Electric Utilities (SF6)	0.05	0.04	0.03	0.02	0.02	0.02
Semiconductor Manufacturing (HFC, PFC & SF6)	0.07	0.11	0.06	0.03	0.03	0.01
Limestone & Dolomite Use	0	0.03	0.02	0.03	0.01	0.016
Soda Ash Use	0.006	0.006	0.006	0.005	0.005	0.005
Waste Management	**0.24**	**0.28**	**0.31**	**0.29**	**0.27**	**0.26**
Solid Waste	0.18	0.22	0.25	0.23	0.21	0.20
Wastewater	0.06	0.06	0.06	0.06	0.06	0.06
Agriculture	**1.0**	**0.93**	**0.96**	**0.92**	**0.88**	**0.85**
Enteric Fermentation	0.59	0.56	0.56	0.53	0.53	0.52
Manure Management	0.12	0.12	0.14	0.15	0.17	0.18
Agricultural Soils	0.29	0.24	0.26	0.24	0.18	0.15
TOTAL GROSS EMISSIONS	8.11	8.45	8.86	9.34	8.37	8.43
Change relative to 1990	-	*+4%*	*+9%*	*+15%*	*+3%*	*+4%*

Figure 1. Historical VT (1990-2009) & US (1990-2010)[3] Gross GHG Emissions

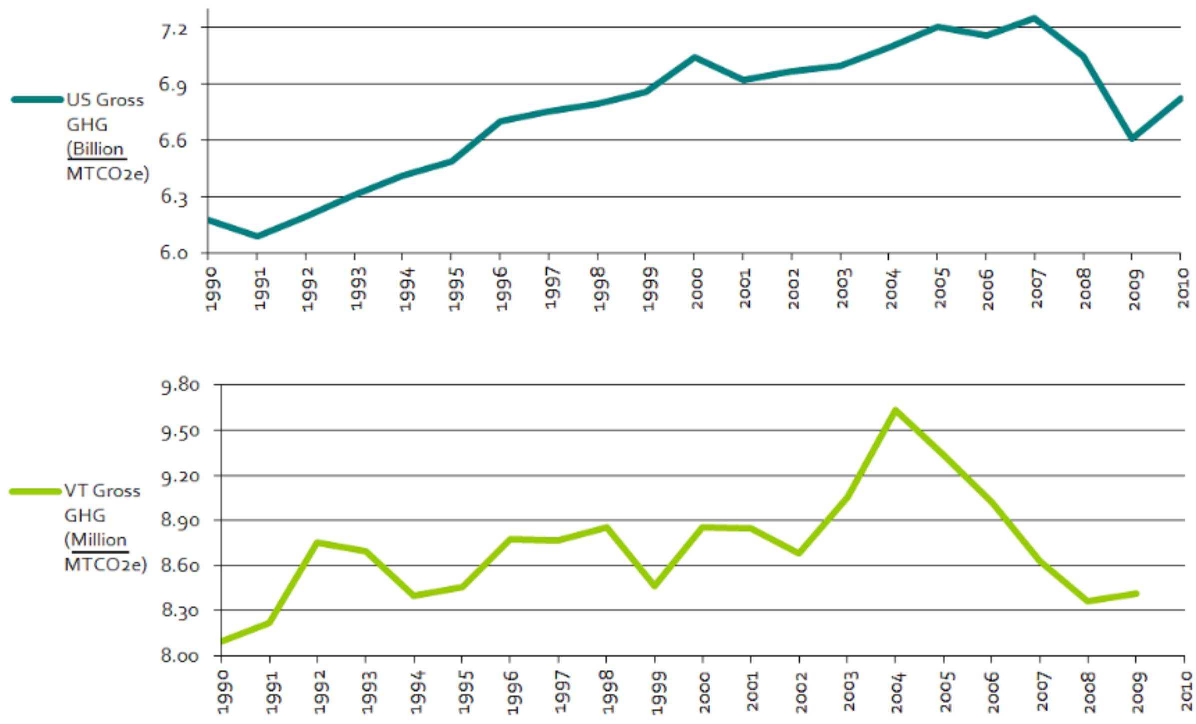
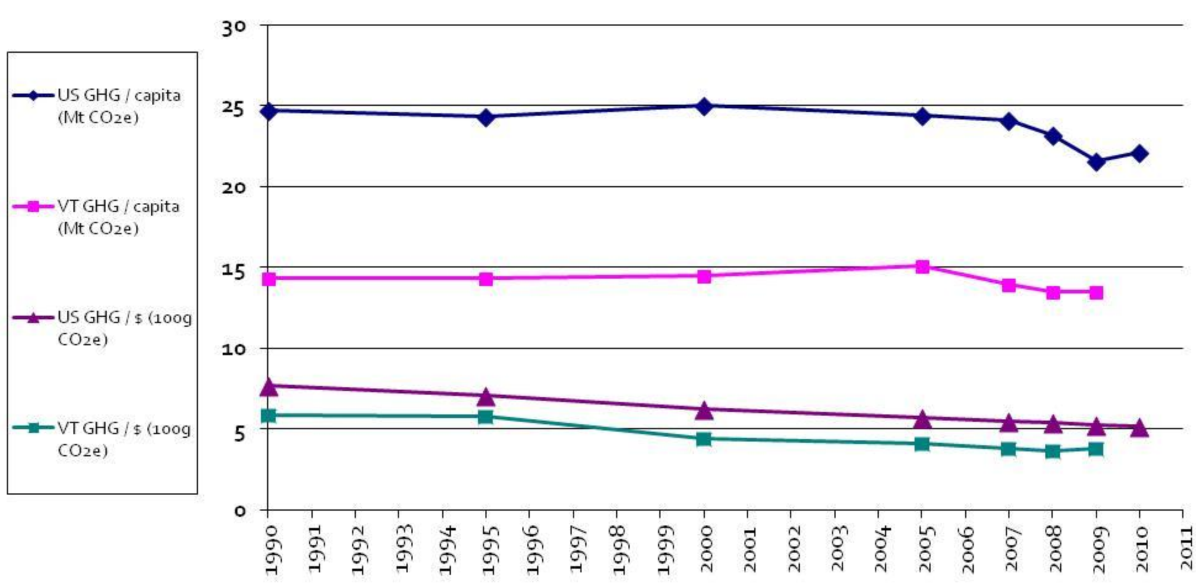


