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

1. Accumulation of P in upstream soils and freshwater sediments threatens water with eutrophication (Bennett et al., 2001).
2. FOCUS: There is an ongoing debate about whether N or P is more important in terms of causes of eutrophication. Most studies have shown P to be the main cause (Carpenter, 2008).
3. P is the main limiting nutrient in freshwaters, while N is limiting in the oceans (Correll, 1999).
4. FOCUS: P plays the dominant role in limitation/eutrophication, but there has historically been a debate over which nutrient is more important. Lakes have undergone oligotrophication in response to P reduction efforts (Foy, 2005).
5. N-limitation may be a function of P enrichment in eutrophic lakes (Havens, 1995).
6. TP plays the dominant role in trophic state based on chlorophyll-a, except in hypereutrophic lakes where both nutrients are important. This was studied only in the northeast and northern Midwest US (Liang et al., 2020).
7. FOCUS: Another study only about P eutrophication (Ngatia & Taylor, 2019).
8. N alone cannot be reduced to control eutrophication because as lakes shift toward N-limitation, N-fixing bacteria allow productivity to continue, thus not alleviating the trophic state problem (Schindler et al., 2008).
9. Internal loading of P is much greater than that of N. Focus on internal P reduction may reduce eutrophication (Sun et al., 2022).

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

1. Argues that most lakes in the northern hemisphere were N-limited prior to an influx in N-deposition. This increase resulted in elevated N concentrations and a shift from natural N-limitation to P-limitation as well as eutrophication and higher chlorophyll-a concentrations (Bergström & Jansson, 2006).
2. N deposition can significantly alter ecosystems in the Western US (Fenn et al., 2003).
3. P has been the main focus for eutrophication management because of the possibility for N-fixing bacteria to compensate for N-limitation, but P reduction alone is no longer an adequate strategy.
   1. We need increased research on nutrient amounts and ratios and nitrogen’s impact on eutrophication (Yao et al., 2018).
4. Most studies have focused on P and no single-ecosystem scale study has shown promising results of N reductions. Thus, more research regarding N and eutrophication is needed (Schindler & Hecky, 2009).
5. The precipitation patterns predicted by climate change models will likely increase N loading into freshwaters (Sinha et al., 2017).

## Balanced approach

1. Connectivity of freshwaters across the landscape necessitates the need for stoichiometrically balanced nutrient management since along the continuum of freshwaters to the ocean, limitation may shift. Management strategies that focus on a sole nutrient could increase availability of the other limiting nutrient in subsequent waters, thus intensifying eutrophication downstream (Conley et al., 2009).
2. There is complexity in nutrient management strategies related to nutrient proportions and nutrient forms and managing only N or P can lead to unintended ecological consequences caused by availability of the other nutrient (Glibert, 2017).
   1. Suggestion that within lakes, controlling TP and bioavailable N rather than TN may assist in eutrophication reduction (Lewis et al., 2011).
3. Changing climate and other human-induced stressors will likely exacerbate eutrophication and the need for management. Assuming a single nutrient is limiting can lead export of other nutrients and increased productivity problems downstream (Wurtsbaugh et al., 2019).

## Methods

1. TN:TP < 20 lakes are N-limited. TN:TP > 50, lakes are P limited. Primary productivity is a product of both N and P concentration and the N:P ratio (Guildford & Hecky, 2000).

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