Analyzing Chloride Concentrations in Major Lake Chains of the Twin Cities Metro Area (TCMA)

Anna Curtler and Alexa Chesley

Why study chloride?

Important contaminant in MN – road salt

- Estimated ~250k tons of road salt used in the TCMA yearly

Affects Aquatic Life

- High levels toxic

Affects water quality

- Stratification
- Algal blooms

Minneapolis-St. Paul Long Term Ecological Research (LTER)

Researchers from the University of MN, UST, USDA Forest Service, The Nature Conservancy, and Water Bar

Studying how urban stressors affect ecological structure and functioning of urban nature

- Well-established data on chloride concentrations in different lakes in the TCMA

Project Overview

Analysis of LTER chloride data

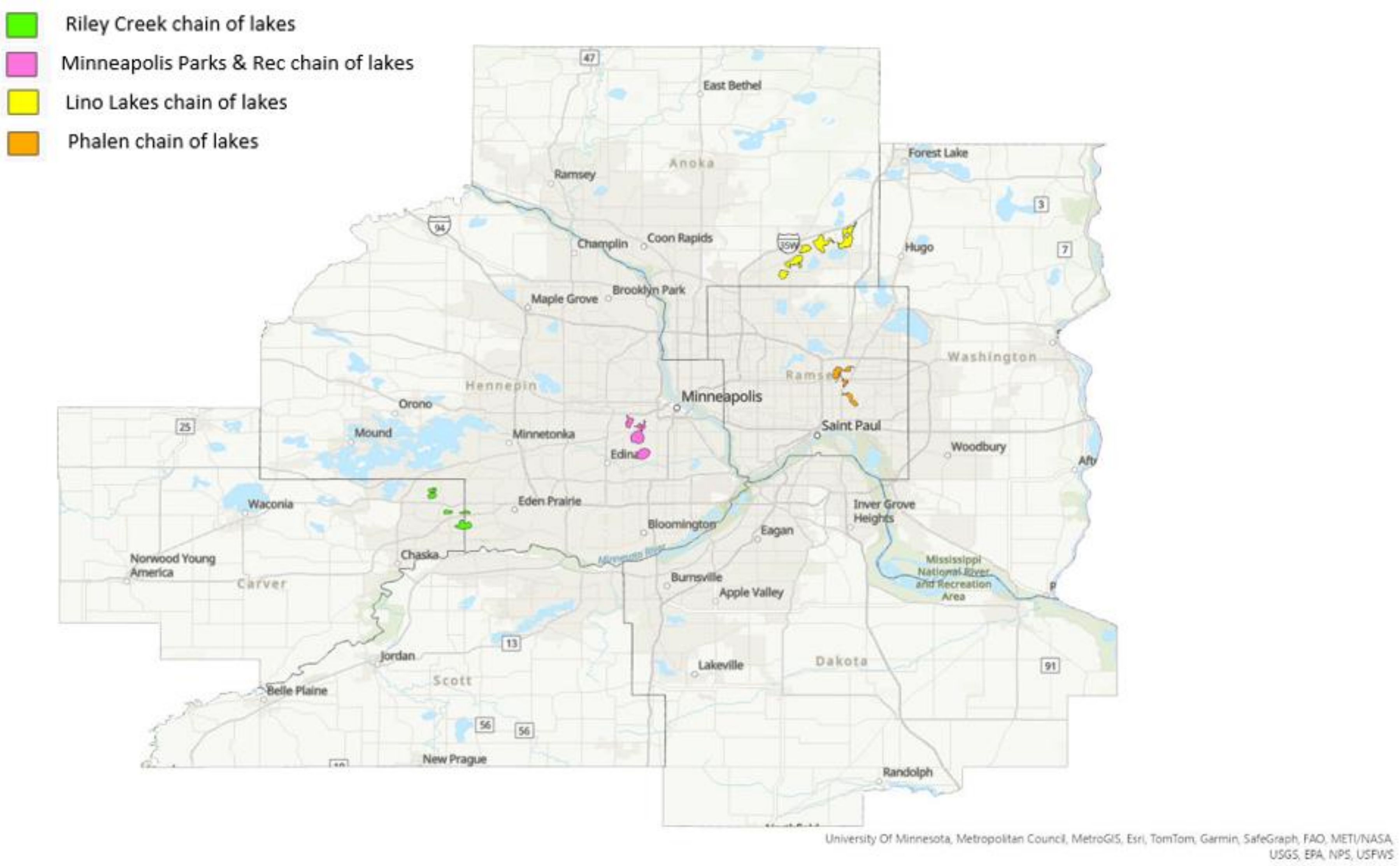
Temporal Analysis (R)

- Expected increasing chloride concentrations over time

Spatial Analysis (ArcGIS Pro)

- Expected lakes in watersheds with higher road densities to have higher chloride concentrations
- Expected lakes downstream to have increased chloride concentrations

