Vermont in Transition:

A Summary of Social Economic and Environmental Trends

A study by

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for the

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Chapter 2: ENVIRONMENT AND CLIMATE

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Chapter 2:

ENVIRONMENT AND CLIMATE

The natural beauty of Vermont's physical environment and the prudent stewardship of our natural resources by both the public and private sectors are among the best known qualities of the state. Vermont's topography is unusual in that the state is bisected along most of its length by the Green Mountains, which are a part of the greater Appalachian chain. Vermont is bordered on the West by Lake Champlain and on the east by the Connecticut River. The North/South chain of the Green Mountains then creates two major watersheds, the Connecticut River on the east and Lake Champlain on the west.

Vermont is located within the latitudes dominated by the prevailing westerlies, an influential upper-air wind pattern that brings much of our weather from the west. Large-scale air masses that affect Vermont also come from several other sources. Cold, dry air originating in Canada descends from the north. Warm, moist air, ultimately from the Gulf of Mexico comes up from the south and, with somewhat less influence, cool moist air from the North Atlantic enters the state from the northeast. Because of these competing air masses, Vermont's weather patterns are highly variable.[1]

Many measures in support of our distinctive reputation for environmental quality abound. The Congressional Quarterly Press places Vermont among the lowest of the 50 states in air pollution, in proportion of polluted streams and rivers, and in number of toxic waste sites. It is also among the best in the quality of drinking water.[2] Another state ranking index ranks Vermont as lowest in per capita energy related carbon dioxide emissions in each of their four sampled years between 1990 and 2003.[3] In yet another ranking, Vermont is rated as the greenest state in the nation.[4]

Recent statewide polls also show that Vermonters themselves are committed to protecting the environment and reflect how the "green" reputation of the state is of continuing importance in the minds of residents. For example, a recent University of Vermont poll found that 97% of Vermonters agreed with the statement that "I value the working landscape and its heritage," and the four "Pulse of Vermont" polls of 1990, 1995, 2000, and 2005 sponsored by the Vermont Business Roundtable consistently document that Vermonters are committed to preserving the physical environment.[5, 6] This commitment to the state's environment is not consistent, however. In 2005, a poll found that half of Vermonters believe that the government is showing "the right amount of concern" for the environment, yet significant numbers (34%) felt that the government was "not worried enough" about threats to the environment, or that "people worry too much about human progress harming the environment"(18%).[7] Even a casual newspaper reader is aware of the ongoing tensions between various environmental groups, the State and local authorities, and various forms of economic development.

Vermonters alone are not responsible for the quality or management of their environment. There are innumerable factors that influence the quality of the physical environment; from Vermont's geographic location in the northeastern corner of the 48 contiguous states to the sharing of

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1 State climatologist downloads: http://cdo.ncdc.noaa.gov/climatenormals/clim60/states/Clim_VT_01.pdf; http://www.uvm.edu/~ldupigny/sc/; http://www.vermonthistory.org/journal/70/vt701_204.pdf.

2 Hovey, Kendra and Harold Hovey, CQ's State Fact Finder, 2007, Congressional Quarterly Press, 2004 and 2007.

3 Morgan Quinto State Trends, 4th Edition, Morgan Quinto Press, 2007.

4 America's Greenest States, Brian Wingfield and Miriam Marcus. October 10, 2007.

5 Council on the Future of Vermont, "Looking Ahead: Vermonters' Values and Concerns" by the Center for Rural Studies, August, 2008, Michael Moser, Jessica Hyman, Fred Schmidt.

6 Vermont Business Roundtable, "Pulse of Vermont—Quality of Life Study, 2005" Social Science Research Center, Vince Bolduc and Herb Kessel.

7 Vermont Business Roundtable, "Pulse of Vermont—Quality of Life Study, 2005" Social Science Research Center, Vince Bolduc and Herb Kessel.

watersheds. Events in other states and Canada affect Vermont's ecosystems, as is evidenced by invasive species or acid rain occurrences. On a larger scale, there are important global climate changes occurring which have and will affect Vermont for years to come.

The people of Vermont also have an impact on the environment; even with its relatively low population growth rate and low density per square mile, increasing numbers of people unavoidably leave their footprints and increase the environmental burden. The need for space in which to live demands that natural areas be replaced by roads, housing developments and commercial parks. The manner in which we organize human communities has much to do with the environmental impact. Vermont has been proactive in this regard, putting into place a complex network of land use regulations, discussed in Chapter 3, Land Use, to rationalize the process of development and to lessen the damage to the environment. While we have one of the most comprehensive set of environment regulations in the country, the state still struggles to find better ways to deal with sewage, manure, and compost as well as increasing volumes of non-organic solid waste—some benign, some toxic. Vermont has been a national leader in creative measures to protect the environment—from early bottle return legislation and billboard regulation to tax incentives and credits for conservation, to fees and fines to mitigate damage. Civic life in Vermont is, in part, about trying to maintain (or find) a balance between life styles, economic development and our natural heritage that comprise the state's complex ecosystem.

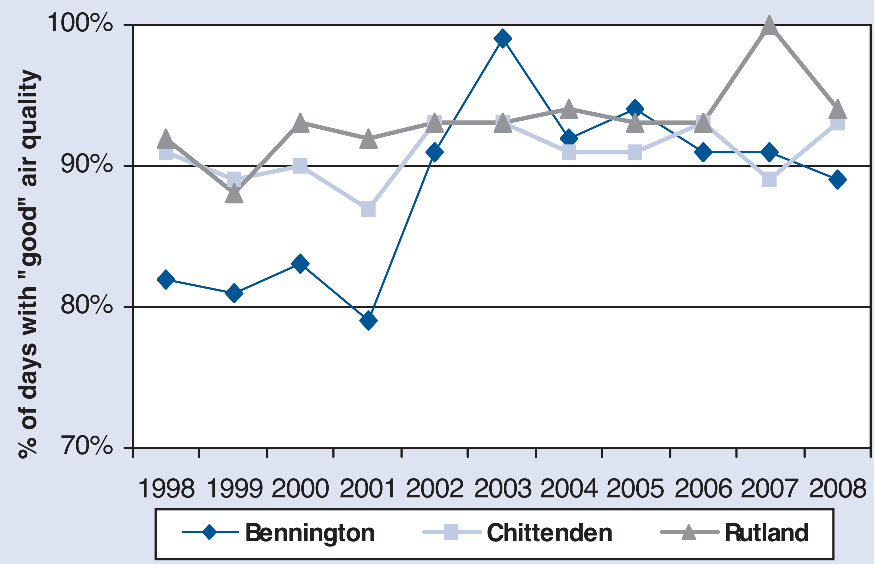
The threats to Vermont's environment manifest themselves through air and water quality, the health of forests and animals, the disposal of solid wastes, as well as the effects of worldwide climate change. Each of these areas is reviewed briefly in the following pages.

Trends in Vermont's Environment and Climate

Trend number 1: Air quality in Vermont has improved slightly over the last decade.

Vermont releases the second smallest amount of toxic chemicals in the air of any state, less than one pound per capita, must less than the national average of 14 pounds per capita, and far less than Nevada and Alaska, both releasing more than 100 pounds per capita.[8] The U.S. Environmental Protection Agency (EPA) also ranks Vermont 47th in the amount of air

Air Quality Index
Percent Days Per Year With "Good" Air Quality* in Bennington, Chittenden and Rutland Counties
1998 to 2008



Source: The U.S. Environmental Protection Agency

* The air quality categories include: good, moderate, unhealthy for sensitive groups and unhealthy

[8] "Toxic Release Inventory" U.S. Environmental Protection Agency.

pollution emissions per short ton, with a very low per capita figure.[9] The Morgan Quinto 2007 State Rankings also placed Vermont last in pollution released from manufacturing plants in 2004, the latest year available.[10] Unfortunately for Vermont, air pollution is best controlled at the point of origin, so air quality is a product of wider regional and national airsheds and prevailing winds than pollutants released within the state's political boundaries.

Air quality in Vermont has improved over the last decade, especially with reduction in the levels of sulfur oxides. While the EPA records air quality data for five counties in Vermont, the data from Chittenden, Rutland and Bennington are the most complete.[11] Because of differences in proximity to sources of pollution, prevailing winds, and even elevation, dramatic differences in pollution levels can be found within a state. The EPA's index shows that air quality has improved in Bennington and Rutland and remained largely constant in Chittenden County during the past 11 years. Overall, the EPA labeled the air quality in these three counties as "good" during 90% of the year. During this period of time there was only one day in each county where the EPA's index indicated that the air quality was unhealthy (see Appendix, chart 2-1).

Sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) annual average concentrations from 1991 through 2006 from the Chittenden and Rutland county monitoring sites indicate little change over time. These data are presented as averages for a given year, but are so consistent as to suggest there are no significant differences from year to year. Both sulfur dioxide and nitrogen dioxide concentrations are recorded in parts per million and are well below the annual average standard of the National Agency of Air Quality standards of 0.03 and 0.053 parts per million respectively.[12]

[9] Hovey, Kendra and Harold Hovey, CQ's State Fact Finder, 2007, Congressional Quarterly Press, 2007.

