ECOTONE ANALYTICS

Impact Analysis
and **Social Return on Investment**

A supplement to the Perennial Forage and Grazing Impact Analysis

CLC and GLBW Investor Communication Package

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Ecotone Analytics Communication Package

A Supplement to the Perennial Forage and Grazing Impact Analysis

ECOTONE
ANALYTICS

About this Report

Ecotone Analytics conducted this impact analysis for Green Lands Blue Waters (GLBW). This report considers the strategies to foster Continuous Living Cover (CLC) through a networked-approach. It serves as a supplement to the social return on investment (SROI) estimation on perennial forage and grazing, outlined in a separate technical document.

About Ecotone Analytics

Ecotone Analytics is an impact accounting organization that does benefit-cost analysis for clients' social and environmental impacts. Combining evidence-based research analysis and monetization of impact outcomes, Ecotone derives a social return on investment ratio and identifies the key stakeholder groups to whom those impact benefits accrue. Results are communicated using a proprietary visualization of the flows of value that result from the initial investment.

INTRODUCTION

Green Lands Blue Waters fills a unique role in the continuous living cover landscape. It is tasked with supporting, balancing and aligning agendas of network partners and broader market players to advance the adoption of CLC. This can come in many forms from supporting experimentation and articulation of needs in pre-development, to the aggregation of knowledge, pooling resources, network building and stronger institutional support and capacity building in acceleration of ideas.

Facilitating this networked-approach would benefit from a roadmap to support communication of activities, fundraising, and continued thinking around projects to support, market needs, opportunities, and partners needed. This document serves to support the outlining of the roadmap.

MARKET NEED

The costs associated with conventional agriculture practices in the Upper Midwest are large and are accrued through many channels. The accompanying analysis to this document projected annual costs mitigated by transitioning to perennial forage and grazing from annual row crops under conventional practices to be approximately $338. That is the projected cost per acre per year that would otherwise be externalized and transferred to the public. This figure can compound rapidly as hundreds of thousands of high priority acres utilize inefficient and damaging practices. Boehm (2020) finds that on average the equivalent of 3,100 standard-sized shipping containers per year of excess nitrogen has washed off Midwest cropland into the Mississippi and Atchafalaya rivers, and ultimately into the Gulf of Mexico. This nitrogen has contributed up to **$2.4 billion in damages to ecosystem services generated by fisheries and marine habitat every year since 1980.** Most of the nitrogen that contributes to the dead zone — between 60 and 80 percent — originates on farms and livestock operations in the Midwest, largely in the form of synthetic fertilizers that run off fields of corn and other crops (Boehm, 2020). Similarly climate change may result in more variation in weather conditions, larger extremes in drought severity, flood severity, temperature extremes, etc. (IPCC, 2014) which would all increase the value of CLC.

Further Crews et al., (2018) describe an ‘agricultural treadmill’ that forces technological change, increasing efficiency, reduced food prices and effectively reduced farmer incomes. The efficiency and change requires specialization that promotes reduced diversity and increased farm sizes. This process implies that early non-risk averse adopters are the ones who benefit most from new technologies while the majority are forced to adopt if they want to stay in business although face smaller and smaller margins (Crews et al., 2018).

On the livestock side too we see the implications of confinement livestock, with Raff and Meyer (2020) estimation that concentrated animal feeding operations account for water quality losses of $35-$51 per household per year in Wisconsin - a total value of $82 - $119 million per year.

These are a taste of the types of impacts conventional agricultural practices have on our health, economy and environment.

INVESTMENT OPPORTUNITY

The need for CLC adoption and the mission and purpose of GLBW make it a potentially highly valuable vessel for raising and funneling funding and investment for network partner projects.

With the range of new crops and products that exist within the spectrum of CLC, there is going to be a need for research and investigation of market potential. This effort can be costly however and the incentive to do this in an uncoordinated market would likely be very low. The coordination and management of the value chain however can build buy-in for each stakeholder in the chain to recognize new market opportunities. This value chain may include not only growers, processors, distributors, etc. but also ecosystem service markets, local communities providing social capital, government entities providing cost-share or technical supports, among other stakeholders. The coordination of these players allows for a deeper analysis of potential to develop a product that will create mutually beneficial outcomes, driving new market equilibriums that would otherwise be unseen and potentially lead to scaling of the product. Recognition of this coordination and the long-term mindset of that coordination can serve as a signal to funders that there is opportunity to invest and not only protect their investment but sustainably grow it.

The funder adds weight to the network and allows it to better manage and alleviate the otherwise large risk of implementing a CLC strategy. Funding can encourage more players to partner and particularly those players who have other resources to contribute and leverage.

The opportunity for investment is great and comes in many forms - more forms than an investor may otherwise be familiar with. This variety has been an obstacle for fundraising for sustainable agriculture initiatives, but should not be when the initiatives are organized appropriately and have a central body such as GLBW that can coordinate and receive funding.

For example, investment needed to support policy change is huge but could have large payoffs. Peterson et al. (2011) note the benefits of freeing farmers from the restrictions of the Farm Bill and allowing them to plant more appropriate crops without giving up subsidies and insurance protections. For example, the authors estimate the outcomes of this change to lead to:

- 50 percent reduction in the nitrogen loading from the watersheds within 25 years;
- more diverse crop choices;
- landscape with more than 15 percent perennial crops;
- the creation of region-specific solutions that result in new opportunities for the emerging bio-economy;
- in total and in parts, models of sustainable ecosystem management that incorporate democratic participation at the community level and a legacy of guidance for future generations.

Direct investment into farms may also be appropriate and tailored to address a key set of barriers restricting adoption of CLC practices. These barriers include:

- Debt load: Farmers may feel their only way out of debt is continued yield growth and high revenue products, even if the costs are high as well.
- Land availability and access: Quality agricultural land is expensive. Having access to it can preclude new and underrepresented farmers from having the opportunity to bring new practices to light.
- Upfront investment of CLC: For many CLC strategies, the cost to transition to them is high. Without appropriate risk mitigation and funding support, the uncertain prospects of a CLC strategy may make the investment hurdle appear very high.

Financial vehicles to invest in farmland, in farm products, in training services, in political lobbying, etc. are all viable channels for driving CLC.

CLC TYPES

There are 5 primary CLC strategies.

AGROFORESTRY	Agroforestry is a land management approach that integrates trees and shrubs with plant and animal farm operations*. . .There are five types of agroforestry: 1. Silvopasture is when trees, livestock, and forages are grown together. 2. Alley cropping is when agricultural and horticultural crops are grown between rows of woody plants, like when corn is planted between pecan trees. 3. Forest farming or multi-story cropping combines forestry with small-scale farming or gardening of high-value crops like ginseng and mushrooms. 4. Windbreaks are used to protect soil and improve crop yields as well as control snow drifts and improve wildlife habitat. 5. Riparian forest buffers use trees and other plants to protect waterways from the negative impacts of agricultural fields.
PERENNIAL BIOMASS	Perennial biomass crops are perennial plants that are grown and used for renewable energy. They can be grown as cover crops, perennial grasses, and short-rotation trees. Many of these crops can also be used as forage for livestock. While not widely produced for energy needs now, perennial biomass crops offer a renewable energy source with ecological benefits. Compared to grain ethanol crops, growing perennial biomass plants may benefit the environment rather than harm it by storing carbon in soil, and requiring less fuel, fertilizer, pesticides, and water*. . . Beyond uses for fuel/renewable energy, the application of perennial biomass crops is also being explored in the emerging field of “plant-based chemistry” (also known as “green chemistry”). Switchgrass (Panicum virgatum), a highly productive hay and forage crop native to the Midwest, is an example of a perennial biomass species.
PERENNIAL FORAGE	Perennial forage refers to land planted with perennial plants that feed livestock like alfalfa, white clover, and red clover* . . . Carefully managed grazing can benefit the environment by improving soil, reducing runoff and soil erosion, creating wildlife habitat, sequestering carbon, and conserving resources. However, studying the environmental benefits is challenging and additional research is needed to fully understand its impact on carbon sequestration and conservation.
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 runoff and erosion. Compared to annual crops, perennial grains maintain and capture more carbon in soil, require smaller amounts of fertilizer and herbicide, and need less tillage. Because they don’t need to be tilled each year, perennial grains could build soil and store carbon rather than deplete and release it as annual crops do.
WINTER ANNUALS AND ROTATIONS WITH COVER CROPS	Cover crops are legumes, grasses, and other forbs planted within the regular growing season or outside it to improve or maintain the ecosystem (United States Department of Agriculture).

*Text taken from Green Lands Waters website. Ellipses indicate omitted text.

GRADIENTS

Networked approach to CLC is not bound by the specifics but leverages what's needed and when to drive change, aligning with market and political trends to help further its mission. This can encompass the range of approaches in place to further CLC. Those approaches reviewed are noted below:							
Market Approach	Technological Approach	Entrepreneurial Approach	Political Approach	Legal Approach	Scientific Approach	Civic / grassroots Approach	Practical Approach

The various CLC strategies exist along gradients in terms of ease of adoption, marketability, ecosystem service provision, policy support, and financial opportunity. We map them along these gradients to help communicate the strengths and weaknesses of each CLC strategy *(see Table 1 on next page)*.

EQUITY

Rebuilding the agricultural system to reflect the natural processes of prairies and continuous cover must also be done in a socially responsible way, supporting equity in land ownership and access. **Black, Indigenous and people of color (BIPOC) represent nearly one-quarter of the U.S. population, yet they operate less than 5% of the nation's farms and cultivate less than 1% of its farmland** (Monast, 2020). The historic expulsion, subjugation and marginalization of BIPOC has turned the existing agricultural system into an inequitable system.

Expanding access to agricultural capital, land, and technical information can all help increase equity in agriculture. **GLBW's role as a network node positions it to foster social capital with underrepresented organizations and individuals, building bridging ties to support opportunities for BIPOC farmers**.

Table 1. Ease of adoption by CLC strategy

	Ease of adoption for farmer - these are the economic and political levers transposed to the perspective of the farmer for each CLC strategy				
Gradient of CLC Practices	**Market-based Argument**	**Adaptability of on-farm practices**	**Financial Argument**	**Ecosystem Service Argument**	**Policy Support**
Cover Crops (with or without livestock integration) - perhaps on the fringe of CLC but noted for comparison	High marketability	Does not disrupt existing annuals production and may boost annuals	Can reduce input costs, increase yields of cash crops in some cases, serve as a source of revenue with forage income	Reduced nutrient runoff/leached, reduced soil erosion, improved water infiltration	Financially supported by Feds - EQIP
Winter Annuals	Market options are growing but still smaller for winter annuals.	Does not disrupt existing annuals production and may boost annuals	Second cash crop option within a single year	Winter annuals don't provide the same level of service as perennials but are better than no cover	Lack of policies - winter annuals won't qualify for cover crop support from the government since they can be harvested.
Perennial Forage and Grazing	Utilizing existing dairy and beef markets - potentially selling forage/ land access as well; Need new types of contracts	Networks and mentoring support adaptation of existing practices	Net income argument generally supported	Big outcome is reducing soil and water erosion on land.	Policy supports could be better aligned to support perennial grazing through EQIP or GRP programs
Agroforestry	Fruit and nut trees are a direct source of revenue in existing markets. Lease arrangements are a weak point.	The supply chain, harvesting, processing of agroforestry crops (e.g. elderberries) requires a whole new set of equipment, very limited processing capacity (similarly with hazelnuts). The whole value chain is not really well established.	When structured to integrate with existing practices, there is opportunity for financial returns. The obstacle is time and investment needed to grow the trees if they are not already there.	Silvopasture is a major tool to address climate impacts. Other agroforestry strategies can provide additional erosion and water control benefits as well.	Very adaptable, diversified and flexible (complex multi-tier) making it harder for policymakers to create a simple, prescriptive, easy to understand, policy.
Perennial Biomass	Low Marketability	May require removing annuals/ new set of farming practices	Limited financial argument to be made but would benefit from ecosystem service payments	High Ecosystem services	Lack of policy support
Perennial Grains	Low Marketability	May require removing annuals/ new set of farming practices	Financial argument enhanced with ecosystem service payment	High Ecosystem services	Lack of policy support

LOGIC MODELS
FOR CLC AND GLBW/NETWORK

The following tables show the logic model, identifying the planned inputs, activities, and outputs for the CLC vision and GLBW's networked approach as a whole, and from there, describing the outcomes accruing from all those activities conducted. These outcomes can be distinguished by whether they were short-term outcomes, intermediate outcomes or long-term outcomes (those achieved indirectly from the short-term and intermediate outcomes achieved). Last are the impacts directly attributed to CLC and GLBW.