Area of Interest

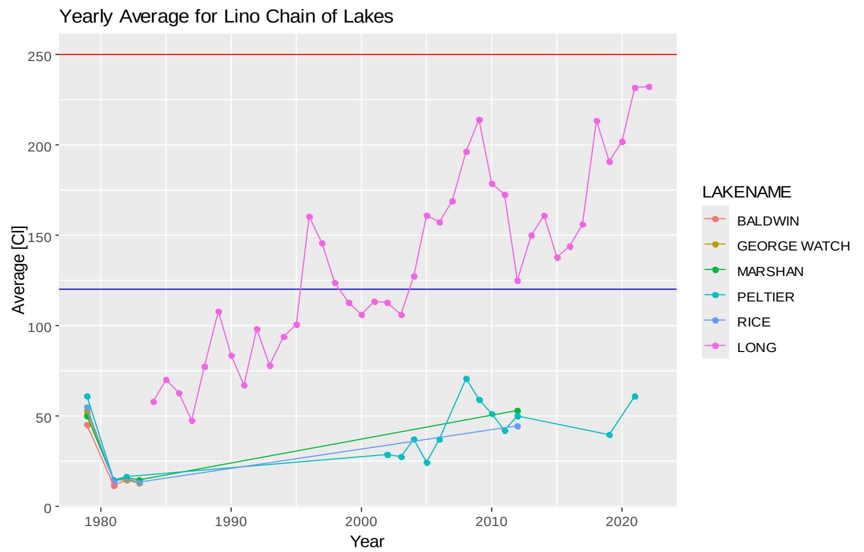


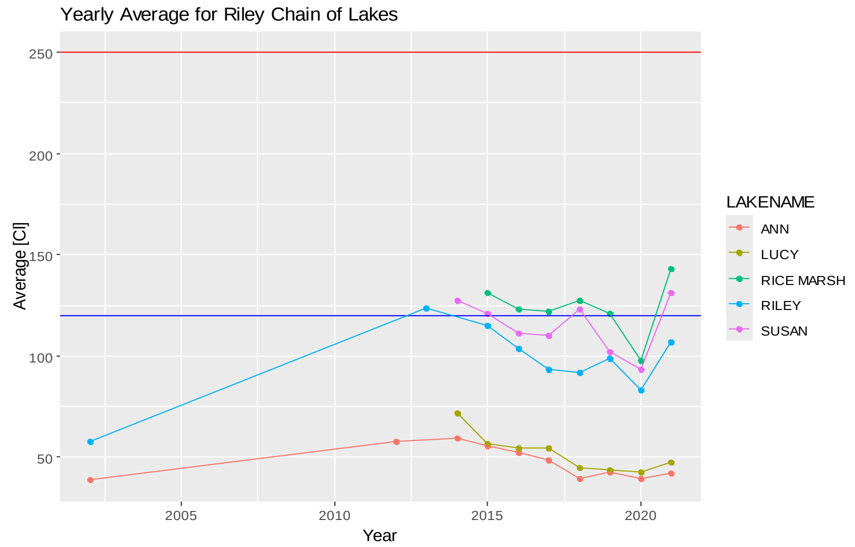
R Methods

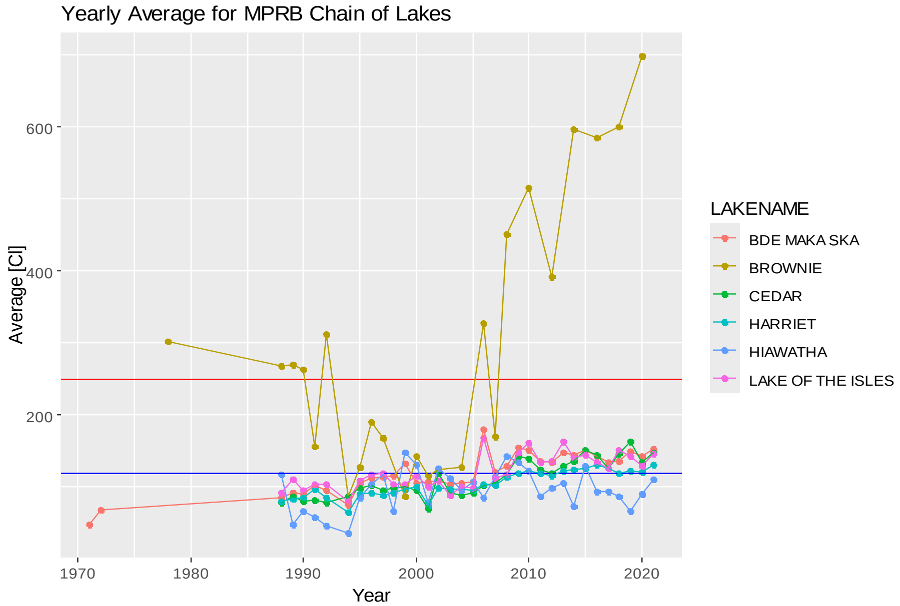
```
#adding chloride and LTER data together to allow for further data manipulation
LTERdata <- left_join(precip_all, LTERdata)


#seperate lakes by specific chains
Phalenlakes <- LTERdata %>%
  filter( DOW %in% c("62004000", "62000600","62000700", "62001002", "62001200", "62001300" ))
Rileylakes <- LTERdata %>%
  filter( DOW %in% c("10000700", "10001200","10000100", "10000200", "10001300", "27008000"))
Linolakes <- LTERdata %>%
  filter( DOW %in% c("02000400", "02000500","02000700", "02000800", "02001300", "62006700" ))
MPRBlakes <- LTERdata %>%
  filter( DOW %in% c("27003800", "27003900","27004000", "27003100", "27001600", "27001800" ))

