LAND STEWARDSHIP PROJECT

Green Lands Blue Waters

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Farming with Well-Managed Grazing & Continuous Living Cover Enhances Soil Health & Addresses Climate Change

One of the best approaches for combating climate change lies beneath every Midwestern farm: the soil. By increasing soil organic carbon, farmers build soil health in ways that increase resilience, boost their bottom lines, and benefit their communities. Improving soil health is a bridge for row crop farmers to integrate greater continuous living cover into annual cropping systems. It also provides a way for livestock utilizing well-managed grazing systems to be integrated into cropping operations. An important side benefit is that improved soil health can help address climate change by lowering greenhouse gas emissions from farming while sequestering carbon.

Building Soil Health with Living Cover & Managed Rotational Grazing

Building healthy soil (Figure 1) requires the presence of a diversity of plants on the land and living roots in the soil via "continuous living cover" (CLC), along with reduced disturbance from tillage and pesticides. Examples of CLC systems, also called "regenerative agriculture," include cover crops planted during or between the regular corn, soybean, or wheat growing seasons; multi-year crop rotations that include small grains and a perennial legume; organic systems; prairie strips in row crops; trees integrated into pastures (silvopasture); agroforestry; rotationally-grazed pastures; and the integration of crops with livestock that are distributed out on the land in a grazing system.

Managed rotational grazing (MRG) of ruminant livestock significantly enhances soil health and is a highly effective system for managing perennial grasslands and utilizing cover crops. Managing the intensity, frequency, duration, stocking density, and timing of grazing events helps improve pastures, makes near-term use of cover crops as forage, and improves soil health. Also known as "management intensive rotational grazing," "regenerative grazing," or "adaptive multi-paddock grazing," MRG systems are more feasible with newer technology such as easily erected mobile fencing, watering systems, and shade structures. This differs from continuous grazing, a system under which cattle have access to an entire area for an extended amount of time, giving plants little chance to recover. MRG provides a variety of nesting, brood-rearing, and foraging habitats for wildlife, and increases carrying capacity on existing acreage.

Figure 1: The 5 Principles of Soil Health

Soil health is "the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans."[1]

1. **Soil Armor:** "Armoring" the soil with growing plants and plant residue doesn't just protect it from erosion, but reduces evaporation rates, moderates soil temperatures, reduces compaction, suppresses weeds, and provides a habitat for the soil food web's critters.
2. **Minimize Soil Disturbance:** Damaging soil disturbance can include: biological and chemical disturbance, such as from over-application of nutrients and pesticides; and physical disturbance, which includes plowing and other tillage.
3. **Plant Diversity:** Just as biodiversity creates other kinds of healthy ecosystems, a diversity of plants builds a functional food web. Cover crops, multiple-species covers, multiple species pastures, and longer rotations are examples.
4. **Continuous Living Plants and Roots:** Plants on top and roots underneath, 12-months-a-year, when possible, create a healthy soil ecosystem.
5. **Livestock Integration:** Animals, plants, and soils have long interacted in a synergistic way to build enough organic matter to make soil self-sustaining, especially in grassland environments. Such integration requires getting livestock out onto the land grazing in a way that the nutrients are spread evenly while plants are given balanced periods of disturbance and rest. Managed rotational grazing mimics natural systems.[2]

"Livestock are the rock stars of building soil health." **— Justin Morris, NRCS soil health expert**

This practice can be utilized by landowners in rental agreements and by farmers without livestock through contract grazing.

Continuous living cover and managed rotational grazing provide multiple benefits, including:

- Stimulates plants to release root exudates, which increases soil biological activity, contributing to improved soil health.
- Provides resilience to drought from increased water holding capacity and better regulated soil temperatures.
- Reduces erosion from heavy rains.
- Increases mycorrhizal fungi and the soil microbiome by increasing plant species, which dramatically expands the reach of roots to absorb minerals and water, increases resilience of crops to stress, increases soil carbon in aggregates, and transfers carbon to more stable forms in the pores between soil aggregates.
- Improves the value and aesthetic of farmland.
- Decreases costs of production over time, improves resilience, and can help small and medium-sized farms survive.[3]

Initiatives such as the USDA's Environmental Quality Incentives Program and the Conservation Stewardship Program help defray upfront expenses for adopting soil health practices. But limiting factors are the support and encouragement needed to plan and try out these new systems, followed by ongoing technical assistance to troubleshoot management challenges as they arise. If farmers and ranchers could be assisted in implementing these systems across significant parts of farm and range landscapes, there would be significant societal benefits.