The first logic model (beginning below) outlines the value proposition of continuous living cover strategies as a whole.

INPUTS → ACTIVITIES → OUTPUTS → IMPACT

Farmers, Network Partners, GLBW

INPUTS	ACTIVITIES	OUTPUTS

Farmer		• Number of acres of:
		  ◦ Agroforestry
		  ◦ Perennial Biomass
		  ◦ Perennial Forage
		  ◦ Perennial Grains
		  ◦ Cover Crops/ Winter Annuals/ Rotations
		• Number of acres of each in high priority areas
		• Acres of annuals replaced/ incorporating continuous cover
		• Acres of increased crop diversity
		• Number of crop types
		• Number of crop types with market

• New farm investments and equipment • Learning costs, adaptability, risk compensation, support network	• Application of CLC and best practices to farm context	
Managing Leverage Points		
• Financial Capital - funding/revenue • Human Capital - managers, marketers, fundraisers, researchers, etc. • Social Capital - partners, trust, etc. • Produced Capital - facilities, offices, laboratories, test fields, internet, technology	• Learning and teaching about CLC practices • Supporting implementation of CLC practices (e.g. financial, TA, peer connections, policy, etc.) • Engagement with other market stakeholders (agribusiness, etc.) and indirect stakeholders (consumers, etc.)	

INPUTS → ACTIVITIES → OUTPUTS → **IMPACT**

CONTINUOUS LIVING COVER

In comparison to no additional CLC practices being implemented

SHORT-TERM	INTERMEDIATE	LONG-TERM	IMPACT
• Increased income diversity • Increased crop diversity • Increased continuous cover • Increased livestock integration with cropping systems • Increased root structure • Reduced soil disturbance • Increased tree and agroforestry cover • Increased soil health • Increased soil porosity • Increased soil texture (particularly for sandier soils) • Reduced energy consumption • Potentially increased labor • Increased biomass	• Potentially increased net income • Reduced soil erosion from water and wind • Increased water infiltration, retention and flood resiliency • Improved soil temperature moderation • Reduced nutrient runoff • Reduced input application (pesticide, herbicide, fertilizer, etc.) • Increased carbon sequestration • Potentially interrupted disease, pest, and weed cycles • Increased productivity/ variable effects on yields • Increased nutrition of food • Reduced risk of insurance claims • Increased aesthetic value and recreational opportunities • Increased wildlife and pollinator habitat • Reduced ecotoxicity	• Improved air quality from reduced particulate matter • Increased and/or more stable crop yields across weather conditions • Improved water quality • Improved drinking water quality, reduced water treatment, and improved community health • Increased wildlife and biodiversity • Reduced global climate risks • Reduced risk and insurance payments • Increased area recreation • Increased water conservation, efficiency, water supply stability and flood cost reduction • Increased property values • Increased long-term productivity (including on marginal lands) • Reduced eutrophication, hypoxia and sedimentation	• Improved water quality and quantity • Improved soil health • Improved climate adaptation and climate change mitigation • Improved rural economic/social vitality • Supported ecosystem health • Enhanced justice, equity, and inclusion in food and agricultural systems • Healthier people • Increased biodiversity • Landscape resiliency • Improved air quality

CONTINUOUS LIVING COVER COMPLETE LOGIC MODEL (AN AGGREGATION OF THE PREVIOUS TWO PAGES)

<table>
<tr><th rowspan="2">INPUTS</th><th rowspan="2">ACTIVITIES</th><th rowspan="2">OUTPUTS</th><th colspan="4">In comparison to no additional continuous living cover practices being implemented</th></tr>
<tr><th>SHORT-TERM</th><th>INTERMEDIATE</th><th>LONG-TERM</th><th>IMPACT</th></tr>
<tr><td colspan="2">Farmer</td>
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<tr><td>• Financial Capital - funding/revenue
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• Social Capital - partners, trust, etc.
• Produced Capital - facilities, offices, laboratories, test fields, internet, technology</td><td>• Learning and teaching about CLC practices
• Supporting implementation of CLC practices (e.g. financial, TA, peer connections, policy, etc.)
• Engagement with other market stakeholders (agribusiness, etc.) and indirect stakeholders (consumers, etc.)</td></tr>
</table>

The second logic model (see below) is focused on the work of Green Lands Blue Waters, outlining the types of outcomes that may accrue as a result of their activities. These outcomes are by their nature developed to support the realization of the outcomes included in the CLC logic model. This concept is referred to as a nested logic model such that the logic of one initiative (e.g. GLBW) is designed to support the logic of another (e.g. CLC).

GLBW seeks to support transformative change - this can be mapped along three dimensions as outlined by Kivimaa et al., 2019:

> *“Transformative change in socio-technical systems occur through interplay between three levels, including micro-level spaces in which radical innovations emerge (so called ‘niches’), relatively stable and shared technologies, practices and institutions (‘regimes’), and slow-moving developments in the exogenous environment (‘landscape’).”*

INPUTS → ACTIVITIES → OUTPUTS → IMPACT

INPUTS

- Financial Capital - funding/revenue
- Human Capital - managers, marketers, fundraisers, researchers, etc.
- Social Capital - network partners and their involvement, trust, etc. with three sub-types: bonding, bridging, and linking capital
- Produced Capital - facilities, offices, laboratories, test fields, internet, technology, etc.

ACTIVITIES

- Conducting essential research and building proof of concept
- Improving the genetics of old and new crops
- Translating knowledge into Continuous Living Cover farming systems
- Developing and coordinating new extension and outreach capacity
- Distributing political, social, and financial risk
- Shaping policy and connecting levels of government
- Building profitable markets for new crops
- Changing the narrative around what’s possible through agriculture
- Researching and advocating financial mechanisms
- Building new collaborations
- Facilitating multi-stakeholder engagements (round tables, food policy councils, etc.) to manage conflict, build consensus and trust
- Sharing information and best practices with regular communication
- Pooling and mobilizing resources
- Identifying network needs

OUTPUTS

- Events and meetings held
- Conversations started, introductions made
- Conversations facilitated
- Resources shared
- Research authored, published
- Number of trainings supported
- Number of policies supported, drafted, presented
- Number of public education/outreach events, brochures, social media postings, etc.
- Number of newsletters sent
- Number of network partners
- Number of people in the network and/or affiliated with the network

INPUTS → ACTIVITIES → OUTPUTS → **IMPACT**

NETWORKED APPROACH TO CLC

In comparison to no GLBW and its networked approach

SHORT-TERM	INTERMEDIATE	LONG-TERM	IMPACT
• Improved awareness, access, knowledge, etc. of CLC • Increased rate of information exchange • Increased knowledge of agroecology, problem-solving skills, group building and political strength • Increased multi-stakeholder knowledge production • Increased connection to resources • Improved ecological literacy • Increased use of CLC related resources	• Improved attitudes, behaviors, skills, etc. associated with CLC • Increased interest and discussion around CLC - particularly with new sets of stakeholders • Reduced resistance to changing practices • Increased structural revisions to support CLC • Increased rate of ‘redesigning’ the system • Increased exploration of CLC potentials • Increased mainstream understanding of CLC practices • Increased shift in economic structure and incentives	• Increased accelerated adoption and use of CLC (which can simultaneously lead to cycling back through the outcomes as other people become more aware, learn more, change attitudes, etc.) • Increased system productivity • Increased acreage under CLC practices • Increased maintenance of CLC practices/ reduced drop-off • Increased change in understanding of what the ‘dominant’ agricultural practices entail • Increased shift in governance structures and corporate decisions	• Transformative, landscape scale change **CLC Impacts** • Improved water quality and quantity • Improved soil health • Improved climate adaptation and climate change mitigation • Improved rural economic/social vitality • Supported ecosystem health • Enhanced justice, equity, and inclusion in food and agricultural systems • Healthier people • Increased biodiversity • Landscape resiliency • Improved air quality

NETWORKED APPROACH TO CLC COMPLETE LOGIC MODEL (AN AGGREGATION OF THE PREVIOUS TWO PAGES)

INPUTS	ACTIVITIES	OUTPUTS	*In comparison to no GLBW and its networked approach*			
			SHORT-TERM	**INTERMEDIATE**	**LONG-TERM**	**IMPACT**
• Financial Capital - funding/revenue • Human Capital - managers, marketers, fundraisers, researchers, etc. • Social Capital - network partners and their involvement, trust, etc. with three sub-types: bonding, bridging, and linking capital* • Produced Capital - facilities, offices, laboratories, test fields, internet, technology, etc.	• Conducting essential research and building proof of concept • Improving the genetics of old and new crops • Translating knowledge into Continuous Living Cover farming systems • Developing and coordinating new extension and outreach capacity • Distribute political, social, and financial risk • Shaping policy and connect levels of government • Building profitable markets for new crops • Changing the narrative around what's possible through agriculture • Researching and advocating financial mechanisms • Building new collaborations • Facilitating multi-stakeholder engagements (round tables, food policy councils, etc.) to manage conflict, build consensus and trust • Share information and best practices with regular communication • Pool and mobilize resources • Identifying network needs	• Events and meetings held • Conversations started, introductions made • Conversations facilitated • Resources shared • Research authored, published • Number of trainings supported • Number of policies supported, drafted, presented • Number of public education/ outreach events, brochures, social media postings, etc. • Number of newsletters sent • Number of network partners • Number of people in the network and/ or affiliated with the network	• Improved awareness, access, knowledge, etc. of CLC • Increased rate of information exchange • Increased knowledge of agroecology, problem-solving skills, group building and political strength • Increased multi-stakeholder knowledge production • Increased connection to resources • Improved ecological literacy • Increased use of CLC related resources	• Improved attitudes, behaviors, skills, etc. associated with CLC • Increased interest and discussion around CLC - particularly with new sets of stakeholders • Reduced resistance to changing practices • Increased structural revisions to support CLC • Increased rate of 'redesigning' the system • Increased exploration of CLC potentials • Increased mainstream understanding of CLC practices • Increased shift in economic structure and incentives	• Increased accelerated adoption and use of CLC (which can simultaneously lead to cycling back through the outcomes as other people become more aware, learn more, change attitudes, etc.) • Increased system productivity • Increased acreage under CLC practices • Increased maintenance of CLC practices/ reduced drop-off • Increased change in understanding of what the 'dominant' agricultural practices entail • Increased shift in governance structures and corporate decisions	• Transformative, landscape scale change **CLC Impacts** • Improved water quality and quantity • Improved soil health • Improved climate adaptation and climate change mitigation • Improved rural economic/ social vitality • Supported ecosystem health • Enhanced justice, equity, and inclusion in food and agricultural systems • Healthier people • Increased biodiversity • Landscape resiliency • Improved air quality

LEVERAGE POINTS

Systems have leverage points that can be pushed on to generate a shift in the system. CLC and the agricultural food system has many leverage points all of which influence the ability to create viable market opportunities for farmers to adopt CLC strategies. All established crops have a social-ecological-technical system in place with interlocking and mutually supportive pillars. The pillars are structured to support the ongoing production of the crop. New crops however don't have these pillars - the pillars have to be established at a cost and a risk. The pillars are difficult to create in isolation as well. New crops cannot be adopted without markets, the creation of markets for the crops needs a supply chain, and the development of the supply chain is dependent on finance, policy, etc. All these features are interconnected. The network player, however, is unique in its position above all these components. This role allows the network to develop those essential pillars of support that are most needed for the given market opportunity. This then is the key value of networks - de-risking investments in an otherwise highly risky market situation. The role of networks is developing those pillars of support to de-risk the investments.