```

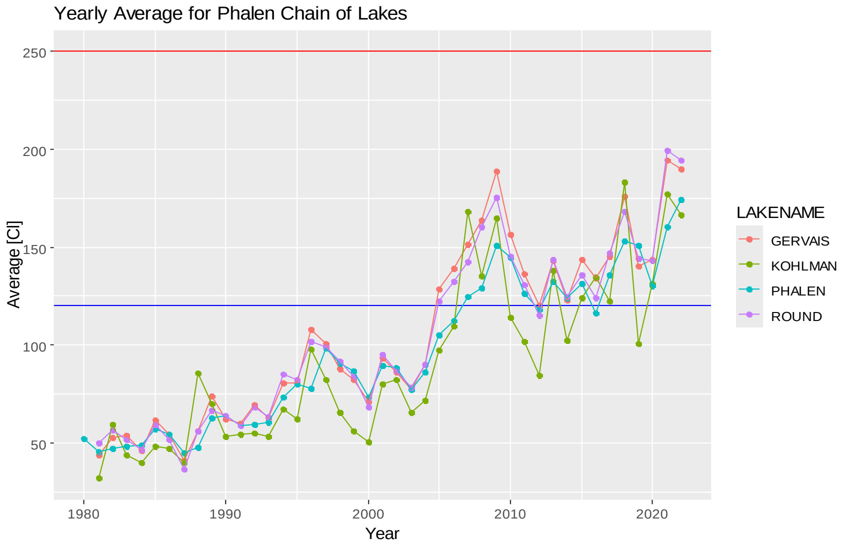
```
Rileylakes_yearly <- Rileylakes%>%
  mutate(Year = year(sampleDate), Month = month(sampleDate))
Rileylakes_yearly_avg <- Rileylakes_yearly%>%
  group_by(Year, LAKENAME)%>%
  summarize(avg_cl = mean(Cl.mg_L, na.rm = TRUE))
Rileylakes_yearly_avg <- left_join(Rileylakes_yearly_avg, s_sum, relationship = "many-to-many")
```

Temporal Trends









CAN standard for chronic toxicity (120 mg/L)

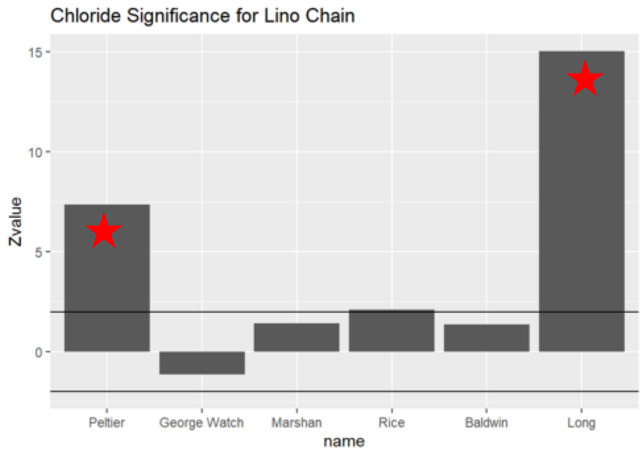
US standard for chronic toxicity (250 mg/L)