Figure 2. Historical VT & US Gross GHG Emissions per Capita and per Unit Gross Product[4]



[3] US data source: US EPA -DRAFT INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2010, April 2012 - http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

[4] GDP data source: Bureau of Economic Analysis – US Dept. of Commerce - http://www.bea.gov/regional/index.htm

Figure 3. 2009 Gross GHG Emissions Percent Contribution by Sector, Vermont and the United States[5]

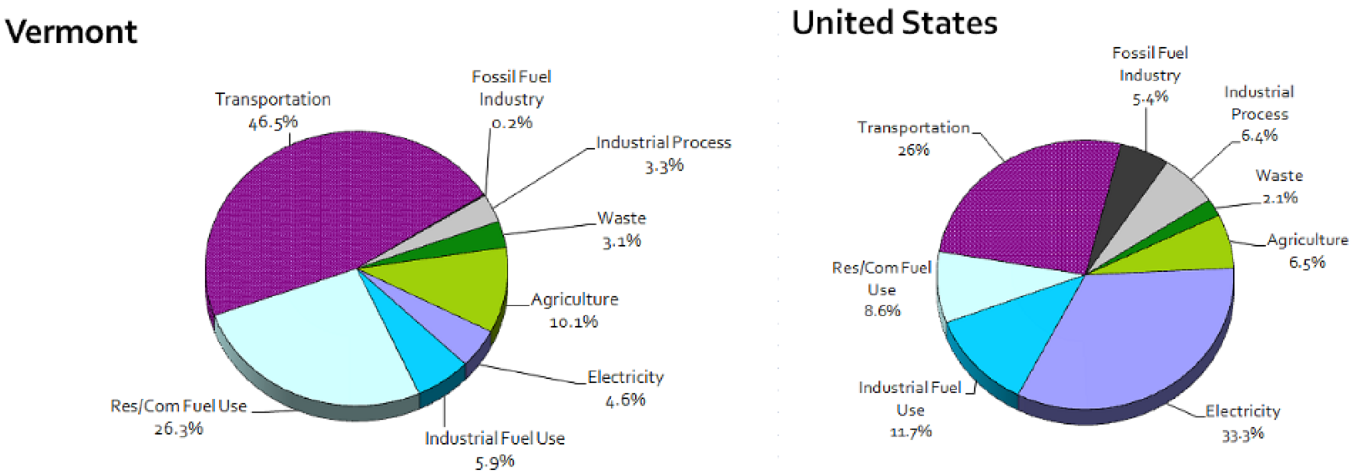
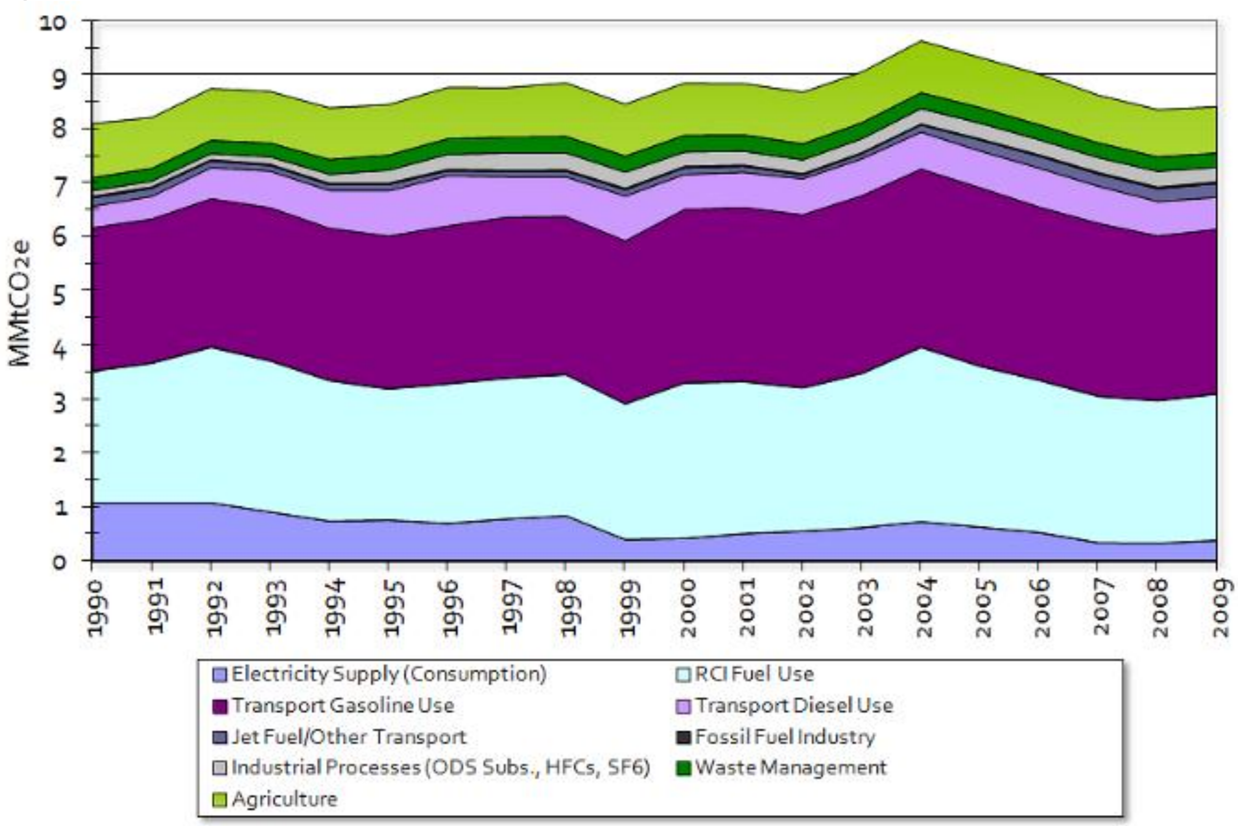