In this photo, Mark Erickson moves beef cattle in late September on rented land in west-central Minnesota. Soil health is key to his operation, and he passes that message on to his landlords. "It's important to talk about what the future of the land is, and what the value of it is to children and grandchildren, and how you can make a system that will fit something other than just be all big farms," he says. "Is there a value to that, is there a value to returning the soil to the organic matter standards it used to be?" (*LSP Photo*)[4]

Agriculture, Greenhouse Gases & Carbon: The Possibilities from Adding Living Cover

Building soil health through CLC and MRG means that agriculture could reduce greenhouse emissions and be a carbon sink — one of the few sectors that can accomplish both.[5, 6, 7, 8] However, agriculture is currently a major contributor to emissions that impact the climate — accounting for 9% and 24% of U.S. and Minnesota greenhouse gas emissions, respectively.[9, 10]

A growing number of farmers are utilizing these practices, but overall, widespread adoption of CLC and MRG is lagging. Only about 3% of Minnesota cropland was planted to cover crops as continuous living cover in 2017; that figure was 6.7% for the U.S. as a whole.[11] The 2017 U.S. Ag Census estimated only 27% of U.S. farms and ranches with cattle and sheep use some form of rotational grazing on pasture and rangelands covering 528 million acres of private acres.[12]

The potential acreage that could benefit from soil health improvement is significant. At least 20% of corn and soybean fields in Minnesota and 26% in the Corn Belt as a whole, totaling 19 million acres overall, can be considered "marginal" because they consistently produce low yields of corn and soybeans. Together, with another 21 million acres that are "unstable low yielders," these fields annually lose $485 million from unused nitrogen and emit 7.5 million short tons of greenhouse gases from wasted fertilizer.[13] Erosion, water runoff, and lost nutrients also contribute to surface and groundwater pollution, including hypoxic zones.[14, 15, 16]

Shifts to CLC options make particular sense in areas dominated by marginal and low-yielding acres. Improvements in soil health are also possible when using cover crops on the remaining, best yielding, U.S. cropland.[17]

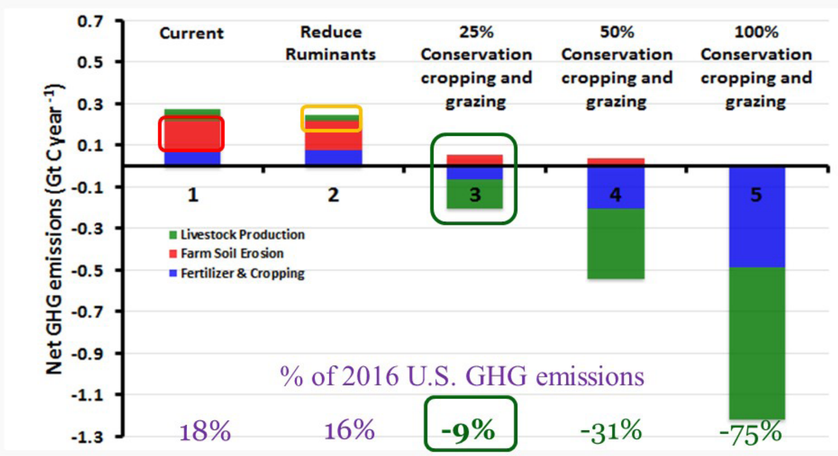
With the right public investments, there is room for significant improvement in a short period of time.

Adoption of CLC or MRG on 25% of U.S. Cropland & Pasture Could Reduce U.S. Emissions by 9%

A team of researchers from the USDA, Iowa State University, Texas A & M University, Ohio State University, and Michigan State University, among other institutions, collected years of peer-reviewed research and compared the relative contributions of greenhouse gas emissions from dominant and continuous living cover-based systems.[18] Estimates included emissions from the production systems used to grow grain for feed, and included losses from soil erosion. The loss of soil carbon through erosion is not considered in most calculations, but can be significant (Figure 2).

In this analysis, conservation cropping includes reduced tillage and CLC systems. "Conservation grazing" is equivalent to "managed rotational grazing" in this analysis. Based on previously conducted field studies, higher rates of carbon sequestration were assumed for this study than identified by other analyses.[7, 19]

Figure 2: Net Emissions from Regenerative Cropping with Continuous Living Cover, and Managed Rotational Grazing



(Adapted from Teague et al. 2016, citation 18; U.S. EPA data added, citation 9)

Notably, this analysis found that simply halving the number of ruminants netted very small reductions in emissions because soil erosion, fertilizer use, and cropping practices wouldn't necessarily change under that scenario.[18] A shift of 25% of the acres could both reduce emissions and sequester carbon in amounts equivalent to 9% of U.S. emissions as estimated by the U.S. Environmental Protection Agency.[7] Erosion reduction from reduced tillage, CLC, and MRG is a significant component of the reduced emissions.

