# Carbon and Agriculture: Getting Measurable Results
## A Report of the Coalition on Agricultural Greenhouse Gases
## EXECUTIVE SUMMARY

**Introduction**
The agricultural sector has a pivotal role to play in addressing, mitigating, and helping to adapt to climate change. Agriculture has significant potential to remove carbon dioxide ($CO_2$) from the atmosphere and store (or sequester) carbon while at the same time reducing its GHG emissions—in many cases at relatively low cost. With proper policies, the agricultural sector—which currently emits an estimated 6% of annual U.S. GHG emissions—can play a significant role in meeting the U.S. goal of achieving an 80% reduction in GHG emissions by 2050. In doing so, agricultural climate policy can both make an important contribution to the sustainable incomes of farming communities and provide a host of ancillary environmental benefits.

Careful consideration of the complexities of agriculture is warranted in order to craft and capture these opportunities in a way that is consistent with producing food, feed, fiber and fuel. Agriculture depends on many diverse biological processes and a great number of equally diverse actors across a variety of managed landscapes. Climate policies that consider the role of agriculture must address these complexities while creating programs that secure broad sectoral participation and maintain environmental integrity. It is also imperative that considerations of GHG emission abatement activities be integrated with other nutrient management issues associated with agricultural resource management, rather than considering them in a nutrient-specific or activity-specific manner. Conversely, incentives to achieve optimal environmental outcomes should consider and reward the many impacts of management activities or practices that have multiple beneficial outcomes.

**The Basic Science of Agriculture and Greenhouse Gases**
Agricultural emissions and sequestration affect three GHGs: carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), and methane ($CH_4$). The basic atoms of these GHGs are carbon and nitrogen. These atoms are also the main building blocks of plants and organic matter. Carbon and nitrogen molecules cycle dynamically between the landscape and the atmosphere through what is known as the carbon and nitrogen cycles. Much of agriculture is fundamentally about managing ecological landscapes and soils in a way that "tightens up" the carbon and nitrogen cycles to retain these valuable atoms in the production chain rather than releasing them to the atmosphere. Farmers can "grow" soil carbon at the same time that they grow crops and livestock. Policies that support both GHG reduction benefits (more stored soil carbon, less $CO_2$ and $N_2O$ emissions) while supporting traditional farm products will create tangible and globally beneficial results and outcomes. Further, capturing the GHG benefits as a marketable commodity, a carbon offset or credit, will allow the agriculture sector to leverage the broader carbon markets and related pools of investment.

**Quality in Agricultural Carbon**
Quality is typically a big differentiator in any purchasing decision. Whether one is buying coffee, corn, or carbon, it is important to know the quality of the commodity we seek. Basic levels or standards of quality are needed if markets are to function properly.

Because of the intangible nature of carbon credits, the quality criteria that buyers seek in carbon markets focus on the transparency of accounting and the use of unambiguous standards or metrics. Typically, the application of these standards is verified by independent, third-party "verifiers." Verifiers increases confidence in the marketplace that the GHG offset is real, and ensures that the quality of the offsets meet the established quality criteria.

The participants of C-AGG are confident that efforts to reduce agricultural GHG emissions and increase soil carbon sequestration can benefit farmers, landowners, and the environment if guided by science and undertaken transparently and with appropriate measurement, monitoring, and verification protocols.

**Principles to Guide Policy Design**

The members of C-AGG propose the following guiding principles for designing policies to enable the agricultural sector to participate effectively in the effort to mitigate climate change. Each principle is further delineated in the full report:

- ***Science-based.*** The design of agricultural climate policy must be informed by the best available science and should be adaptable over time to integrate improved science.
- ***Quantifiable, Verifiable, and Results-Based.*** Only quantifiable and verifiable programs and activities that deliver net reductions of atmospheric GHG concentrations should be rewarded.
- ***Innovation.*** Accelerating innovation is critical to delivering substantial net reductions in atmospheric GHG concentrations.
- ***Additionality.*** Only net reductions of atmospheric GHG concentrations beyond business as usual should be rewarded.
- ***Permanence.*** Programs and activities should provide for continued storage of sequestered carbon over timeframes that are meaningful in the context of mitigating climate change.
- ***Comprehensive GHG Accounting.*** A comprehensive accounting should be made of all significant GHGs affected by a program or activity.
- ***Co-benefits.*** Programs and activities should identify social and non-GHG environmental impacts and take steps to mitigate those impacts where possible.
- ***Bundling Environmental Benefits.*** Activities that generate multiple environmental benefits that can be clearly identified should potentially qualify for multiple credits or incentives.
- ***Stakeholder Engagement.*** Stakeholders should be engaged in a transparent, accountable consultation process with program administrators.