Figure 4. Total Vermont Gross GHG Emissions (1990-2009)



[5] US data source: US EPA -DRAFT INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2010, April 2012 - http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

Figure 5. Vermont Gross GHG Emissions – Individual Sector Trends (1990-2009)

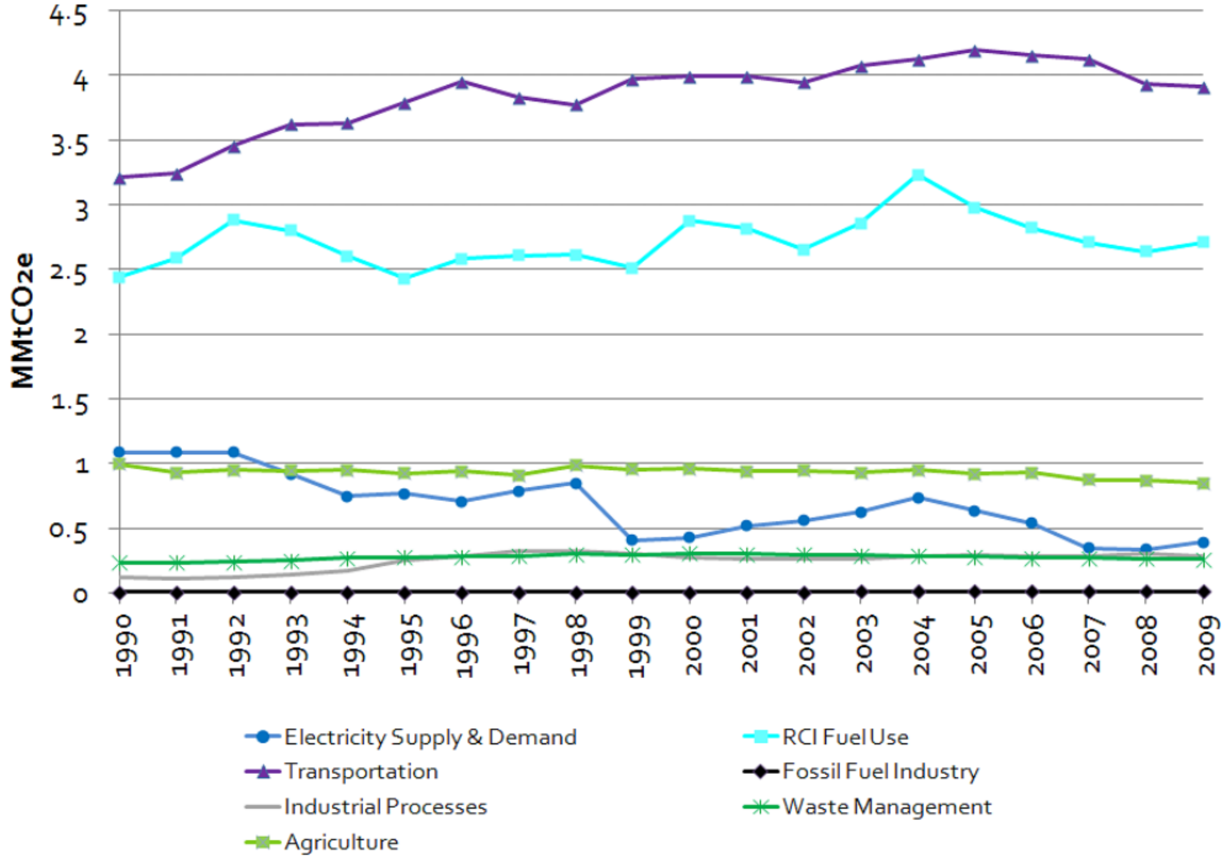
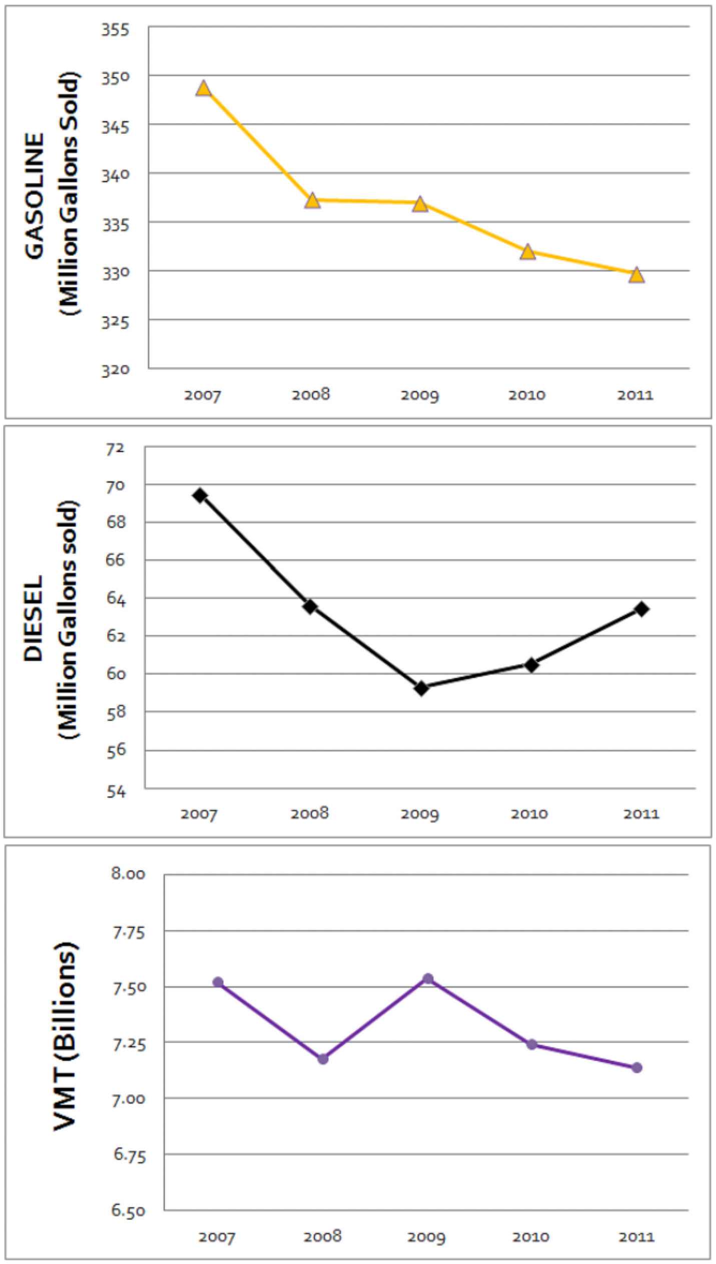


