



## Key Continuous Living Cover Cropping Strategies

An extensive toolbox of CLC crops and cropping systems is available to use in a wide range of situations. One way to organize that toolbox is in terms of five key CLC strategies promoted by Green Lands Blue Waters.<sup>1</sup>

### Agroforestry



Agroforestry is a land management approach that integrates trees and shrubs with plant and animal farm operations. A commonly-used definition identifies five types of agroforestry: silvopasture, alley cropping, forest farming or multi-story cropping, windbreaks, and riparian forest buffers. The common theme of all these practices is that they involve positioning a strategically sized and placed subset of the agricultural system into tree cover. This can bring disproportionate benefits back in the form of conservation impacts and increased productivity of other crops in the system. When an agroforestry cropping system involves harvested tree crops, such as fruit and nut trees, it can provide supplemental economic returns, or can become the central economic activity in the field. Well-managed agroforestry systems bring a high level of conservation benefits in general, but notably in climate change mitigation. Out of all perennial crop options, tree crops have a uniquely high potential to store carbon in standing biomass – tree trunks, branches, and roots in the soil. This provides easily assured carbon sequestration, sidestepping the complexities involved in managing and measuring soil carbon.

### Perennial Biomass



Perennial biomass crops are grown and used for renewable energy. They can be grown as cover crops, perennial grasses, and short-rotation trees. Many of these plants can be used as forage for livestock. While not widely produced for energy needs now, perennial biomass crops offer future opportunities for a renewable energy source with ecological benefits. The conservation benefits provided by herbaceous perennial biomass crops are similar to those provided by perennial forages, discussed below. Woody biomass crop benefits are likewise similar to those provided by other tree crops. Woody plants, however, require managing the harvest with great care to avoid introducing a window of high vulnerability to soil erosion and other problems.

## Perennial Forage



Perennial forage refers to land planted with perennial plants that feed livestock, including grasses, legumes like alfalfa and clover, and other herbaceous species. Carefully managed grazing or hay production can benefit the environment by improving soil health, reducing runoff and soil erosion, creating wildlife habitat, sequestering carbon, and conserving resources. One standout characteristic of well-managed perennial forage crops is the ability to produce extensive root systems that provide highly assured benefits for soil health and water quality, and potential for substantial soil carbon sequestration. Well-managed rotational grazing of ruminants can benefit farmers by improving the quality and production from these systems.

## Perennial Grains



Unlike annual grains, perennial grains are crops that are alive year-round and are productive for more than a year. They can have deeper root systems and longer growing seasons and therefore absorb and hold more rainwater and better capture nutrients – leading to less erosion and runoff of soil and nutrients into water supplies. Compared to annual crops, perennial grains may maintain and capture more carbon in soil, require smaller amounts of fertilizer and herbicide, and reduce or eliminate the need for tillage. Perennial grain crop options are just beginning to emerge, with early-stage varieties of intermediate wheatgrass Kernza® (*Thinopyrum intermedium*) perennial grain in limited production in the Midwest and other parts of the U.S. More than half a dozen other perennial grain crops are under development around the world,<sup>2</sup> with researchers aiming to combine conservation benefits – traditionally only obtainable from perennial forages and tree crops together – with a level of productivity and food quality historically only available from annual grains. Perennial grains may be grown in a dual-purpose grain and forage system, providing management benefits and multiple revenue streams.

## Cover Crops, Winter Annual Crops, and Rotations



A variety of options exist for adding CLC to existing annual crop rotations when converting a field to permanent perennial cover is not possible. Cover crops are legumes, grasses, or other plants grown to maintain and improve a farm's natural resource base, as well as the broader surrounding ecosystem. While the cover crop role is most often filled by annual species, increasing attention is being placed on developing options for perennial cover crops, also known as mulch crops: short-stature perennials that annual grain crops can be interplanted into each year. There are also promising harvestable winter-annual oilseed crops currently in development that can be grown in a double or relay cropping system. For example, field pennycress (*Thlaspi arvense*) and winter camelina (*Camelina sativa*) can provide the conservation benefits of traditional annual cover crops, but can also be harvested and sold as another crop in a farm's portfolio. Finally, perennial forages or perennial grains can be placed into rotation with annual grain crops, providing two or more years of perennial cover in the system. Well-managed rotational grazing of ruminants may prove to be helpful in managing these systems and provide another revenue stream.