LEVERAGE POINTS

Network Strategies and Needs

Working with GLBW network partners, Ecotone identified critical leverage points (i.e. the pillars) to help drive the expansion of CLC and indirectly support the argument for 'CLC-by-network'. Each leverage point may be a: strength, constraint, opportunity, and/or gap. This will vary by CLC strategy and by farm context. The table here is meant to capture those considerations that reflect the state of CLC in the Upper Midwest. For a given project, a selection of these leverage points may be addressed. Recognition of how the leverage points fit into different categories and how they relate to each other should inform where GLBW work is concentrated, where relationships are needed, and where key bottlenecks are occurring for CLC strategies. If it appears that projects are repeatedly addressing science and social leverage points (noted in the lower rows) this should signal either movement in the Economic and Political leverage points or if movement is not occurring in those columns, that future projects must work to more directly incorporate those columns.

Note: Columns are categories of leverage points. Columns are often interconnected and as a result concepts may appear in multiple columns.

Note 2: Network activities should seek to connect Science and Social rows with Economic and Political columns whenever possible. Economic and political power are built from social and science leverage points.

Economic Power							Political Power		
Markets		Science		Social			Legal		Policy
	On-farm economics / financials	Evidence Base	Biophysical	Behavioral	Consumer / Public Education	Farmer / Landowner Education	Financial Instruments		
• Markets for agricultural commodities • Emerging markets for environmental benefits, ecosystem services, etc • Supply chain infrastructure and technology - inputs, harvesting, processing, distribution • Demand from consumers • Local economic conditions • Measures of success • Multi-stakeholder governance of the supply chain • Address environmental vulnerability (risk from climate volatility) and economic opportunity • Maintaining social contract - reliance on public goodwill • Investor ESG screens / impact investor appetite • Institutional investor investment timelines • Co-production: Agricultural products and ecosystem services • More efficient production and use of resources (solar, water, nutrient, etc.)	• On-farm costs, economic pay back periods, supporting Year 1 • Margins: combination of high prices on inputs (fertilizers/pesticides) and low prices on commodity crops • Financial planning/ economic analysis to demonstrate underlying financial benefits and resilience • Debt load—concerns about reduced production per cow, investment in infrastructure, and ability to service debt • Ease of use of equipment, cost, repairs, lifespan • Availability of necessary equipment • Framing the give and take in economics - lose some here but gain more over there	• CLC approach = integrated benefits. Effectiveness of CLC practices/systems to improve bio-physical environment • Expansion of ecological and agronomic research of perennials • Measures of success • Initiation and acceleration of breeding programs - Need to extract maximum performance from existing genetics while also improving genetics - yield and yield stability • Understanding those incremental changes that lead to transformation change - moving from on-farm change to off-farm impacts • Data tracking and data sharing • Maintaining yields in various conditions (such as sandy soils) • GHG potentials • Perennials evidence base is limited - more anecdotal - for on-farm economics, on-farm soil changes, off-farm water, air, climate impacts, off-farm economy and equity	• Natural infrastructure • Land availability—concern about whether there will be enough to meet feeding requirements • Identifying global regions for introduction of perennial grains • Functioning as natural ecosystems. Its really beyond mimicry its actual natural systems. • Changes in marginal land's existence and its use • Microbial behavior, climate and carbon sequestration, • Increased efficiency of solar, water, resources	• Consider activities that can be "gateways" to new thinking/behavior transformation vs tweaks (and the sequencing of them) • Hyperbolic discounting (reality of human decision making) vs. exponential discounting ("rational" economic decision making) is a common limitation. • Make CLC management practices 'stickier' • Re-frame risks (risk of under application of nutrients vs. risk of poor soil health) • Make changes more 'observable' and measurable • Practicality and lifestyle—concerns about lack of time for moving cattle or how daily routines would fit lifestyle needs • Negativity bias - particularly with regard to potential income losses • Status Quo bias • Incompatibility of CLC practices with current farming practices • Recognition of loss aversion - people want to protect what they have over gaining more. This may include framing communication to be about protecting a farm's operations for years to come. • Nudging with the 'how' along with the 'what' of the CLC. This applies to all stakeholders, not just farmers/ landowners. • Leverage what is already familiar - grains are common (annual grains = corn, wheat). • Comparisons against peers. People often want to outperform peers. Have to help identify the metrics to compare against	• Food system awareness and health impacts. The spectrum of mono-crop to natural prairie • Consumer value drivers include: Health & Wellness; Safety; Social impact; Experience; Transparency (an overarching driver) • Education - specifically younger ages being engaged through current activities (revisits social norms) • Training of scientists and students in the breeding, ecology, and management of perennial crops. • Translate the right to renew into national policy • Join mass movements struggling against extractive agriculture and food • Recognition of CLC and differentiation between other sustainable ag concepts • Need to communicate mid- to long-term horizons - it's not a quick fix. Need institutional patience.	• Technical assistance • Training • Institutional support • Education of practices and benefits attainable - specifically younger ages being engaged through current activities (revisits social norms) • Peer to peer learning and mentoring • Measures of success—concern for production per cow, rather than profit per cow or per unit of land area. Net income vs. yield • Demonstration programs; Information and technology transfer programs • BIPOC represent nearly one-quarter of the U.S. population, yet they operate less than 5% of the nation's farms and cultivate less than 1% of its farmland. • Need to consider different grower audiences. There are some open to it, and some very strictly corn/soybean. • Need a culture of innovation to support CLC strategies • The shift in narrative is happening around taking the holistic farming approach. • Understanding this is the old way • Using what you already have - e.g. woodlands become silvopasture	• Cost share programs, access to lending/capital • Debt restructuring/forgiveness; Debt for carbon swaps • No-interest loans; Revenue assurance; Crop insurance for pasture; Green payments • Opportunity cost of taking land out of production to meet policy goals and/ or unintentionally due to climate change • Long-term patient capital - 10-20 years in agroforestry's case	• Ownership options • Lease terms • Insurance terms • Internalized risk for supply chain (as opposed to pushing risk onto the farmer or the government) • Contract terms • Public Health	• Getting CLC into political discourse - Need to build public support that leads to financial incentive is very important. • Funding support • Public incentivization (enforcement, tax, subsidy, training/guidance, etc.) • Public-private dialogue mechanisms / bottom-up policy development • Rural economy and diversification • Environmental health (may tie into different interest groups - Audubon, Pheasants Forever, conservation land trusts, etc.) • Insurance terms • Reducing existing policy 'prescriptiveness' (may be a bipartisan framing) • Lack of policies - winter annuals won't qualify for cover crop support from government since you harvest them. • Need economic risk diversification and avoiding overproduction. • Food injustice is the bigger obstacle for global hunger - not production capacity. • If CRP land could be harvestable • Understanding the implications when integrating livestock. Obstacle of pesticides and herbicides withdrawal - have to wait to graze after applying it! Systems are really built now to be segregated. • Biggest challenge - orienting towards integrating • Natural infrastructure investment plan • Government spending, debt • Anti-trust guidance - protecting competition • Investor fiduciary duty

EVIDENCE MAP OF CLC

An important aspect to this analysis was a review of the literature, recognizing where and to what extent evidence exists for the impacts of CLC associated practices. This literature review also complements the above leverage points and serves as a recognition of the gaps in the research that are needed to strengthen this analysis. This led to the creation of a Evidence Map and Gap Analysis (included as separate documents). We arranged the Evidence Map along a portion of the logic model, focusing on the short-term, intermediate, and long-term outcomes, and from there the monetization points required to attach a dollar value to the long-term outcomes. This serves to structure the existing evidence along a causal chain as well as to maintain an orientation towards long-term outcomes through which changes are experienced by stakeholders.

The Evidence Map and Gap Analysis are designed to serve as "living" documents that are continually added to and refined. The logic model pathways can be rearranged to allow for new evidence that may develop as well as the recognition of new outcomes not previously recognized.

Use and interpretations of the evidence map requires a few introductory points:

1. This is not an exhaustive literature review. The evidence base is deep in aspects of CLC although highly variable in terms of what is being studied. As such this mapping exercise clarifies the subjects of Ecotone's literature review to date.
2. Farm context is an overarching principle for use of this map. The types of outcomes noted are being realized across the Upper Midwest but may not be realized on every field tested.
3. This map focuses on the social, economic and environmental "returns" from the given activities, focusing on water quality, water quantity, carbon emissions and producer economics as qualitatively identified in the logic model.
4. The structure of the Evidence Map does not convey feedback loops, but rather a one-way trajectory towards a cost-occurring event. This is not to say feedback loops are not occurring - indeed we would expect and know that in natural environments there are constant feedback loops responding to changes. Future revisions of the evidence mapping may take this into account.

SUMMARY OF GAPS SEEN IN THE EVIDENCE MAP

To organize the evidence, we broke it down by the given CLC strategy adopted and as feasible noted what counterfactuals were being referenced in each study. The strategies laid out were:

1. Cross-strategy - two or more CLC strategies included
2. Perennial biomass
3. Perennial forage and grazing
4. Agroforestry
5. Perennial grains
6. Cover crops and winter annuals.

As a whole, and as noted by Basche and DeLong (2019), evidence of perennial systems is often limited. Basche and DeLong, even when combining agroforestry, perennial grasses and managed forestry into a single perennials category found only eight total studies that met inclusion criteria for their meta-analysis.

Among the CLC strategies, however, PFG, due to the long history of grazing practices, did have a larger evidence base to draw from. As previously noted, evidence did not always consider the PFG system as a whole or necessarily capture perennials as much as it did livestock integration more generally. Those areas that had strongest evidence were included in our SROI projection.

