Low Sodium Diet

Curbing New York's Appetite for Damaging Road Salt

FOREVER WILD

ADIRONDACK COUNCIL

Defending the East's Greatest Wilderness

Low Sodium Diet:
Curbing New York's Appetite for Damaging Road Salt

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TABLE OF CONTENTS

Executive Summary

The vast majority of the roads and the population of the United States are located within regions that receive at least five inches of snowfall annually.[1] Parts of upstate New York receive well over 100 inches per year, even up to 200 inches on the Tug Hill Plateau just west of the Adirondack Park. The rise of the automobile a century ago allowed people to live farther apart and farther from where they worked, creating entirely new issues for winter road management. As roads were cleared, the exposed pavement contained melted snow which refroze into ice. This led to a need for salt and sand to minimize the dangers of ice formation and unsafe road conditions. Use of these materials has increased steadily since the 1930's and now costs local and state governments hundreds of millions of dollars each year.

Sodium chloride, or road salt, along with sand, are the most widely used tools in winter weather management due to their low costs. However, they have their share of negative consequences. Road salt is particularly harmful to the environment; the effects of which include, but are not limited to killing trees, providing opportunities for invasive species, adversely affecting annual cycling in waterways, tainting drinking water supplies, and increasing erosion. Studies in the Adirondack Park have found that salt loadings have had significant impacts on lakes and ponds near treated roadways, resulting in long-term damage that would cost millions of dollars to mitigate. Sand builds up in lakes and streams, clogging the water and altering the natural environment. It also dramatically increases particulate air pollution, affecting plant, animal, and even human health

It is necessary to reevaluate and possibly reduce the use of these materials in the future. Effective road management must balance public safety concerns with short and long-term environmental and economic concerns. Keeping roads open throughout the winter is vital to the economic health of the Adirondack Park. However, current road management strategies cannot be continued without serious environmental risk.

Fortunately, numerous tools are available which can considerably reduce the use of road salt and sand. These tools include chemical alternatives, infrastructure improvements, and encouragement of smarter and safer winter driving behaviors. Instituting these methods will require collaboration between the state and local jurisdictions in charge of snow and ice removal as well as long-term planning. The benefits will easily outweigh the costs, especially as rising salt and fuel costs and continuing budget shortfalls affect local and state government. This report will detail how the use of road salt and sand affects the environment, human health, and government budgets, by examining the numerous studies that have been undertaken in upstate New York, the United States, and around the world.

[1] Salt Institute. "Highway Deicing and Anti-Icing for Safety and Mobility."

Recommendations of this report include:

- Anti-Icing
  - Whenever feasible, the process of anti-icing should be undertaken, because it reduces the amount of deicing materials needed and keeps roads clear from the beginning of a weather event. The state should create an incentive program to encourage this practice.
- Road Weather Information System (RWIS)
  - By understanding the current road conditions, the precise amount of deicers can be applied to keep roadways safe for drivers. The state should provide localities with grants or some other financial incentive to utilize or upgrade their snow and ice removal procedures with an RWIS.
- Centralize winter road weather management operations and responsibility
  - NYSDOT should complete a feasibility study to determine the effectiveness and possible costs savings of centralizing more of the operation and responsibility for winter road management to state agencies. Localities should still be given some discretion within state guidelines over management procedures to maximize safety and minimize damage to the environment, roadways, and vehicles.
- Chemical Alternatives
  - State and local officials should assess the use of chemical alternatives to road salt. These alternatives can recoup the initial investment by requiring less maintenance and upkeep on spreading equipment, cars and roadways, replanting of vegetation and cleanup or replacement of drinking water supplies.
- Environmental Risk Assessments
  - Highway departments should use assessments of their winter management plans that give significant weight to environmental impacts. While public safety will and should remain the top priority, greater appreciation of the long-term environmental damage caused by excessive usage of road salt will assist in adopting less harmful practices.
- Encouraging Safer Winter Driving
  - New York should adopt an aggressive approach to encouraging safer winter driving, which can include lower winter speed limits, strategically placed variable message boards, and greater enforcement of safe speed limits during winter weather.

Introduction

Winter weather has a significant impact on transportation in northeastern areas like the Adirondack Mountains. The use of road salt and sand in the first half of the 20th century assisted in significantly improving winter travel in both rural and urban settings. Unfortunately, these techniques have produced negative and costly side effects, such as environmental damage, corrosion, and pollution of air and water.

This paper will examine past and current winter road management strategies applied in the United States generally and New York specifically. It will summarize recent research on the effects of road salts and abrasives such as sand, explore alternatives to road salts, and make recommendations for dealing with the delicate balance between preserving the environment and the safety needs of the driving public.

History of Winter Road Management

The vast majority of U.S. roads and population are located within regions that receive at least five inches of snowfall annually.[2] Most of the densely populated Midwest and Northeast states receive much more than this. Parts of upstate New York receive well over 100 inches per year, even up to 200 inches on the Tug Hill Plateau of the Adirondack Park. While residents of these regions have always had to deal with storms that measure in the feet, it was only in the past century that these events shut down travel in these regions for only a few hours.

In the 18th and early 19th centuries these storms were less disruptive to daily life given that populations were relatively sparse and residents typically did not rely on deliveries of food to sustain themselves. This changed as the economy diversified and urban areas became larger. Buildup of snow presented not only a hazard for traveling, but also for buildings whose roofs were not built to withstand the weight and for firefighters whose equipment might freeze. The first major attempts at snow removal came in the early 1860's with initial uses of snowplows attached to horse-drawn carts.[3]

Following the great blizzard of 1888 which paralyzed the Northeast, cities realized they had to do more than just attempt to plow following snowstorms. This was partly the motivation to create subways in New York and Boston. Following these, motorized vehicles began to appear, with cities quickly motorizing their snow removal fleets.[4] The rise of the automobile, coupled with its effect in allowing people to live further and further apart, created entirely new issues for winter road management. As roads were cleared, the resulting pavement contained melted snow which refroze into ice. This led to an increased need for salt and sand to minimize the dangers of ice formation and unsafe road conditions. Use of these materials has increased steadily since the 1930's and now costs cities and states hundreds of millions of dollars each year.

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[2] Salt Institute. "Highway Deicing and Anti-Icing for Safety and Mobility."
[3] Chesire et. al. "Have Snow Shovel, Will Travel." National Snow and Ice Data Center.
[4] Ibid.

Recent years have seen Montreal exceeding sixty million dollars for snow removal in one winter.[5]

This increased use, combined with environmental concerns, the climbing costs of snow removal, and ineffectiveness of salt and sand under certain conditions, has lead to increased interests in alternatives. Despite the steady rise in use of alternatives, there have been only minimal reductions in the amount of road salt used in most areas. As winter road management has become more efficient and used more chemicals, drivers have also come to expect clear roads throughout the winter. This expectation has lead to hesitance regarding acceptance of alternative deicers or reduced de-icing or anti-icing practices.

Current Strategies for Winter Road Management

The two basic concepts for removing snow and ice from roadways are anti-icing and de-icing. Deicing, which traditionally has been the common practice, involves attempting to remove ice and snow from roads during or following a winter weather event. Unfortunately, this method is relatively ineffective, requires greater quantities of de-icing materials (road salt or alternatives) or abrasives (sand), and leaves roads unsafe for a significant portion of a storm. When winter road management was in its infancy in the early 20th century, de-icing was the most viable option due to imprecise weather forecasts, lack of technology required to coordinate efficient operations, and smaller populations. With the increase of population and technological innovations over the past half century, it has become much more efficient and cost-effective to switch over to anti-icing practices.

Anti-icing, as the name implies, is the application of deicers prior to the onset of a winter weather event. Crews will commence spreading road salt or other alternative deicers hours before snow begins to fall. Not only do maintenance crews need to know the weather forecast and when the snow will begin to fall, the air temperature, and the time it will take to treat the roadways, but even more importantly, they must know the pavement conditions as well. This includes the pavement temperature, which for effective ice removal is vital since the deicers must melt the ice on the pavement, not in the air. This may require an extensive network of sensors and processing computers (known as a Road Weather Information System or RWIS, which is addressed later). Anti-icing may also require different chemical mixers and spreading equipment than the traditional de-icing procedures and there may be conditions which arise where a crew must switch from one treatment to the other.

Despite these concerns, anti-icing is more effective, cheaper, and less damaging than the traditional practice of deicing. Since the deicers are spread prior to the formation of ice and buildup of snow, they only have to play a preventative role, rather

[5] Ibid.

than a reactive one, which increases their overall effectiveness. Requiring fewer materials on fewer runs, and thus fewer man-hours can create a significant savings. In the 2006-2007 season, the NYSDOT spent over $36 million on road salt and $22 million on labor costs.[6] Thus, while New York has implemented fairly widespread anti-icing processes, even a further 5% boost in efficiency would be a total savings of nearly $3 million dollars, not including the decreased need for upkeep on vehicles and the lessened environmental damage.