## On-Farm Integration and Stacking of CLC Practices

On the farm, these strategies rarely operate in isolation. An integrated, whole-farm system is the goal. All of these strategies offer paths to get there and any individual farm often “stacks” several of these practices, arranging them in a mosaic structure or rotating them sequentially on the same piece of land to capture maximum benefits. These integration efforts are a key stimulus for innovation on the part of farmers and scientists. Definitions periodically need to expand to encompass these innovations. Prairie strips in the middle of fields, herbaceous perennial buffer practices at the edge of fields, and perennial cover crops are all examples of integration and stacking.

## Outcomes from CLC agriculture

### Outcomes for soil

The starting point for resilient, healthy soils is addressing soil erosion – by first slowing and ultimately reversing it. Soil erosion reduction efforts in the U.S. have largely stagnated since 1997,<sup>3</sup> and most agricultural systems are still losing soil significantly faster than new soil is being formed.<sup>4</sup> Continuous living cover systems can deliver superior erosion reduction outcomes,<sup>5</sup> because they not only provide superior aboveground vegetative cover relative to conventional annual systems that leave crop residue on the soil surface, but also provide a greater abundance of living roots belowground. Benefits are enhanced when combined with reduced tillage such as strip-till or no-till. This is particularly relevant for fighting two erosion pathways of greatest concern for the Midwest: rill and ephemeral gully erosion.<sup>6</sup> Fields converted to perennial grassland or tree cover are at least 10 times more likely to experience soil formation that exceeds the rate of soil erosion,<sup>5</sup> the true benchmark for long-term



*Healthy Soil - Credit: Anne Queenan*



*Gully erosion - Credit: Anne Queenan*

sustainability. CLC systems also deliver outstanding outcomes for soil health and soil quality, including traditional indicators like porosity, aggregate stability, and nutrient availability, as well as fostering a favorable environment for beneficial soil microorganisms and soil organic carbon content.<sup>7-9</sup> Recent research has underscored that the core idea behind CLC – diversity that works – is beneficial with respect to soil quality, finding that adding perennials and cover crops to annual crop rotations provides greater soil carbon benefits than adding the same amount of diversity in the form of additional summer annuals.<sup>10,11</sup>



## Outcomes for water

Continuous living cover systems are arguably the paramount water quality intervention available in agriculture. Adding perennials or winter annuals to a cropping system can increase crop uptake of soluble nutrients like nitrogen, resulting in decreased leaching and contamination of groundwater.<sup>12-16</sup> Through decreasing the rate of surface runoff and soil erosion,<sup>5</sup> CLC systems also reduce sediment loading of surface waters, with associated soil-bound nutrients.<sup>17-19</sup> Meanwhile, increased infiltration and soil water storage result in better ability of agricultural land to buffer flooding events,<sup>20,21</sup> which provides improved outcomes not only for rural and agricultural stakeholders, but for urban residents and everyone who has a stake in reducing flood damage to public infrastructure.



*Salem Creek, MN, filled with sediment - Credit: Erin Meier*



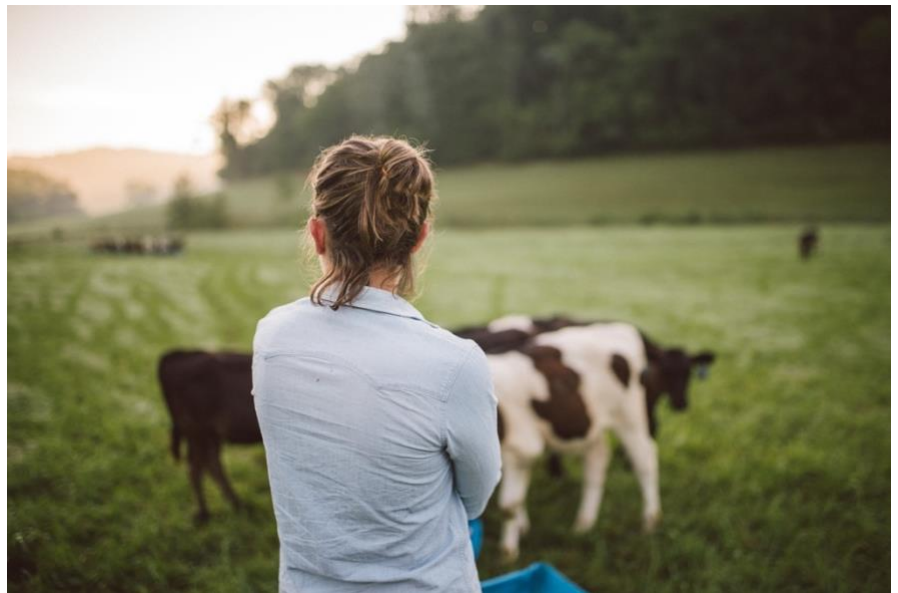
*St. Croix River, MN/WI - Credit: Anne Queenan*