**Getting Measurable Results**

There is increasing recognition that participation by the agricultural sector is essential to achieving maximum environmental and climate benefits if we are to truly tackle the problem of climate change. Better information on a broad suite of agricultural activities and processes across the sectoral landscape is needed to fully incorporate the potential for agricultural offsets into climate change mitigation policies that both increase farm income opportunities and effectively remove GHGs from the atmosphere. Programs and activities to reward GHG mitigation should focus on the desired results, or performance, rather than the means of achieving the results, although certain practices have proved to deliver results.

Many ancillary benefits accrue to farmers and the environment as a result of activities that reduce GHG emissions and increase biological sequestration of carbon on agricultural lands. Carbon credits therefore provide a unique opportunity to financially reward farmers for beneficial ecosystem services. Properly crafted, market-based mechanisms that create the right market signals can also increase agricultural innovations that can enhance production efficiency and increase productivity as well.

**The State of the Science of GHG Measurement in Agriculture**

Measurement and verification is an essential underpinning to credible carbon markets and to efficient and effective carbon trading programs. All relevant and significant avoided GHG emissions and carbon sequestration from agricultural systems will require accurate measurement in order to be credited.

Measuring or quantifying GHGs from agricultural systems is challenging, but not necessarily more so than for stationary sources. For instance, emissions reductions measured from irrigation pumps or similar equipment will be estimated based on models and inputs that incorporate fuel used, time in use, engine type, etc. . In agricultural soils, carbon sequestered or nitrous oxide and methane emissions avoided can be measured or estimated in one or more ways:

- Measured directly using on-the-ground technologies,
- Measured indirectly through proxy variables,
- Estimated using remote sensing techniques, or
- Estimated using biogeochemical process modeling.

Each individual approach and technology has unique constraints related to costs, limitations, and sampling design requirements, and thus, resulting levels of uncertainty. As in any other industry or technology, all measurements will be associated with some uncertainty due to limitations of the measurement technology itself. Uncertainty can be managed through policy design, such as the use of a discount factor. Policymakers must determine both minimum acceptable levels of uncertainty and how the level of uncertainty will affect the credits granted.

Many credible, rigorous, scientifically valid technologies and methodologies to accurately measure and monitor soil carbon content and changes in content over time exist and are in use, and others are being developed. The challenge for carbon credit accounting will be integrating and commercializing these technologies with rigorous measurement protocols in the future as they become more mainstream and cost-effective; and building better methods for measuring net GHG fluxes from soils.

Models can scale up GHG point measurements to the farm or landscape scale, enabling an ecosystem view of GHG emissions. By incorporating multiple variables into GHG quantification, models push the boundaries of measurement beyond the plot or farm scale. Two types of models are used today to monitor soil GHG emissions and sequestration: empirical and process-based or mechanistic models.

Empirical models use field measurements to develop statistical relationships between soil carbon levels and agricultural management factors. Process-based (or mechanistic) models link important biogeochemical processes that control the production, consumption, and emission of GHGs. Over time, models have provided and will continue to provide increasingly robust data. While models can be very useful and informative, they do have limitations. At this time, however, models represent the most viable way of including methane and nitrous oxide in agricultural projects.

**Integrating Direct Measurements with Process Models to Cost-Effectively Quantify GHG Reductions**

The participation of agricultural projects in emerging carbon markets will be intricately tied to the methods used to understand, measure, and monitor GHG flux from agricultural landscapes. The key issue is that uncertainty in GHG measurements is generally inversely related to cost. Measurement costs at whole-farm scales present challenges that are best met by integrating direct measurement with process models in order to achieve the least amount of uncertainty at the lowest possible cost, particularly when considering non-$CO_2$ trace gases. As measurement costs decrease over time due to technological advances, experience, and improved data, smaller-scale and more diverse farm operations are more likely to benefit from direct measurement strategies. The right policies and incentives can drive continued investment and innovation in measurement technologies that increase certainty, reduce discounting, and ultimately result in more marketable carbon credits and financial returns to the agricultural sector—all while achieving GHG emissions reductions and ensuring the environmental integrity of the GHG mitigation program.