An additional advantage of anti-icing over deicing that may not be obvious to the general public is the speed at which materials can be spread. Partially due to the fact that spreaders have become more effective, and also partially to the fact that anti-icing happens prior to a weather event, equipment can be used at much higher speeds. The NYSDOT sets guidelines for speed limits between 40 and 50 mph for pre-storm anti-icing and 15-35 mph for activities during a storm.[7] This means that a much greater area can be treated in much quicker time using anti-icing, thus even further saving labor and vehicle maintenance costs.

Regardless of whether de-icing or anti-icing is practiced, road salt remains the most widely used solution. This is mostly due to its being relatively effective and very cheap compared to other deicers. Despite recent increases in costs due in part to increased fuel prices, road salt is still available in many places for approximately $40 - $60 per ton[8], compared to costs of three or four times that amount per ton for many of the alternatives. Road salt is particularly efficient at temperatures above 22 degrees Fahrenheit. The effective temperature, defined as "the lowest temperature for practical use" of sodium chloride is 15 degrees Fahrenheit.[9] Not only does it require exponentially more road salt to melt ice at lower temperatures, but it also takes much longer. At 25 degrees, it would only take 5 minutes for road salt to remove 1/8" of ice. This same process would take over 40 minutes at 15 degrees.[10] This means that frequently in large portions of New York and especially the Adirondacks, the temperature may be too low for salt to work effectively unless applied in dramatically and unnecessarily large amounts. Despite this, New York State uses over a million tons of road salt annually to clear the roads.[11]

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[6] Lashmet, Michael. Presentation of "Snow and Ice Control Operations in New York State."
[7] New York State Department of Transportation. "New York State Department of Transportation, Office of Operations Management, Highway Maintenance Guidelines: Snow and Ice Control." Page 31.
[8] Sampier, Kevin. "Road Salt Costs Shoot Up: Tazewell County Will Pay $58,600 Extra for this Winter's Supply,"; Murphy, Jennifer. "High Fuel Prices Drive up Price of Salt,"; and Minichiello, Patricia. "Officials Find Tough Road Salt Market."
[9] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." Page 86.
[10] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 64.
[11] Correspondence with NYSDOT Snow and Ice Program Engineer, July 21, 2008.

The Initial Cost of Road Salt: Increasingly Expensive

Department	2007-08 Price Per Ton	2008-09 Price Per Ton
NYSDOT	$38	$52
Clinton County, NY	$54	$99.67
Essex County, NY	$52	$68.51
Franklin County, NY	$42.63	$89.92
Herkimer County, NY	$31.82	$42.82
Saratoga County, NY	$41.85	$58.29
Warren County, NY	$48.14	$59.95
Washington County, NY	$43	$61

[12]

Evaluation of Current Practices

Road salt can be applied in numerous ways. No matter what process is used, the same chemical processes work to either keep ice off the roadways or remove the existing ice. When temperatures drop, water molecules bond to create ice. The ions in road salt attract these molecules instead and help to prevent ice creation by depressing the temperature at which the water will freeze. The saltier the water the lower the freezing point. If used in de-icing procedures, road salt can simply be spread in its raw form, since it will bond to the preexisting water molecules in the ice. This process, however, requires more salt compared to anti-icing. In anti-icing, salt is pre-wetted so that it will keep ice from forming in the first place when spread over roadways prior to a weather event. This helps to reduce the loss of salt through bouncing and blowing, as well as requiring less salt overall by spreading before ice can form.

Sand is also used in winter road management. While not a deicer because it does not prevent or reduce the formation of ice, sand can be a deterrent to slippery road conditions by providing additional traction for vehicle tires. While sand use has been dramatically reduced in recent years due to its negative environmental side effects and its relative ineffectiveness, it is still the cheapest material used in winter road management at only $6-16 per ton[13], and can be used somewhat effectively on low-volume roads and in particularly dangerous locations such as sharp curves, bridges, steep hills or major intersections. The problem with sand is that any application will be partially blown away in the spreading process and it can take only a dozen vehicles passing over it to completely remove it from the roadway.[14]

While sand and salt remain the most commonly applied materials during winter road management, many chemical and infrastructure alternatives exist. Many of these alternatives have been used effectively and efficiently as part of a more comprehensive plan by certain municipalities, states and provinces.

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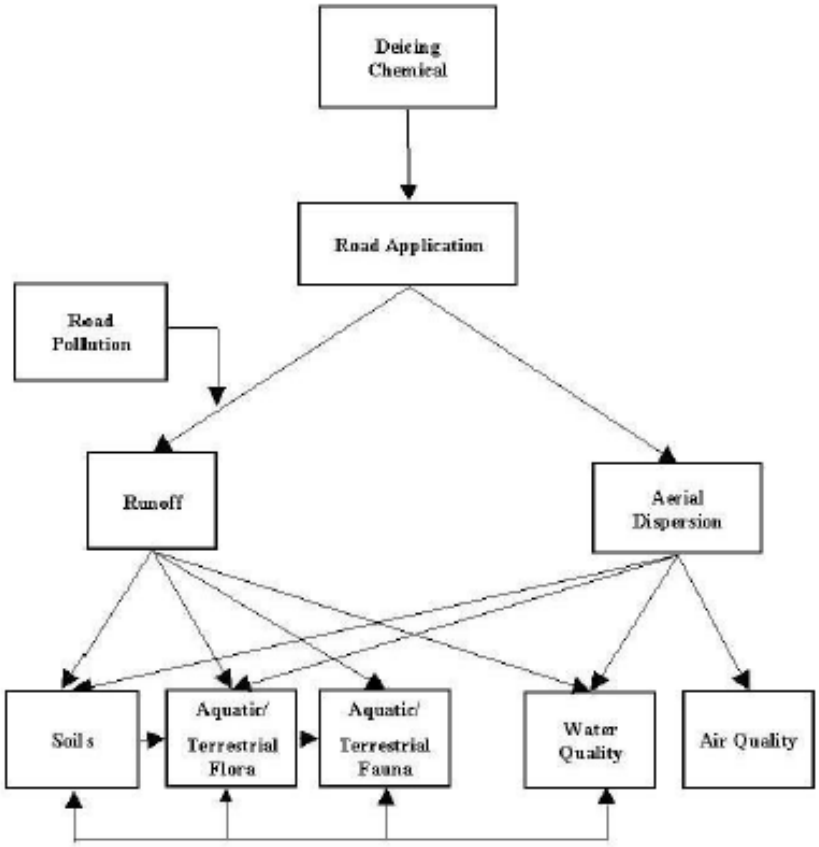
[12] Heath, Dan. "Clinton County Faces Highest Road-Salt Prices in State."; Reisman, Nick. "Pinching Pennies, Salt."; Monroe, M. Lisa. "Road Salt May Be Concern This Year."; Harding, Jessica. "Road Salt Costs Up; Demand Constant."; Carleo-Evangelist, Jordan. "Salting Away Extra to Keep Roads Clear this Winter."
[13] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." Page 87.
[14] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 78.

The Negative Effects of Road Salt and Sand

Current usage of road salt and sand are unsustainable long-term and their use needs to be both curbed and reevaluated. Effective road management must balance public safety concerns with short and long-term environmental and economic concerns. There is no question that keeping roads open throughout the winter is vital to the economic health of the northern third of the country, including many of the largest metropolitan areas. However, current road management strategies cannot be continued without serious environmental harm. These environmental problems can then lead to economic losses, thereby putting into doubt whether the short-term gains of clear roads are greater than the long-term consequences.

The use of sodium chloride has resulted in numerous ill effects which have been well known for decades. From corrosion of roads and vehicles, pollution of the water and soil, and death of vegetation to contamination of drinking water, road salt has many costly long-term effects which when considered properly add tremendously to its relatively low initial price.

How Salt and Sand Get Everywhere



Taken from Fischel, 2001, page 18.

When road salt is spread by large machinery or stationary sprinklers in its pure form, bouncing and blowing are of primary concern. Over 50 percent of the material can be lost this way and it can be transported dozens of feet from the road, with most falling within 65 feet.[15] If it is pre-wetted, this loss can be mostly mitigated, and much of the material will remain on the road. Fully functioning equipment and speed of spreading vehicle are also key factors. Equipment that is not properly working will lead to uneven and unnecessary spreading. Excessive speed can also cause more bouncing of deicing materials.

Road salt and sand, as well as other abrasives, do not evaporate or disappear, but remain on the roadway until they are either physically removed, drain into nearby water, or seep into the ground soil. This is where the process of pollution and contamination of the environment begin to take effect. When materials are applied they either stay on the road or are dispersed through the air. Those materials that do remain on the road eventually become runoff through which they can affect soil quality, aquatic and terrestrial flora and fauna, and water quality.[16] If airborne, they can affect all of these elements in addition to causing air pollution. Air pollution is particularly troublesome with some of the abrasives, especially sand.

