On behalf of the Agroecology Graduate Group at the University of Minnesota, we appreciate the opportunity to provide our perspective to strengthen the updated Minnesota Nutrient Reduction Strategy. We are a multi-disciplinary group of researchers focused on improving our agricultural systems to support farmers, rural communities, and the environment. We are galvanized by the challenge to transform our agricultural production in a manner that supports farmers' economic realities, while dramatically reducing the nitrate that leaves farm fields and enters our waterways each year. We believe that the NRS has a rare opportunity to drive the State's vision for a more diversified agricultural landscape that reduces nutrient pollution, increases regional production of diverse, nutrient-dense food, and supports thriving rural economies. We offer these suggestions from our perspective as early-career scientists who will spend the coming decades studying the best solutions to this complex problem.

1. **Definition of "cover crop."** The language of cover cropping describes "living cover crops" (page 199), which is unclear language. There is a need in the NRS document to clearly differentiate "classic" cover crops which are not fertilized or harvested versus "cash" or "commodity" cover crops such as winter annual crops which receive some fertilization and are harvested for profit. Both have their place in Minnesota agricultural systems, but function differently and can have different end results. For example, additional fertilizer applied to a "cash cover crop" grown in a vulnerable watershed may have differing implications for nitrate reduction than a cover crop for which no added fertilizer is applied.

2. **Research priorities.** We see important research needs that will support the success of the NRS. We ask the State to support–financially and otherwise–the following priority research needs:
    a. Comprehensive breeding efforts are urgently needed to improve cover crops, develop winter-annual "cash cover crops" that provide direct economic returns, and continuous living cover (CLC) cropping systems;
    b. Breeding programs should incorporate traits that improve nitrate uptake and winter hardiness while improving soil health parameters;
    c. Development of a suite of perennial grains, forages, and agroforestry species, to be grown alongside cropping systems like silvopasture and riparian buffers, that can support diverse landscapes and agricultural business models;
    d. To ensure CLC adoption at scale, social science research must be meaningfully integrated to identify equipment, labor, supply chain, and knowledge barriers, support peer-to-peer learning networks, and communicate the impact alternative cropping systems can have on rural livelihoods;
    e. Novel systems, such as manure injection into cover crops or pairing cover crops with short-season summer cash crops to extend the fall-to-spring growing window, should be tested for their combined nutrient-reduction and economic impacts;

    A systems-focused research program should weave together plant breeding, agronomy, ecosystem science, and human dimensions. By coupling biophysical and participatory

action research, Minnesota can develop resilient, diverse, and CLC cropping systems that mitigate nutrient runoff while meeting farmers' operational realities.

3. **Economic incentives and market-based solutions.** While research has shown that CLC crops have environmental benefits to farmers and the public, farmer adoption of these systems is slowed by the limited economic support. We urge the adoption of a cooperative strategy among farmers, researchers, crop educators, non-profits, agency-run cost-share programs, and supply chain partners to implement these changes. There is an opportunity to help farmers economically in their transition to these systems through ecosystem service incentives and supporting the development of alternative supply chains that can provide a stable market for nascent CLC crops. In addition, cost-share dollars would be more beneficial if these were tied to ecosystem outcomes rather than just practice implementation (e.g., the Olmsted County Soil Health Program, the Economic Clusters of Opportunity (EECO) Implementation Program). Research on experimental programs like these is critical to ensure that these models will be successful, as is farmer education and peer-to-peer learning through programs including UMN Extension, MN Soil Health Coalition farmer mentors, and Land Stewardship Project’s soil health hubs.

4. **Climate adaptation.** The Minnesota Climate Mapping and Analysis Tool (MN-CliMAT) is a powerful application that predicts future climate scenarios in Minnesota. In general, the state of Minnesota is expected to experience an additional 0.5 - 3.5” of annual precipitation, and daily average temperatures are expected to rise by 3 to 5°F by mid-century. With a changing climate, producers need to adapt their practices to be resilient to many stressors and uncertain weather patterns, while ensuring these adaptations do not incur greater nutrient losses to the environment. The majority of the expected increase in rainfall is projected to occur in the spring, when soils are most vulnerable to nutrient losses. “Classic” and “cash” cover cropping can help mitigate nutrient losses during this period. However, as discussed above, better education, risk mitigation, and crop genetics are needed to incorporate CLC crops into climate-resilient cropping systems.