The research gaps discovered in this analysis are multi-fold. Gaps to be addressed include:

- PFG as an aggregate area of study
- Change in economic, environmental and health effects

from moving between a confinement system to grazing system

- The social impacts of PFG
- The on-farm economic benefits (existing evidence is tied most strongly to livestock integration with grazing cover crops)
- Ecosystem service valuation literature (currently varied and can be highly context specific)
- Valuations (which can vary significantly by economic valuation approach as well as from study to study within approaches)
    - Ecosystem service valuation is not often tied to cropping practices or grazing systems but the results of those agricultural systems, such as nitrogen, phosphorus, water quality, sedimentation, etc.
    - Quality of valuations vary by type of outcome (e.g. health effects of poor surface water quality vs. changes in recreational use of water vs. fish and wildlife habitat vs. property values from being near surface water vs. property value from unstable/risky drinking water supply).

Based on these findings a few takeaways became apparent.

1. Carbon sequestration is the most straightforward pathway to monetization (even if on-field measurement is not so straightforward) due to already established estimations of the social cost of carbon and the global impacts of carbon.
2. Changes in net income from PFG systems are by their nature monetized, and thus straightforward to incorporate in a cost-benefit analysis (albeit existing evidence is not well developed).
3. Water quality, water quantity and air quality tend to utilize a benefits transfer valuation approach (as this analysis does). This means we are more reliant on regional-level estimations that are less specific to a given field.

KEY TAKEAWAYS

USES OF THE EVIDENCE MAP AND GAP ANALYSIS

These documents can serve multiple purposes for partner organizations.

Library of resources and Research needs:

- A tool for GLBW and network partners to add to as resources are discovered/studies implemented;
- A library for studies on specific causal mechanisms;
- A signal for future specific research needs;
- Resource mapping for future SROI estimations (the cells are the puzzle pieces that can be rearranged to monetize individual pathways);
- Continued increase in valuation efforts.

Community and Stakeholder engagement:

- Create a tool for stakeholder engagement and value propositions for stakeholders;
- Help farmers/landowners quickly recognize potential costs/benefits from specific practices;
- Foster specific discussions with local farmers, networks, knowledge sources, to help understand how best to go about realizing the benefits noted here;
- Ask local farmers to contribute to the evidence map - creating a community-building tool as well as a local evidence base.

EVIDENCE OF NETWORKS

The following section outlines key points noted in the external literature around networks and social capital in agricultural systems. These points can be used to support GLBW's communication around their own value-add as well as recognize potential strategic insights for opportunities to further leverage their position as a network.

Collaborative networks provide substantial benefits to the actors and organizations involved

- Networks serve as a mechanism through which information is exchanged, expertise is combined, and knowledge is co-produced among individuals with multiple perspectives and experiences
- They provide opportunities to pool and mobilize resources, distribute political, social, and financial risk, and connect multi-scalar governance levels to coordinate effort and maintain support
- Furthermore, networks allow diverse actors to negotiate conflict, build consensus and trust, identify complementary adaptation goals, and enable collective action

(Dow et al., 2013).

Different types and strengths of social capital can influence the nature and extent of collective action that occurs within a given system

Three primary types of social capital include: bonding, bridging, and linking. Bonding social capital reinforces ties and connections between closely related or homogenous groups and serves to strengthen such ties and relationships. Bridging social capital encourages links between diverse groups who share some common element, and linking social capital facilitates such connections between diverse groups from different power or authority gradients (Dow et al., 2013).

The influence of social networks are a reflection of the balance of weak-tie and strong-tie relationships within and between network members

Effects of networks on farmer decision making differ according to whether they comprise weak-tie relationships, which bridge across disparate people and organizations, or strong-tie relationships, which are shared by groups in which members are well known to one another (Manson et al., 2016).

The role of the intermediary must adapt to the stage of development for the associated agenda

Intermediation is paramount from prede- velopment to stabilisation of a transition. Intermediary functions change from sup- porting experimentation and articulation of needs in pre-development, to the aggregation of knowledge, pooling resources, network building and stronger institutional support and capacity building in acceleration (Kivimaa et al., 2019).

Intermediaries can come in many forms and take on different roles depending on the task at hand. Recognition of other complementary intermediaries can boost the strength of the GLBW network and leverage other organizations' agendas

Intermediary actors include: innovation funders, energy agencies, NGOs, membership organisations, or internet discussion forums (Kivimaa et al., 2019).

Intermediary types to engage range from user-level to systems-level:

- Systemic intermediary: Pursues given (sustainability) goals on a system level; ambitiousness towards disruption to existing system
- Regime-based transition intermediary: Pursues given (sustainability) goals through typically more incremental solutions or political aims

- Niche (or grassroots) intermediary: Pursues given (sustainability) goals and solutions from a perspective of a given niche
- Process intermediary: Implementing context-specific priorities, informed by broader transition trajectories
- User intermediary: Acts as facilitator, representative, or broker of end-use or end-users

(Kivimaa et al., 2019).

Many challenges exist to create a value-add supply chain - but network strategies can be used to address those challenges and collectively build the market opportunity

Challenges to address include:

- Finding appropriate supply chain partners and developing mechanisms for building trust, transparency and decision-making
- Determining effective strategies for product differentiation, branding and regional identity
- Developing food quality control systems that address weather, seasonality, multiple production sites and quality-preserving distribution mechanisms
- Developing equal economic power for supply chain negotiations
- Determining appropriate strategies for product pricing that are based on understanding true cost structures. Two contrasting strategies are cost-based pricing and paying premiums above commodity market prices
- Building sufficient trust among competing producer groups to form networks of farmers, ranchers or fishers large enough to supply significant and consistent volumes of high-quality, differentiated food products
- Acquiring adequate capitalization and competent management
- Accessing adequate technical, research and development support
- Creating meaningful standards and consistent certification mechanisms across the supply chain

(Stevenson and Pirog, 2013).

The benefits of social capital facilitated by networks are multi-faceted stretching across agroecosystems, landscapes and farm household economies.

At the individual level, social capital increases the world view of farmers and empowers women and underrepresented stakeholders/farmers (Pretty et al., 2020). Social capital at the agricultural system level can boost crop productivity, increase tree and agroforestry cover and reduce the use of pesticides (Pretty et al., 2020). Finally, the resulting change in practices at the agricultural system level due to social capital can improve productivity of forage and secondary products, increase carbon sequestration and reduce surface water flows and soil erosion (Pretty et al., 2020).

KEY PERFORMANCE INDICATORS (KPIS)

KPIs can be arranged across dimensions of GLBW/Network partners, CLC strategies, and Ag Transformation indicators. Each of the KPIs feed into the next, creating a detailed hierarchy of metrics for tracking and maximizing impact.

The KPIs in Table 2 and 3 are recommended for future tracking of CLC and GLBW. Scale KPIs are outputs and sub-sets of outputs that can be used to understand the scale of impact of CLC. Quality KPIs are the maximization of benefits generated on those acres that adopt a CLC system.

Of note, these figures do not have to be an annual figure, and instead could simply reflect 1) the present state and 2) the direction pursued. Target columns are noted to help guide program planning as these cells may be filled in as programs are being developed, implemented, and grown.

Note: these figures do not necessarily place the burden on GLBW to collect these KPIs. These KPIs are those signals of value creation.

Table 2. GLBW KPIs

GLBW Key Performance Indicators (KPIs)			
Scale KPIs	**Target**	**Quality KPIs**	**Target**
Number of public education/outreach events, brochures, social media postings, newsletters, etc.		Ease of connecting to other network partners	
Number of network partners		Duration of engagement between network partners	
Conversations started, introductions made		Change in cross-strategy projects	
Resources shared		Change in number of cross-partner collaborations	
Research authored, published		Rate of spread of knowledge	
Number of referrals made			

Table 3. CLC KPIs

CLC Key Performance Indicators (KPIs)			
Scale KPIs	**Target**	**Quality KPIs**	**Target**
# of acres or farms implementing CLC strategies		Annual rate of adoption of practices in acres (shorter-term KPI)	
Proportion of high priority acres using CLC strategies		Proportional reduction in N and P runoff and soil erosion per field	
Pounds of N, P and Soil prevented from erosion		CO2e sequestered per acre	
Tons of CO2e sequestered		% of CLC strategies in high priority areas of watershed	
		% of farms with CLC strategies reporting net income gains over time	

AG TRANSFORMATION INDICATORS

- ***Increased Farmer Adoption***
  Number of farms/acres implementing CLC strategies
- ***Increased System Supports***
  Market and policy support for CLC, new philanthropic, federal and private funding and investment for CLC
- ***Increased Equitable Ag Opportunities***
  Expanded and equitable access to ag capital, land and technical information
- ***Decreased Ecosystem Degradation***
  Reduced erosion of nutrients and soil, improved water quality and other ecosystem services
- ***Decreased Greenhouse Gas Emissions and Climate-Related Risk***
  Reduction of greenhouse gas emissions, improved carbon sequestration, increased on-farm resilience
- ***Decreased Risk***
  On farm resilience and income stability in the face of severe weather events, reduced infrastructure replacement costs for municipalities, increased stability of regional food supply

IMPACT COMMUNICATION

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (UN SDGS)

These are the blueprint, established by the United Nations, to achieve a better and more sustainable future for all and include 17 distinct goals. They serve as an easily recognizable marker of agreed upon impact areas for stakeholders. See pages 22 - 24 for the SDGs that GLBW and CLC strategies align with.

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Target 2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

Indicator 2.4.1 Proportion of agricultural area under productive and sustainable agriculture

Target 2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries

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Goal 3: Good Health and Wellbeing

Target 3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

Goal 6: Ensure availability and sustainable management of water and sanitation for all

Target 6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Target 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending

Goal 10. Reduce inequality within and among countries

Target 10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status

Goal 13: Take urgent action to combat climate change and its impacts*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Target 15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

Target 15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

Target 15.A Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems

Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

Target 17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships

For more information on UN SDGs: un.org/sustainabledevelopment

IMPACT MANAGEMENT PROJECT FIVE DIMENSIONS OF IMPACT

The Impact Management Project (IMP) is a community of 2,000+ organizations building consensus on how to measure, compare and report impact on environmental and social issues. The IMP community has developed a set of 5 dimensions of impact in order to help build consensus and a common language when organizations and investors discuss their impact. This has been a rapidly growing field, and future alignment of GLBW's and CLC's impact with the 5 dimensions could help attract additional investment as CLC strategies and GLBW network partner initiatives are developed.

Table 4. Details for the Five Dimensions of Impact

Impact Dimension	Impact Questions Each Dimension Seeks to Answer
WHAT	• What outcome occurs in period? • How important is the outcome to the people (or planet) experiencing it?
WHO	• Who experiences the outcome? • How under served are the affected stakeholders in relation to the outcome?
HOW MUCH	• How much of the outcome occurs--across scale, depth and duration?
CONTRIBUTIONS	• What is the enterprise's contribution to the outcome accounting for what would have happened anyway?
IMPACT RISK MITIGATION	• What is the risk to the people and planet that impact does not occur as expected?

IMPACT MANAGEMENT PROJECT

Table 5. Continuous Living Cover (CLC) Five Dimensions of Impact

Continuous Living Cover FIVE DIMENSIONS OF IMPACT

IMPACT MANAGEMENT PROJECT

WHAT: CLC cropping strategies and the perennialization of the agricultural landscape produce food, feed, fuel and fiber and deliver environmental and socioeconomic benefits, including soil health, biodiversity, climate change resilience, quality of life, and equitable access/support for all farmers.