Damage to Roads and Vehicles

As road salt is a fairly corrosive chemical, it can cause rust on vehicles, including the machinery used by highway departments to spread it. While recent innovations in car design, such as the increased use of plastics parts and application of anti-rust materials, have somewhat lessened the costs of this side effect, it is still a concern and causes vehicles used on treated roads to deteriorate faster than those used on untreated roads.

Innovations in vehicle design have decreased the corrosion and rust due to road salt, but one 1992 study found that there was a "$113 excess depreciation per ton of salt."[17] Even if this has now been cut in fourth an additional cost of $30 per ton of road salt would still equal approximately 50% of the current cost. A 1991 study found that measures to protect vehicles against corrosion cost auto manufacturers $4 billion each year, so that even as overall corrosion has been minimized, the costs of outfitting and research and development are still passed on to consumers by auto companies.[18]

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[15] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 19-20.
[16] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." See chart on Page 18.
[17] Vitaliano, Donald F. "An Economic Assessment of the Social Cost of Highway Salting…" Page 401.
[18] *Stormwater: The Journal for Surface Water Quality Professionals*. "Environmental Impacts of Road Salt and Alternatives in the New York City Watershed."

In addition to damaging the vehicles that drive over it, road salt also seeps into the cracks in concrete and causes them to expand, thus requiring higher than normal maintenance costs. This is especially problematic on bridges or other sensitive areas where infrastructure integrity is extremely important to maintain. The constant melting and freezing of roadways also has a negative impact on the pavement materials and causes tension and stress. The added maintenance required because of the use of road salt only adds to the already busy and short construction season that exists in many of the snowiest areas of the United States and Canada. While sand is not used as prevalently and is not as corrosive as road salt, it must be removed each spring to prevent damaging roadside buildups and runoff into waterways and thus requires additional machinery and operating costs for highway departments.

While estimates vary by study, there is unquestionably a significant impact on road maintenance caused by the use of sodium chloride. A 1992 study, which would undoubtedly be conservative compared to current estimates, found that the additional expenditures on only bridge maintenance is $332 per ton of salt applied, and significantly higher than this in states with higher snow falls, including New York.[19] That same study found the overall maintenance costs for roadways to be over $600 per ton. Even with recent increases in price, salt initially only costs around $60 per ton. But there are significant long-term expenses that should be taken into consideration when considering which materials to utilize.

Damage to Flora and Fauna

Salt can be especially toxic to roadside vegetation. It is by far the most visible negative impact. Trees near roadways where salt is frequently used typically look sickly and suffer from leaf burn, the browning of needles or leaves. Other flora can be scorched by the toxicity of the chloride and are susceptible for replacement by non-native species more tolerant to salt. These are just a few of the ways in which road salt harms the terrestrial environment.

The first reported damage to trees due to road salt was in 1948 and by 1957 New Hampshire was replanting thousands of dead trees.[20] White pines were planted in Iowa for aesthetic purposes only to quickly die due to the preexisting salt load in the soil.[21] In early July 2008, the New York State Department of Transportation (NYSDOT) announced that it had spent $20,000 to replant and reestablish natural vegetation along a two-mile stretch of highway in the Adirondacks.[22] NYSDOT treats 42,500 lane miles per year.[23] If only one tenth of those lane miles were damaged, at $10,000 per mile, that would be millions of dollars for revitalization. Vitaliano estimated in 1992, that the

[19] Vitaliano, Donald F. "An Economic Assessment of the Social Costs of Highway Salting..." Page 398-399.
[20] Ibid. Page 405.
[21] Shapley, Dan. "Salt Helps Drivers, Hurts Environment."
[22] New York State Department of Transportation Press Release. "NYSDOT Recognizes Re-vegetation Work Done on Route 73: Multi-Agency Effort Improves Corridor Aesthetics and Reduces Impacts of Salt Usage."
[23] Lashmet, Michael. Presentation of "Snow and Ice Control Operations in New York State."

aesthetic damage to trees in the Adirondacks due to road salt was $75 per ton. If adjusted for inflation, that would be over $110 today, about twice the amount of a ton of salt.

Just over half of all chloride ions in road salt are removed in surface runoff while the remainder seeps into the soil and groundwater[24]. The chloride interacts with the soil by creating swelling, reducing stability, increasing the possibility of erosion and obviously increasing the salinity. It can also cause a chain reaction of growth inhibition for plants by reducing water availability, leeching essential nutrients, increasing the toxicity of the soil and stunting root growth.[25] As these actions occur, it increases the possibility of erosion, which would in turn create easier runoff and dispersion of the chloride ions through the soil and in to the groundwater or directly into nearby waterways. Soil microorganisms, which also maintain soil stability, have been found to be particularly sensitive to salt. They are unable to survive above low levels of sodium, which can be found nearly 100 feet from salted roadways.[26]

Road salt can act to disrupt plant life in both the short and long-term as well. While some plants can survive through a spring with increased salinity and inhibited growth, annual damage places enormous stress on many types of flora. This can lead to direct damage such as leaf burn and tissue death. Plants and trees which experience annual stress from road salt residues are more susceptible to disease, insects, and drought.[27] Eventually, the death of these species can prevent re-growth, leading to a significant change in the ecological community as a new plant takes its place. While some efforts have been made to replace lost plants with more tolerant native species, the initial loss also creates a window of opportunity for nonnative invasive species, which can then continue to disrupt surrounding environments. Using sand in conjunction with the road salt, which frequently occurs in colder regions, such as the Adirondacks, results in a "synergistic" effect to further reduce soil vitality and hasten the decline of surrounding plant life.[28]

Road salt damage to coniferous trees along Adirondack Northway.

[24] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." See chart on Page 17.
[25] Ibid. Page 20.
[26] Ibid. Page 20.
[27] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 97.
[28] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 22.

Damage to trees and plants, as stated above, is relatively easy to diagnose given the observable differences between healthy and injured vegetation. With coniferous trees, there is an obvious yellow or browning of the needles as well as premature drops. If damage is extensive, there may be numerous branches without any needles on them, typically near the base of the tree.[29] Deciduous trees will experience delayed budding and the buds will swell into the growing season. Just as with conifers, there can be leaf burn as well as a reduction in size and growth and wilting.[30]

While vegetation damage is most prevalent within about 15 feet of roadways, sensitive species can be affected as far away as 650 feet, or about the length of two football fields. The typical affected area is up to 260 feet for a four-lane highway and about 115 feet for a two-lane highway.[31] Parts of plants below the snowline or above the salt spray are less damaged, which leads to oddly configured patterns of damage on vegetation. The side of the plant which faces the roadway receives the most damage as do those plants on the downwind side of the road.[32]