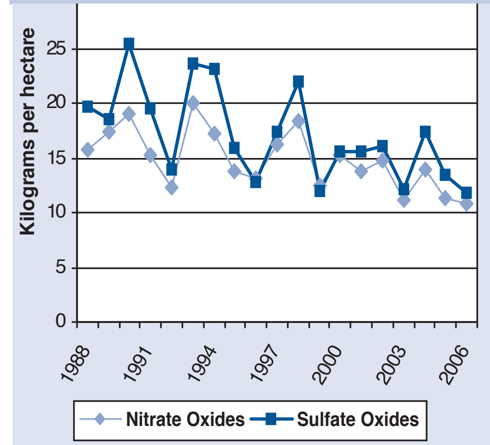
[10] State Rankings 2007: A Statistical View of the 50 United States, Morgan Quinto Press, 2007.

[11] The EPA has created an index to track air quality in various locations around the country. The index combines measurements for carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, and particulate matter. See http://www.epa.gov/air/data/help/hmonaqi.html?st~VT~Vermont#aqi_pollutant

[12] Vermont Department of Environmental Conservation, Air Pollution Control Division, Vermont Air Quality Reports, 2007.

Although the Chittenden and Rutland county sites do not indicate sulfur dioxide reductions in air quality, the Water Quality Division of the Vermont Agency of Natural Resources states that "significant reductions in sulfur dioxide emissions and deposition have been recorded throughout the northeastern United States and the Atlantic Provinces of Canada."[13] Similar trends have not been observed in nitrogen oxides.

Atmospheric Deposition for Nitrate Oxides and Sulfate Oxides



Source: National Atmospheric Deposition Program/NTN, Annual/Seasonal Depositions

Data from the National Atmospheric Deposition Program (NADP) for Vermont indicates a definite trend in sulfate oxide reduction between 1988 and 2006. The three-year average, 1988-1991, in sulfate oxide deposition was 21.19 kilograms per hectare. For the most recent three-year data, 2004-2006, it was 14.18kg/ha. The single year's greatest deposition of 25.49kg/ha occurred in 1990, the least (11.76 kg/ha) in 2006.[14] The mandate of the Clean Air Act seems to be making a positive difference in the northeast. Both oxides are significant contributors to acid precipitation.

The national standard for ozone is 0.08 parts per million. At the Bennington and Chittenden monitoring sites, ozone concentrations ranged from 0.07 to 0.09 parts per million, exceeding the national standard from 1991 through 1993, being at or below the standard by 0.01 parts per million in the other years (see Appendix, 2-2).[15] These data suggest that ozone is the most prevalent air quality pollutant in Vermont.

[13] Vermont Department of Environmental Conservation, Water Quality Division,"Acid Rain—the Vermont Perspective," updated, June, 2003. http://www.anr.state.vt.us/DEC/WATERQ/BASS/HTM/BS_ACIDRAIN-VT.HTM

[14] National Atmospheric Deposition Program. http://nadp.sws.uiuc.edu/NADPDATA

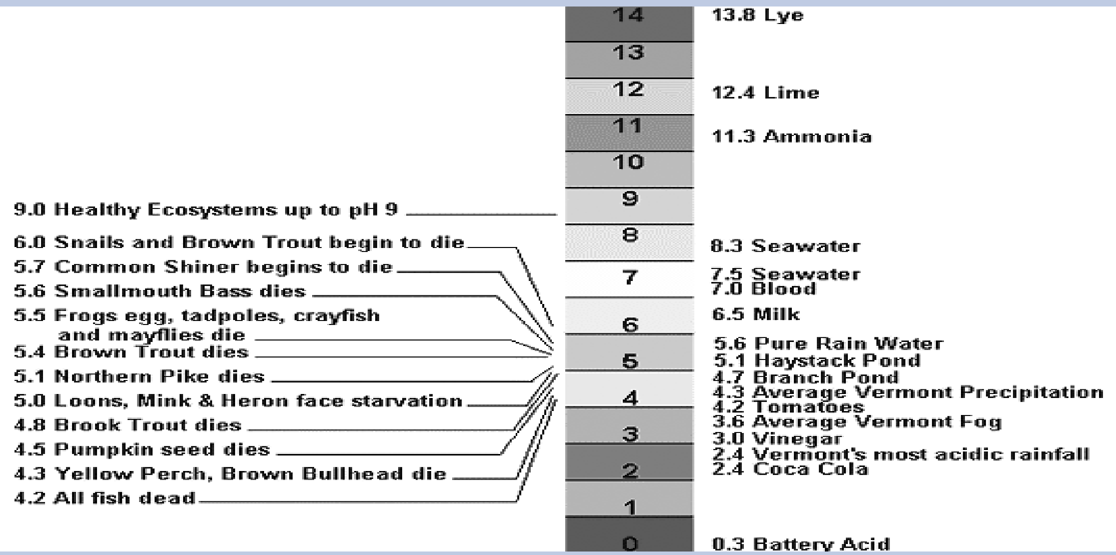
[15] Vermont Department of Environmental Conservation, Air Pollution Control Division, Vermont Air Quality Compliance Plots, http://www.anr.state.vt.us/AIR/MONITORING/HTM/O3TRENDS.HTM

***Trend number 2**: Vermont has experienced reductions in sulfur oxides but without reductions in acid precipitation.*

According to the Agency of Natural Resources, there has been a reduction in airborne sulfur oxides in recent years, but without a corresponding reduction in the acidity of precipitation.[16] As a result, the general trend is that there has been little change in acid (pH) precipitation in recent years and "no improvements in pH over time."[17]

Sulfur and nitrogen oxides are byproducts of the burning of fossil fuels by utilities, automobiles, residences and other energy users. When these oxides enter into the atmosphere and combine with water in the presence of an oxidizing agent such as ozone, they become oxidized to nitric and sulfuric acid. Prevailing easterly winds carry these pollutants from large coal-fired power plants in the mid-West to Vermont and the rest of the Northeast where they fall as acid precipitation. In addition to acidifying waterways, these acids also leach mineral nutrients from the soil. Pure rainwater is naturally acidic, with a pH of 5.6. Any precipitation with a pH value below 5.6 is considered to be acid precipitation. The acidity of pure rainwater can be buffered (neutralized) by mineral nutrients in the soil and rocks. Because of the effects of pollution, the average pH of precipitation currently falling on Vermont is 4.3, well within the acidic range.

The Effects of pH in Vermont Aquatic Ecosystems



Source: Agency of Natural Resources, Vermont Water Quality Division. http://www.vtwaterquality.org/bass/htm/bs_acidrain.htm

The effect of pH on aquatic organisms is quite dramatic, and specific examples are given in the chart below. As the pH of an aquatic ecosystem becomes progressively more acidic, we start to see significant problems. At 6.0, snails and brown trout begin to die; at 5.6 smallmouth bass die; at 5.1, northern pike die; at 5.0 loons, mink and heron face starvation; and at 4.5 and 4.3 even pumpkin seeds and bullheads die. At a pH of 4.2, virtually all of the fish are dead, and by 3.0 the water has the acidity of vinegar. Since precipitation falling on Vermont has a pH of 4.3, it is imperative that buffering occurs to reduce the acidity of this precipitation. Larger lakes with higher mineral concentrations have a greater buffering capacity and organisms in these lakes are at less risk. The most seriously affected lakes tend to be those that are small and located at a higher elevation because of less buffering soil runoff and with bedrock that has low buffering capacity. Data from 1998 provided by the Vermont Department of Forests, Parks and Recreation indicates the "percent of lakes and streams affected by acid atmospheric deposition" to be one percent of river miles and eight percent of lake area, both with a stable trend.[18]

[16] The acidity or alkalinity of a liquid is measured on a pH scale that ranges from zero, extremely acidic to fourteen, extremely alkaline. A pH of seven is neutral, below seven acidic and above seven alkaline.

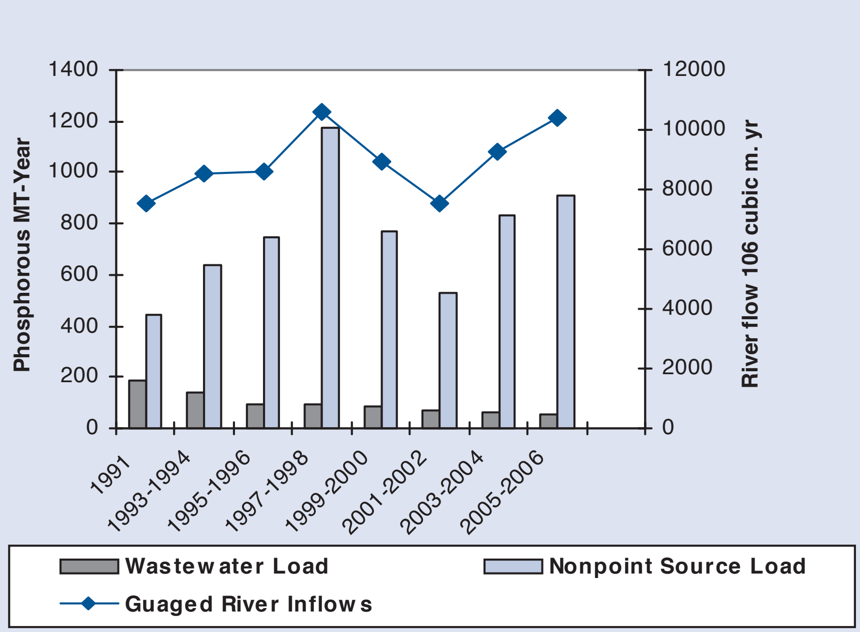
[17] Vermont Department of Environmental Conservation, Water Quality Division,"Acid Rain—the Vermont Perspective," updated, June, 2003. http://www.anr.state.vt.us/DEC/WATERQ/BASS/HTM/BS_ACIDRAIN-VT.HTM

[18] Vermont Department of Forests, Parks and Recreation, "The Vermont Forest Resource Plan, 1999-2008, Assessment Report and Key Indicators, 1999." http://www.vtfpr.org/FORPLAN/KEYFOREST.HTM.