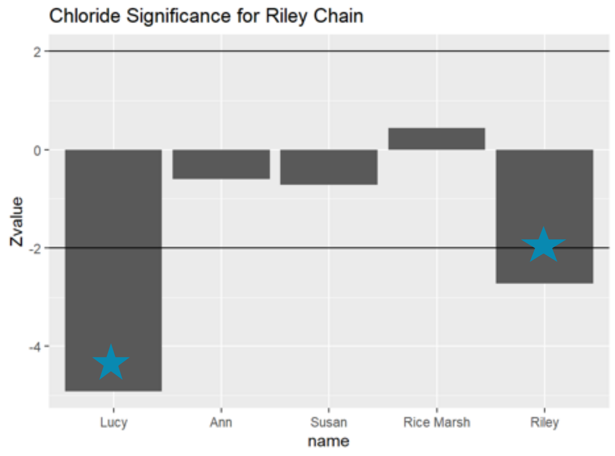
Mann-Kendall For Monotonic Trend

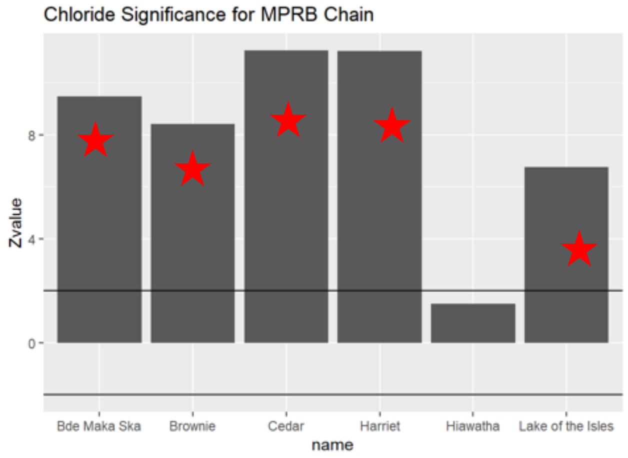
```
#Riley chain of lakes
z_Rileylakes <- mk.test(Rileylakes$Cl.mg_L, continuity =  FALSE)
z_Lucy<-  mk.test(LUCY$Cl.mg_L,  continuity =  FALSE)
z_Ann <- mk.test(ANN$Cl.mg_L, continuity = FALSE)
z_Susan <-  mk.test(SUSAN$Cl.mg_L,  continuity =  FALSE)
z_RiceMarsh <-  mk.test(RICEMARSH$Cl.mg_L,  continuity =  FALSE)
z_Riley <-  mk.test(RILEY$Cl.mg_L,  continuity =  FALSE)
#Plotting Z values for Lino Chain
z_indiv_Rileylakes <- data.frame(
  name = c("Lucy", "Ann", "Susan", "Rice Marsh", "Riley"),
  Zvalue = c(z_Lucy$statistic,z_Ann$statistic, z_Susan$statistic, z_RiceMarsh$statistic,
             z_Riley$statistic))
# Define the order you want
desired_order_Riley <- c("Lucy", "Ann", "Susan", "Rice Marsh", "Riley")

# Reorder the levels of the 'name' column in the data frame
z_indiv_Rileylakes$name <- factor(z_indiv_Rileylakes$name, levels = desired_order_Riley)

```

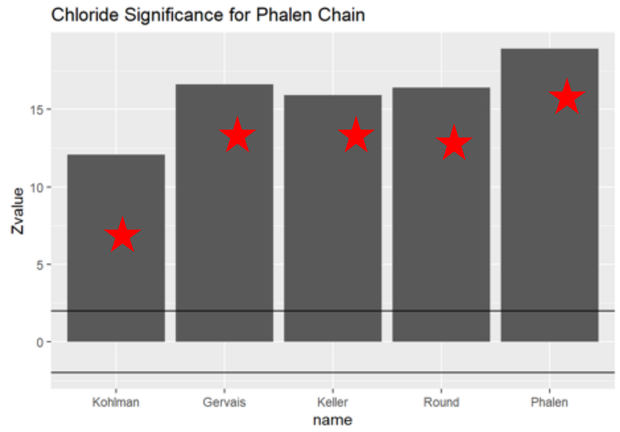
Significant Trends

- 12 lakes found to have significant increases in [Cl]
- 2 lakes found to have significant decreases in [Cl]