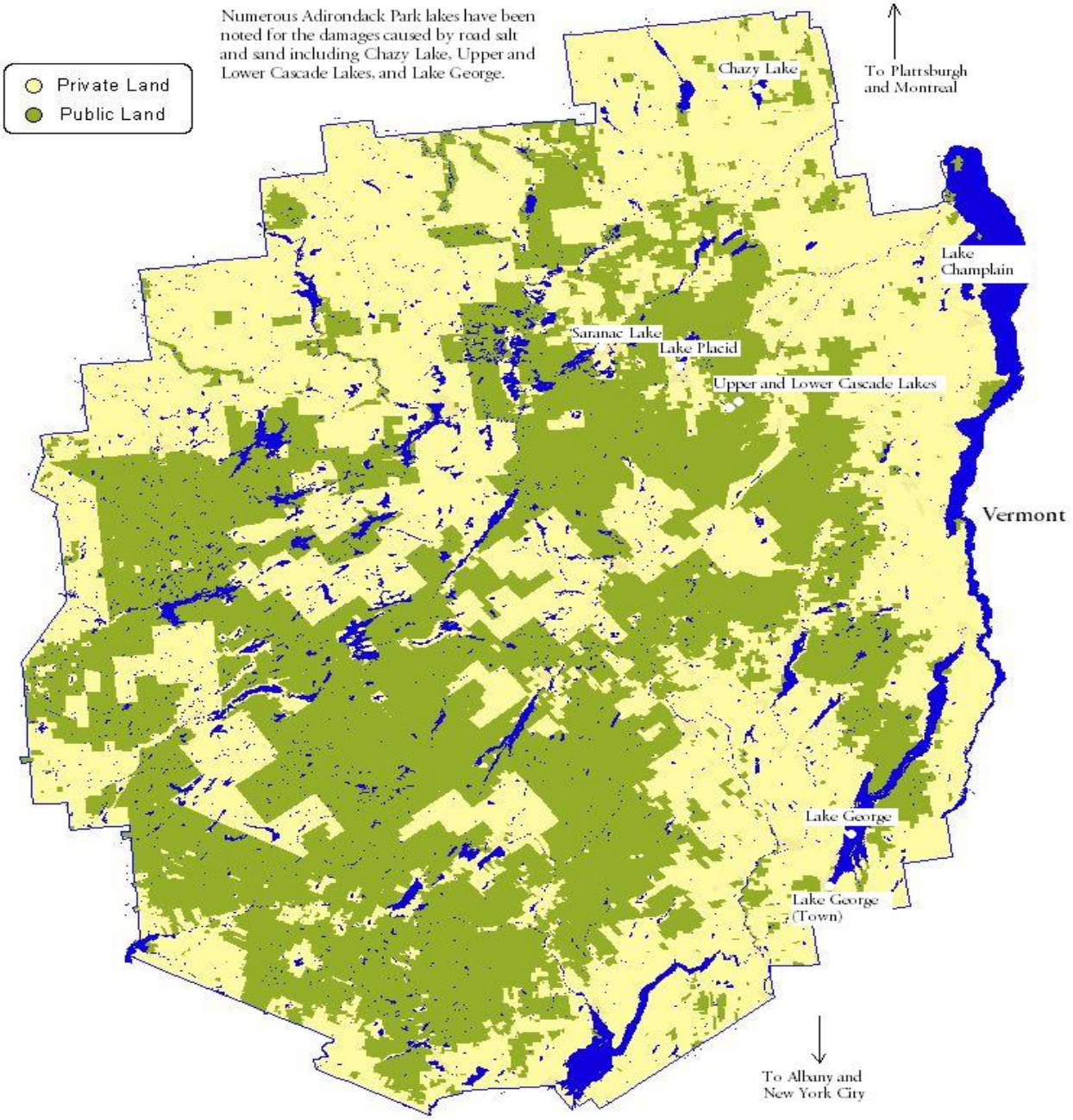
The indirect effects of road salt can also be significant. Some animals, such as deer and moose, are attracted to salt and will find their way onto roadways to consume the salt. This can increase the possibility of vehicle collisions with wildlife. Birds may not be able to differentiate between road salt pellets and grit their diets require. For some species, eating just one salt pellet can actually result in death. Numerous large bird kills have been reported in the U.S., Canada, and northern Europe.[33] Finally, wildlife may be indirectly affected simply by the loss of their original habitat, as water bodies are salinized and trees poisoned.

Damage to Water Quality and Aquatic Life

Salt's greatest and most pervasive effect is on the quality of water near roadways and the aquatic ecology within them. While the effects are greatly diminished on waterways with constant flows, slow moving streams, ponds, or lakes with only seasonal outflow can be particularly affected by salt runoff. Elevated salinity increases the density of water, possibly leading to resistance to annual mixing. Without this mixing process, whereby the surface water and its abundance of oxygen is transferred to the deeper portions of the lake, the deep water may become anoxic and cause severe

[29] Ibid. Page 29.
[30] Ibid. Page 29.
[31] Ibid. Page 33.
[32] Ibid. Page 28.
[33] *Stormwater: The Journal for Surface Water Quality Professionals*. "Environmental Impacts of Road Salt and Alternatives in the New York City Watershed."

Lakes and Road Salt: A Bad Combination



Map data provided by the Adirondack Park Agency

trauma and death among the plant and animal life. Additionally, essential nutrients are no longer transported back up to the surface where they are used by phytoplankton.[34]

Chloride, once introduced into a relatively stagnant body of water, can remain in elevated levels for surprisingly long time spans. Studies have shown that levels can increase by over 50 times their original amount up to 300 feet away from the treated roadway and those levels can persist for months afterward.[35] The organisms inhabiting these stationary water can suffer both acute and chronic toxicity leading to significant changes in populations and even entire kill offs.[36] Studies have shown that the number of aquatic species in a body of water decreases when salinity concentrations reach 1,000 – 3,000 parts per million (ppm).[37]

While waterways naturally vary in their concentration of salt based upon composition of their surrounding environments, inland water typically have low salinity. Concentrations in excess of 1,000 ppm are considered brackish rather than fresh water. The EPA recommends a concentration close to 25 ppm and the American Medical Association suggests a maximum of 22 ppm for salt sensitive dieters.[38] Very few unaffected waterways exceed either of these thresholds and those that do are not used for drinking water.

Unfortunately, waterways near treated roads easily exceed these concentrations. In February of 2007, a creek in Wisconsin was measured at 6,470 ppm for a few hours and seven out of twelve streams in metropolitan Milwaukee were found to have had symptoms of acute toxicity on multiple forms of aquatic life.[39]

While death is the most obvious consequence of salt toxicity in aquatic wildlife, prior to that point, the concentration level can affect numerous bodily functions. Fish and other aquatic life may need to spend more energy coping with the changed environment. In turn, this limits their growth and reproduction, providing greater opportunity for more tolerant species to take over.[40] Due to the effects increased salinity has on annual mixing processes, fish species that require high amounts of oxygen but lower water temperatures are at particular risk.[41] This includes lake trout, an important draw for fishing in many of the lakes in the Adirondacks. Some key types of phytoplankton, at the base of the food chain, are fatally susceptible to salt toxicity under 100 ppm and many are adversely affected under 600 ppm, both levels of which are easily reached in waterways near treated roads.

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[34] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 80.
[35] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." See chart on Page 23.
[36] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 59.
[37] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." See chart on Page 26.
[38] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 39, and University Corporation for Atmospheric Research (UCAR). "Salinity, Dissolved Salts, Measuring Salinity."
[39] Bergquist, Lee. "Road Salt Delivering a Toxic Shock: Saline Runoff Into Streams May Harm Aquatic Animals."
[40] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 37.
[41] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 41.

Aquatic species are also affected by the change in composition of the metal in water.[42] As chloride salts, which are highly soluble, enter waterways, they enhance the movement of trace metals. Since the mixtures in road salt also contain numerous trace metals such as copper, zinc, and cadmium,[43] the applications of road salt which seep into nearby surface water or through groundwater can affect not only the movement of metals but also their density and composition. In addition to the initial salt toxicity, in stagnant bodies of water, such as vernal pools or ponds, these accumulations can have particularly toxic effects to the aquatic environment.[44] Amphibians may be at particular risk to increased salinity. Studies have shown that some frogs experience adverse developmental consequences due to salt concentrations as low as 78 ppm. Since many species of amphibians utilize stationary vernal pools for reproduction, where the risk of salt toxicity is greater, entire life cycles can be disrupted.[45]

A final concern of road salting is the possible effects on human health. As stated above, the EPA recommends a chloride concentration in water of 25 ppm and warns that maximum concentration should be no higher than 250 ppm. While this is primarily a concern for the taste of the water, there are important health considerations as well. People with salt-restricted diets should be cautious at any concentrations above 22 ppm.[46] Another way of reporting salt concentration is in milligrams per liter (mg/L), for which the average concentrations are typically around 30 mg/L.[47] In the 1970's, however, water from two communities in New York had concentrations well over 200 mg/L. This can dramatically increase the salt intake for humans and is particularly troublesome for those with high blood pressure.

Millions of dollars are spent annually by states on prevention and remediation of salt damage to drinking water infrastructure. Maine alone spends about $250,000 each year providing water to residents where wells exceed healthy salt levels.[48] The main concern with salinity on human health is the possibility of increased hypertension, which can cause numerous adverse side effects, such as heart disease. While researchers are unsure the exact correlation between drinking water salinity and hypertension, there is broad consensus that it can increase the number of cases by lifting borderline cases over the threshold and it can also adversely affect those already at risk.[49]

While the human health risk may be relatively small, the overall effects of increased salt toxicity in water are numerous and concerning. It can change entire ecosystems, reduce habitat viability of waterways, and increase the metal pollution of lakes and rivers. Charles Fiegl, writing for the Glen Falls, NY Post Star, summed up salts affects on water well, "Increased levels of chloride and sodium effect habitats by

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[42] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 38.
[43] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 79-80.
[44] Ibid. Page 80.
[45] Langen et. al. "Environmental Impacts of Winter Road Management..." Page 42.
[46] Ibid. Page 39
[47] "Road Salt Impacts on Drinking Water." *Highway Deicing*
[48] "Road Salt Impacts on Drinking Water." *Highway Deicing*; "Road Salt Takes a Toll; Mix Used to Treat Ice Often Pollutes Water, Kills Plants." Red Orbit News.
[49] "Road Salt Impacts on Drinking Water." *Highway Deicing*

interfering with fish spawning, degrading streams for fish and invertebrates and creating a new environment for invasive species."[50]

Air Pollution

Most of the damage to air quality is a result of the use of sand, which typically is placed on packed snow, at dangerous points in a roadway, or when the temperature is well below zero degrees Fahrenheit and no deicing alternative is feasible to use. Sand does not prevent the formation of ice nor affect already existing ice. Rather it is used as a form of traction between the roadway and car tires. While it is initially relatively effective, a lot of sand is required to maintain safe roads. This is because much of the sand blows away in the spreading process, and a few vehicles passing over the sand remove the rest.[51] For a certain size particulate, sand increases the given concentration by 50-90% in the air during the first 24 hours following a treatment. Sand, which is commonly premixed with salt prior to the application process to help reduce the amount of salt used, also ends up in streams, where it causes damage including spoiling fish spawning habits and creating deltas. Studies have shown that air quality in Denver has been adversely affected by sanding.[52] In short, sand is an ineffective and environmentally unfriendly option which is only helpful to those first few drivers immediately following an application.