Trend Number 3: *Phosphate contamination is largely stable for Lake Champlain, but there are areas where it is increasing. In major lake tributaries, it is decreasing.*

Phosphorus, primarily used as a fertilizer for commercial and residential use, is one of the essential nutrients needed to promote plant growth and crop production. But when phosphorus is not absorbed by the growing vegetation, it leeches into watersheds and promotes excessive aquatic algae growth, depleting waterways of oxygen, and as a consequence the numbers and types of fish. When the vegetation is eaten, the phosphorous that is not incorporated into animal tissues becomes part of the manure/fecal deposition and is spread on fields as fertilizer or makes its way to sewage treatment plants.

Phosphorous Load to Lake Champlain Compared to River Flow 1991 to 2006



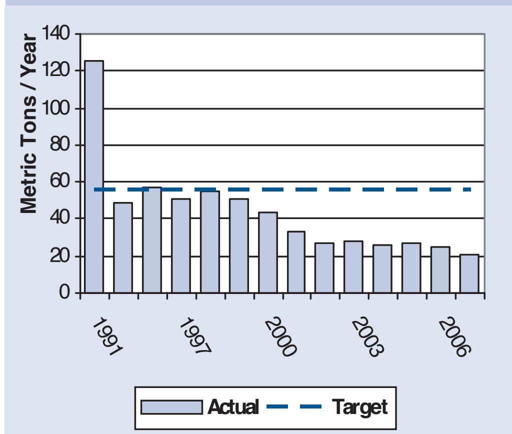
Source: Vermont Agency of Natural Resources

Phosphorus contamination varies by location, but the general trends are stable levels for Lake Champlain and decreasing phosphate contamination in some of its tributaries. This phosphorous is carried into Lake Champlain by rivers and other types of runoff. This more diffuse entry is referred to as non-point source contamination.[19] Basically, when river flow into a body of water is high, the non-point phosphorous load is also high.

Generally, since 1990, there has been no appreciative change in phosphorous concentration in Lake Champlain, Burlington Bay, Shelburne Bay, Mallets Bay, and Cumberland Bay. Several monitored areas of the lake are either at or near target levels for phosphate. Missisquoi Bay, St. Alban's Bay and the Northeast arm of the lake continue to exceed established targets, and the latter two indicate a disconcerting trend of increasing phosphorous concentration (see Appendix, 2-3, 2-4).[20]

The Lake's phosphorous levels have remained fairly constant, but the load from wastewater treatment plants has improved considerably between 1990 and 2007; Vermont, New York and Quebec are all below their respective total maximum daily load targets. Vermont has made the greatest improvement, decreasing its phosphate load from approximately 125 metric tons per year in 1991 to 25 in 2007 while New York's Lake Champlain' phosphate load decreased from approximately 60 metric tons in 1991

Phosphorus Loads from Wastewater Treatment Plants Vermont 1991 to 2007



Source: Lake Champlain Basin Program, State of the Lake and Ecosystem Indicators Report, 2008, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 9

[19] By comparison, discharge from a well-defined sewage treatment plant is termed a "point source."

[20] Vermont Agency of Natural Resources, Water Quality Division, "Lake Champlain Long term Monitoring" http://www.vtwaterquality.org/CFM/CHAMPLAIN/lp_longterm-lakes.cfm

to approximately 30 in 2007, and Quebec's dropped from 18 to approximately five. Such progress is impressive in light of the fact that Vermont now has more wastewater treatment plants on Lake Champlain than New York and Quebec combined. With all this effort, Vermont is now well below the established daily load target level, clearly a positive trend.[21]

Trend number 4: *Mercury levels in Lake Champlain are increasing; in Vermont's section of the Connecticut River, concentrations found in fish tissue are at a higher level than in other states.*

Mercury, a neurotoxin, is a significant contaminant of Vermont waters. Although naturally occurring, much of the mercury in the Lake Champlain watershed is airborne from coal-fired power plants in the Midwest (as noted in the Energy chapter, the state does not have any coal burning plants). Mercury containing products such as fluorescent bulbs and thermometers that are disposed of in landfills also contribute to mercury in the watershed and lakes. Mercury has increased by a factor of 2 - 4 as a consequence of human industrialization.[22] Effluent from wastewater treatment plants is also a contributor. Organisms living in a confined area such as a lake are unable to move away from a pollutant. Once ingested and absorbed into living tissues, much of the mercury is retained in a process of bioaccumulation.

When mercury and other contaminants enter the food web, the most threatened animals are the top consumers, basically those that eat other animals containing mercury. This causes an eventual increase in concentration within an organism, called biomagnification. Fish with long life expectancies generally contain more mercury because they have had more bioaccumulation time. The combination of absorption and ingestion and subsequent tissue storage and the longevity of a species lead to higher concentrations of mercury. Walleye and lake trout have especially high mercury levels in their tissues. Specific advisories are available as to the recommended maximum number of meals of Lake Champlain fish per month ranging from none to no more than nine eight ounce meals per month, depending on the fish species and size. The avoidance of mercury consumption is especially important for children below the age of six and women who either are or who might become pregnant.[23]

In 2000 the Environmental Protection Agency worked with state agencies and river organizations along the Connecticut River watershed to study the level of contaminants in fish tissue and the relative danger to human and other fish eaters. The stretches of the Connecticut River that bordered Vermont were shown to have significantly higher levels of total mercury in fish tissues sampled than in those sampled in most of the lower portions of the river. The risk level for fish eating birds and mammals was also likely to be higher in these regions along Vermont's river border. Other contaminants tested, such as PCBs, were often shown to have a lower concentration in fish tissue sampled along Vermont's stretches of the Connecticut River, although the study concluded that the risk of eating fish from the river still exists.[24] This study was just released in 2006, and it was meant to establish a baseline of data for further trend line analysis over time.

In general, the Environmental Protection Agency gives Vermont one of the best rankings for percent of rivers and streams that are polluted, a ranking that typically places the state among the cleanest five or ten states in the country. For example, in 2000, Vermont reportedly had 21% of the miles in its EPA-surveyed rivers and streams that were considered polluted. The highest state was Louisiana (89% of miles polluted), and the best state was Maine with only 2%. The U.S. average was 38%.[25]

[21] Lake Champlain Basin Program, State of the Lake and Ecosystem Indicators Report, 2008, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 9

[22] Vermont Department of Conservation, 2007.

[23] Lake Champlain Basin Program, State of the Lake and Ecosystem Indicators Report, 2008, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 19.

[24] Connecticut River Fish Tissue Contaminant Study, 2000, http://www.epa.gov/region01/lab/reportsdocuments/ctriverftr2000/chapter7.pdf pg. 280-283

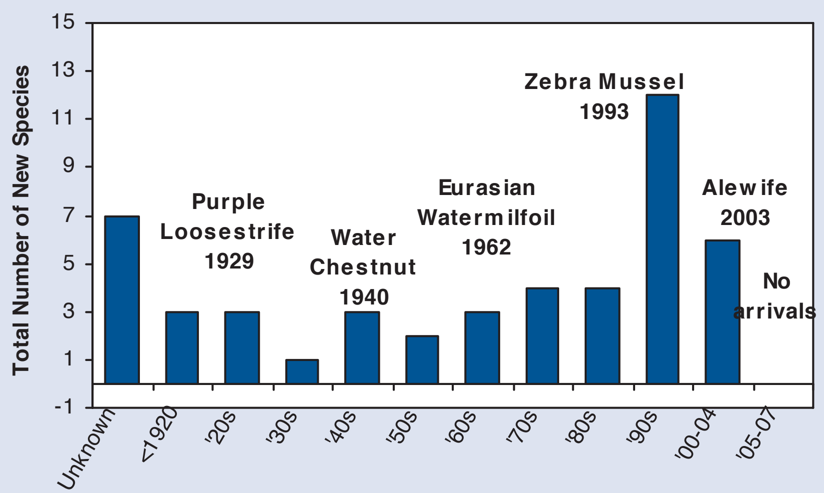
[25] Hovey, Kendra and Harold Hovey, CQ's State Fact Finder, 2007, Congressional Quarterly Press, various years.