The degree and longevity of carbon sequestration from agricultural soil management systems is getting more deserved focus.[5, 20] A growing number of scientists, including those with the International Panel on Climate Change (IPCC), calculate that CLC, along with reduced tillage and MRG, are likely to reduce emissions and sequester carbon.[5, 21, 22, 23]

Robust Shifts to CLC & MRG: Scenarios Show Potential to Help Meet Minnesota Climate Goals

In 2019, the Minnesota Pollution Control Agency (MPCA) published the rates by which agricultural best management practices could potentially reduce greenhouse gas emissions.[24] The MPCA identified rates for carbon sequestration and avoided greenhouse gas emissions from shifting corn-soybean crops to longer rotations and grasslands, as well as the benefits of including winter cover crops and practices such as no-till.

Managed rotational grazing was not included in the MPCA's estimates.

MPCA's rates assume carbon storage for up to 20 years. However, Ciborowski noted that one ton of carbon sequestration must remain in storage for 52 years to offset one ton of fossil fuel emissions (carbon dioxide equivalents or CO_2e). Unless longer-term storage in other systems or permanent grasslands was assumed, rates were therefore lowered by 60%.

An LSP analysis utilized the MPCA estimates and added a tier of higher sequestration rates derived from the literature. Higher rates for very well-managed CLC and MRG were adjusted for impermanence using the MPCA methodology (pastures were assumed to be permanent).[25] Minnesota agricultural emissions (not including forests) increased from 2005 to 2016; therefore, 2016 was used as the baseline.[10] Increased emissions resulted from fertilizers and use of liquid manure systems by large confined animal feeding operations, according to the MPCA.

LSP then formulated three scenarios based on shifts of corn-soybean and pasture acreages to include conservation practices, CLC and/or MRG. The first scenario assumed existing conservation practices on 2017 acreage, as reported by agencies. Landscape change scenarios included shifts to CLC on marginal corn and soybean fields, the addition of cover crops on acres well suited for annual crops, and a shift from continuous grazing to MRG.

The scenarios were:

- 2017 conservation practices from Minnesota agency estimates using MPCA greenhouse gas reduction and carbon sequestration rates.

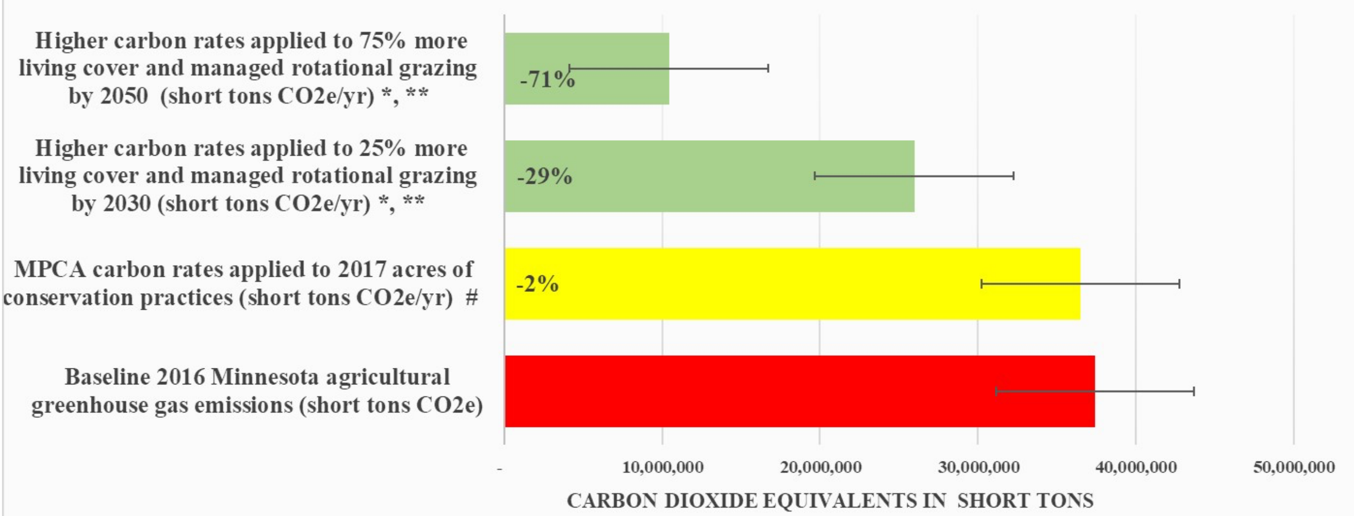
- More significant acreage change, assuming high levels of management of CLC and MRG and using the tier of higher sequestration rates for:
    - Shifts on 25% of marginal corn/soybean land to CLC, 25% cover crops on good land, and 25% more MRG on pastures.
    - Shifts on 75% of marginal corn/soybean land to CLC, 75% cover crops on good land, and 75% more MRG on pastures.

This analysis shows that bold action to assist farmers in adopting CLC and MRG with robust levels of management is needed. Also, the MPCA, select University of Minnesota faculty, and the USDA Natural Resources Conservation Service should gather with a team of expert farmers, researchers, and NGOs studying increased rates for carbon sequestration from CLC and MRG to formulate agreed-upon rates commensurate with high levels of management. This may be applicable in other states working with Green Lands Blue Waters (GLBW).