New York Practices

While New York State does not officially practice a bare roads policy, it still uses over a million tons of road salt each year and over 10,000 tons of sand. During the 2007-2008 season 1.154 million tons of salt were purchased at a cost of $38 per ton ($43.9 million total). In 2009, with the price of salt over $50 per ton, even if the state purchased 100,000 less tons, it will spend nearly $10 million more.[53] The New York State Department of Transportation (NYSDOT) is responsible for 42,500 lane-miles throughout the state. At one million tons spread over these roads, that's an average of 23.5 tons per lane mile per year. Typical application rates are 225 lbs per lane mile in the initial run and 115 lbs per lane mile in a follow-up run[54] with variances according to the weather conditions and what type of precipitation is occurring (i.e. freezing rain, sleet, snow, etc.). While the public safety benefits of road salts are indisputable, reduction in overall usage would have great financial and environmental benefits.

The NYSDOT states as their objective, "to provide a reasonably safe pavement surface given the available resources and limitations imposed by weather conditions."[55]

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[50] Fiegl, Charles. "Salting Roads Draws Concern: As Winter Weather Looms..."
[51] Langen et. al. "Environmental Impacts of Winter Road ..." Page 78.
[52] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." See chart on Page 37.
[53] Correspondence with NYSDOT Snow and Ice Program Engineer – July 21, 2008.
[54] Lashmet, Michael. Presentation of "Snow and Ice Control Operations in New York State."
[55] New York State Department of Transportation. "New York State Department of Transportation, Office of Operations Management, Highway Maintenance Guidelines: Snow and Ice Control." Page 19.

Considering the increase in costs of fuel and road salt, those available resources may become scarcer, especially as the state faces a multi-billion dollar deficit as part of the next several budgets and state agencies are required to make significant cuts. These price increases will have an even more dramatic effect on local highway departments. Essex County, fully within the Adirondack Park, manages 50 miles of the county road system, yet uses thousands of tons of salt each year. In 2007, road crews spread over 24,000 tons, and in the first half of 2008, they used over 15,000 tons. This road salt has come at a cost per ton that has risen from $45.54 to over $68 in just two years.[56] Franklin and Clinton counties, partially within the park, are both expecting significant price increases on road salt as well. Franklin, which paid approximately $43 per ton last year, has seen estimates as high as $90. While the county only uses about 500 tons per year, it is responsible for only 13 miles of roads and a handful of parking lots and driveways. On average, that's almost 40 tons per mile each winter. Clinton County, which has decided to contract for salt without the assistance of the state this year, paid just over $53 per ton last winter, but is worried about a warning of a possible 80 to 90 percent increase in price by New York State Office of General Services.[57]

Salt Fact

The NYSDOT spreads approximately 105 pounds of salt per person each winter.

In addition to the extremely high fuel costs of operating the spreading equipment itself, this results in a dramatic increase in cost to county budgets which are relatively small to begin with. As opposed to the state, which applies approximately 225 lbs of road salt per lane mile, Essex County spreads 850 to 1200 lbs depending on conditions.[58] In total there are 5,285 miles of public roads within the Adirondack Park.[59] While not all of these are maintained during the winter season, with application rates by local highway departments well above state averages, it is easy to see how the amount of road salt is having a detrimental affect on both local budgets and the environment.

Cascades Lakes and Lake George: Case Studies in New York's Adirondack Park

In 2006, a group of researchers from the Clarkson Center for the Environment, with funding from the NYSDOT, submitted a report titled, "Environmental Impacts of Winter Road Management at the Cascades Lakes and Chapel Pond." This was the most in-depth study undertaken regarding the effects of deicers within the Adirondack Park. The study found that while applications of road salt were actually lower than on highways in other states, the total amount annually deposited was extremely high because of the frequency and severity of weather events.

The researchers examined three bodies of water near a major thoroughfare in the Park. They found soil near the roadways dramatically altered, dried out, prone to

[56] Correspondence with Essex County Highway Superintendent – July 14, 2008; Raymo, Denise. "Road-Salt Pricing Puts Counties on Slippery Slope."
[57] Ibid.
[58] Correspondence with Essex County Highway Superintendent – July 23, 2008.
[59] Jenkins, Jerry and Andy Keal. The Adirondack Atlas. Page I.

Photo of healthy birch trees (above) taken in 1993 along Cascade Pass—Route 73 between Keene and Lake Placid. A decade later, all of the birch trees had died from salt contamination as illustrated below.

erosion and nutrient-poor. While current birch tree populations are being naturally replaced in the area, mortality has been accelerated near the roadway due to the salt loadings and recruitment of new plants has been severely stunted. This further serves to leave the soil prone to erosion. Chloride has drained from the road to the Cascade Lakes, resulting in levels over 100 times beyond those seen in comparable Adirondack lakes not situated next to treated roadways. The chloride levels are high enough to cause meromixis, or lack of turnover, although this has yet to occur. Lower Cascade Lake, which is the most highly affected of the bodies of water studied, had significant enough oxygen depletion to affect Lake Trout at deeper depths. Additionally the water has become too warm near the surface for the current fish populations which have a delicate range of tolerance.

Salt loading occurs throughout the year in all of the bodies of water studied, meaning that toxicity is chronic, but mild. At current levels there will likely be some changes to the most sensitive populations of phytoplankton and periphyton, but not enough to drastically alter overall lake productivity. The research models predict that the chloride levels of Lower Cascade Lake may reach EPA recommended maximums within a few years. At that level, chronic exposure will be potentially fatal for aquatic life. The lake also will continue to be at risk of becoming meromitic. While the researchers have found that recent applications of alternative deicers have been ineffective on the nearby road surfaces, they do suggest behavioral and infrastructure changes to reduce the current amount of deicers applied. These include encouraging speed reductions, better weather monitoring, and improvements to the roadway to reduce runoff into roadside soils and waterways.

Lake George, a Class AA-Special rated lake, which means the water is suitable for drinking, is also being affected by road salt. The chloride levels in the lake more than doubled between 1980 and 2000, rising from less than 5 ppm to over 12 ppm, with additional increases since that time.[60] While this is still within safe limits, citizens with salt-restricted diets may have to take precautions in the near future.

Around 42 tons of sand and 13 tons of road salt are spread on each lane mile within the Lake George watershed each winter.[61] The sand deposited can drain into the lake, especially affecting bays and deltas. Removing these sediments from clogged waterways can cost millions of dollars and take years to complete. The town of Queensbury has three street sweepers which specifically clear the remaining sand from the streets in the spring.[62] State Senator Elizabeth Little announced a $200,000 state grant in the winter of 2008, which would fund both scientific research and a pilot project on alternative deicing methods in the Lake George watershed.[63]

Other lakes in the Adirondacks are experiencing similar negative effects from the increased use of road salt and sand. Chazy Lake, which was sampled over the course of

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[60] Decker, D.J., "Salt and Sand Dispersion Survey."; and Fiegl, Charles, "Salting Roads Draws Concern: As Winter Weather Looms, Officials Worry about Impact on Lake George."
[61] Ibid.
[62] Fiegl, Charles. "Salting Roads Draws Concern: As Winter Weather Looms..."
[63] "As Lake George Gets Saltier, State Senator Grows Alarmed..." *Lake George Mirror*.

four years, is also seeing a dramatic rise in chloride levels. While the conductivity level of the lake increased 40 percent, the chloride level doubled just over the course of the study.[64]

It is clear that road salt is adversely affecting waterways throughout the Adirondacks, despite the limited number of lane miles in the Park compared to similar rural areas outside of it. Protecting these environmentally sensitive areas is vitally important for long-term sustainability of the Park as a preserve and tourist destination.

Alternatives to Road Salt

Despite its prevalence, road salt is not the only solution available for creating safer roadways during winter weather events. Numerous other remedies exist, including other chemical deicers, infrastructure improvements, and simple driver behavior changes. Many of them can be used in conjunction with lighter salting practices to substantially decrease the negative impacts on the environment.