***Trend number 5**: Lake Champlain has experienced an increase in invasive species over many years. Efforts to control the spread have been environmentally and politically challenging. The Connecticut River, due in part to different patterns of use, does not have all the same challenges.*

In general, an invasive species is one that has not been part of an existing ecosystem, and that has the potential to disrupt the established homeostasis or internal environmental equilibrium. As of 2007, Lake Champlain had 48 known invasive species. The connecting waters of the Saint Lawrence had 87 and the Great Lakes, 184 (see Appendix, 2-6). Clearly, Lake Champlain is on the receiving end of a larger invasion from throughout the watershed from the Hudson River/Champlain Canal and the Saint Lawrence/Richelieu Rivers. There have been no known new arrivals since Alewife in 2003. The documentation of invasive species began in the 1920s. Well-known new species introduced into Lake Champlain include Purple Loosestrife in 1929, Water Chestnut in 1940, Eurasian Water Milfoil in 1962, Zebra Mussels in 1993 and Alewife in 2003.[26]

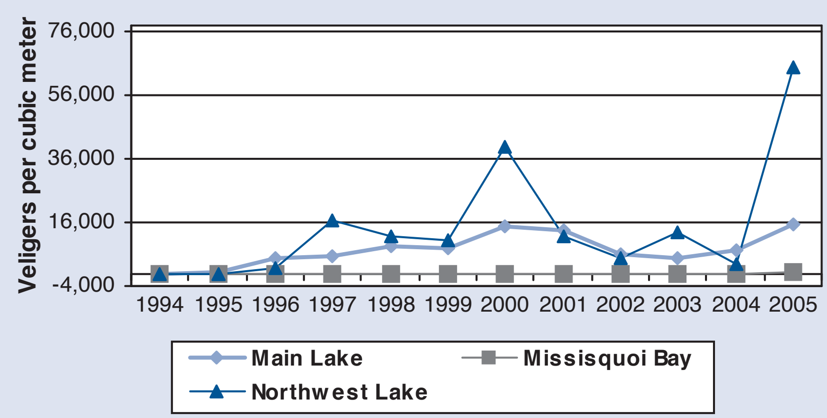
A well-chronicled case of invasive species is that of the zebra mussel, thought to have arrived via ballasts of ships from the Great Lakes in 1993. The free swimming larval stage in the zebra mussel life cycle is called a veliger. Examining veliger densities over time in the various Lake Champlain regions, numbers have generally increased, with considerable fluctuation over time from 1994 through 2005, ranging from close to zero to over 60,000 per cubic meter of lake water. In the South and Central Lake, considerable variation exists from one sampling station to another and from year to year. In the Northwest Lake, there are fluctuations, with a significant increase in veligers in 2005. Density of veligers from the Northeast Lake has been very stable from 1997 through 2005. All three of these stations indicated increases in larva in 2005 as compared to at least the preceding 6 or 7 years. The Northeast Lake is more isolated. Except for a few exceptional years, the zebra mussel density here has been low,

Aquatic Invasive Species Arrivals to Lake Champlain Pre 1920's to 2007



Source: Lake Champlain Basin Program, "State of the Lake and Ecosystem Indicators Report, 2008," Lake Champlain Basin Program, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 27

Lake Champlain Zebra Mussel Larval Densities in Each of Three Lake Regions 1994 to 2005



Source: Vermont Agency of Natural Resources, Water Quality Division, Lake Champlain Monitoring Program, http://www/vtwaterquality.org/lakes/htm/lp_lczebramon.graphs.htm

[26] Lake Champlain Basin Program, "State of the Lake and Ecosystem Indicators Report, 2008," Lake Champlain Basin Program, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 27.

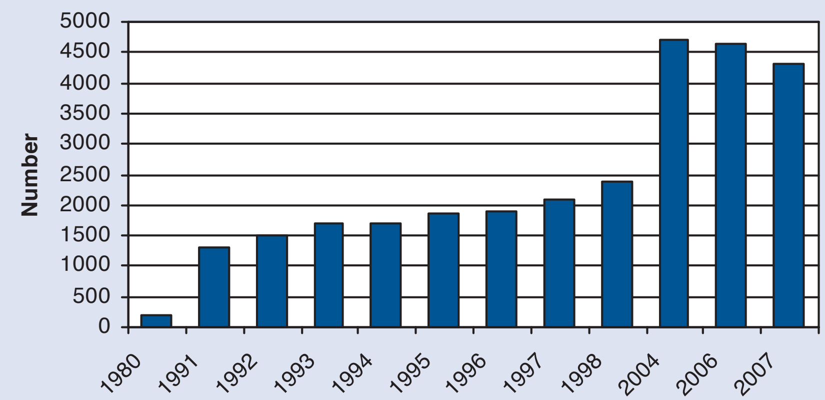
usually below 500 larva per cubic meter of lake water.[27] In all areas, zebra mussels are out-competing native mussels for resources and decimating the native populations. Thus far, the focus on "control" has been an attempt to limit their spread. Like other invasive species, zebra mussels are not part of the environmental balance of the Lake Champlain ecosystem. According to the U.S. Fish and Wildlife Service, zebra mussels have not yet been found in the Connecticut River watershed.[28]

Although not an invasive species per se, the sea lamprey is a migratory fish that spends its lifetime in fresh and salt waters. In its larval form, a sea lamprey will spend 5 years or more living buried in the mud and feeding on invertebrates in a river or lake. As an adult, the lamprey is a parasitic fish that attaches to larger fish, with a suction cup oral opening which it uses to suck fluids from the host fish, usually in the ocean. In inland bodies of fresh waters, such as the Great Lakes and Lake Champlain, sea lamprey cannot return to the sea as part of their natural migratory maturation process and do much damage to the native fisheries. In recent years, lamprey populations have been artificially suppressed by the use of lampricides in rivers and streams where they breed. A primary way to calculate lamprey populations is by the number of lamprey caused wounds per 100 fish sampled. The population of lamprey in Lake Champlain has caused target wound rates for both lake trout and salmon to be exceeded (see Appendix, 2-5).[29]

Trend number 6: *Vermont's forests are growing and healthy, while the estimated moose and deer populations have increased over the past twenty years.*

The health of Vermont's forests is explored in Chapter 7, Forestry. The conclusion reached is that the state's forests are in relatively sound condition (also, see Appendix, 2-7 and 2-8). Forests, of course, provide cover for moose and deer and other game animals as well as non-game animals. The trend in both moose and deer populations is a positive one of expansion, though populations are artificially regulated through management programs such as the number and type of hunting permits granted yearly. The state moose population has increased from an estimated 200 animals in 1980 to an estimated 4,300 animals in 2007.[30]

Statewide Moose Population Estimates
Vermont
1980 to 2007



Source: Vermont Agency of Natural Resources, Department of Fish and Wildlife, personal communication.
* Note that there is a gap in estimates between 1980 and 1991 and between 1998 and 2004.

The number of deer harvested by hunters over time can be used to estimate the health of the Vermont deer population. The interpretive difficulty, of course, is that the numbers are largely controlled by the number of various licenses issued in any given year. In 1979, the Vermont Fish and Wildlife Department instituted a three phase long-term strategy to manage the deer herd. Phase one from 1979-1982 reduced the herd by permitting liberal antlerless harvests. The purpose of phase two, through 1987, was to keep the herd at lower densities to allow for reestablishment. Phase three, through the mid-1990's, allowed the herd to grow slowly. "Unfortunately, this necessary management action then reduced densities through the 1980s. This was generally unpopular…" but over time, the

[27] Vermont Agency of Natural Resources, Water Quality Division, Lake Champlain Monitoring Program, http://www/vtwaterquality.org/lakes/htm/lp_lczebramon.graphs.htm

[28] Connecticut River Coordinator's Office, U.S. Fish and Wildlife Service, http://www.fws.gov/r5crc/zebra_mussel.htm

[29] Lake Champlain Basin Program, "State of the Lake and Ecosystem Indicators Report, 2008," Lake Champlain Basin Program, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 25

[30] Vermont Agency of Natural Resources, Department of Fish and Wildlife, personal communication.

plan worked and the deer herd has improved[31] (see Appendix, 2-9). Although there were fewer bucks taken in the 1980s when the plan was instituted, there has been a steady increase in average dressed buck weights since 1975.

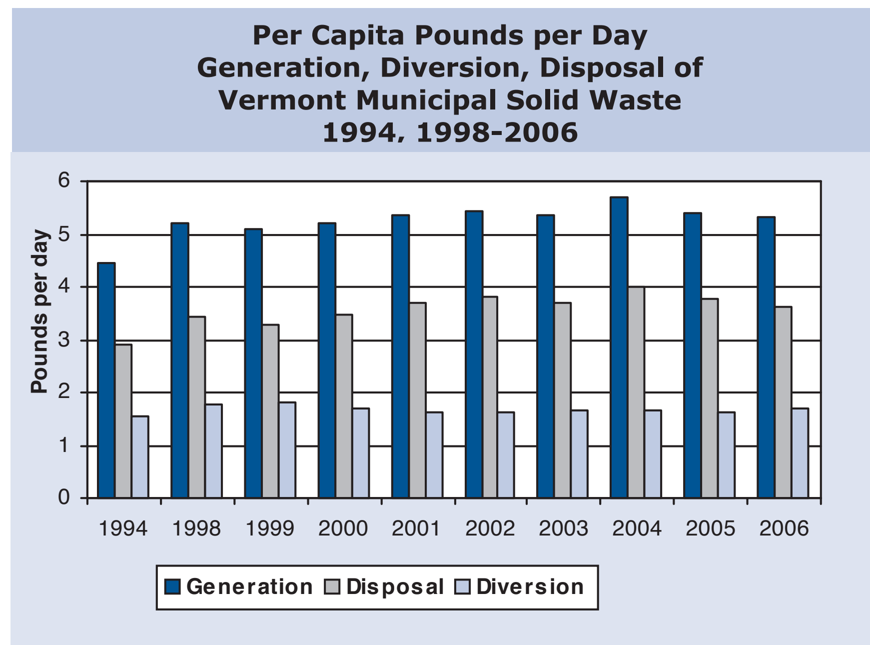
As well as the moose and deer populations are doing, there are many non-game animals that are either threatened or endangered—the former refers to "high possibility of becoming endangered in the near future" while the latter means "in immediate danger of being extirpated in the state."[32] The list of threatened and endangered includes both aquatic and terrestrial animals. Similarly, there are threatened and endangered species of plants in Vermont. Tree families on the list include birch, dogwood, oak, mulberry, pine and willow. Although there is no clear time trend line that could be created, any reference to endangered or threatened is a negative trend.[33]

***Trend Number 7**: There has been an increase in the amount of solid waste generated in Vermont, but there has been little significant change in the disposal/diversion ratio in recent years.*

There has always been solid waste created by humans that required disposal. With increased population density, urbanization and industrialization, municipal solid wastes have increased significantly, and the means of its disposal in ecologically conscientious ways has become challenging.