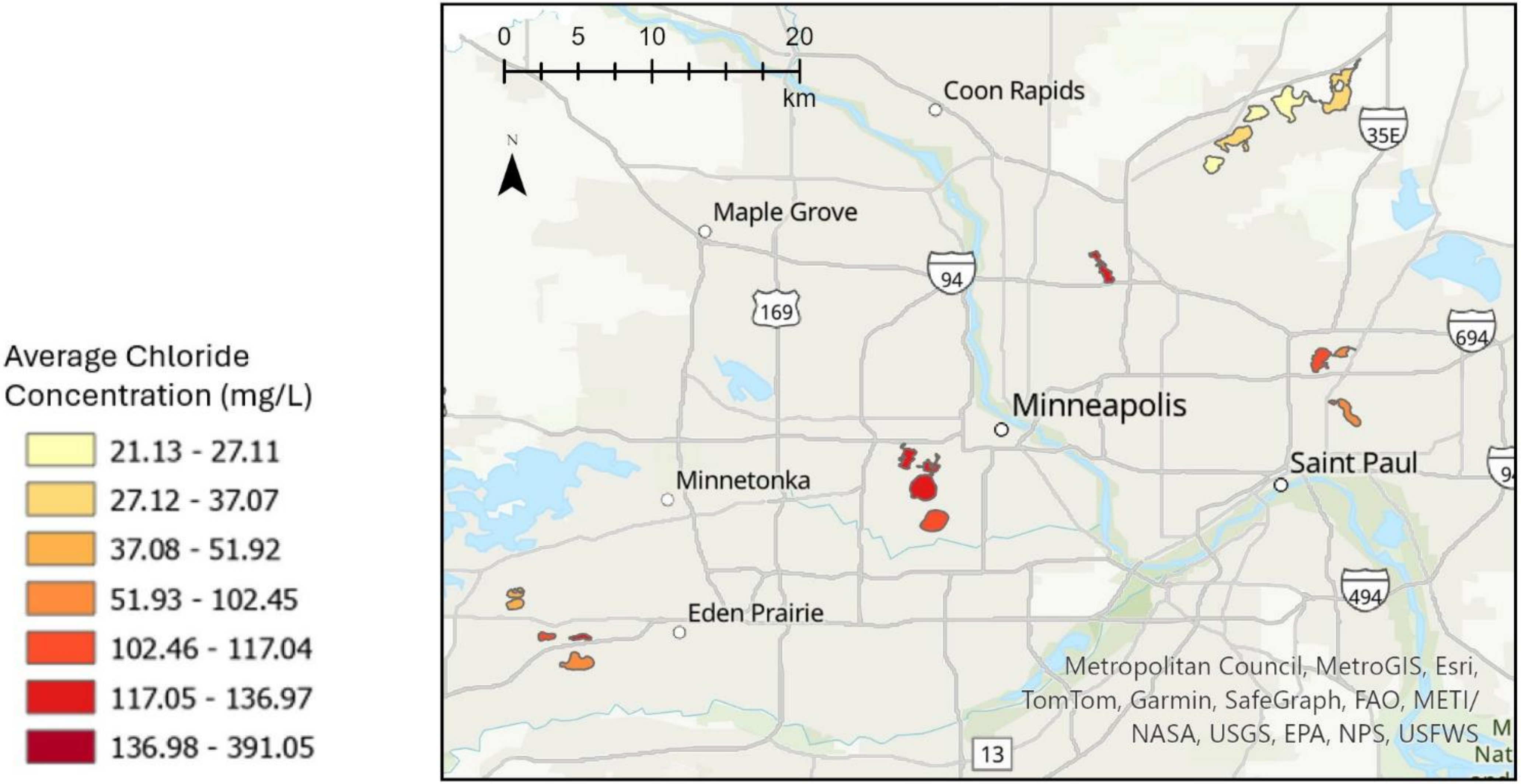






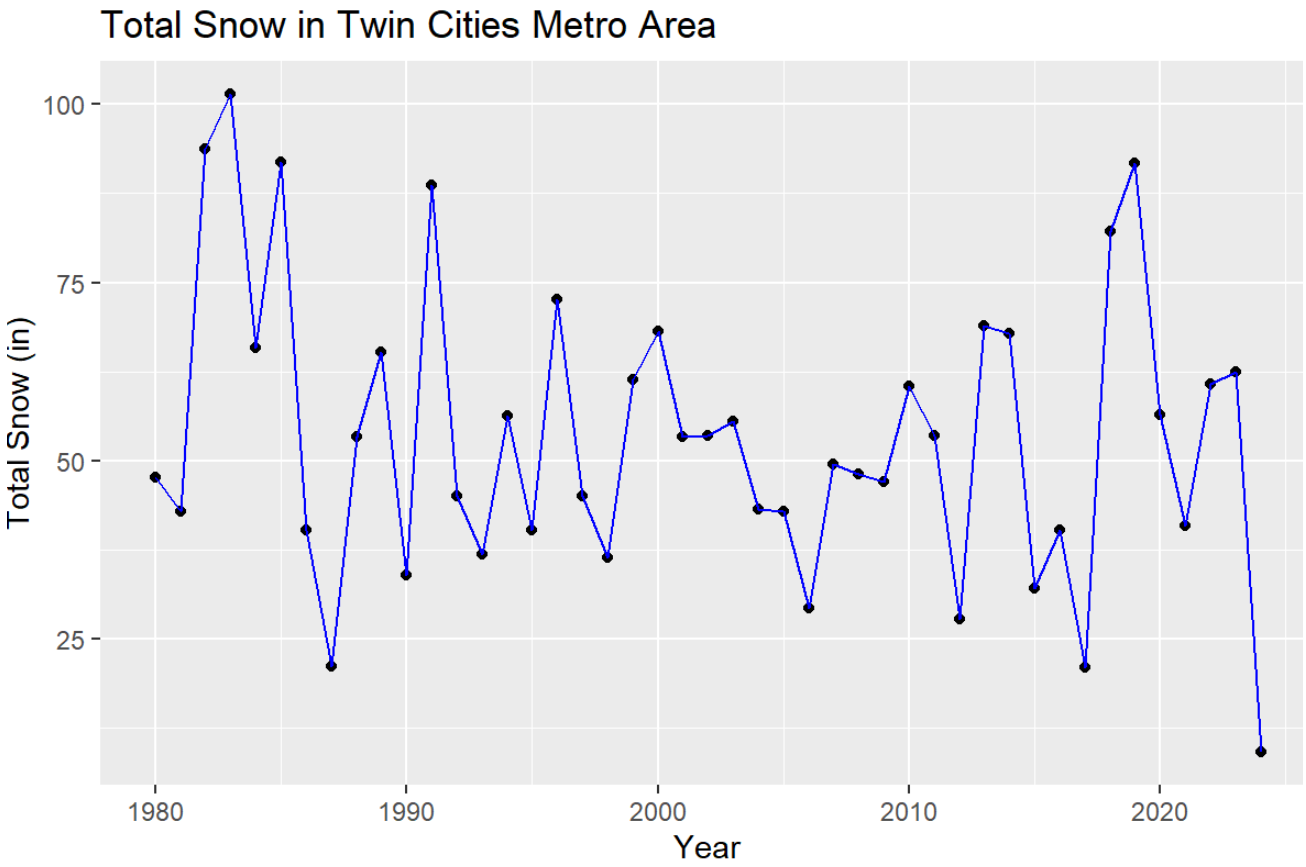


Spatial Distribution of [Cl]