**Permanence**

If land-based credits or offsets are to be fully fungible, certain quality assessments must be undertaken and buyer assurances must be made. The question of permanence, which is really a measure of durability of carbon in terrestrial sinks, is complicated since offset projects involve biological systems influenced by natural events and managed by diverse and sometimes changing individual actors, as is the case for agriculture. It is possible, however, to ensure that the durability of environmental benefits from agricultural offset projects. A number of approaches have been developed in voluntary and regulatory carbon markets to account for potential losses or reversals of carbon from forestry and agriculture projects. It should be noted also that avoided emissions of nitrous oxides and methane from agricultural sources are by comparison permanent, and do not pose the same potential reversal as carbon in terrestrial sinks.

The potential for carbon loss or reversals is not a sound reason to exclude terrestrial sequestration activities, as there are many ways in which these risks can be addressed. Policy decisions will determine the terms under which offset trading will be allowed for carbon sequestered in soils and vegetation.

**Risks of Carbon Loss or Reversal**

Projects may suffer carbon losses from a variety of causes over which the project owner may or may not have control, including fire, drought, and pests. While some carbon losses may constitute reversals, others may represent relatively minor change in carbon stocks over time. Certain projects have more inherent risk than others. In addition, there is a difference between intentional and unintentional carbon loss or reversals. Intentional actions within the control of the project owner should be required to follow clearly defined requirements to replace affected credits quickly.

Policies can take into account the nature and risk of reversals, and project accounting can be designed with to account for all changes, regardless of intent.

**Tools for Managing Permanence Risk**

Forestry and agricultural commodity markets have developed a wide range of tools to manage risk over long periods of time, and many of these tools can be used with offset markets. In general, markets will reward projects that have been designed or structured to reduce the risk of carbon loss or reversal.

Project eligibility rules and accounting procedures will need to recognize and develop risk management strategies for each type of risk. The most common risk mitigation strategy in commodity markets is the use of standards to define minimal criteria to gain market entry. Products that do not meet standards cannot be sold. Frequently, discounting is also used. Discounts are based on predefined risk coefficients that assess the probability of a GHG loss or reversal occurring over a certain time period for a defined region or project type. Insurance mechanisms can also be used to assess risks of future reversals over a specified period of time. Types of insurance mechanisms in use in carbon markets include project buffer accounts, pooled buffer accounts, insurance contracts, and pooled vehicles (a hybrid of pooled buffers and insurance contracts). Temporary liability mechanisms and term offset credits have also been used, with mixed results.

**Agricultural Projects and Practices that Can Reduce GHG Emissions and Increase Sequestration**

Enormous potential exists for farms and ranches in North America to reduce GHG emissions and increase carbon sequestration—potential found everywhere from intensive dairy operations to extensively grazed ranches, from prime cropland to marginally productive wet fields and drought-prone areas. The activities that can reduce emissions on farms range from cutting-edge innovations using biochar pyrolysis and anaerobic methane digesters to simple practices like adjusting crop rotations or setting aside marginal areas for habitat restoration.

The C-AGG report briefly reviews some agricultural emission reduction/carbon sequestration practices and project types. The initial set of treatments included in the report is not an exhaustive list, but it is meant to be a "living document," with new information and activities added over time.

**Policy Issues**

Well-designed climate policies can support rural economic development and advance agricultural goals. The Coalition on Agricultural Greenhouse Gases has developed five overarching policy recommendations for incorporating agricultural GHG emissions reduction activities into U.S. climate change policies and programs. In summary, C-AGG believes that U.S. climate policy should:

- **Use a variety of policies and programs** to encourage GHG abatement in the U.S. agricultural sector.
- **Use the best available science and technology** to develop and reward GHG abatement activities in the U.S. agricultural sector.
- **Enable the federal government to create institutional arrangements that promote and facilitate improved GHG data collection and analysis**, and ensure accessibility of accurate, current data for all stakeholders.
- **Promote and encourage additional/ancillary benefits and positive impacts wherever possible**, and prevent or minimize any adverse impacts.
- **Enable the voluntary market to play a role in the transition to a fully regulated U.S. greenhouse gas market,** particularly through the development of early offset credits and methodologies.

**Conclusion: Key Agriculture and Carbon Policy Issues**

The agricultural sector should be included from the start in future GHG carbon offset trading systems for a number of important scientific, economic, and political reasons. Whether agriculture can meaningfully participate, however—and to what extent—will depend on the design of carbon crediting systems and the recognition of agriculture's unique role as a source of GHG emissions reductions as well as its ability to sequester carbon and reduce GHGs—all while providing society with food, feed and fiber.

Initially, the marketplace will determine where it is possible to use performance-based approaches, and where it is not. The role of regulations and the marketplace should be to create incentives that foster performance/measurement-based approaches that are economically feasible and practical at a variety of scales, including at the farm scale, across aggregated farms, and at watershed and regional scales.