Water Quality and Other Benefits

Many co-benefits result from improving soil carbon and overall soil health on farmland. Integrating continuous living cover and managed rotational grazing on farms could help reduce agricultural nitrogen and phosphorus runoff, as well as cut soil erosion. It could also help meet

Figure 3: Current and Potential Minnesota Agricultural Greenhouse Gas Emission and Carbon Sequestration Scenarios for 2017, 2030 and 2050 Compared to a 2016 Baseline--citation 25



The three scenarios in Figure 3 are shown in relation to 2016 baseline emissions. The percentage change from baseline can be compared to goals of 30% reduction by 2025 and 80% by 2050 called for in Minnesota's Next Generation Energy Act. Although farmers are currently making management changes to improve soil health, we calculated that carbon sequestration from the current rate of adoption of conservation practices is insufficient to help meet state goals. However, if shifts on an additional 25% of these acreages to CLC and MRG could be achieved, agriculture could help meet proportionate reductions for its sector. Combined emissions reductions and sequestration would be the equivalent of removing 2.3 million cars from the road per year.

state and regional water quality goals.[25] By building soil's organic carbon, more water can be stored in soil, resulting in less runoff, cleaner water, and more resilient crop fields and pastures.

Policy Recommendations

Robust federal and state policy, along with market shifts, will be needed to advance widespread adoption of CLC and MRG. Farmers and ranchers must be supported by markets, lenders, and government policies to manage in ways that are finely tuned to the specifics of the land, water, weather, and ecology of each farm and its surrounding landscape. Small and medium-sized farmers need urgent aid to survive the farm crisis that is being compounded by the COVID-19 pandemic. Resources and suggestions for addressing the farm/COVID crisis can be found through the Land Stewardship Project, Practical Farmers of Iowa, state departments of agriculture, and land grant universities.

Longer term policy shifts to support more CLC and MRG adoption can best be understood and developed in a frame of "True Cost Accounting." This framework allows for the comparison of the full costs and benefits with and without added CLC and MRG in farming systems. Benefits include removing negative environmental externalities, regeneration of soils, health of landscapes and food supplies, rural community vitality, equitable economic markets for all farmers, equitable wages and working conditions for labor (especially people of color), and equitable chances of success for community-based food businesses. Research and frameworks are being developed through TEEB-AgriFood.[27] LSP's carbon farming white paper includes further discussion, along with details of recommended policy shifts.[25]

Recommendations for bold policy shifts include:

A. Expand funding for research initiatives related to CLC and MRG. This includes the Forever Green Initiative and the Iowa STRIPS project, as well as initiatives related to studying organic and/or pasture-based dairy, managed rotational grazing of ruminant livestock, cover crops, organic and long crop rotations, carbon sequestration rates of CLC and MRG across soils and moisture regimes, and platforms to advance soil health payment systems that are equitable for small and medium-sized farmers.

B. Make CLC and MRG critical components of state climate change efforts, the Green New Deal, and other federal climate change policy proposals.

C. Increase support for technical assistance, cost-share, and risk management programs at federal and state levels that emphasize building soil health through CLC and MRG systems. This must include expanded organizing to engage and educate farmers about the benefits and practical considerations of using CLC and MRG.

D. Support expansion of existing and creation of new value-chains for products raised in CLC and MRG systems, especially those that can be accessed by small and medium-sized farm operations. Limiting the expansion of large-scale concentrated animal feeding operations may help keep markets available for small- to-mid-sized livestock operations utilizing CLC and MRG.

E. Apply true cost accounting principles to designs for Payment for Ecosystem Services Programs at state, federal, and private levels to assist farmers shifting marginal row crop fields to perennial systems involving MRG, and/or are adding cover crops to annual row crop systems.

F. Reform federal Farm Bill programs to focus on soil health.

Conclusion

There will always be trade-offs when it comes to land management. Humans remove material from agricultural ecosystems for our food, energy, fiber, and industrial raw materials. Emissions are necessarily part of the life cycle of any human technology or biological activity. With clear-eyed and bold farmer, scientific, market, and policymaker leadership, the soil can reduce excess atmospheric carbon if we allow it to function as is possible. We can see the results on farms and ranches practicing regenerative agriculture in the form of the greatly improved water infiltration and production that results from greater carbon in the soil. Science is starting to describe and explain the shifts farmers are observing on the land. The interests of farmers/ranchers and the portion of the public that seeks climate mitigation coincide. That is because healthy soil helps build agricultural resiliency in the face of climate change, makes our land a carbon sink, reduces costs of production in the long run, and broadens options for healthy food choices that support local economies.

Credit:
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