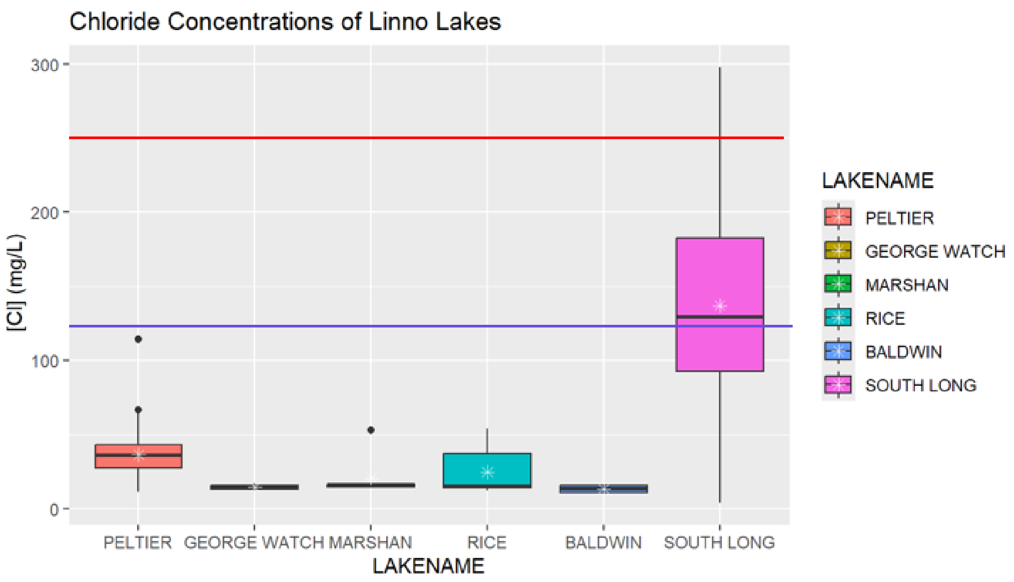


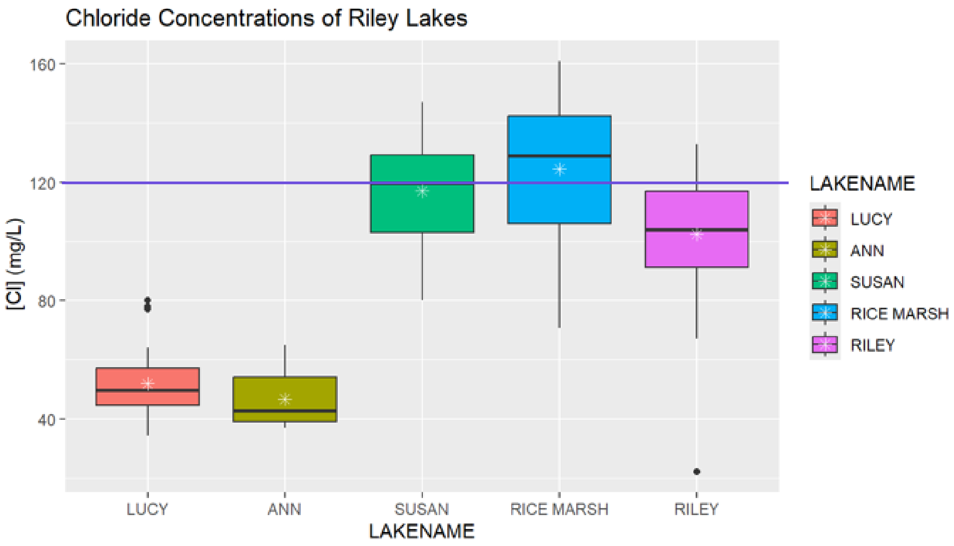
Snowfall in TCMA

- No obvious correlation with [Cl] increases
- Corroborates complexity in Cl distribution and life cycle