The amount of municipal solid waste generated by Vermont in 1994 was about 474,800 tons. By 2006 it had risen to 606,276 tons and is projected to be 640,120 by 2011 (see Appendix, 2-10).[34] The generation of municipal solid waste correlates with population growth, although technology and consumption patterns are also important. On average, per capita tons per year or pounds per day of municipal solid waste generated has remained relatively stable between 1999 and 2006, with the pounds per day ranged from 5.11 in 1999 to 5.68 in 2006. According to the Northeast Recycling Council, Vermont recycled 52,368 tons of scrap metal and glass and 82,010 tons of paper in 2005. This resulted in "forest carbon sequestration benefits equal to 4,058,912 tree seedlings grown for 10 years…and…saved 270,633 cubic yards of landfill space."[35]

Reducing and reusing resources and recycling decreases the pressures on landfills. By reducing the need for "virgin" resources, less energy is used, water quality is improved, and fewer greenhouse gases are created. The amount of municipal solid waste that has been diverted in Vermont from disposal (including recycled material) has fallen slightly, ranging from a low of 1.61 pounds/day/person in 2005 to a high of 1.81 in 1999. Even with a greater awareness of recycling, diversion numbers from 2006 were 1.68



Source: Vermont Agency of Natural Resources, Waste Management Resources. 2001 State of Vermont Revised Solid Waste Management Plan. http://www.anr.state.vt.us/dec/wmd.htm

[31] Vermont Agency of Natural Resources, Vermont Department of Fish and Wildlife, 2008.

[32] Vermont Agency of Natural Resources, Fish and Wildlife Department, "Non-Game and Natural Heritage Program, 2005.

[33] Vermont Agency of Natural Resources, Fish and Wildlife Department, "Non-Game and Natural Heritage Program, 2005.

[34] Vermont Agency of Natural Resources, Waste Management Resources. http://www.anr.state.vt.us/dec/wmd.htm

[35] Northeast Recycling Council. *Vermont Fact Sheet*. http://www.nerc.org/documents/fsheets/vt-factsht.html

pounds/day/person, less than it was in 1999. The Department of Energy Conservation has been assigned the task of reaching a 50% diversion rate by 2011. This will necessitate significant increases from the 32% diversion rate recorded in 2006, especially when one considers that the percent diverted from disposal has not changed appreciably since 1994.[36]

Some of our existing municipal solid waste is hazardous. Vermont has eleven hazardous waste sites and was ranked 39th in 2004 in the number of sites, all listed as a "priority" for cleanup. Given Vermont's small population, this number is strikingly high. However, of the 38,347,000 tons of hazardous solid waste generated in the United States in 2005, only 3,500 tons were generated in Vermont and another 300 were received; about 2,800 tons were eventually shipped out of state.[37]

Vermont is divided into three principle climate regions: the northeastern, western and southeastern. Some data in this report have been collected from stations covering all of these regions, while other data are just from the Burlington International Airport, the location of the National Weather Service's station, which is in the western region of the state. Variations in average temperature between these sites are generally not much more than a couple of degrees. Data on percent sunshine show that Burlington averages 49%.[38] Across the United States, these percentages range from 30% in Juneau, Alaska to 90% in Yuma, Arizona with an average and median of 60%."

***Trend number 8:** The average temperature has increased over the past century, with much of the increase occurring during the most recent 50 years.*

Between 1895 to 2007, the temperature in Burlington has averaged 44.7° Fahrenheit (F), only slightly cooler than for the Northeast region as a whole at 46.3° F. The coldest year in Burlington was in 1917 when the temperature averaged 40.8° F, while the warmest year was in 1998 when the temperature averaged of 48.3° F.

[36] Ibid

[37] U.S. Bureau of the Census, Statistical Abstracts of the United States, 2008.

[38] Measured as the total time that sunshine reaches the surface and expressed as the percentage of the maximum amount possible from sunrise to sunset with clear sky conditions.

The possibility of global warming and climate change has been a major concern in the worldwide environmental movement. The causes and significant of this phenomena are well beyond the scope of this study, but it is fair to say that the recent trend in Burlington's temperature has been moving upwards, but the magnitude of the change identified depends on the data points examined. From 1892 to 1950, the trend was slightly negative, but from 1951 through 2007, the trend was positive with the temperature increasing by about one tenth of a percent per year.[39] It should be pointed out that while increments of this sort may seem negligible as far as tactile human sensitivity is concerned, these changes can be significant from a meteorological standpoint; small changes to a chaotic system like the atmosphere can produce dramatically different climate results.[40] Fifty years in meteorological time does not represent a long-term trend, and over the millennia trends have reversed themselves, but to the extent this short-term movement continues into the future unabated, the consequences on all aspects of life in Vermont will be profound.

Temperature in Burlington and Vermont 1895 to 2007

Years	Location	Average Temperature (°F)
1892 - 2007	Burlington	44.8
1892 – 1920	Burlington	44.9
1921 – 1949	Burlington	44.2
1950 – 1978	Burlington	44.2
1979 - 2007	Burlington	45.7
1895 - 2007	Vermont	42.5
1987 - 2007	Vermont	43.0
1895 - 2007	Northeast US	46.3
1895 - 2007	Washington state	48.0
1895 - 2007	Northwest US	46.8

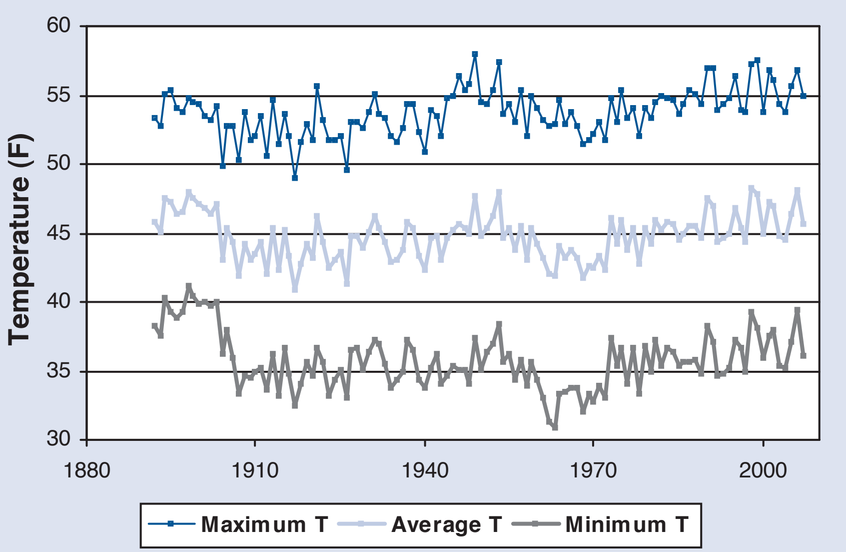
Source: National Climatic Data Center (NCDC)
http://www1.ncdc.noaa.gov/pub/orders/5941021404338.txt
http://www.ncdc.noaa.gov/oa/climate/research/cag3/nt.html
National Weather Service, Burlington, VT
http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

[39] Among the warmest ten years in Burlington since 1892, four have occurred since 1990.