WHO: Midwest farmers; local, downstream, and regional communities and ecosystems; global climate.

HOW MUCH: Environmental and ecological improvements are provided while perennial practices are implemented. Farmer incomes stream are diversified and stabilized, mitgitating weather and market crises. Ecological and socioeconomic benefits accrue on individual farms, across communities, and at a landscape level.

CONTRIBUTION: CLC and perennial cropping strategies offer longer growing seasons, deeper roots, improved soil health and water quality, more resilient ecosystems, and varied market opportunities over annual monocropping production systems.

IMPACT RISK MITIGATION: Farmers can adopt CLC cropping strategies in a variety of ways; various on-ramps offer flexibility and expanded accessibility; a network approach informed by multiple sectors de-risks investment in adoption and supportive infrastructure.

APPENDIX A: ADDITIONAL LITERATURE FINDINGS

The following section provides excerpts from the literature reviewed. These served to both help frame our analysis and may provide useful insights when implementing the ecosystem services market.

Ecosystem services

- "Ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being. Services are not benefits nor are they necessarily the final product consumed. For example, recreation often is called an ecosystem service. It is more appropriately considered a benefit produced using both ecological services and conventional goods and services." (Boyd and Banzhaf, 2007)
- "In an ecosystem market, the environmental good is a public good and the buyer is therefore indifferent to its quality. The buyer is concerned only about satisfying the regulator's definition of an adequate unit. . . An aim then of our inquiry is to advocate units that will improve governments' ability to consistently and defensibly measure and police environmental quality affected by regulation, ecosystem trades, compensation, and expenditures." (Boyd and Banzhaf, 2007)

Carbon credit risks in agricultural contexts

- "Inadequate measurement tools: A recent study showed that three commonly-used measurement tools for soil carbon all yielded different results. Other studies show that focusing on the top 6 to 12 inches of the soil profile may overestimate the amount of carbon sequestered through no-till. Another challenge is how much soil carbon stocks differ geographically. Even in apparently uniform fields, soil carbon content may vary by as much as fivefold." (Ritter and Treakle, 2020)
- "Impermanence: any carbon sequestered in the soil can be released with a change in land management practices or through severe weather events." (Ritter and Treakle, 2020)
- "Volatile prices: Historically, carbon credit prices have been far too low to fairly incentivize such large-scale land management changes." (Ritter and Treakle, 2020)
- "Carbon markets undermine more effective and holistic agricultural practices: offset projects in a carbon market tend to work best for large-scale farms, raising concerns that corporate investment in carbon markets will contribute to further consolidation of agricultural land and disadvantage small to mid-sized farmers. Focusing on resilient agroecological systems rather than on the amount of carbon sequestered can benefit farmers of all sizes." (Ritter and Treakle, 2020)

- "**The price of tradable emissions permits under cap-and-trade systems will almost never meet the requirements for using cost as a proxy for value**" (EPA, 2009). It is with this understanding we note that our estimation here and that over other researchers should serve as a valuation against which to compare the market price of the carbon credits, noting that the credits will generally be undervalued.

Structuring Payments for Ecosystem Services

- "Payment schemes should capture all effects of ecosystem management (e.g., affecting multiple ES). They should consider scale and lead to measurable, verifiable outcomes that go beyond what would have happened in the absence of the payment scheme. Most important, they should not be burdened with objectives such as income transfers that go beyond delivery of ES. This is one of the hardest lessons of decades of politically driven agricultural subsidies." (Kinzig et al., 2011)

Appendix B: LEVELS OF EVIDENCE and BIBLIOGRAPHY

Table B1: Levels of Evidence of Causality – Ranked from highest to lowest, 1 to 7

1	Evidence from a systematic review or meta-analysis of all relevant RCTs (randomized controlled trial) or evidence-based clinical practice guidelines based on systematic reviews of RCTs or three or more RCTs of good quality that have similar results.
2	Evidence obtained from at least one well-designed RCT (e.g. large multi-site RCT).
3	Evidence obtained from well-designed controlled trials without randomization (i.e. quasi-experimental).
4	Evidence from well-designed case-control or cohort studies.
5	Evidence from systematic reviews of descriptive and qualitative studies (meta-synthesis).
6	Evidence from a single descriptive or qualitative study.
7	Evidence from the opinion of authorities and/or reports of expert committees.

In the table on the following page, specific sources referenced or whose figures were directly used, are included. Each study is ranked by its level of evidence and includes its relevant finding. This helps to communicate the relative strength of the findings estimated and used. Whenever possible, the highest level of evidence is utilized.

Green Lands Blue Waters IN PARTNERSHIP WITH ECOTONE ANALYTICS

Level of Evidence	Study	Relevant Finding
Level 1 Evidence: Meta-analysis of RCTs	Basche, A. & DeLonge, M. (2017). The Impact of Continuous Living Cover on Soil Hydrologic Properties: A Meta-Analysis. Soil Science Society of America Journal. 81. 10.2136/sssaj2017.03.0077.	CLC significantly increased soil porosity and water retained
	Basche, A.D., DeLonge, M.S. (2019). Comparing infiltration rates in soils managed with conventional and alternative farming methods: A meta-analysis. PLoS ONE 14(9): e0215702. https://doi.org/10.1371/journal.pone.0215702	Perennials had large increases in infiltration rates over crop rotations alone
	Cates, A. M., G. R. Sanford, L. W. Good, & R. D. Jackson. (2018). What do we know about cover crop efficacy in the North Central United States? Journal of Soil and Water Conservation, 73: 153A-157A.	Cover crops can increase SOM although costs and benefits can vary by case
	DeLonge, M., & Basche, A. (2018). Managing grazing lands to improve soils and promote climate change adaptation and mitigation: A global synthesis. Renewable Agriculture and Food Systems, 33(3): 267-278. doi:10.1017/S1742170517000588	Grazing management practices can influence infiltration rates and Soil Carbon
	Tamburini, G., Bommarco, R., Wanger, T.C., Kremen, C., van der Heijden, M.G.A., Liebman, M. & Hallin, S. (2020). Agricultural diversification promotes multiple ecosystem services without compromising yield. Science Advance, 6(45).	Agricultural diversification promotes multiple ecosystem services without compromising yield
Level 2 Evidence: Randomized Controlled Trials	Basche, A.D., Kaspar, T.K., Archontoulis, S.A., Jaynes, D.B., Parkin, T.B., Sauer, T.S., Miguez, F.E. (2016). Soil water improvements with the long-term use of a cover crop. Agricultural Water Management, 172: 40-50. doi 10.1016/j.agwat.2016.04.006	Cover crops can boost water storage
	Culman, S., Snapp, S., Ollenburger, M., Basso, B. & DeHaan, L. (2013). Soil and Water Quality Rapidly Responds to the Perennial Grain Kernza Wheatgrass. Agronomy Journal, 105: 735–744. doi: 10.2134/agronj2012.0273.	Perennial kernza reduced NO3 leaching by 86% compared to wheat
	Davis, A.S., J.D. Hill, C.A. Chase, A.M. Johanns, & M. Liebman. (2012). Increasing Cropping system diversity balances productivity, profitability and environmental health. PLoS ONE 7(10): e47149. doi:10.1371/journal.pone.0047149.	Increasing Cropping system diversity balances productivity, profitability and environmental health.
	de Oliveira, G., Brusnell, N.A., Sutherlin, C.E., Crews, T.E. & DeHaan, L.R. (2018). Energy, Water and Carbon exchange over a perennial Kernza wheatgrass crop. Agriculture and Forest Meteorology, 249: 120-137.	Kernza has high water use efficiency and acts a carbon sink
	Gelfand, I., S. K. Hamilton, A. N. Kravchenko, R. D. Jackson, K. D. Thelen, and G. P. Robertson. (2020). Empirical evidence for the potential climate benefits of decarbonizing light vehicle transport in the U.S. with bioenergy from purpose-grown biomass with and without BECCS. Environmental Science & Technology 54:2961-2974.	Bioenergy yield by feedstock type can vary considerably

Level of Evidence	Study	Relevant Finding
Level 2 Evidence: Randomized Controlled Trials	Gelfand, I., Shcherbak, I., Millar, N., Kravchenko, A.N. and Robertson, G.P. (2016). Long-term nitrous oxide fluxes in annual and perennial agricultural and unmanaged ecosystems in the upper Midwest USA. Glob Change Biol, 22: 3594-3607. doi:10.1111/gcb.13426	N2O emissions were higher from annual grain and N-fixing cropping systems than from nonleguminous perennial cropping systems
	Gesch, R.W. & Johnson, J.M.-F. (2015). Water Use in Camelina–Soybean Dual Cropping Systems. Agronomy Journal, 107: 1098-1104. doi:10.2134/agronj14.0626	Winter Camelina can be effectively dual cropped with soybean
	Gesch, R.W., Archer, D.W. and Berti, M.T. (2014). Dual Cropping Winter Camelina with Soybean in the Northern Corn Belt. Agronomy Journal, 106: 1735-1745. doi:10.2134/agronj14.0215	Winter Camelina increased costs but also included additional income to offset the costs
	Hummel, A. Dalman, N., Liu, R. & Garcia y Garcia, A. (2017). Mitigating Water Loss in Soybean-Corn Rotations with Winter Cover Crops.	Winter cover crops can reduce water loss
	Jungers, J.M., DeHaan, L.H., Mulla, D.J., Sheaffer, C.C. & Wyse, D.L. (2019). Reduced nitrate leaching in perennial grain crop compared to maize in the Upper Midwest, USA. Agriculture, Ecosystems and Environment, 272: 63-73.	Intermediate wheatgrass significantly reduced nitrate leaching compared to maize
	Liebman, M., M.J. Helmers, L.A. Schulte C., & A. Chase. (2013). Using biodiversity to link agricultural productivity with environmental quality: Results from three field experiments in Iowa. Renewable Agriculture and Food Systems, 28(2): 115–128.	Crop diversity and rotations can boost yields and reduce costs
	Ott, M., Eberle, C., Thom, M., Archer, D., Forcella, F., Gesch, R. & Wyse, D. (2019). Economics and Agronomics of Relay-Cropping Pennycress and Camelina with Soybean in Minnesota. Agronomy Journal. 111. 10.2134/agronj2018.04.0277.	The extra effort in growing pennycress may be worthwhile in some years
	Pimentel, D., Hepperly, P., Hanson, J., Douds, D., Seidel, R. (2005). Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. BioScience 55(7): 573-582.	Organic practices reduce water runoff
	Randall, G.W. & M.J. Gross. (2008). Nitrate losses to surface water through subsurface tile drainage. In: Nitrogen in the Environment: Sources, Problems, and Management, (Ed.) J.L. Hatfield and R.F. Follett. Elsevier Sciences B.V: 145-175.	Tile drainage and annual crops together increase likelihood of NO3 losses
	Sanford, G. R., J. L. Posner, R. D. Jackson, C. J. Kucharik, J. L. Hedtcke, and T.-L. Lin. (2012). Soil carbon lost from Mollisols of the North Central U.S.A. with 20 years of agricultural best management practices. Agriculture, Ecosystems & Environment 162:68-76.	Perennial crops reduced SOC loss but did not support gains in carbon sequestration

