We didn't plan to talk about it, but since you asked . . .

- Here’s a topic a few of you asked to hear about (and many students in prior years): **ROAD SALT**
  - “What is the long term impact of road salt, sand and synthetic chemicals used in deicing frozen surfaces? What would be better?”
Let’s take the materials that we apply to our roads one at a time:

**Road Salt**

- **Basically NaCl**
  - readily dissolves producing Na\(^+\) and Cl\(^-\) ions in water (salt lowers the freezing temperature of ice, causing it to melt)
    - Na\(^+\) in diet is associated with cardiovascular problems.
    - Cl\(^-\) can bind with cationic metals in soils, increasing their mobility
    - Na\(^+\) and Cl\(^-\) ions in water increase its conductivity, increasing the rate of corrosion [an economic consequence]
  - In Ithaca, the Town and City apply approximately 2,000 to 3,000 tons of salt per year. Most of it ends up in Cayuga Lake. At the present rate of increase, in 100 years Na\(^+\) levels in city water will reach 250 mg/L, which is considered too contaminated to drink.
**Mass balance:** The amount of road salt input to an area over a certain amount of time can be measured in comparison to the output in the exiting water. The difference gives the amount of salt which is trapped within the ground.

**A specific example:**
- Highland Creek basin of the Metropolitan Toronto region watershed.
- This area receives \( \approx 200 \, \text{g/m}^2 \) of NaCl each year.
- The amount of Cl\(^-\) leaving the basin from stream flow was recorded at 15-minute intervals over a two-year period and was only 45% of salt applied.
- Since the addition of chloride is greater than the mass of chloride leaving the stream, the chloride is building up in ground water.
- Predictions suggest if salt is added at its present rate and 45% enters the subsurface, steady state discharge of chloride concentrations will exceed 400 mg/L. This level is unsuitable for drinking water.
Sand

- basically crystalline silica (SiO$_2$).
  - applied for purposes of improving traction.
  - SiO$_2$ is extremely inert, i.e. non reactive.
  - the Town and City of Ithaca formerly had a combined application rate of 9,000 tons/year. At this rate, it would take approximately 700,000 years to fill up Cayuga Lake.
  - the Town and the City have stopped using sand because of it’s erosion and clogging of drains and because of the dust it generates.
  - Also applied sand does not “stay put” and is displaced by traffic off of the road surface.
Other deicing chemicals or substances used to improve traction

- MgCl\(_2\) is occasionally used. It melts ice more readily than NaCl
  - More expensive, consequently use for desalting of roads in Ithaca is restricted to low temperature extremes.

- Cinders and fly ash are also occasionally used.
  - The City of Ithaca previously used cinders from the Cornell heating plant but no longer does.
  - The Town of Danby also formerly applied fly ash to roads.
  - Both cinders and fly ash have relatively high concentrations of toxic trace metals such as Cd, and of polycyclic aromatic hydrocarbons (suspect and known organic carcinogens) so mobilization of these contaminants into the environment can result.
How does winter salting of roads and walkways affect the soil and vegetation?

- We found a study by the University of Washington in which salt was shown to have moderate or severe effects on 16 or 17 species of trees studied.
- In Massachusetts cranberry bogs with roads running through them have proven to be extremely sensitive to salt.
“Synthetic” chemicals

- Calcium-magnesium acetate (CMA) is said to be an “environmentally safe” deicer.
  - manufactured by Chevron Chemical Company under the trade name of “Ice-B-Gon”.
  - Has been used by the city of Ithaca during cold weather.

PROs:
- CMA is less corrosive than salt.
- In studies at the University of Washington, CMA had an effect on only 1 of 17 tree species studied.
- CMA requires less frequent application than salt (≈ 1/2 as often), and the amount needed is ≈ 2/3 the amount of salt.
- CMA dissolves to give \( \text{Ca}^{+2}, \text{Mg}^{+2} \) and acetate \( (\text{CH}_3\text{COO}^-) \). The acetate is readily degraded by soil bacteria.

CONs:
- like any other organic compound released to the environment, bacterial degradation of acetate will use oxygen.
  - CMA costs 30X more than salt ($600 to $650/ton vs. $20/ton for salt). [Using 2/3 the amount & applying 1/2 as often ➔ 10x cost increase. BUT salt has “hidden costs” associated with corrosion.]
Other alternatives

- The City of Ithaca tried using another product marketed under the trade name of **Clear Lane** but stopped.
  - Clear Lane is basically MgCl$_2$ mixed with molasses and is combined with road salt.
    - The MgCl$_2$ provides for melting of ice at low temperature.
    - The molasses helped the product stick to the road salt and helped the mix to stick to the road surface (vs. being bounced off by passing traffic as is the case with sand).

- The City is now using **Magic Minus Zero**
  - Magic Minus Zero is a blend of MgCl$_2$ combined with a grain and/or sugar based distilling process by-product.
    - The organic component is biodegradable.
    - The manufacturer states that it is safe to use on concrete, is non-corrosive, does not harm curbside grassed areas or plants, and continues to melt ice to below -35F°.
Some quotes:

- 13,000 tons of road salt is spread on roads within Tompkins County each winter.
- Inhibits water uptake and damages plants up to 650 feet from a road.
- City of Ithaca's water plant has seen salt levels rise ... since 2007, the city has been required to send out notices to customers [warning of high sodium levels & effect on blood pressure].
- The sodium level has been steadily increasing since 1991 -- doubling from 9.8 mg/L then to 20 mg/L in 2009.
What might be the consequences if we quit using salt?

- The city of Tulsa Oklahoma banned salt use.
  - The result was accidents that were so frequent, news teams would set up on street corners for live broadcasts (they would just sit and wait for an accident and interview the people).
The End