Figure 6. Vermont Transportation Indicator Trends[6]

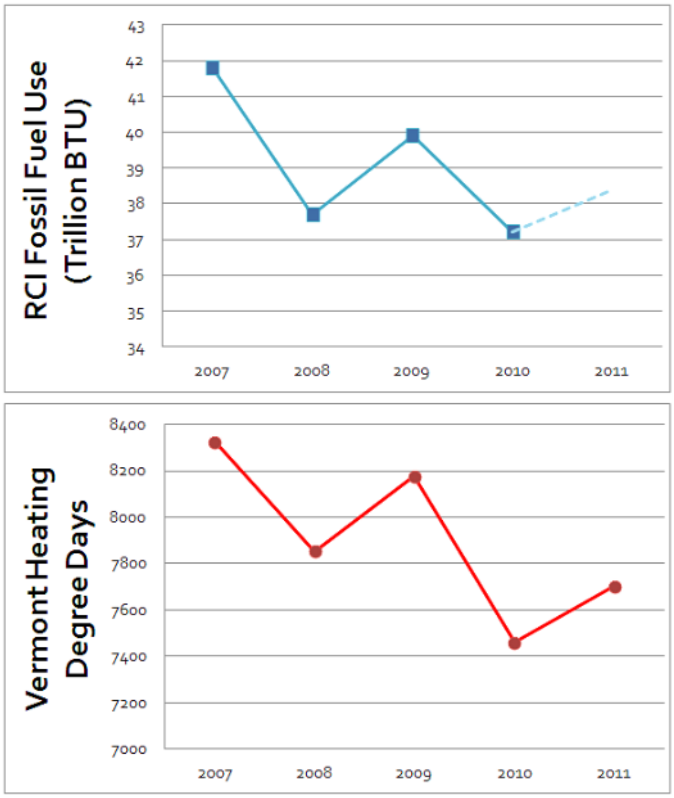


Although a more thorough analysis to include all sectors and other GHGs such as methane (CH_4), nitrous oxide (N_2O), etc. will be performed for calendar 2010 in the next inventory update, a preliminary analysis is presented below that considers only carbon dioxide (CO_2) emissions from the Transportation and RCI sectors.[7] Statewide gasoline and diesel fuel sales data from the Legislative Joint Fiscal Office (JFO) indicate that 2009 gasoline sales were approximately equal to 2008 sales, while 2009 diesel sales were down nearly 7% from 2008 sales. Gasoline sales declined slightly for 2010 and 2011, while diesel fuel sales rebounded to 2008 levels by 2011 (see Figure 6). Vehicle Miles Traveled (VMT) data from the Vermont Agency of Transportation (VTrans) indicate that VMT during 2007-2011 varied less than +/- 3% from the five year average of 7.32 billion VMT (see Figure 6).