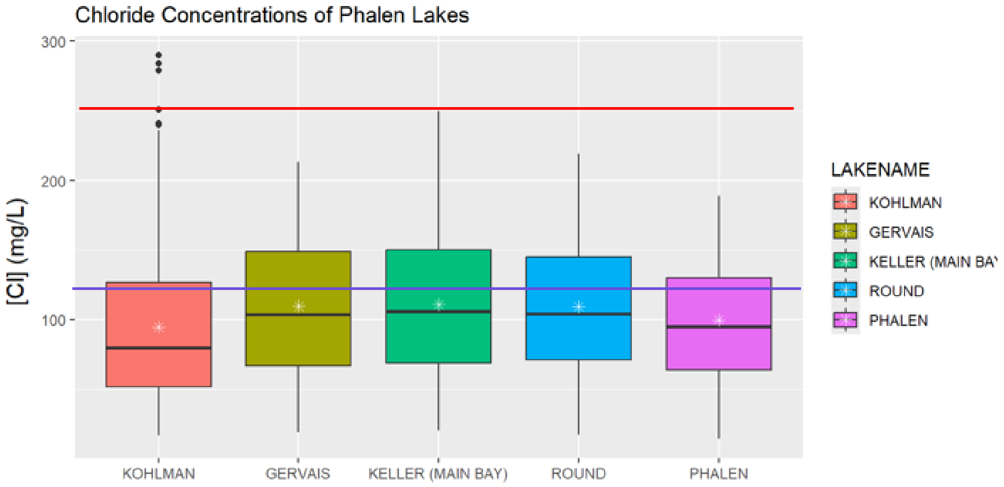


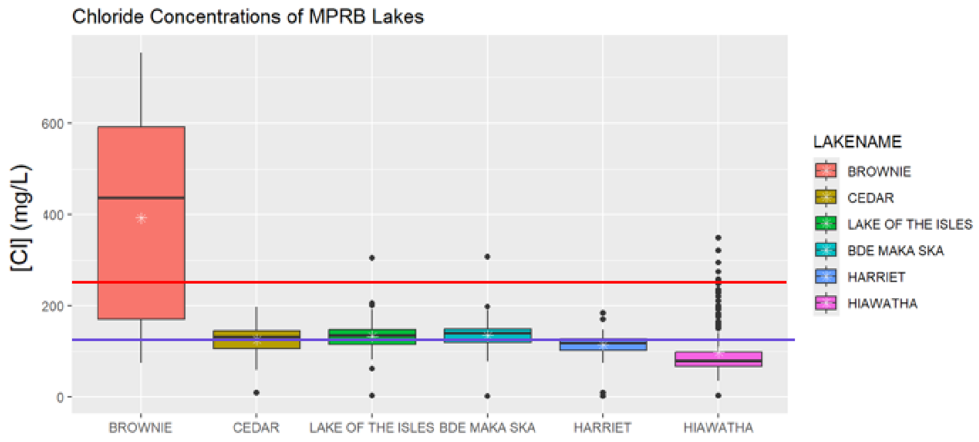
All Examined LTER [Cl] Data





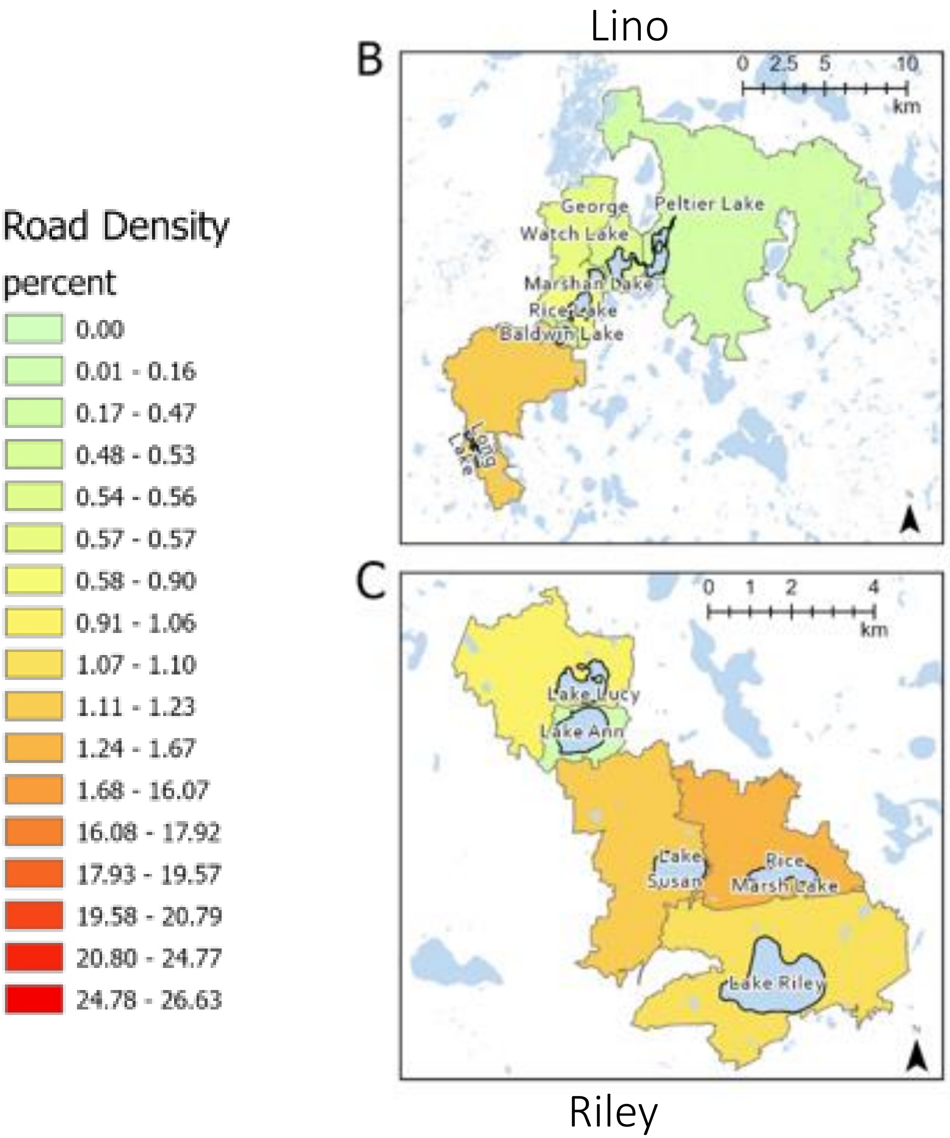
CAN standard for chronic toxicity (120 mg/L)