[40] Special thanks for much of the data goes to the Vermont State Climatologist: http://www.uvm.edu/~ldupigny/sc/

***Trend number 9:** The average heating degree-days has decreased over the past century, while the average cooling degree-days has increased over the same period.*

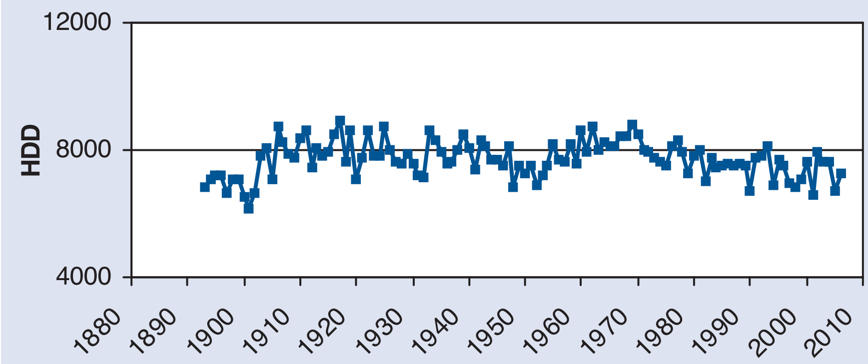
Average Temperature and Average Maximum and Minimum Temperature Burlington 1892 to 2007



Source: National Weather Service, Burlington, VT
http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

Heating degree-days (HDD) are obtained by taking the daily mean temperature and subtracting it from the reference temperature of 65° F. Each degree of temperature that the daily mean is lower than 65° F constitutes one heating degree-day. For example, if the average temperature on a given day was 57° F, the heating degree-day for that day would be 8. The daily results are then added to give a single total value for the year. This number is meant to give a relative measure of how often you would need to keep the heat on. Since winter months see the largest values of heating degree-days, the records are usually listed for an entire heating season. Thus, the heating degree-day values for 1995 imply data that are summed from about the fall of 1994 to the summer of 1995. The trend in the Burlington area from 1892 to 2007 shows a decrease in heating degree-days. The average yearly heating degree days from 1892 to 1950 were 7,713. Between 1951 and 2007, the average annual heating degree days were 7,670, a decline of 43 from the first period. For the precise figures, see Appendix, 2-11. See also "Trend 7" in Chapter 10 on Energy.

Heating Degree-Days
For Burlington
1892 to 2007

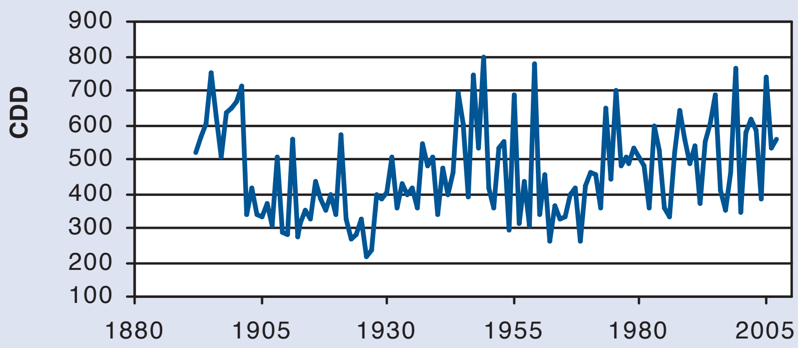


Source: National Weather Service, Burlington, VT
http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

Cooling degree-days (CDD) are simply the warm-weather version of heating degree-days. The reference temperature is still 65° F, which is subtracted from the daily mean temperature. Each degree of temperature that the daily mean is higher than 65° F constitutes one cooling degree-day. These results are then added to give a single total value for the year. Thus, in this case it gives a relative measure of how often you might keep an air conditioner on. In the case of Vermont, the cooling degree-days usually only occur during the summer months. The trend over the past century shows an increase of 79 cooling degree-days in the Burlington area from 424 to 503.[41]

[41] Trends in this section are based upon OLS regression procedures.

Cooling Degree-Days
Burlington
1892 to 2007

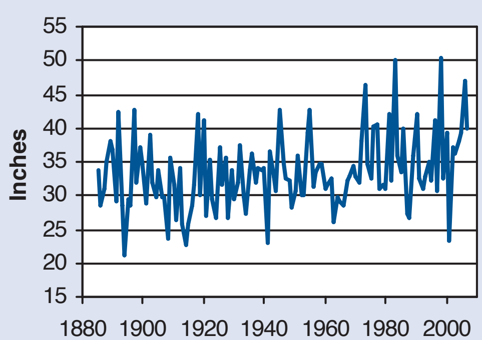


Source: National Weather Service, Burlington, VT
http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

***Trend number 10:** The average total precipitation, including snowfall levels, has increased over the past century, as have annual variations.*

All forms of precipitation measured on a liquid water basis fall into this category. During the period from 1895 to 2007, the precipitation trend for Vermont shows an increase of 2.1 inches, from an average of 39.8 inches to 41.9 inches. Burlington precipitation data from 1884 to 2007 show an increase of 5.4 inches, from an average of 30.7 inches to 36.1 inches.[42] To illustrate the effect of location on these data, the average precipitation over a 30-year period from 1971 to 2000 from 10 regions of the State is 45.6 inches. However, this includes heavier precipitation values from the two mountain regions of Jay Peak and Mount Mansfield. If one removes the data from these two locations, the average result drops to 39.3 inches. Finally, a glance at the precipitation plot for Burlington suggests that the variations in precipitation have increased in recent years. This is supported by the data, which show increases in standard deviations in 20-year time spans from a low in the 1940s of ±4.0 inches to about ±6.0 inches in the last twenty years. The relatively large swings in yearly participation, in part, suggest that the particular set of years examined impacts the significance of the trends uncovered. For precise figures, see Appendix 2-12.

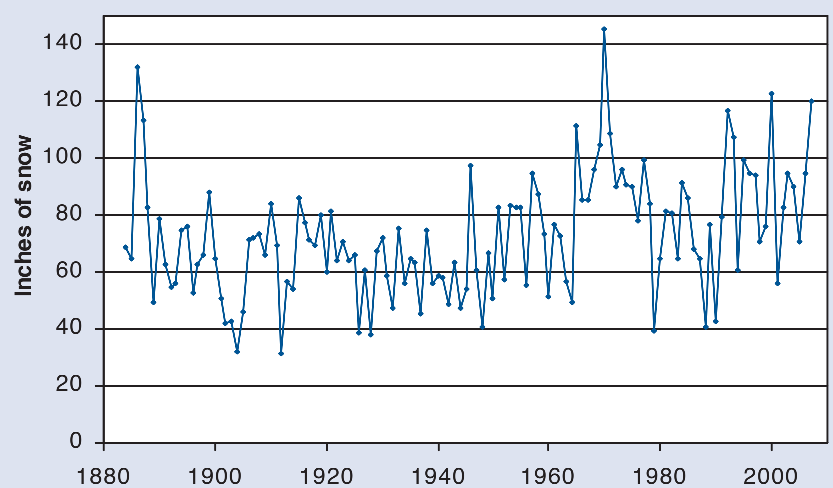
Precipitation
Burlington
1884 to 2007



Source: National Weather Service, Burlington, VT
http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

Average snowfall for the period from 1884 to 2007 in the Burlington area shows an increase of 24.5 inches from 60.2 inches to 84.7 inches. For the last twenty years, Burlington snowfall has increased by 8.0 inches, from an average of 69.3 inches to 77.3 inches. For Vermont, the last twenty years show an average increase of 15.6 inches, from 72.6 inches to 88.1 inches. As with precipitation, the larger amount here is due to the inclusion of

Snowfall
Burlington
1884 to 2007



Source: National Weather Service, Burlington, VT
http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

[42] Unlike temperature, trends in participation in Burlington have not increased since the 1950's.

parts of the state that tend to incur heavier snowfall than Burlington. For example, if one looks at the years between 1971 and 2000, the average is 114 inches. Removing the two mountain records from the average calculation gives an average of 89 inches. As with the precipitation data, snowfall amounts have shown an increase in standard deviation from a low of ±11 inches in the 1940's to about ±22 inches in the past twenty years.

Vermont's environment does not stop at the political borders of the state. It is encouraging, therefore, that many of the trends show progress in bringing about a healthy ecological balance, yet Vermonters remain mindful of the need for the further improvements.

The major trends that we have identified are as follows:

1. Air quality in Vermont has improved slightly over the last decade.
2. Vermont has experienced a reduction in sulfur oxide deposition but without reductions in acid precipitation.
3. With the exception of smaller northeast bays, phosphate levels in Lake Champlain have remained relatively constant. Phosphate levels in major Vermont tributaries are decreasing.
4. Mercury levels in Lake Champlain are increasing; in Vermont's section of the Connecticut River, concentrations found in fish tissue are at a higher level than in nearby states.
5. Lake Champlain has experienced an increase in invasive species over many years. Efforts to control their spread have been environmentally and politically challenging.
6. Vermont's forests are growing and are healthy, while the estimated moose and deer populations have increased over the past twenty years.
7. With the growth in population and modernization, there has been an increase in the amount of solid waste generated in Vermont, but there has been little significant change in Vermont's disposal/diversion ratio in recent years.
8. The average temperature has increased over the past century, with much of the increase occurring during the most recent 50 years.
9. The average heating degree-days has decreased over the past century, while the average cooling degree-days has increased over the same period.
10. The average total precipitation, including snowfall levels, has increased over the past century, as have annual variations.

For the appendices and for pdf versions of this report, please visit the Council on the Future of Vermont's website; www.futureofvermont.org or visit Vermont Council on Rural Development at www.vtrural.org.