Level of Evidence	Study	Relevant Finding
Level 2 Evidence: Randomized Controlled Trials	Schulte, L. A., J. Niemi, M. J. Helmers, M. Liebman, J. G. Arbuckle, D. E. James, R. K. Kolka, M. E. O'Neal, M. D. Tomer, J. C. Tyndall, H. Asbjornsen, P. Drobney, J. Neal, G. Van Ryswyk, and C. Witte. (2017). Prairie strips improve biodiversity and the delivery of multiple ecosystem services from corn-soybean croplands. Proceedings of the National Academy of Sciences 114:11247-11252.	Prairie strips reduced total water runoff from catchments by 37%, resulting in retention of 20 times more soil and 4.3 times more phosphorus
	Skinner, R.H. and Dell, C.J. (2016), Yield and Soil Carbon Sequestration in Grazed Pastures Sown with Two or Five Forage Species. Crop Science, 56: 2035-2044. doi:10.2135/cropsci2015.11.0711	Reference for increased carbon sequestration from livestock integrations
	Snapp, S. S., Gentry, L. E., Harwood, R. (2010). Management intensity - not biodiversity - the driver of ecosystem services in a long-term row crop experiment. Agriculture, Ecosystems and Environment 138: 242-248.	Management intensity can drive ecosystem services
	Syswerda, S. P., Robertson, G. P. (2014). Ecosystem services along a management gradient in Michigan (USA) cropping systems. Agriculture, Ecosystems and Environment 189(0): 28-35.	Management systems have large effects on ecosystem services
	Tobin, C. , Singh, S. , Kumar, S. , Wang, T. and Sexton, P. (2020) Demonstrating Short-Term Impacts of Grazing and Cover Crops on Soil Health and Economic Benefits in an Integrated Crop-Livestock System in South Dakota. Open Journal of Soil Science, 10, 109-136. doi: 10.4236/ojss.2020.103006.	Net income changes from livestock integration; reference for changes in bulk density
	Tomer, M.D. & M. Liebman. (2013). Nutrients in soil water under three rotational cropping systems, Iowa, USA. Agriculture, Ecosystems and Environment 180: 105-114.	More crop rotations is associated with reduced NO3-N concentrations
	Turner, R.E. (2020). Reference List draft paper in progress. Manuscript in preparation.	Diversification of crops can boost profits and increase carbon storage
	von Haden, A.C. & Dornbush, M.E. (2017). Ecosystem carbon pools, fluxes, and balances within mature tallgrass prairie restorations. Restoration Ecology, 25(4): 549-558.	Tallgrass prairie restorations can quickly accrue organic C in soil and biomass
Level 3 Evidence: Quasi-experimental Analysis	Ahlering, M.A. and Merkord, C.L. (2016). Cattle grazing and grassland birds in the northern tallgrass prairie. Jour. Wild. Mgmt., 80: 643-654. doi:10.1002/jwmg.1049	Birds can benefit from grazing intensity
	Asbjornsen, H., Hernandez-Santana, V., Liebman, M., Bayala, J., Chen, J., Helmers, M., . . . Schulte, L. (2014). Targeting perennial vegetation in agricultural landscapes for enhancing ecosystem services. Renewable Agriculture and Food Systems, 29(2), 101-125. doi:10.1017/S1742170512000385	Reestablishment of perennial grasslands on former agricultural lands could rebuild soil organic C pools to levels equivalent to unplowed native prairie within 55–75 years

Level of Evidence	Study	Relevant Finding
Level 3 Evidence: Quasi-experimental Analysis	Berti, M., Johnson, B., Ripplinger, D., Gesch, R. & Aponte, A. (2017). Environmental impact assessment of double- and relay-cropping with winter camelina in the northern Great Plains, USA. Agricultural Systems, 156: 1-12.	There is reduced erosion but increased emissions from double or relay cropping with winter camelina
	Dinnes, D.L., Karlen, D.L., Jaynes, D.B., Kaspar, T.C., Hatfield, J.L., Colvin, T.S. and Cambardella, C.A. (2002), Nitrogen Management Strategies to Reduce Nitrate Leaching in Tile-Drained Midwestern Soils. Agron. J., 94: 153-171. https://doi.org/10.2134/agronj2002.1530	70% of NO3 leached comes from less than 30% of the field
	Glover, J.D. et al. (2010a). Harvested perennial grasslands provide ecological benchmarks for agricultural sustainability. Agriculture, Ecosystems and Environment 137: 3–12.	Perennials have a series of positive environmental benefits
	Glover, J.D. et al. (2010b). Increased food and ecosystem security via perennial grains. Science 328: 1638–1639. doi:10.1126/science.1188761	Perennial grains provide many ecosystem services
	Leopold Center for Sustainable Agriculture & Iowa Cattleman's Association. (2006). Final Report: Impacts of Managed Grazing on Stream Ecology and Water Quality.	Maintaining adequate forage cover boosts stream ecology
	Meehan, T. D., Gratton, C., Diehl, E., Hunt, N. D., Mooney, D. F., Ventura, S. J., Barham, B. L. & R. D. Jackson. (2013). Ecosystem-service tradeoffs associated with switching from annual to perennial energy crops in riparian zones of the US Midwest. PLoS One 8:e80093	Perennial grass production reduced incomes but increased ecosystem services relative to continuous corn
	Morandin, L. A., Long, R. F., Kremen, C. (2016). Pest Control and Pollination Cost-Benefit Analysis of Hedgerow Restoration in a Simplified Agricultural Landscape. Journal of Economic Entomology 109(3): 1020-1027.	Hedgerows can boost pollination and profitability
	Moriasi, D.N., Duriancik, L.F., Sadler, E.J., Tsegaye, T., Steiner, J.L., Locke, M.A., Strickland, T.C., & Osmond, D.L. (2020). Quantifying the impacts of the Conservation Effects Assessment Project watershed assessments: The first fifteen years. Journal of Soil and Water Conservation, 75(3): 57A-74A; DOI: 10.2489/jswc.75.3.57A	Forage can reduce sediment and nutrient loss compared to row crops by upwards of 90%
	Phillips, R. L., M. R. Eken, and M. S. West. (2015). Soil Organic Carbon Beneath Croplands and Re-established Grasslands in the North Dakota Prairie Pothole Region. Environmental Management 55:1191-1199.	CRP grasslands boost SOC
	Rowntree, J., Ryals, R., DeLonge, M., Teague, W.R., Chiavegato, M., Byck, P., Wang, T. & Xu, S. (2016). Potential mitigation of midwest grass-finished beef production emissions with soil carbon sequestration in the United States of America. Future of Food: Journal of Food, Agriculture and Society, 4: 31.	Beef production in well-managed grazing systems can aid in soil carbon sequestration
	Stanley, P.L., Rowntree, J.E., Beede, D.K., DeLonge, M.S., Hamm, M.W. (2018). Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems. Agricultural Systems, 162: 249-258.	Emissions from the grazing system were offset completely by soil C sequestration

Level of Evidence	Study	Relevant Finding
Level 4 Evidence: Case Control/ Cohort Studies	Benbrook, C. et. al. (2010). The Organic Center. A Dairy Farm's Footprint:Evaluating the Impacts of Conventional and Organic Farming Systems.	Pasture-based dairy farms reduce methane from reduced manure lagoon usage
	Binder, S., Isbell, F, Polasky, S, Catford, J, Tilman, D. (2018). Grassland Biodiversity Can Pay. PNAS April 10, 2018 115 (15) 3876-3881	Profitability for landholders is maximized at 9-12 species
	Boehm, R. (2020). Reviving the Dead ZoneSolutions to Benefit Both Gulf Coast Fishers and Midwest Farmers. Union of Concerned Scientists.	Nitrogen runoff causes upwards of $2 billion in economic damages ot the Gulf of Mexico fisheries
	Boody, G., Vondracek, B., Andow, D.A., Krinke, M., Westra, J., Zimmerman, J. & Welle, P. (2005). Multifunctional Agriculture in the United States. BioScience, 55: 27-38.	Changes in agricultural land management improve watershed quality without additional costs
	Dodds, W. K., Bouska, W. W., Eitzmann, J. L., Pilger, T. J., Pitts, K. L., Riley, A. J., ... & Thornbrugh, D. J. (2009). Eutrophication of US freshwaters: analysis of potential economic damages.	Eutrophication from Nitrogen runoff poses multiple costs
	Duffy, M. (2012). Value of Soil Erosion to the Land Owner. Iowa State University, Ames.	Soil erosion can be highly costly and is widespread
	Fargione, J. E., Bassett, S., Boucher, T., Bridgham, S. D., Conant, R. T., Cook-Patton, S. C., ... & Gu, H. (2018). Natural climate solutions for the United States. Science Advances, 4(11), eaat1869.	Grazing optimization, grassland restoration and legumes in pastures are all associated with soil carbon sequestration
	Fargione, J.E. et al. (2018). Natural Climate solutions for the United States. Science Advances, 4.	The two largest lower-cost opportunities for carbon sequestration: cover crops and improved natural forest management
	Fissore, C., Espeleta, J., Later, E.A., Hobbie, S.E. & Reich, P.B. (2009). Limited potential for terrestrial carbon sequestration to offset fossil-fuel emissions in the upper midwestern US. Frontiers in Ecology and the Environment.	Terrestrial carbon sequestration to offset foss-fuel emissions is unlikely
	Friedman, S. & Sands, L. (2019). How conservation makes dairy farms more resilient, especially in a lean agricultural economy. Environmental Defense Fund and KCoe Isom.	Conservation practices on a dairy farm are shown to be profitable
	Gourevitch, J., Keeler, B. & Ricketts, T. (2018). Determining socially optimal rates of nitrogen fertilizer application. Agriculture, Ecosystems and Environment, 254: 292-299.	Social cost of nitrogen
	Hashem Mousavi-Avval, S. & Shah, A. (2020). Techno-economic analysis of pennycress production, harvest and post-harvest logistics for renewable jet fuel: Renewable and Sustainable Energy Reviews, 123.	Pennycress has potential as a renewable jet fuel although remains expensive