[6] Gasoline and Diesel gallons sold data obtained from the Vermont Legislative Joint Fiscal Office http://www.leg.state.vt.us/jfo/transportation.aspx . Vehicle Miles Traveled (VMT) data obtained from VTrans http://www.aot.state.vt.us/Planning/Documents/HighResearch/Publications/AVMTCrashFatal.pdf

[7] Estimates of CO_2 emissions were calculated using fuel-specific emission factors available from http://www.eia.gov/oiaf/1605/coefficients.html

Figure 7. Vermont Residential / Commercial / Industrial (RCI) Fuel Use Indicator Trends[8]

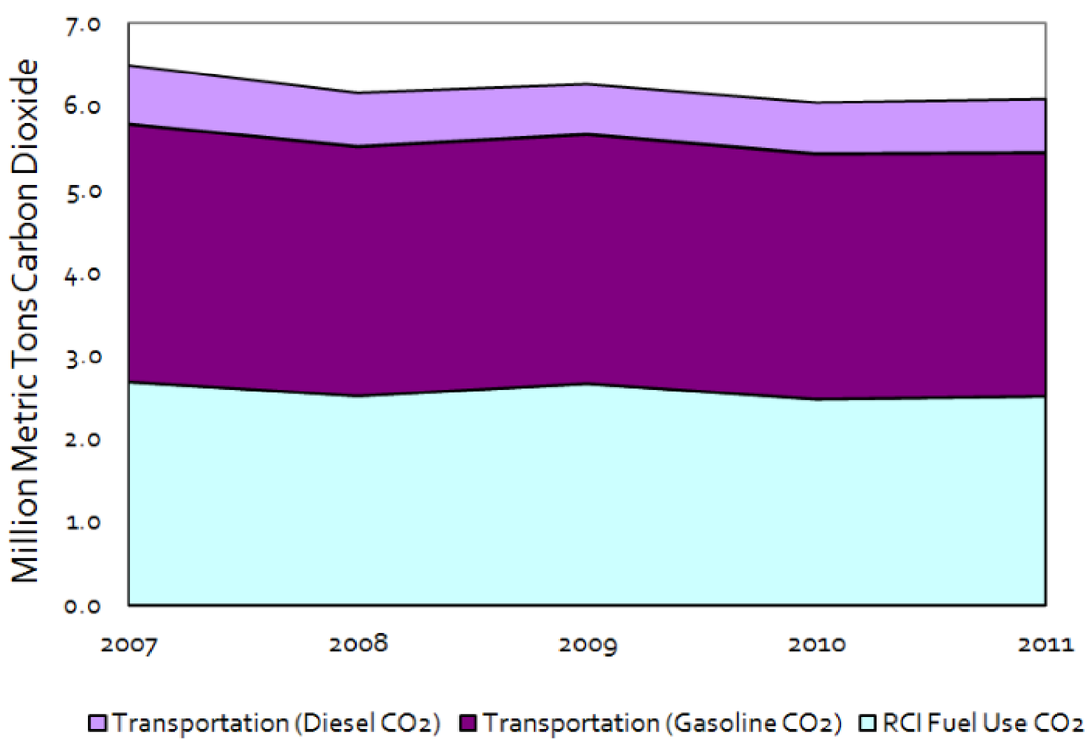


Fossil fuel consumption data for the Residential / Commercial / Industrial sectors in Vermont show an increase of roughly 7% between 2008 and 2009, followed by a return in 2010 to levels comparable to 2008. The US Energy Information Administration data for RCI fuel consumption are not yet available for 2011. However, since much of the RCI fuel is consumed for space heating purposes, the data correlate reasonably well with annual Heating Degree Day (HDD) data for Vermont which are available for 2011 (see Figure 7). Given the slight increase in HDD between 2010 and 2011, it is likely that 2011 RCI fuel consumption will also be higher than 2010 levels.

[8] RCI Fuel consumption data obtained from the U.S. Energy Information Administration (EIA) – State Energy Data System (SEDS) http://205.254.135.7/state/seds/seds-states.cfm?q_state_a=VT&q_state=Vermont. Heating Degree Day data obtained from ftp://ftp.cpc.ncep.noaa.gov/htdocs/products/analysis_monitoring/cdus/degree_days/archives/Heating%20degree%20Days/monthly%20states/

A preliminary analysis of CO_2 emissions from the Transportation and RCI sectors using these data shows that the CO_2 emissions trend for these sectors is relatively flat from 2009 through 2011 (Figure 8). Since Transportation and RCI are responsible for approximately 79% of total statewide GHG emissions, it is likely that the statewide total gross GHG emissions trend between 2009 and 2011 will also be relatively flat.

Figure 8. Estimated Carbon Dioxide (CO_2) emissions from Transportation and Residential / Commercial / Industrial Fuel consumption (2007-2011)



Forestry and Land Use[9]