The Appendix for this chapter contains the following charts:

1. Air Quality Index, Chittenden County, VT. 1998 and 2007
2. Ozone Running 3-Year Averages of Annual, Fourth Maximum 8-Hour Averages, Concentration in Parts per Million, 1991 to 2006
3. Total Phosphorous in Lake Champlain and Missisquoi Bay, 1992-2007
4. Changes in Phosphate Levels in Lake Champlain and Four Tributaries, 1992 and 2007
5. Sea Lamprey Wounding Rates on Lake Trout and Atlantic Salmon in Lake Champlain, 1985-1998, 2002-2007
6. Aquatic Invasive Species, Threats to Lake Champlain from Connected Waterways
7. Health and Vigor of Forests as Indicated by Changes to Average Crown Condition Vermont, 1986, 1996
8. Health and Vigor of Sugar Maple Based on Crown Dieback, Vermont, 1991, 1996
9. Deer Harvest Trends; Total and Buck Harvest, Vermont, 1995-2007
10. Diversion as Percent of Vermont Municipal Solid Waste Generation, and Per Capita MSW Generation in Pounds/Day, 1987, 1994, 1998-2006
11. Heating Degree-days, and Cooling Degree-days, Burlington and Vermont, 1892-2007
12. Summary of Precipitation and Snowfall, Burlington, Vermont, Northeast, 1895-2007

Vermont in Transition:

A Summary of Social Economic and Environmental Trends

A study by

Center for Social Science Research at Saint Michael's College

Vince Bolduc, Ph. D. and Herb Kessel, Ph. D.

for the

Council on the Future of Vermont

December 2008

Chapter 2:

ENVIRONMENT AND CLIMATE ~ APPENDIX

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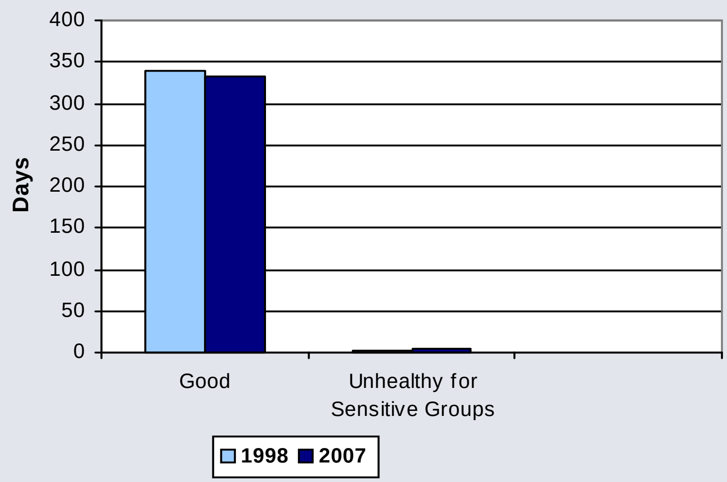
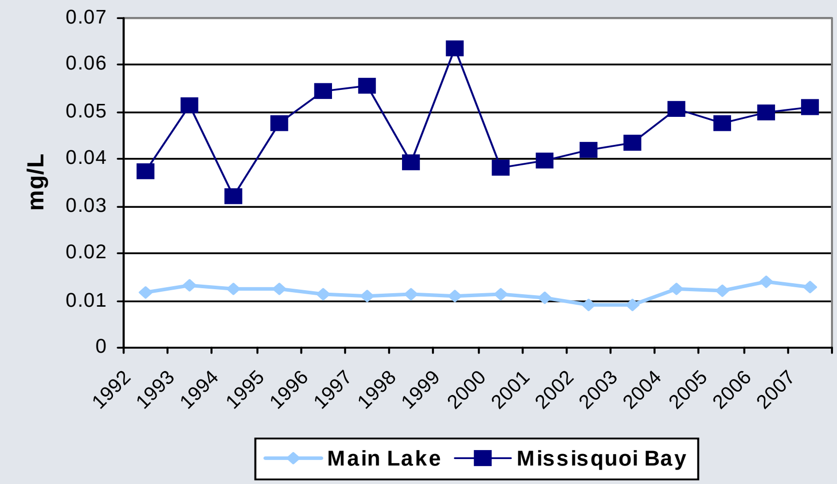
Chart 2-1: Air Quality Index
Chittenden County, VT
1998 and 2007



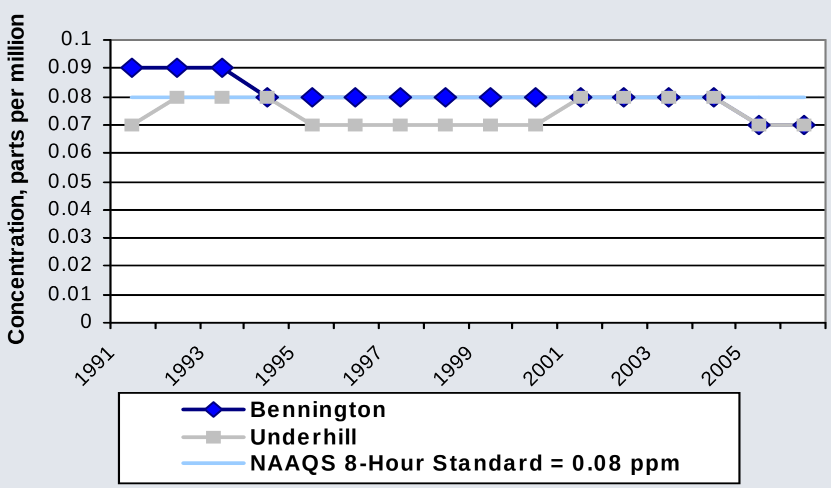
Source: United States Environmental Protection Agency. Air Data,

Chart 2-3: Total Phosphorous in Lake Champlain and Missisquoi Bay
1992 to 2007



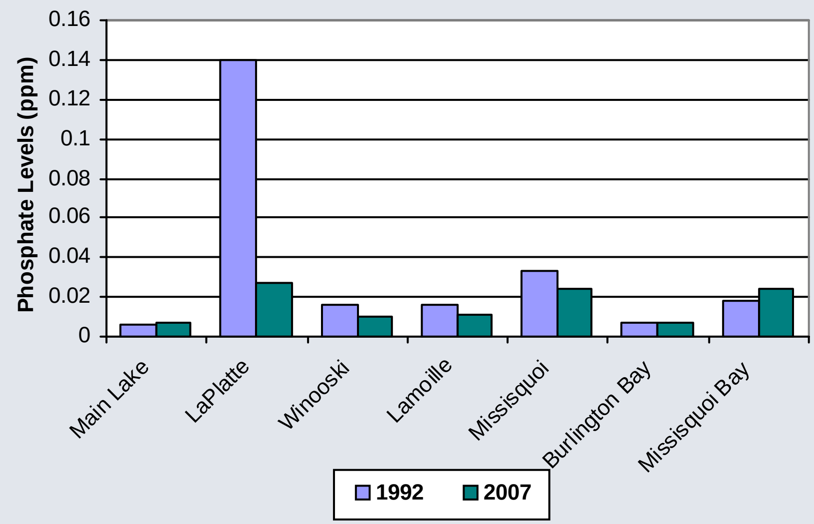
Source: State of the Lake and Ecosystem Indicators Report – 2008, Lake Champlain Basin Program, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg.

Chart 2-2: Ozone Running 3-Year Averages of Annual Fourth Maximum 8-Hour Averages Concentration in Parts per Million



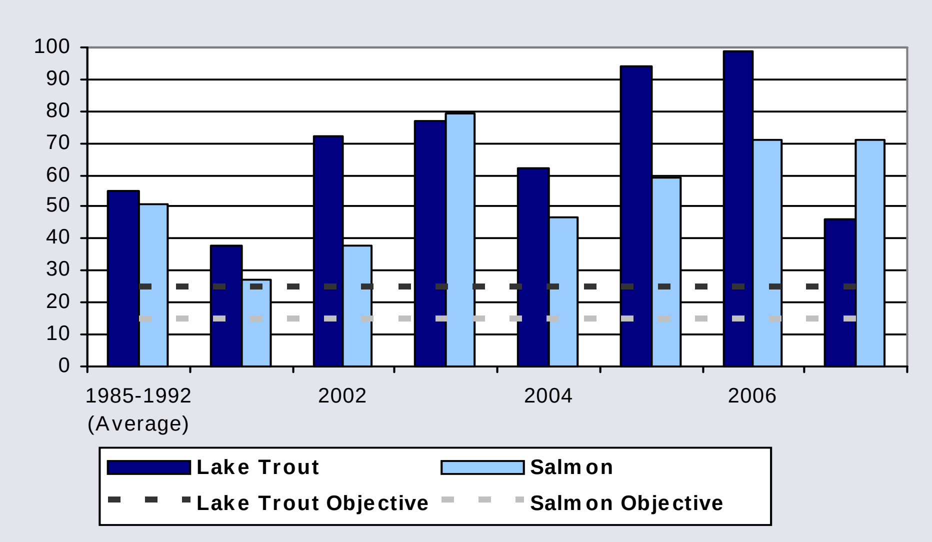
Source: Vermont Department of Environmental Conservation, Air Pollution

Chart 2-4: Changes in Phosphate Levels in Lake Champlain and Four Tributaries
1992 and 2007



Source: Vermont Water Quality Division, Agency of Natural Resources, Lake Champlain Long-Term Monitoring, Lake Station Data

Chart 2-5: Sea Lamprey Wounding Rates on Lake Trout and Atlantic Salmon Lake Champlain