Level of Evidence	Study	Relevant Finding
Level 4 Evidence: Case Control/ Cohort Studies	Henderson, B. B., Gerber, P. J., Hilinski, T. E., Falcucci, A., Ojima, D. S., Salvatore, M., & Conant, R. T. (2015). Greenhouse gas mitigation potential of the world's grazing lands: Modeling soil carbon and nitrogen fluxes of mitigation practices. Agriculture, Ecosystems & Environment, 207, 91-100.	Grazing optimization, grassland restoration and legumes in pastures are all associated with soil carbon sequestration
	Hungate, B.A. et. al. (2017) The economic value of grassland species for carbon storage. Sci Adv 3:e1601880	There are diminishing economic returns to species richness
	Jha, M.K., Wolter, C.F., Schilling, K.E. & Gassman, P.W. (2010). Assessment of total maximum daily load implementation strategies for nitrate impairment of the Raccoon River, Iowa. Journal of Environmental Quality 39: 1317-1327.	Nitrate reduction strategies can be highly effective
	Krohn, B.J. & Fripp, M. (2021). A life cycle assessment of biodiesel derived from the "niche filling" energy crop camelina in the USA. Applied Energy, 92: 92-98.	Without considering land-use change the camelina scenarios emit more GHG than soybeans
	Langemeier, M. & M. O'Donnell (2020). Conventional and Organic Enterprise Net Returns. Farmdoc Daily (10): 161, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.	Returns on conventional corn and soybeans are often low
	Leclère, D., Obersteiner, M., Barrett, M. et al. (2020). Bending the curve of terrestrial biodiversity needs an integrated strategy. Nature, 585: 551–556. https://doi.org/10.1038/s41586-020-2705-y	Increasing terrestrial biodiversity must consider food provision needs
	Ledo, A, Smith, P, Zerihun, A, et al. (2020). Changes in soil organic carbon under perennial crops. Glob Change Biol, 26: 4158– 4168. https://doi.org/10.1111/gcb.15120	Transitioning from annuals to perennials increased SOC
	Manson, S. M., Jordan, N. R., Nelson, K. C., & Brummel, R. F. (2016). Modeling the effect of social networks on adoption of multifunctional agriculture. Environmental modelling & software : with environment data news, 75, 388–401. https://doi.org/10.1016/j.envsoft.2014.09.015	Social networks are important to rotational grazing (RG) adoption but their impact is contingent on social and spatial factors
	Mathewson, P. D., Evans, S., Byrnes, T., Joos, A. & Naidenko, O. V. (2020). Health and economic impact of nitrate pollution in drinking water: a Wisconsin case study. Environmental Monitoring and Assessment, 192(11), 724. https://doi.org/10.1007/s10661-020-08652-0	Direct medical cost estimates for all nitrateattributable adverse health outcomes range between \$23 and \$80 million annually in WI
	McIsaac, G.F., X. Hu. (2004). Net N Input and riverine N export from Illinois agricultural watersheds with and without extensive tile drainage. Biogeochemistry 70: 251-271.	Tile drainage system increases nitrate runoff
	Meehan, T. D., A. H. Hurlbert, and C. Gratton. (2010). Bird communities in future bioenergy landscapes of the Upper Midwest. PNAS 107:18533-18538.	Perennial bioenergy crops can boost avian richness
	Meehan, T. D., Werling, B. P., Landis, D. A., & C. Gratton. (2011). Agricultural landscape simplification and insecticide use in the Midwestern United States. PNAS 108:11500-11505.	Landscape simplification is associated with increased pesticide use

Level of Evidence	Study	Relevant Finding
Level 4 Evidence: Case Control/ Cohort Studies	Mercer, D.E., Li, X., Stainback, A. & Alavalapati, J. (2017). Chapter 4: Valuation of agroforestry services. In: Schoeneberger, Michele M.; Bentrup, Gary; Patel-Weynand, Toral, eds. Agroforestry: Enhancing resiliency in U.S. agricultural landscapes under changing conditions. Gen. Tech. Report WO-96. U.S. Department of Agriculture, Forest Service. 63-72.	Agroforestry can access other revenue streams such as hunting leases
	Minnesota Board of Water and Soil Resources. (2018). Working lands watershed restoration feasibility study and program plan.	Subsidies are often needed for CLC strategies
	Natural Resources Conservation Service. (2010). Final Benefit-Cost Analysis for the Grassland Reserve Program (GRP). United State Department of Agriculture.	Grassland management valuation is difficult but has been estimated for many ecosystem services
	Park, J.Y., Ale, S., Teague, W.R., & S.L. Dowhower (2017). Simulating hydrologic responses to alternate grazing management practices at the ranch and watershed scales. Journal of Soil and Water Conservation, 72 (2): 102-121; DOI: 10.2489/jswc.72.2.102	Utilizing multi-paddock grazing as opposed to heavy continuous can significantly reduce surface runoff and streamflow
	Pattison, I. & Lane, S.N. (2011). The link between land-use management and fluvial flood risk: A chaotic conception? Progress in Physical Geography, 36(1) 72–92.	Impact of land management activities impact upon flood risk at larger catchment scales has proved to be elusive
	Peterson et al. (2011). A Once and Future Gulf of Mexico Ecosystem: Recommendations for restoring a healthy and productive natural system. Pew Environmental Group.	Without the subsidies, the net farm income would often be negative
	Raff, Z., & Meyer, A. (2019). CAFOs and Surface Water Quality: Evidence from the Proliferation of Large Farms in Wisconsin. Available at SSRN 3379678.	The marginal CAFO in Wisconsin produces non-market surface water quality damages of at least $203,541 per year.
	Randall, G.W. & D.J. Mulla. (2001). Nitrate nitrogen in surface waters as influenced by climatic conditions and agricultural practices. Journal of Environmental Quality 30: 337–344.	N management systems can significantly reduce N losses
	Robertson, B. A., Doran, P. J., Loomis, L. R., Robertson, J. R. & D. W. Schemske. (2011). Perennial biomass feedstocks enhance avian diversity. GCB Bioenergy 3:235-246.	Avian richness was higher in perennial plantings with greater forb content and a more diverse vegetation structure
	Rowntree, J., Stanley, P. L., Maciel, I. C., Thorbecke, M., Rosenzweig, S. T., Hancock, D. W., & Raven, M. R. (2020). Ecosystem Impacts And Productive Capacity Of A Multi-species Pastured Livestock System. Frontiers in Sustainable Food Systems, 4, 232.	A multi-specieis pastured livestock can significantly reduce GHG emissions as opposed to siloed row crop production and concentrated feed lots
	Russelle, M. P., Entz, M. H., & Franzluebbers, A. J. (2007). Reconsidering integrated crop–livestock systems in North America. Agronomy Journal, 99(2), 325-334.	Perennial forage and grazing and reduce risk of environmental damage and increase soil carbon

Level of Evidence	Study	Relevant Finding
Level 4 Evidence: Case Control/ Cohort Studies	Schullehner, J., Hansen, B., Thygesen, M., Pedersen, C. B., & Sigsgaard, T. (2018). Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study. International journal of cancer, 143(1), 73-79.	Nitrate in drinking water increases risk of colorectal cancer
	Shibu, J., Gold, M. & Zamora, D. (2017). Appendix A: Regional summaries: Midwest. In: Schoeneberger, Michele M.; Bentrup, Gary; Patel-Weynand, Toral, eds. Agroforestry: Enhancing resiliency in U.S. agricultural landscapes under changing conditions. Gen. Tech. Report WO-96. U.S. Department of Agriculture, Forest Service. 177-183.	Local food production can boost indirect economic activity over conventional food
	Stanley, P. L., Rowntree, J. E., Beede, D. K., DeLonge, M. S., & Hamm, M. W. (2018). Impacts of soil carbon sequestration on life cycle greenhouse gas emissions in Midwestern USA beef finishing systems. Agricultural Systems, 162, 249-258.	Emissions from the grazing system were offset completely by soil C sequestration
	Undersander, D. & Pillsbury, B. (1999). Grazing Streamside Pastures. University of Wisconsin Extension.	Fencing costs $0.10 per foot with returns expected from improved forage quality
	Undersander, D., Temple, S., Bartlet, J., Sample, D. & Paine, L. (2000). Grassland birds: Fostering habitats using rotational grazing. University Wisconsin Extension.	Rotational grazing reduces feed, fuel, feretilizer, labor, equipment costs and provides nesting habitat
	Ward, M. H., Jones, R. R., Brender, J. D., De Kok, T. M., Weyer, P. J., Nolan, B. T., ... & Van Breda, S. G. (2018). Drinking water nitrate and human health: an updated review. International journal of environmental research and public health, 15(7), 1557.	Drinking water nitrate has several negative human health implications
	Zhou, X., Al-Kaisi, M. & Helmers, J. M. (2009). Cost effectiveness of conservation practices in controlling water erosion in Iowa. Soil & Tillage Research, 106: 71-78.	No-till is most beneficial in areas prone to higher water erosion
Level 5 Evidence: Systematic Review of Descriptive Studies	Blay-Palmer, A., Sonnino, R. & Custot, J. (2016). A food politics of the possible? Growing sustainable food systems through networks of knowledge. Agric Hum Values 33: 27–43. https://doi.org/10.1007/s10460-015-9592-0	Network building is one of 6 shared issues for growing sustainable food systems!
	Brainard, S. & Selosse, F. (2019). Overcoming Bottlenecks in the Midwest Hazelnut Industry: An Impact Investment Plan. Savanna Institute and Hyphae Partners.	Hazelnuts are positioned to replace soybeans in the Midwest and create climate benefits
	Chavas, J. & Nauges, C. (2020). Uncertainty, Learning, and Technology Adoptionin Agriculture. Applied Economic Perspectives and Policy, 42(1): 42-53.	Reference for methods to facilitate practice adoption
	Compton, J.E., Harrison, J.A., Dennis, R.L., Greaver, T.L., Hill, B.H., Jordan, S.J., Walker, H. and Campbell, H.V. (2011), Ecosystem services altered by human changes in the nitrogen cycle: a new perspective for US decision making. Ecology Letters, 14: 804-815. doi:10.1111/j.1461-0248.2011.01631.x	Social costs of nitrogen

Level of Evidence	Study	Relevant Finding
Level 5 Evidence: Systematic Review of Descriptive Studies	Conant, R. T., Cerri, C. E. P., Osborne, B. B., and Paustian, K. (2017). Grassland management impacts on soil carbon stocks: a new synthesis. Ecol. Appl. 27, 662–668. doi: 10.1002/eap.1473	Improved grazing management, fertilization, sowing legumes and improved grass species, irrigation, and conversion from cultivation all tend to lead to increased soil C
	Crews, T.E. & Rumsey, B.E. (2017). What Agriculture Can Learn from Native Ecosystems in Building Soil Organic Matter: A Review. Sustainability, 9, 578. https://doi.org/10.3390/su9040578	Potential soil organic carbon accumulation rates in fields converted from annual to perennial grains of between 0.13 and 1.70 t ha−1 year−1.
	Delta Institute & Earth Economics. (2017). Valuing the Ecosystem Service Benefits from Regenerative Agriculture Practices: Farmland LP 2017 Impact Report.	Large valuations of ecosystems services from agriculture practices stem from many value pathways
	Dow, K., Haywood, B.K., Kettle, N.P. et al. The role of ad hoc networks in supporting climate change adaptation: a case study from the Southeastern United States. (2013). Reg Environ Change 13, 1235–1244. https://doi.org/10.1007/s10113-013-0440-8	Networks can strengthen climate adaptation capabilities
	Feather, P., Hellerstein, D. & Hansen, L. (1999). Economic Valuation of Environmental Benefits and the Targeting of Conservation Programs: The Case of the CRP. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 778	Reference for valuation of off-farm benefits of CRP land
	Franzluebbers, A.J., Paine, L.K., Winsten, J.R., Krome, M., Sanderson, M.A., Ogles, K. & Thompson, D. (2012). Well-managed grazing systems: A forgotten hero of conservation. Journal of Soil and Water Conservation, 67(4): 100A-104A; DOI: 10.2489/jswc.67.4.100A	Well-managed grassland can have significant environmental benefits but must overcome financial and behavioral obstacles
	Garrett, H.E., Kerley, M.S., Ladyman, K.P., Walter, W.D., Godsey, L.D., Van Sambeek, J.W., Brauer, D.K. (2004). Hardwood silvopature management in North America. Agroforestry Systems, 61: 21-33.	Tree planting can boost intergenerational equity
	Garrett, L. and Neves, B. (2016) Incentives for Ecosystem Services: Spectrum. Food and Agriculture Organization of the United Nations, Rome, Italy.	Incentive mechanisms span a spectrum of policy-driven investments to voluntary investments
	Grimsbo Jewett, J. & Schroeder, S. (2015). Continuous Living Cover Manual. Green Lands Blue Waters.	CLC can deliver simultaneous profitability, community benefits, and ecosystem services
	Hansen, L. & Ribaudo, M. (2008). Economic measures of soil conservation benefits: Regional values for policy assessment. USDA Technical Bulletin, (1922).	Costs of soil loss are large