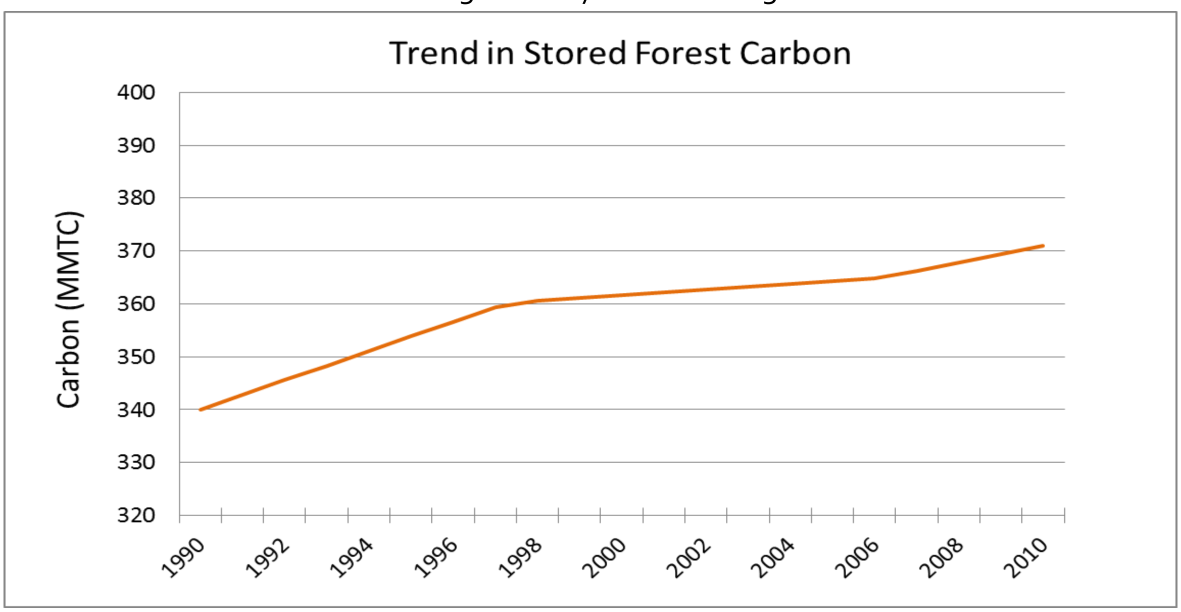
New data from the USDA Forest Service made it possible to update the estimates for annual carbon sequestration (flux) and total carbon stocks during the period from 1990 to present.

Forests remove carbon dioxide from the air and store vast quantities in above and below ground organic material. Carbon dioxide removal by forests can be examined in two ways: the annual change or flux of carbon (a negative number indicates removal or uptake by forests), and storage of carbon in live and dead trees, and in soil and forest floor organic matter (see figures). In turn, these calculations depend on the acres of forestland (which may have been decreasing since 1997), tree growth and forest age (which continues to increase), the types of species (hardwoods store more carbon above ground whereas conifers store more in the soil), and disturbances to forests (e.g. ice storms, wind storms, insect outbreaks, etc).

Both carbon storage and uptake were adversely affected by the 1998 ice storm, which covered nearly a million acres of forestland. Compounding this, acres of forestland started to decline, resulting in a substantial increase in the carbon flux (reduced carbon uptake) before rebounding to the current level of -1.61 million metric tons carbon per year [-5.89 MMTCO2e/yr] (uptake)], and carbon storage increased to over 370 million metric tons of stored carbon [1,360.8 MMTCO2e].

These updated carbon flux estimates indicate that the annual carbon flux in Vermont's forests is not as large as shown in the original *Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030* developed by the Center for Climate Strategies (CCS)[10]. However, this does not diminish the fact that Vermont forests play an extremely important role in removing carbon dioxide from the atmosphere, and stockpiling substantial quantities of carbon for the long term.

Figure 9. Trend in total forest carbon stored above and below ground. The 1998 ice storm contributed to slower carbon storage in the years following that event.



[9] This section courtesy of Sandy Wilmot (VT Dept. of Forests, Parks and Recreation). [Data source for Figs. 9-11: US EPA Land Use, Land-Use Change, and Forestry State Inventory Tool (SIT) Module - Draft 2/11/2013; Data source for Fig. 12: USDA Forest Inventory & Analysis (FIA)]
[10] See http://www.anr.state.vt.us/anr/climatechange/Vermont_Emissions.html

Figure 10. Trends in carbon stored in above ground materials (trees, deadwood and litter) and below ground (roots and soils). Trees and soil are the main storage units for forest carbon.

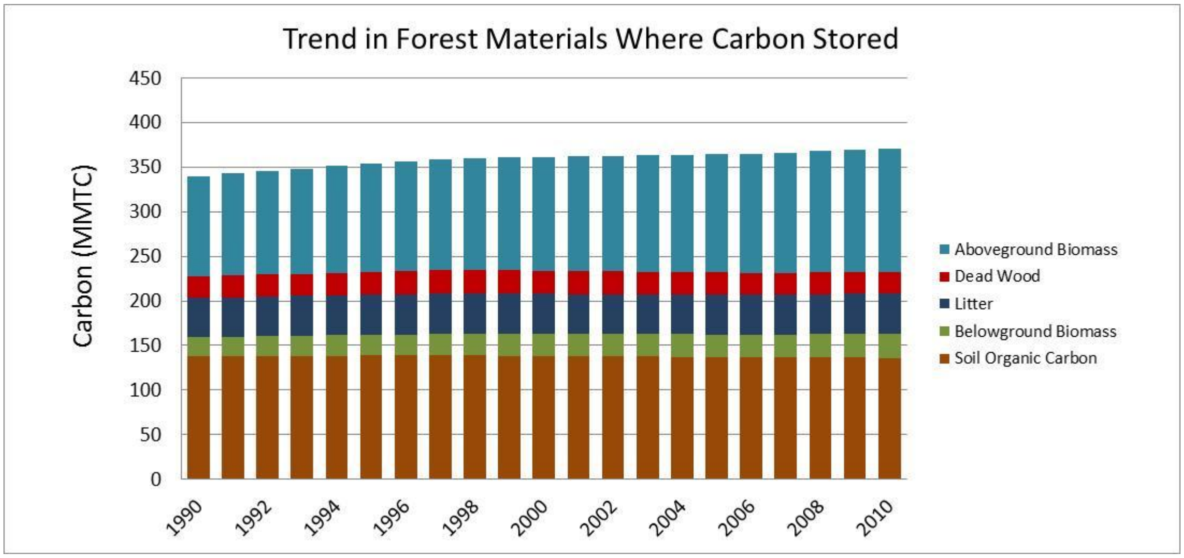


Figure 11. Annual forest carbon uptake is measured as the difference in storage from one year to the next. Trees and soil are the main components in the forest carbon cycle. The change in soil carbon flux from negative to positive is mainly due to conversion of forest land to non-forest uses.