Chemical Alternatives

There are several chemical alternatives to sodium chloride available on the market. Many of them have higher initial costs compared to road salt, but are generally more environmentally friendly, less corrosive to roads and vehicles and more effective over a longer period of time. When all factors are taken into full consideration, the long-term costs may be comparable to road salt or even less.

The first grouping of alternatives is within the same family as road salt. These each contain chloride, which means that they have many of the same effects on the environment and corrosion as sodium chloride. Calcium chloride, which is much more expensive than road salt, works very quickly, and most importantly, at very low temperatures. The effective temperature is approximately -10 degrees Fahrenheit, although it can continue to melt ice at much lower temperatures.[65] It does leave the pavement wet, which can be a concern for both hydroplaning and refreezing, but is less corrosive than its sodium counterpart. Special handling is necessary for the material, because it easily draws moisture, which would reduce its effectiveness for spreading.[66]

Magnesium chloride, which is also more expensive than road salt, is less corrosive and works at lower temperatures, though not as low as calcium chloride. Both of these alternatives also positively affect soil structure and increase the hardness of water, thereby reducing the mobility of possibly toxic metals.[67] Both materials are marketed under a variety of brand names, which are typically mixed with some

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[64] Van Valkenburg, Andrea. "Road Salt May be Damaging Chazy Lake."
[65] Environment Canada and Health Canada. "Priority Substances List Assessment Report: Road Salts." Page 10.
[66] Dell Joyce, Shawn. "Road Salt Alternatives."; and *Road Management Journal*. "Using Salt and Sand for Winter Road Maintenance."
[67] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." Pages 21, 24.

proprietary substance to lower the effective temperature even further or make them somehow more efficient. These alternatives may come in a number of colors when they are treated. The New York State Thruway has been using the chloride alternatives with a blue-green color.[68]

A second main grouping of chemical alternatives is acetate-based. These include Potassium Acetate (CF7), Calcium Magnesium Acetate (CMA), Sodium Acetate (NAAC), and CMAK (CMA and Potassium Acetate). While they are all significantly more expensive than road salt (up to ten times), they also are much less corrosive and thus are frequently used on sensitive structures, such as bridges or at airports.[69] All of these acetates contain phosphorus, which is a nutrient for flora and fauna, both aquatic and terrestrial. This can result in both increased soil stability on land and algal buildup in waterways. Additionally, CMAK has high nitrogen levels, which can produce greater algal blooms and enhance opportunities for invasive species. CMA and NAAC are typically used as solid deicers, which increases the risk for air pollution. Liquid CMA, CF7, and CMAK actually can reduce air pollution by lessening the need for use of sand.[70] While these acetate-based deicers reduce the oxygen levels in water, the effect is no worse than that from sodium chloride. On land, these chemicals are relatively harmless, with much less intense effects on flora, and almost none on fauna compared to road salt.[71]

Urea is a fertilizer which can be used to prevent ice formation. It is relatively expensive compared to rock salt, can increase algae growth in water, and has the potential to burn grass at high concentrations. Yet, its overall impacts on the environment are mild compared to those of road salt and it is not corrosive at all.[72]

Alpha methyl glucoside is a corn-byproduct which is often mixed in with salts. It is less corrosive and gentler on the environment, but as with many of the alternatives, it is also expensive compared to road salt.[73]

Some highway departments have begun to use organic chemicals such as sugar beet juice and corn syrup. Mixed with salt, these create a substance significantly more effective at deicing than plain road salt. The use of this solution remains effective even down to zero degrees Fahrenheit and is much less corrosive. While adding Geomelt, a sugar-beet based mixture, to sodium chloride adds $50 per ton in costs, the resulting decrease in salt usage can be better than 25 percent.[74] This reduces the long-term costs of maintaining infrastructure and replanting trees and vegetation in salt-damaged areas.

There are also non-acetate, non-chloride, mixtures being marketed under a variety of names. NC-3000 is made from the processing of starches and sugars, is less

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[68] Correspondence with NYS Department of Transportation, purchasing division January 23, 2009.
[69] Chung, Andrew. "How De-icing Works."
[70] Fischel, Marion. "Evaluation of Selected Deicers Based on a Review of the Literature." Page 34
[71] Ibid. 35-36.
[72] Gannett News Service. "Alternatives to Road Salt."
[73] Ibid.
[74] Associated Press State and Local Wire. "Molasses Product Touted as Road Salt Alternative."; Heeney, Ashley. "City Tries to 'Beet' Snow, Ice with Mixture."

toxic to the environment than road salt, is minimally corrosive, and is effective well below zero degrees. Another product, Apogee, has a very consistent performance pattern, slowly decreasing with temperature. As with NC-3000, Apogee is non-toxic to flora and fauna, only slightly corrosive, and is able to be used at very low temperatures. Both of these chemicals also last up to several days following an application, leading to a need for fewer treatments and thus fewer man-hours and less wear and tear on maintenance vehicles.[75]

Infrastructure Alternatives

Improvements in technology and infrastructure can also significantly reduce the amount of salt, sand, and chemical alternatives that are required to effectively clear roadways of ice and snow. While these have varying costs associated with them, they are all relatively unobtrusive.

A Road Weather Information System (RWIS) utilizes recent improvements in technology and weather forecasting models to most efficiently predict weather events. This allows for the most effective use of anti-icing by knowing where and when a storm will take effect and thus how much material is needed to keep the roadway safe. The three main pieces of a RWIS are: 1) a network of sensors to gather data, 2) a system to process this data and model weather predictions, and 3) specified ways to disseminate this information to the officials who must make important decisions regarding the application of anti-icing materials.[76]

RWIS data collection site located in Rotterdam Junction, NY.

These systems rely on accurate readings and rapid, but informed diffusion of instructions. The most important conditions to collect data on are those of the roadways, because ice will form on the road depending on the temperature of the pavement, not the air. In fact, the difference between the pavement temperature and ambient temperature can be as great as 40 degrees Fahrenheit a few hours after sunrise. Only in the early morning hours does pavement temperature typically drop below the air temperature.[77] RWIS networks place sensors at specified locations on roadways in order to precisely calculate current conditions.

[75] For information on both chemicals, see the appropriate product description sheets available at EnvirotechServices.com
[76] Aurora Project. "About RWIS."
[77] New York State Department of Transportation. "New York State Department of Transportation, Office of Operations Management, Highway Maintenance Guidelines: Snow and Ice Control." Page 24.

While this network of sensors and the corresponding technology needed to process the data and disseminate it can be relatively expensive, the benefits are significant. Maintenance on an RWIS is relatively straightforward, and assuming it is done properly, inexpensive. The equipment is unobtrusive and hardly noticeable to drivers. It can reduce the amount of anti-icing materials needed to effectively combat a weather event, thus also reducing the number of applications, the man-hours needed, and the repair and replacement of the spreading equipment.

In addition to these obvious benefits, a RWIS has others that are more subtle. First, once the system is in place, other tools can be added to enhance its overall productivity. These can include cameras to show actual conditions, lasers to measure visibility, or a remote activation of variable message signs (a topic discussed in detail later), which can assist drivers by warning them of upcoming hazardous conditions.[78] The return on investment in an RWIS for a highway department can be 1,000 percent over time, and the New Jersey Department of Transportation estimated a 10 to 20 percent reduction in deicing expenses.[79]

Thermal mapping uses infrared sensors to create a thermal profile of a roadway section by collecting data at specific points and then inferring temperatures in between. This equipment can be helpful in areas where numerous microclimates may exist in a short distance, large temperature variations may exist, or rapid elevation changes.[80] Infrared thermometers are a similar tool. Portable and relatively inexpensive, these devices can be mounted on vehicles or hand-held and provide constant road surface temperatures while winter management crews are mobile.

Fixed Automatic Spray Technology (FAST) devices allow for rapid dispersal of the correct amount of deicing material exactly when it is needed. These systems use embedded sensors and on-site computers to assess road conditions and apply needed deicers to the roadway prior to a weather event. A device, similar to a lawn sprinkler, spreads the material as needed. Due to the cost of these systems, they are typically used in high-volume areas which are particularly sensitive to frosting or formation of black ice, such as bridges, onramps, or intersections.[81]

A recent technological innovation is the SafeLane product. SafeLane is a mixture of dolomitic limestone and epoxy resin. The material traps deicing chemicals, maintaining their usefulness, and preventing them from blowing away, draining off the roadway, or seeping into the groundwater. This results in greatly reduced application rates and frequencies of deicing materials.[82] In an independent study conducted on a variety of bridges where SafeLane was applied, there was an observable difference in the amount of material needed to keep the road clear and a dramatic reduction in

[78] Center for Environmental Excellence by AASHTO. "Chapter 8: Winter Operations and Salt, Sand, and Chemical Management."
[79] Ibid.
[80] Ibid.
[81] Ibid.
[82] Pacella, Rena Marie. "The End of Road Salt?"

accidents. On one treacherous bridge, accidents in a two-year period dropped from 49 prior to the SafeLane overlay to zero afterwards.[83] In a particularly steep portion of a highway in Vermont, 15-20 trucks had lost traction prior to making it to a SafeLane overlay, but none once they were on it.[84] A similar reduction in accidents across the country could save millions of dollars and hundreds of lives each year. While SafeLane is relatively expensive, one coating can last up to 20 years and it is particularly helpful in hazardous areas, such as bridges.