Level of Evidence	Study	Relevant Finding
Level 5 Evidence: Systematic Review of Descriptive Studies	Hilimire, K. (2011). Integrated crop/livestock agriculture in the United States: A review. Journal of Sustainable Agriculture, 35(4), 376-393.	Integrated crop/livestock agriculture could improve soil quality,increase yield, produce a diversity of foods, augment pollinator populations, aid pest management, and improve land useefficiency.
	Imerman, M. & Imerman, E. (2019). Estimation of Financial Implications Resulting from the Implementation ofFarm Conservation Practices. Regional Strategic, LTD.	Cover crops and no-till can lead to net cost savings
	Interim Final Benefit-Cost Analysis for the Environmental Quality Incentives Program (EQIP). (2009). USDA Natural Resources Conservation Service. www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_007977.pdf	Ecosystem services of sustainable management practices have a postive return on investment
	IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.	Reference for future climate risks
	Kleppel, G. S. (2020). Do Differences in Livestock Management Practices Influence Environmental Impacts. Front. Sustain. Food Syst. 4: 141. doi: 10.3389/fsufs	Grazing management practices may prove to be a valuable tool for climate changemitigation
	Land Stewardship Project. (2013). Farm Transitions - Valuing Sustainable Practices Perennial Forages and Grazing.	Perennial forage production has a series of unique costs and benefits from other CLC strategies
	Landis, D. A. (2017). Designing Agricultural Landscapes for Biodiversity-Based Ecosystem Services. Basic and Applied Ecology, 18: 1-12.	Must redesign agricultural systems to improve ecosystem services
	Montenegro de Wit, M. & Iles, A. (2016). Towards thick legitimacy: creating a web of legitimacy for agroecology. Element: Science of the Anthropocene, doi: 10.12952/journal.elementa.000115	CLC must bundle the threads of legitimacy
	Natural Resources Conservation Service. (2009). Interim Final Benefit-Cost Analysis for the Environmental Quality Incentives Program (EQIP).	Valuation of various benefits from conservation practices eligible for EQIP payments
	Paine, L.K., Klemme, R.M., Undersander, D.J. & Welsh, M. (2000). Wisconsin's Grazing Networks: History, Structure, and Function. Journal Natural Resources and Life Science Education, 29: 60-67.	Grazing networks can address gaps in agricultural knowledge sharing
	Peterson, C.H. et. al. (2011). A Once and Future Gulf of Mexico Ecosystem: Recommendations for restoring a healthy and productive natural system. Pew Environment Group.	Adjusting U.S. farm policy to free up farmers to make locally appropriate decisios can reduce nutrient loss and increase perennialization.

Level of Evidence	Study	Relevant Finding
Level 5 Evidence: Systematic Review of Descriptive Studies	Piñeiro, V., Arias, J., Dürr, J. et al. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nat Sustain 3: 809–820. https://doi.org/10.1038/s41893-020-00617-y	Evidence in mixed in terms of effective interventions for supporting sustainable agriculture practices
	Pratt, M., Tyner, W., Muth, D. & Kladivko, E. (2013). Synergies Between Cover Crops and Corn Stover Removal, Purdue University.	Cover crop economic and environmental benefits
	Robertson, G. P., Gross, K. L., Hamilton, S. K., Landis, D. A., Schmidt, T. M., Swinton, S. M., Snapp, S. S. (2014). Farming for Ecosystem Services: An Ecological Approach to Production Agriculture. BioScience 64(5): 404-415.	Consumer WTP farmers for clean water is greater than GHG reductions
	Rosenberger, Randall S.; White, Eric M.; Kline, Jeffrey D.; Cvitanovich, Claire. 2017. Recreation economic values for estimating outdoor recreation economic benefits from the National Forest System. Gen. Tech. Rep. PNW-GTR-957. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 33 p.	Recreation value estimates
	Schut, M., Leeuwis, C. & Thiele, G. (2020). Science of Scaling: Understanding and guiding the scaling of innovation for societal outcomes. Agricultural Systems, 184.	Networks are often needed to support scaling
	Sobota, D.J. et al. (2015). Cost of reactive nitrogen release from human activities to the environment in the United States. Environmental Research Letters, 10 025006	Social costs of nitrogen are large, particularly in agricultural regions
	Sollenberger, L. E., Kohmann, M. M., Dubeux, J. C. B. & M. L. Silveira. (2019). Grassland Management Affects Delivery of Regulating and Supporting Ecosystem Services. Crop Science, 59:441-459.	Well-managed grazing can reduce GHG emissions
	Spratt, E., Jordan, J., Winsten, J., Huff, P., van Schaik, C., Jewett, J. G., ... & Paine, L. (2021). Accelerating regenerative grazing to tackle farm, environmental, and societal challenges in the upper Midwest. Journal of Soil and Water Conservation, 76(1): 15A-23A.	Benefits of regenerative grazing continue to be undervalued and under-incentivized
	Sustainable Agriculture Research and Education. (2019). Cover Crop Economics Opportunities to Improve Your Bottom Line in Row Crops. SARE Ag Innovations Series Technical Bulletin.	Change in net income from cover crops; Reference for impacts of cover crops
	The Nature Conservancy. (2016). reThink Soil: A Roadmap for U.S. Soil Health A ROADMAP FOR COLLECTIVE ACTION TO SECURE THE CONSERVATION AND ECONOMIC BENEFITS OF HEALTHY SOILS.	Reference for valuation of off-farm benefits from conservation practices
	Turner, B. L., Wuellner, M., Nichols, T., Gates, R., Tedeschi, L. O., & Dunn, B. H. (2017). A systems approach to forecast agricultural land transformation and soil environmental risk from economic, policy, and cultural scenarios in the northcentral United States (2012–2062). International Journal of Agricultural Sustainability, 15(2), 102-123.	Reference for potential long-term social and economic changes from agricultural land transformation

Level of Evidence	Study	Relevant Finding
Level 5 Evidence: Systematic Review of Descriptive Studies	Van Tassel, D.L., Tesdell, O., Schlautman, B., Rubin, M.J., DeHaan, L.R., Crews, T.E. & Streit Krug, A. (2020). New Food Crop Domestication in the Age of Gene Editing: Genetic, Agronomic and Cultural Change Remain Co-evolutionarily Entangled. Front. Plant Sci. 11:789. doi: 10.3389/fpls.2020.00789	Broad-based approches to domestication can also build buy-in to use of the crop
	Wigboldus, S., Klerkx, L., Leeuwis, C, Schut, M., Muilerman, S. & Jochemsen, H.. (2016). Systemic perspectives on scaling agricultural innovations. A review. Agronomy for Sustainable Development. 36. 10.1007/s13593-016-0380-z.	There are many forms of scaling that each can experience their own stress points
Level 6 Evidence: Single Descriptive/ Qualitative Study	Crews, T., Carton, W., & Olsson, L. (2018). Is the future of agriculture perennial? Imperatives and opportunities to reinvent agriculture by shifting from annual monocultures to perennial polycultures. Global Sustainability, 1, E11. doi:10.1017/sus.2018.11	Production systems today are geared towards efficiency and cost reduction, including reduced profit to farmers
	Deloitte. (2016). Capitalizing on the shifting consumer food value equation.	Value drivers (e.g. Health, Safety, Social Impact) are influential on consumer behavior
	Held, L. (2020). Industrial Meat 101: Could Large Livestock Operations Cause the Next Pandemic? Civil Eats.	Zoonotic disease risks exist with confinement livestock
	Kivimaa, P., Hyysalo, S., Boon, W., Klerkx, L., Martiskainen, M. & Schot, J. (2019). Passing the baton: How intermediaries advance sustainability transitions in different phases. Environmental Innovation and Societal Transitions, 31.	Intermediation is paramount from predevelopment to stabilisation of a transition
	Land Institute. (2019). Perennializing Grain Crop Agriculture: A Pathway for Climate Change Mitigation & Adaption.	Investment is perennial grain crop research is dwarfed by that of annual row crops
	Minnesota Pollution Control Agency. (2020). Five-year progress report.	Efforts to reduce nitrogen loss in MN are so far insufficient
	Monast, M. (2020). Financing Resilient AgricultureHow agricultural lenders can reduce climate risk and help farmers build resilience. Environmental Defense Fund.	Existing crop insurance inhibits climate change adaptation practices
	Patel-Weynand, T., Bentrup, G., Schoeneberger, M., Haan Karel, T. & Nair, PKR. (2017). Chapter 9: Challenges and opportunities. In: Schoeneberger, Michele M.; Bentrup, Gary; Patel-Weynand, Toral, eds. 2017. Agroforestry: Enhancing resiliency in U.S. agricultural landscapes under changing conditions. Gen. Tech. Report WO-96. U.S. Department of Agriculture, Forest Service. 131-142.	Economic and ecosystem system research is needed to boost agroforestry

Level of Evidence	Study	Relevant Finding
Level 6 Evidence: Single Descriptive/ Qualitative Study	Pretty, J., Attwood, S., Bawden, R., Van den Berg, H., Bharucha, Z., Dixon, J., . . . Yang, P. (2020). Assessment of the growth in social groups for sustainable agriculture and land management. Global Sustainability, 3, E23. doi:10.1017/sus.2020.19	Social capital formation can boost sustainability and farm economies
	Stevenson, G.W. & Pirog, R. (2013). Values-based food supply chains: Strategies for agri-food enterprises-of-the-middle.	Many challenges exist to create a value-added supply chain, but strategies can be used to address those challenges
Level 7 Evidence: Expert Opinion or Non-impact studies	Boyd, J. & Banzhaf, S. (2006). What are ecosystem services: the need for standardized environmental accounting unit. Resources for the Future.	Reference for ecosystem service definition and valuation
	Costanza, R. et al. (2017). Twenty years of ecosystem services: How far have we come and how fardo we still need to go? Ecosystem Services, 28:1-16.	Reference for state of ecosystem service literature
	Jackson, W. (2008). The necessity and possibility of an agriculture where nature is the measure. Conservation Biology, 22(6): 1376-1377.	The farm bill has insufficient time horizons
	Keeler, B., Polasky, S., Brauman, K., Johnson, K., Finlay, J., O'Neill, A., Kovacs, K. & Dalzell, B. (2012). Linking water quality and well-being for improved assessment and valuation of ecosystem services. Proceedings of the National Academy of Sciences, 109 (45): 18619-18624.	Reference for structuring a valuation of ecosystem services
	Osmond, D., Meals, D., Hoag, D., Arabi, M., Luloff, A., Jennings, G., McFarland, M., Spooner, J., Sharpley, A. & Line, D. (2012). Improving conservation practices programming to protect water quality in agricultural watersheds: Lessons learned from the National Institute of Food and Agriculture–Conservation Effects Assessment Project. Journal of Soil and Water Conservation 67(5): 122A-127A.	Reference for managing conservation practices to maximize water quality benefits

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