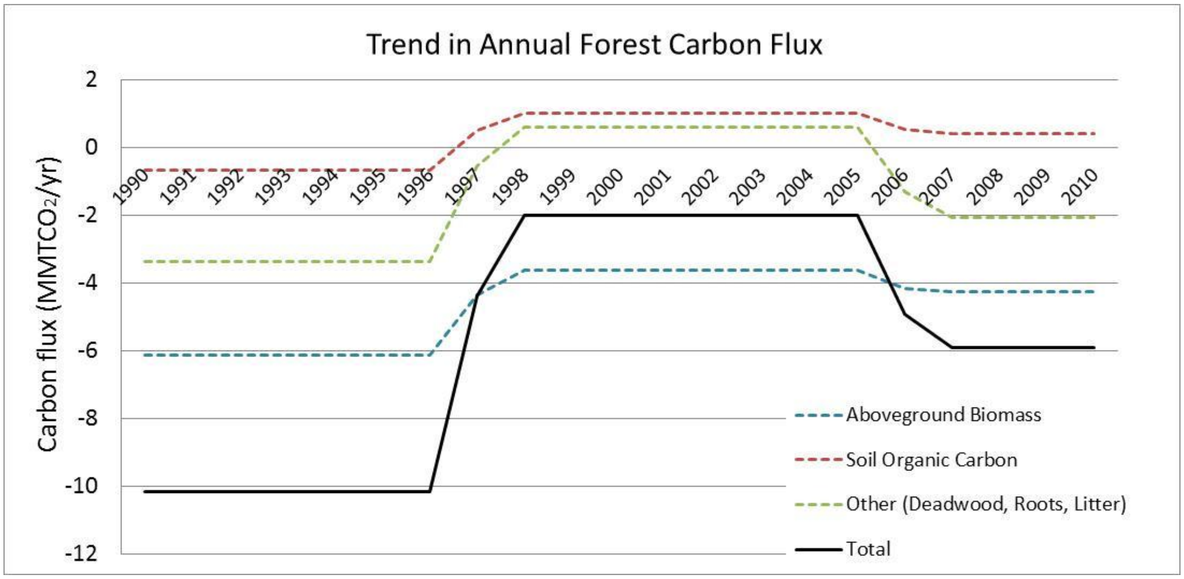
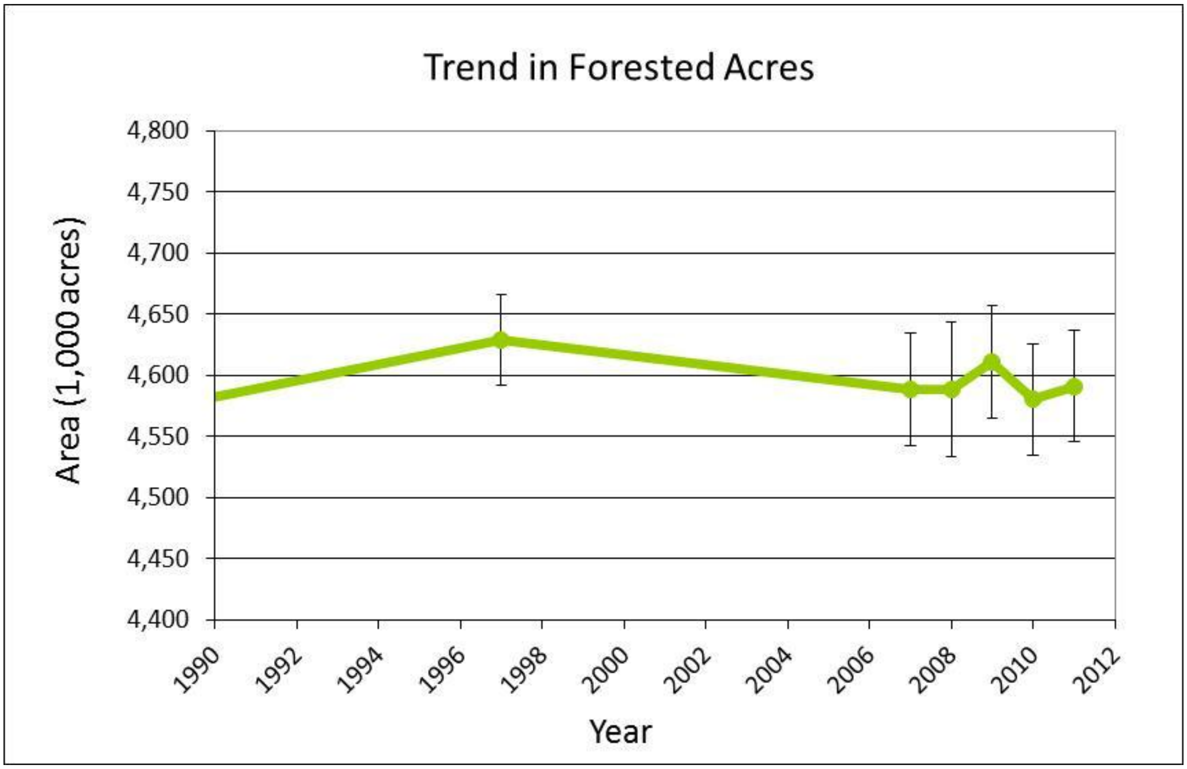