*Kernza Field , MN - Credit: Brad Gordon*

variability in exactly how much carbon can be stored in perennial grassland systems or how long that carbon may last, especially if perennial management changes.<sup>27-30</sup> Well-managed rotational grazing of perennial grasslands, for example, has been shown in some situations to be carbon neutral or negative.<sup>31-33</sup> Annual CLC practices provide much smaller carbon benefits.<sup>34,35</sup> Although the greatest attention has been focused on understanding carbon emissions and drawdown, CLC agriculture also might be a large leverage point in the form of reducing emissions of trace gases with high global warming potential, particularly nitrous oxide (N<sub>2</sub>O). While the research in this area is very new, any cropping system, especially those such as perennial grasslands that are very effective at taking up nitrogen fertilizer and preventing excess leaching into soil or waterways, could result in lower N<sub>2</sub>O emissions.<sup>33,36</sup> CLC crops and practices offer a variety of opportunities for increasing nitrogen uptake and for biological nitrogen fixation in the field.<sup>36-39</sup> Additionally, CLC crops, especially perennials, often perform better in extreme weather events and can help farmers and communities adapt to climate variability.



*Perennial Grazing on Cates Family Farm, WI - Credit: Susie Theis*

Where agriculture can contribute any carbon drawdown to the climate change mitigation effort, CLC crops maximize that potential. Agroforestry practices have the largest potential to sequester stable quantities of carbon aboveground in tree trunks and branches, with longevity of that stored carbon depending on management details<sup>22</sup>. Long-term perennial grassland cover can also sequester large amounts of carbon in the soil over time<sup>23-25</sup> and appropriately selected and managed perennial crops provide very extensive root biomass inputs.<sup>26</sup> While perennial grassland is one of the most promising avenues for carbon sequestration, there is unfortunately a high degree of



## Outcomes for communities and total system resilience

Ultimately, an agriculture based on continuous living cover can deliver increased resilience system-wide: healthier ecosystems, less dependence on external inputs, less vulnerability to weather extremes, greater crop and landscape diversity, a broader spectrum of economic opportunities and - when implemented with equity top of mind by and for a diverse range of people - a more tightly woven social fabric and strengthened communities.<sup>40,41</sup> Every human being on the planet depends on the health of our shared ecosystems. While promoting positive ecological and biophysical benefits does not in any way automatically ensure positive social benefits, the connection between human health and environmental health is undeniable. The central idea of this paper is that CLC, implemented equitably with people and communities at the center, can bring about both environmental and social changes sorely needed in agriculture. Imagine for a moment all the ways that agriculture can be a connection point between vibrant communities and thriving environments; envision agriculture as a solution.

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**Read our new paper on a human-centered, equity-focused approach to continuous living cover!**

### **Our Journey to a Transformed Agriculture through Continuous Living Cover**

Why continuous living cover crops and cropping systems, and a human-centered, equity-focused approach to their implementation, are imperative and exciting, and how this can look on the agricultural landscape

**Green Lands Blue Waters**  
A Paper by Green Lands Blue Waters and its Network  
[www.greenlandsbluwaters.org](http://www.greenlandsbluwaters.org)

This information comes from a 2021 paper written by GLBW and network partners. The full paper can be found here: <https://greenlandsbluwaters.org/human-centered-approach/#read-here-our-journey-to-a-transformed-agriculture-through-continuous-living-cover>

