## Questions

1. DIN:TP was a better indicator of nutrient limitation for oligotrophic lakes (Bergström, 2010), does this hold true for lakes of varying trophic status across the US?
   1. Can we compare models of TN:TP and DIN:TP as predictor of limitation in different trophic states?
2. Is it possible for a lake to be eutrophic for TN but not limiting by DIN?
3. Is trophic status based on chlorophyll more influenced by N or P?
4. Trophic status tends to increase as concentrations of TN and TP increase(Wetzel, 2001), but what about TN:TP ratios?
5. Do the general trends of TN:TP decreasing with increasing trophic state hold true in all ecoregions? At all elevations?

## Eutrophication and water quality

1. Eutrophication can have serious consequences on aquatic ecosystem health including decreased levels of dissolved oxygen, formation of toxic compounds, changes in abundance and composition of various aquatic organisms, and overall loss of biodiversity (Camargo & Alonso, 2006).
2. Anthropogenically caused nutrient enrichment is one of the biggest threats to freshwaters today (Smith & Schindler, 2009).
3. An estimated $2.2 billion in losses because of eutrophication is likely an underestimate of the actual amount. Costs are associated with recreation, fisheries, property values, loss of biodiversity, and drinking water treatment (Dodds et al., 2008).
   1. And determining economic value of freshwater is difficult with many important factors often excluded from these analyses (Keiser et al., 2019).
4. Eutrophication can lead to more frequent and intense harmful algal blooms, one of the greatest risks to freshwaters biodiversity across the world (Reid et al., 2019).
5. Over the past nearly 2 decades, there has been an increase in murky lakes across the US, especially in the Northern Appalachian, Southern Plains, and Xeric ecoregions.
   1. These lakes tend to have high chlorophyl-a and microcystin concentrations as well as high cyanobacterial outbreaks (Leech et al., 2018).
6. In streams, chlorophyll-a concentrations were found to be substantially higher above the thresholds of 30 µg/L of P and 40 µg/L of N (Dodds et al., 2011).
7. As of the writing of this manuscript, the US Environmental Protection Agency (EPA) has been developing nutrient criteria in US waters to control pollution and plan to amend the Clean Water Act with updated information. They have developed guidelines with various models that incorporate regional specifics so that states may develop their own nutrient thresholds (US Environmental Protection Agency, 2021).
8. N enrichment may lead to greater abundance of nitrate in freshwater resources (Wymore et al., 2015).
   1. Increased nitrate in drinking water can cause serious human health impacts including cancers, birth defects, and infections (Camargo & Alonso, 2006).
9. Median TN and TP concentrations in lakes exceeded reference values across all ecoregions in 2008 study (Dodds et al., 2008).

## Methods/data

1. Leech et al., 2018 used NLA data and has a great methods section that I aspire to write. They also have wonderful figures that I am recreating with my NLA dataset and for my questions.
2. Sampling programs often exhibit similar biases including when and which lakes are sampled. Most lake data are collected throughout in the summer and from large lakes (>20 ha) (Stanley et al., 2019). – NLA data follows the collection during summer, but breaks away from the large lakes sampling only by including ## lakes <20…
3. Check out Stutter et al., 2018 diagrams.
4. Frei, et al. – used NLA data – methods section useful – especially bit about averaging sites sampled multiple times over survey to account to seasonality

## Ecoregions and physical attributes that may impact biogeochemistry of lakes

1. Dodds et al., 2011 questioned whether ecoregional categorization of terrestrial vegetation actually has an impact on nutrient loading.
2. In rivers, organic carbon played a key role in mediating stoichiometric imbalances which tended to be strongest in watersheds with higher percentages of urban or agricultural land use (Stutter et al., 2018).
3. Reservoirs have a greater drainage ratio (watershed area:surface area) and thus receive more matter via runoff than a natural lake (Hayes et al., 2017).
   1. Reservoirs serve as settling basins for sediments, nutrients, and other elements (Syvitski et al., 2009).
4. Omernik’s development of ecoregions provides a qualitative understanding of spatial patterns and regional homogeneities that can be used to inform freshwater researchers (Omernik, 1987).
5. Regional scale processes can influence nutrient composition in lakes, including N deposition (Burns, 2004) and vegetation and soil characteristics (Kopáček et al., 2000).

## Biogeochemistry and stoichiometry

1. At high levels of TN (>5 mg/L) and TP (>2 mg/L), a majority of total nutrients was composed of dissolved organic forms. At low levels, the ratios of dissolved organic nutrients to total nutrients were highly variable (Dodds, 2003).
2. In watersheds dominated by forests or wetlands, there is increased loading of bioavailable DOC and decreased loading of N and P into rivers (Stutter et al., 2018).
3. Generally, increased residence time correlates with increased C:N, C:P, and N:P. Residence time may also promote burial of P and lead to higher rates of primary productivity (Maranger et al., 2018).
4. Biological uptake of N and P are coupled; with P cycling often being N limited (Oviedo-Vargas et al., 2013).
   1. Reductions in P pollution in large lakes may lead to the accumulation of N (Finlay et al., 2013).
5. Nutrient stoichiometry is much more difficult to predict than nutrient concentrations (Collins et al., 2017).
6. TN:TP ratios were high in oligotrophic lakes and low in eutrophic lakes (Downing & McCauley, 1992).
7. TN:TP can be used to indicate nutrient deficiency based on the Redfield ratio, which illustrates balanced growth of marine algal cells have a 106C:16N:1P molar ratio (Redfield, 1958).

## Phosphorus focused papers (limitation, eutrophication, etc.)

## Nitrogen focused papers (limitation, eutrophication, etc.)

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