Figure 12. Change in acreage of Vermont forestland from 1997-2011[11]

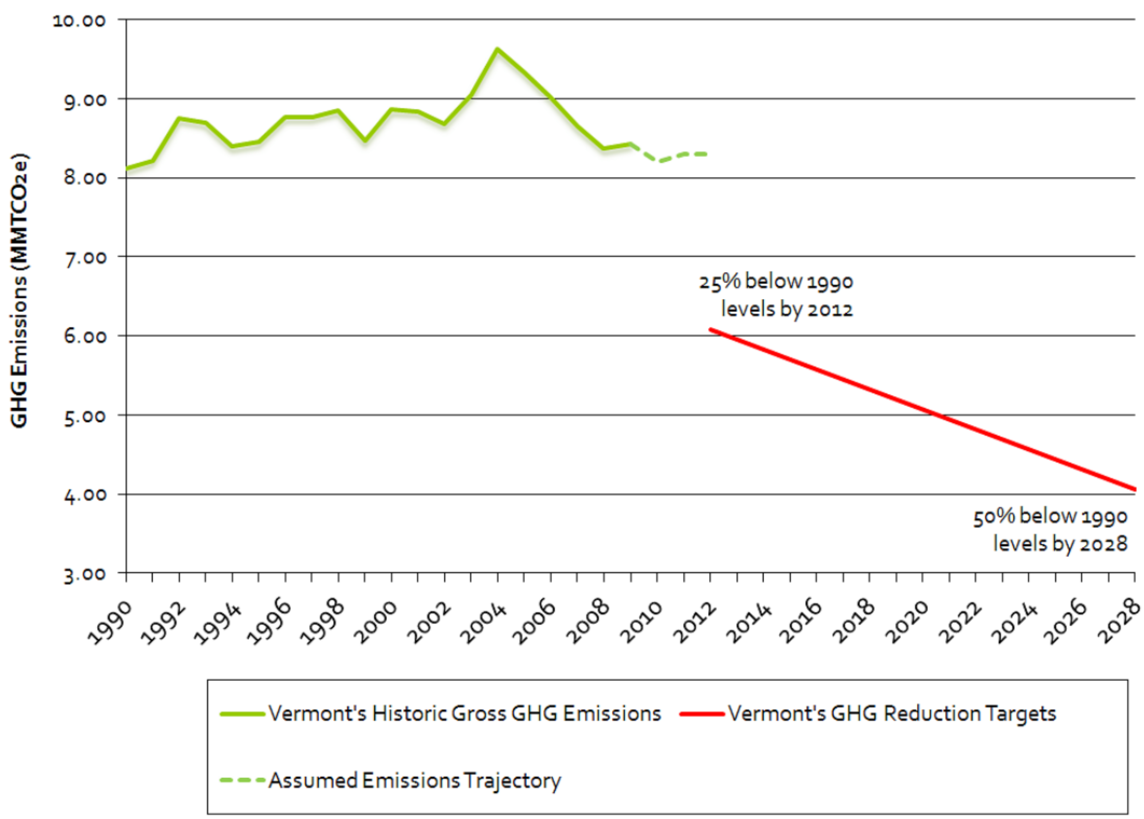


[11] Adapted from Vermont's Forest Resources, 2011: http://www.nrs.fs.fed.us/pubs/rn/rn_nrs141.pdf

Conclusions

Lacking a substantial decrease in emissions from the Transportation, RCI and other important sectors, it is reasonable to conclude that Vermont will fall short of its 2012 goal of reducing GHG emissions to 25% below 1990 levels. This places even greater emphasis on the need for immediate and effective emissions reductions in order to meet the future GHG emissions reduction goal of 50% below 1990 levels by 2028 set forth by state statute (see Figure 13).[12]

Figure 13. Vermont GHG Emissions Relative to Reduction Goals



If pursued assertively, some key strategies that can help move Vermont towards meeting both its energy[13] and GHG emissions reduction goals include:

Electricity Supply & Demand:

- Continual improvements in demand-side management (DSM) programs that encourage efficient use of available electricity.
- Expansion of reliance on clean sources of renewable energy.
- Effective power management through the use of smart meters, etc.

Residential / Commercial / Industrial (RCI) Fuel Use:

- Expansion of weatherization and other thermal efficiency efforts in RCI buildings to reduce heating requirements.
- Promote lower-emissions fuels and heating technologies.

[12] See http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=10&Chapter=023&Section=00578
[13] Vermont Comprehensive Energy Plan http://www.vtenergyplan.vermont.gov/

Transportation:

- Increase availability and wise use of advanced technology vehicles such as pure electric vehicles, plug-in hybrids, etc. as well as the required charging infrastructure.
- Encourage transportation demand management (TDM) strategies such as carpooling, public transit, community planning for walking & biking, teleworking, etc.

Waste Management:

- Expanded recycling, waste reduction, and reuse of waste materials

Agriculture:

- Effective agricultural waste management to reduce methane (CH_4) and nitrous oxide emissions (N_2O).
- Development of on-farm renewable energy production, and / or siting of renewable energy projects, etc.
- Encourage farming practices that promote soil carbon retention / sequestration.

Forest carbon management:

- In broad terms, this consists of managing for healthy forests, establishing and maintaining vibrant forest product economies, conserving forestland where appropriate, and providing forest landowner incentives to keep lands forested. Healthy forests sustain carbon cycles, provide forest products that store carbon and create livelihood for landowners and communities, which in turn encourages keeping lands forested. Activities that contribute to any and each of these assist Vermont in maintaining and increasing forest carbon sequestration.

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