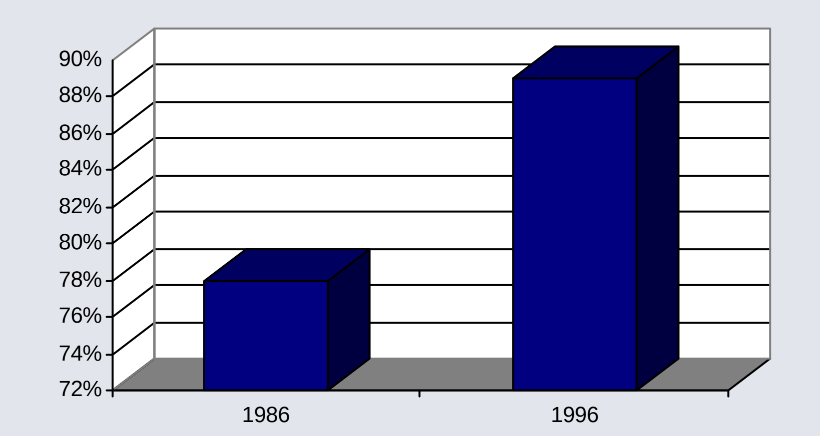
Source: Lake Champlain Basin Program, "State of the Lake and Ecosystem Indicators Report, 2008," Lake Champlain Basin Program, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 25

* Lake trout in the 533-633 mm (21.0-24.9 inches) length interval. For lake trout, pre-control included 1982-92, while experimental control includes 1993-97.* Salmon in the 432-533 mm (17.0-21.0 inches) length interval. For salmon, pre-control included 1985-92, while experimental control includes 1993-98.

Chart 2-6: Aquatic Invasive Species Threats to Lake Champlain from Connected Waterways

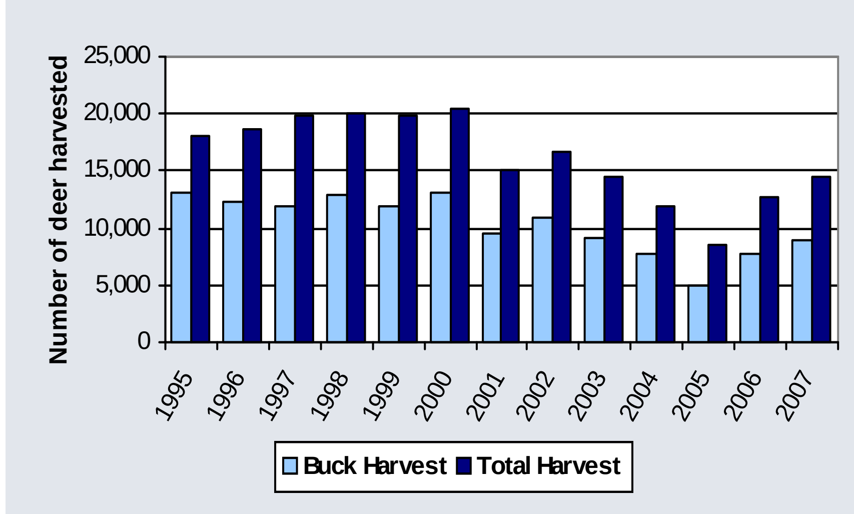
Source: State of the Lake and Ecosystem Indicators Report – 2008, Lake Champlain Basin Program, http://www.lcbp.org/PDFs/SOL2008-web.pdf, pg. 28

Chart 2-7: Health and Vigor of Forests as Indicated by Changes to Average Crown Condition Vermont 1986 and 1996



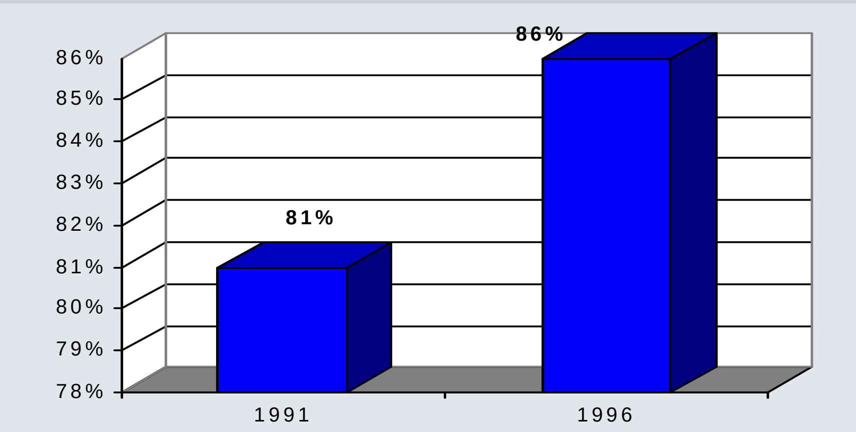
Source: Vermont Department of Forests, Parks and Recreation, The Vermont Forest Resources Plan 1999-2008, Assessment Report and Key

Chart 2-9: Deer Harvest Trends; Total and Buck Harvest Vermont



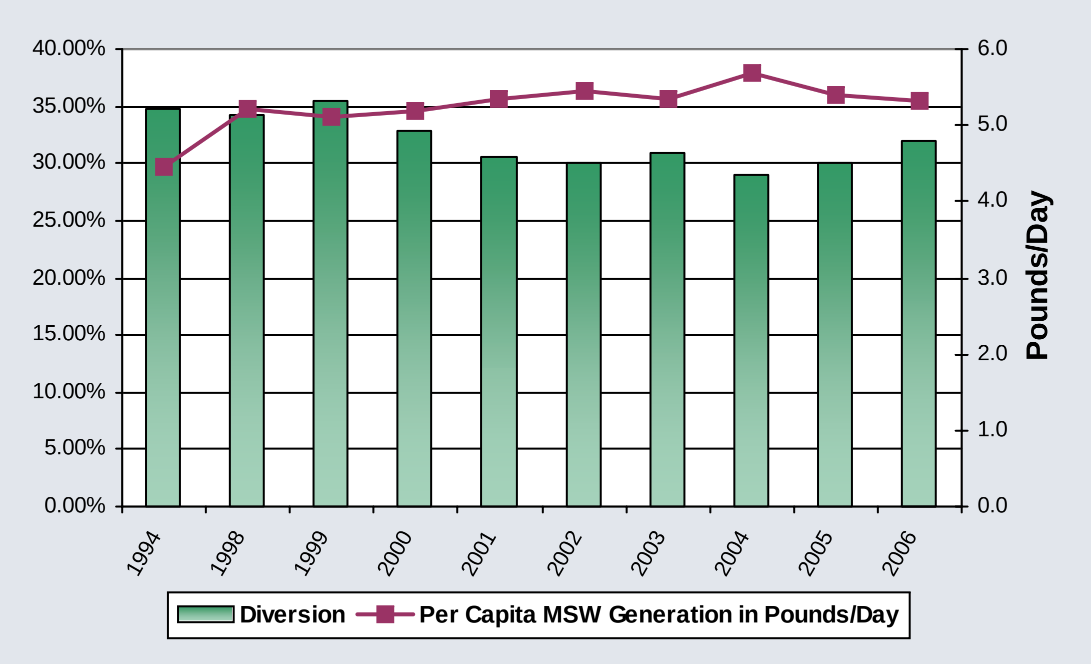
Source: Vermont Agency of Natural Resources, Fish and Wildlife Department.

Chart 2-8: Health and Vigor of Sugar Maple Based on Crown Dieback



Source: Vermont Department of Forests, Parks and Recreation, The Vermont Forest Resources Plan 1999-2008, Assessment Report and Key Indicators, *Key Forest Indicators*, http://www.vtfpr.org/forplan/keyforest.htm , 2-9

Chart 2-10: Diversion as Percent of Vermont Municipal Solid Waste Generation and Per Capita MSW Generation in Pounds/Day



Source: Vermont Department of Health, Fish and Wildlife, 2001 State of Vermont Revised Solid Waste Management Plan

Chart 2-11 Heating degree-days (HDD) and Cooling degree-days (CDD) data 1892-2007

Years	Location	CDD Trend	CDD Average	HDD Trend	HDD Average
1892-2007	Burlington	+ 79	463	- 61	7707
1987-2007	Burlington	+ 30	536	+ 91	7181
1987-2007	Vermont	- 26	418	+ 3	7629

Source: National Climatic Data Center (NCDC) http://www1.ncdc.noaa.gov/pub/orders/5941021404338.txtNational Weather Service, Burlington, VT http://www.erh.noaa.gov/btv/climo/BTV/monthly_totals/index.shtml

Chart 2-12: Summary of Precipitation and Snowfall data 1895-2007

Years	Location	Precipitation Trend (inches)	Average Precipitation (inches)	Snowfall Trend (inches)	Average Snowfall (inches)
1895-2007	Vermont	+ 2.1	40.9	**	**
1987-2007	Vermont	+ 7.7	39.8	+ 15.6	80.4
1884-2007	Burlington	+ 5.4	33.4	+ 24.5	72.5
1987-2007	Burlington	+ 9.1	35.5	+ 8.0	73.3
1895-2007	Northeast US	+ 4.6	41.4	**	**
1987-2007	Northeast US	+ 6.2	43.8	**	**

Source: National Climatic Data Center (NCDC) http://www1.ncdc.noaa.gov/pub/orders/5941021404338.txt
http://www.ncdc.noaa.gov/oa/climate/research/cag3/nt.html
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