Driver Behavior

The simplest, cheapest, and most effective way to increase safety on winter roads is by encouraging motorists to drive or not drive according to the conditions. In many of the snowier areas of the country drivers have become too accustomed to being able to make it to all of their scheduled events regardless of the weather outside. They expect roads clear of ice and snow. The ideal situation for the environment would be to not salt the roads during or after a snowstorm, letting the natural processes of melting occur. Such a practice would halt the economies of many of the United States' largest cities for at least a few days each winter, causing the loss of millions if not billions of dollars in productivity. However, simple attitude adjustments toward slower driving and greater appreciation of the danger of driving in winter, would allow for a reduction in salt use while maintaining relatively safe roads throughout this season.

Variable message board warns drivers of hazardous road conditions. Photo courtesy of Iteris, Inc.

One practice that has been used successfully in parts of the country for a variety of roadway hazards is variable message boards. These signs allow highway departments to display pertinent information warning drivers of upcoming problems ranging from accidents and road construction to rain, snow, and ice. Studies have shown that drivers are much more likely to pay attention to these variable message signs than if the same information is posted on a normal roadside sign. Reductions in average speeds of just a few miles per hour have a dramatic effect on the amount and distance of salt spray off the roadway and the amount of salt needed to effectively treat the roadways.

[83] Nixon, Wilfrid. "An Analysis of the Performance of the Safelane Overlay during Winter 2005-06." Page 11.
[84] McArdle, Patrick. "Road Overlay Proven Effective."

Recommendations

- Anti-Icing

  - While NYSDOT has taken a relatively aggressive stance toward anti-icing procedures over deicing ones, some localities have yet to adopt similar approaches. Whenever feasible, anti-icing methods should be employed, because it reduces the amount of deicing materials needed, thus reducing both short-term and long-term costs. It also keeps roads clear from the beginning of a weather event. This decision, then, both improves safety and reduces environmental impacts. If localities are unable to afford the initial costs of switching to anti-icing procedures, the state should provide funding, either in loans or grants, to encourage this conversion. Long-term benefits will easily recoup any initial costs within a few years.

- Road Weather Information System

  - By understanding the current road conditions, the precise amount of deicers can be applied to keep roadways safe for drivers. Only by having an effective Road Weather Information System can this happen. The state should provide localities with grants or some other financial incentive to implement or upgrade their snow and ice removal procedures with an RWIS. While initial investment costs may be high for some local jurisdictions, subsequent costs savings as well as alleviation of environmental damage would easily recoup those costs. By using these systems, the state could actually reduce long-term costs.

- Centralize winter road weather management operations and responsibility

  - As it is currently practiced, state, county, and local highway departments all hold specific jurisdictions and responsibilities for winter road management. This fragmented system leads to numerous discrepancies in road management as well as costing local governments more in road salt contracts given the smaller size of their orders. The NYSDOT should complete a feasibility study to determine the effectiveness and possible cost savings of centralizing more of the operation and responsibility to state agencies. This would allow for more streamlined approaches, better overall financing for deicing materials and spreading equipment, and greater accountability for highway safety and environmental protection. Localities should still be given some discretion over management procedures, but within state guidelines formulated to maximize safety and minimize damage to the environment, roadways, and vehicles. Additionally, by contracting for the entire needs of the state in terms of road salt and other deicers, this would ensure a sufficient supply and a lower cost per ton. With better access to alternatives, the latest technological improvements, and modern spreading equipment, municipalities and counties would be able to decrease their overall use of

deicers, thus reducing their costs while maintaining safe roadways during winter storms.

- Chemical Alternatives

  - New York State Department of Transportation and the many municipal highway departments across the state should assess the use of chemical alternatives to road salt. This is particularly important in the Adirondack Park and other environmentally sensitive areas, where the use of road salt has already had significantly damaging effects on the vegetation and water quality. Despite initially higher costs, these alternatives can pay for themselves in the long run by requiring less maintenance and upkeep on spreading equipment, cars and roadways, replanting of trees and cleanup or replacement of drinking water supplies. Highway Departments and other local authorities need to look beyond the short-term costs of the upcoming winter and grasp the long-term damages that the use of salt and sand is having on infrastructure and the environment.

- Environmental Risk Assessments

  - The environmental damage caused by road salt has been understood for over half a century, however, these concerns remain a distant second behind those of public safety. Highway departments must accurately weigh the environmental impacts of their winter management plans. While public safety should remain a top priority, greater appreciation of the long-term environmental damage caused by excessive usage of road salt will help supervisors to develop more efficient policies and adopt less damaging practices.

- Driver Behavior

  - The NYSDOT's guidelines state, "During those times when the pavement surface is not 'bare' or 'wet' it is incumbent on the driving public to perceive those conditions and operate their vehicles accordingly."[85] Unfortunately, this doesn't happen often enough. During the non-summer months of 2006, 11 people were killed in vehicle accidents within the Adirondack Park. Hundreds more were killed across the rural areas of the state.[86] Although some of these can be attributed strictly to the weather conditions and not to driver error, studies have shown that the percentage of fatal accidents nationally where speeding occurs is actually higher during the winter and early spring months than it is during the summer.[87] New York should adopt an aggressive approach to

[85] New York State Department of Transportation. "New York State Department of Transportation, Office of Operations Management, Highway Maintenance Guidelines: Snow and Ice Control." Page 19.
[86] Center for Excellence in Rural Safety. "SafeRoadMaps.org."
[87] National Highway Traffic Safety Administration. "Speeding-Related Crash Fatalities By Month, Day, and Selected Holiday Periods."

encouraging safer winter driving. Safety measures can include separate lower winter speed limits, strategically placed variable message boards, and greater enforcement of safe speed limits during winter weather. While changing societal attitudes toward the expectation of clear winter roads may be a daunting task, there are simpler and cost-effective ways to achieve similar results. With governmental encouragement and dispersion of information on new rules, these methods may be able to reduce both the number of accidents on roadways in winter and the amount of deicers necessary to keep the roadways relatively safe and clear.

- Variable Message Boards
  - Informing drivers can be a task in futility, as standard signage is frequently ignored. In contrast, variable message boards warning motorists of upcoming hazards have proven to be effective. The immediateness of the information displayed leads more drivers to pay attention to the warnings. This can result in reduced speeds, fewer accidents, and less need to use deicers on certain segments of roadway.

Conclusion

Winter weather continues to be an important transportation factor throughout much of the United States. While public safety concerns should remain a priority, it is clear that environmental damage and the increasing costs of deicing are unsustainable long-term. With recent improvements in technology and weather forecasting, it has become much easier for highway departments to use fewer deicing materials.

Unfortunately, the inability of many localities to make long-term plans or pay for the initial startup costs of these systems has left them unable to adopt new procedures, despite their obvious benefits. Additionally, the use of road salts and sands continue to affect drinking water, vehicles and highways, sensitive environments, and aesthetic value of the wilderness. To remedy these damages, millions of dollars will have to be spent in just upstate New York's North Country.

Fortunately, there are numerous solutions to lessen the amount of deicing materials necessary to clear the roadways. While some of these alternatives are initially more costly than road salt or sand, long-term benefits may make the costs nearly equivalent or even financially beneficial. We must reduce the amount of harmful deicers spread on roadways throughout the country, the state, and the Adirondack Park. Collaboration between jurisdictions and long-term planning are necessary components of any successful strategy. Drivers must change their expectations of clear roads, which create the need for extremely heavy applications of deicers. By simply slowing down and being attentive to road conditions, drivers can have a dramatic effect on the cost of winter road management.

Appendix A

Recent Adirondack Road Salt Editorials
(all reprinted with permission)

Tupper Lake Free Press
October 29, 2008

High Prices Present Opportunity to Stop Use of Damaging Salt

The high price of road salt this season will dramatically effect the new budgets of many town and county highway departments around the region. The price of road salt in our region is some of the highest in the state.

Some have speculated that our area may again be the victim of fleecing by outside interests. Some of the high prices here are blamed on the high costs this year of delivering salt to our remote section of the state from its western New York sources.