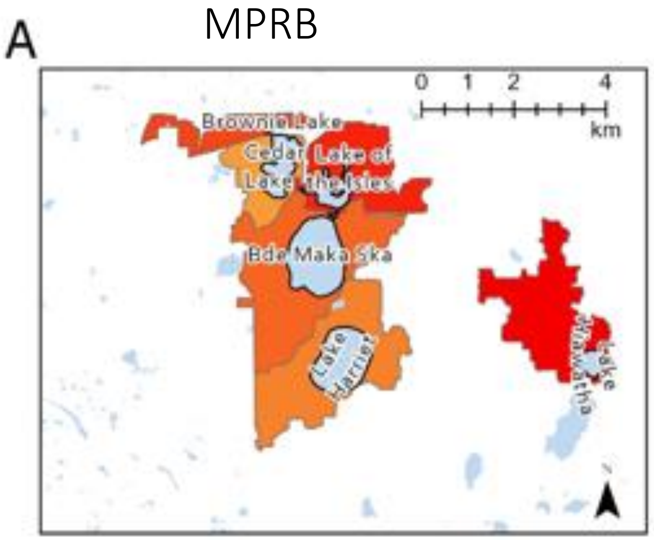




US standard for chronic toxicity (250 mg/L)

Spatial Distribution of Roads

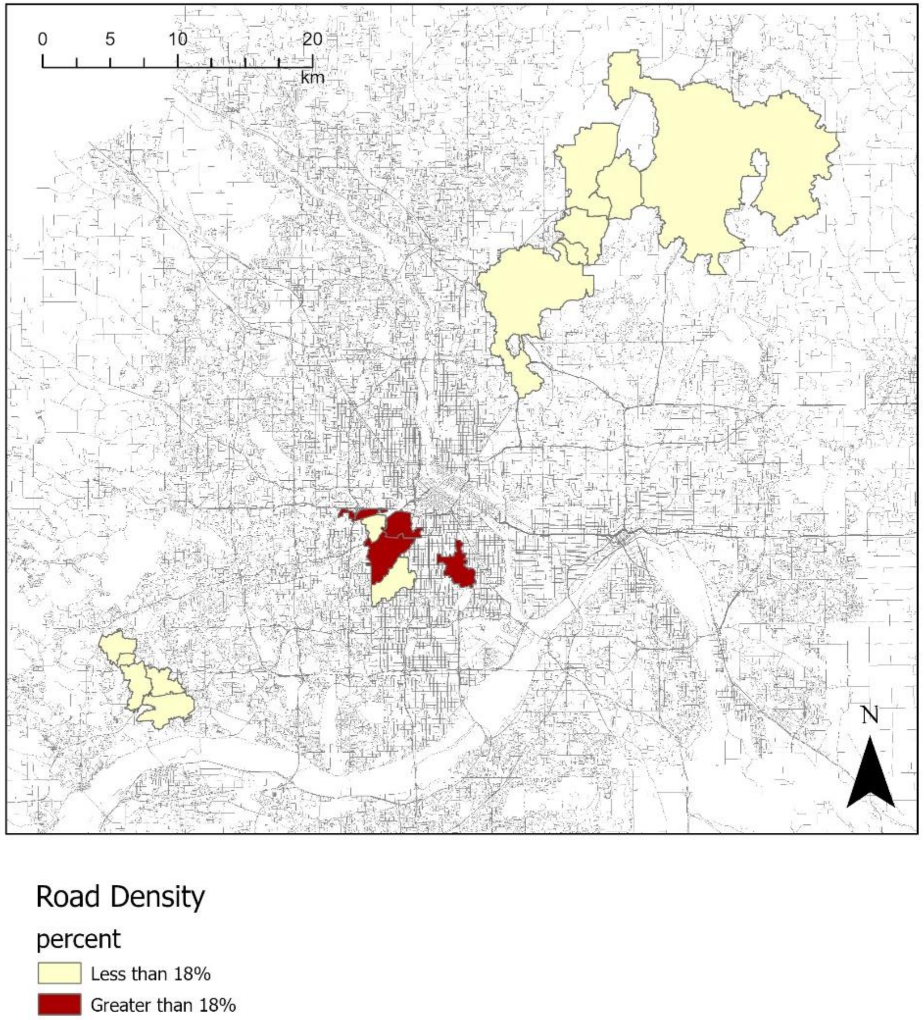




- MPRB was expected to have the highest [Cl] and road density
- Higher road density of roads in the Long Lake watershed contributing to Z-score?

Watersheds with Road Densities >18%

- Only 4/7 lakes exhibiting significant increases in [Cl] were found to have road densities >18%
- Other factors need to be considered i.e. watershed area



Conclusions

Road density is a factor but not the only indication of a lake at risk for chloride concentration

Snowfall does not correlate with chloride trends

A lake’s watershed area is a bigger factor than the lake’s position in the chain

QUESTIONS?