According to recent news reports, Clinton County is paying the highest rate for salt of all the counties in the state. Its rate, purchased under contract through the State of New York Office of General Services, is just pennies shy o f$100 per ton - $56 per ton more than last year. Essex County was able to buy its salt for about $31 per ton less than its neighbor to the north and Franklin County officials were able to buy salt, again under state contract, for $89.92 per ton – about $10 per ton less than Clinton County. St. Lawrence County officials secured a price of $86.51 per ton for the salt they needed for winter.
American Rock Salt, based in Mount Morris, south of Rochester, supplies the salt for all four counties.

The Town of Tupper Lake, which buys its salt under the state contract system in concert with Franklin County, will spend more than twice as much this winter for salt that it did this past year. Town officials have budgeted $26,444 for highway department road salt this year – up from $12,781. The town purchased 294 tons of road salt for this winter. The town mixes its salt with sand each year. The town crew already completed that work here in preparation for winter.

Towns, counties and other municipalities that use salt have to submit a road-salt requirement letter to the OGS by April 1 each year, months before salt prices are announced. The governments are required to buy 70 percent of the salt requested, under the state contract. That makes planning for winter a tough assignment for highway bosses and the elected leaders who oversee their spending.

The big increases in salt for this winter should be seen as an opportunity for state officials to reconsider the state Department of Transportation's "bare roads" policy in this region. Town and county lawmakers should encourage it. The policy was enacted in preparation for the 1980 Winter Olympics in Lake Placid to help drivers who were visiting our region that winter and who were unaccustomed to driving on snow-covered roads. Unfortunately, it's been in force ever since.

We all know that the state's "bare roads" policy and the abundant use of salt spread on our region's highways has accounted for untold millions of dollars in damage to state highways and

roads since 1980, to the landscape and aquifers adjacent to them and to the bodies and structural frameworks of the millions of vehicles that have driven on them.

It's time to stop the use of salt on our roads and highways. For many years through much tougher winters northern New York motorists drove on snow-packed roads that were sanded for traction, particularly on curves and steep inclines. People historically drove slower during the winter months and a return to that in our area is not a bad thing. The trade-off for that slower pace on non-salted roads would be vehicles that last years longer than they do now.

Our friend and local car dealer LeRoy Pickering has told us a number of times over the years how just after even one winter on the roads here how incredibly rusty the undercarriages of vehicles now are. Changing a tire, which has only been on a car less than two or three years, is sometimes a major chore for mechanics because of the copious amounts of rust that fuse metal to metal.

Many would also welcome the elimination of a chemical that kills roadside vegetation and pollutes wells near roadways.

When road surfaces are clear of ice and snow, drivers tend to travel at summer speeds. Black ice on seemingly bare roads, however, has been deadly for many motorists over the years since 1980. The slush generated on salted roads each winter can also be very hazardous.

If our area's roads were plowed and sanded but not salted, we know people would slow down. Reducing highway speeds has been proven to reduce a vehicle's consumption of gasoline, which is another good thing at this time in our economy which just a couple of months ago saw $4.50 per gallon prices at the pumps.

Driving snow-packed roads will make drivers more cognizant of the importance of good traction. Consequently more people may invest in good tires and will replace worn out ones more often. LeRoy also says keeping good tires on your vehicle is one of the secrets of safe driving. More people would install studded tires on their vehicles in the winter months, like they did years ago.

Some believe every cloud has a silver lining. We hope the steep increases in road salt this year will be that lining- the catalyst for local lawmakers to press their counterparts at the state level to rescind this region's controversial bare roads policy to permit our area's highway crews to either stop using salt or dramatically cut back on its use.

-Dan McClelland

Adirondack Daily Enterprise
November 10, 2008

Salt is damaging and, now, expensive

The skyrocketing price of road salt is leaving a sour taste in the mouths of local government officials and, by extension, taxpayers. That fiscal strain might be just the catalyst villages, towns, counties and the state Department of Transportation need to break their reliance on sodium chloride - aka traditional road salt - a substance that is incredibly damaging to some of our most valuable assets, including our vehicles and roadside trees.

One of the main reasons for using traditional road salt is that it's cheap - an argument that is losing its flavor. In late September, the Enterprise reported that the price of road salt had jumped to $89.92 a ton from $34.60 the year before. It's risen more in the month-and-a-half since; the recent town of Franklin budget shows that the price has tripled since the year before.

Sodium chloride is good for melting ice because it lowers the freezing point of water to about zero degrees Fahrenheit, but other salts like calcium chloride lower that freezing point even more.

And traditional road salt's side effects are severe. It kills trees and plants, draws deer to roadsides for cars to hit, corrodes concrete curbs and sidewalks, and the rust damage it does to people's vehicles is amazing - something anyone who drives should be able to identify with.

Plus, on snowy, rather than icy, roads, any deicer can do as much harm as good. It creates standing puddles of slush on the roadway, which are worse for traction than hard-packed snow. Also, with black-looking roads, many drivers are tempted to ignore the road conditions and go at regular speeds - dangerous if they hit a slushy spot. They would properly slow down on hard snowpack, just like they used to.

Not all states use road salt as liberally as New York does. Washington state's department of transportation switched almost exclusively to calcium chloride more than four years ago. Some evergreen needle browning has been reported (Associated Press article in the Seattle Times, March 19, 2008, "De-icer damaging thousands of trees on mountain passes" - seattletimes.nwsource.com/html/localnews/2004291523_treekill19m.html), but is the damage as bad as what we're used to here?

We don't yet know enough to say that our current road salt should be abandoned, but it is time to use it more sparingly and look into the alternatives that exist - ones that do not corrode metal and concrete, do not kill trees and actually counteract the effects of acid rain in soil. Although such chemicals have always been significantly more expensive than salt, that price gap may be closing - and that's not counting the untold cost of road salt to car owners.

Adirondack Daily Enterprise
January 29, 2009

Plowing is great, but go easy on the salt

When it's dumping snow, we are very thankful for the hard work and dedication of the men and women who drive snowplows.

This winter, we're particularly grateful to the road crews that are using less salt than in recent years. Several villages and towns report that they are using significantly less, and it's pleasantly noticeable.

The reason for the cutback is largely that the price of salt has skyrocketed this winter - roughly double its fall 2007 price of $35 a ton - and because the weather has fortunately led to almost no ice buildup since Christmastime, so salt isn't all that necessary. But the lack of salt is also good for vehicles, sidewalks and trees. We hope government officials will notice those things and keep their use of sodium chloride (common road salt) to a minimum even when the price goes down and the weather ices up.

Unfortunately, some snowplow drivers still use salt far too liberally, even when none is necessary.

On Jan. 17 in Paul Smiths, two Enterprise staff members got stuck behind a DOT truck that was dumping pounds and pounds of rock salt behind it on a bare road. The temperature hadn't been above freezing in three weeks, the sun was shining and no storm was brewing. Ice was not a concern.

And this wasn't a sprinkling of salt, nor an even spraying of presoaked salty brine. If one of us had been standing in the back of the truck, shoveling salt on the road as fast as we possibly could, we couldn't have dumped more. It was a classic example of a mindless, blatant waste - your tax dollars at work.

We're not saying this is typical of the DOT. During Wednesday night's heavy snowfall, for instance, we were pleased to see state Route 86 well plowed but apparently unsalted.

The DOT still likes its salt, though - a view that's due for an update. It's a standard department practice to salt roads in advance of a snowstorm; this prevents snow from bonding to the blacktop so it can be plowed up more easily than hardpack.

To be more efficient, DOT spokesman Mike Flick told us Wednesday that many trucks now have equipment to monitor temperature, moisture and other variables, to apply only as much salt as is needed. Plus, many DOT trucks (including most of the 20 in Franklin County) spray salty liquid brine instead of spreading hard salt; this way, more salt stays on the road instead of bouncing off.

But still, hundreds of cars and trucks drive over that salt before it has a chance to do any good, and a huge portion ends up on those vehicles and the roadsides.

Sodium chloride is not only more expensive than ever to buy; it also has expensive and damaging side effects: It rusts people's vehicles like crazy, eats away at concrete and kills roadside trees. The cost of these detriments is untold and is therefore discounted by those that still buy road salt by the ton. While it's still cheaper than other deicers, the price gap has narrowed to the point that

all government agencies that maintain roads in winter should seriously consider alternatives. Calcium chloride, for example, melts ice better than sodium chloride and doesn't rust cars, corrode concrete or kill trees. Washington state's department of transportation switched almost exclusively to calcium chloride more than four years ago.

But any deicer can do as much harm as good on snowy, rather than icy, roads. It creates standing puddles of slush, which can be worse for traction than hard-packed snow. Also, on black-looking roads, many drivers are tempted to ignore the conditions and go at regular speeds - dangerous if they hit a slushy spot.

Deicers should be reserved for ice. As Mr. Flick acknowledged to us Wednesday, the best way to keep snowy roads safe is to plow, plow, plow, and for that, we thank our road crews.

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