Agricultural practices that reduce greenhouse gases (GHGs) and generate co-benefits

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Abstract

Human activities are increasing atmospheric greenhouse gas concentrations, and increasing temperature. The atmospheric concentration of carbon dioxide (CO_2) increased from a pre-industrial level of 280 ppm to 379 ppm in 2005, methane (CH_4) increased form 715 ppb to 1774 ppb, and nitrous oxide (N_2O) increased from 270 ppb to 319 ppb, and globally averaged surface temperatures increased 0.6 + 0.2^o C over the 20th century (Alley 2007 *Climate Change 2007: the Physical Science Basis.* Summary for Policymakers. In IPCC *Fourth Assessment Report*, pp. 1-18).

Stabilizing atmospheric GHG concentrations will require effort in every sector of the economy, including agriculture, forestry, manufacturing, minerals, and oil and gas. Agriculture, however, has a particularly important role to play in terms of carbon sequestration (Pew Center on Global Climate Change 1999 Agriculture's role in addressing climate change. http://www.pewclimate.org/ policy_center/ policy_reports_and_analysis/brief_agricultures. February 8, 2005; and McNaughton 2001 *A Workbook on Greenhouse Gas Mitigation for Agricultural Managers.* Alberta Environmental Sustainable Agriculture). Agricultural practices that offset or reduce GHGs (e.g. store carbon in plants and soil, or decrease methane and nitrous oxide emissions from agricultural lands and livestock) may also have a positive impact on the quality of air, soil, water, wildlife habitats, and indeed the broader environment (U.S. Environmental Protection Agency 2004 Environmental co-benefits of sequestration practices. http://www.epa.gov/sequestration/co-benefits.html. March 1, 2005).

This paper therefore identifies agricultural practices that reduce GHGs and generate environmental and economic co-benefits.

Keywords: climate change, agriculture, greenhouse gas reductions, economic and environmental co-benefits.

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1 Introduction

In light of the necessity to reduce agricultural gas emissions and the economic and environmental prospects for producers, this paper aims to elucidate the opportunities for GHG reductions and co-benefits. Specifically, this paper seeks to determine the reduction and co-benefit opportunities associated with the following agricultural practices: animal management; conservation tillage; crop management; fertilizer management; manure management; reduced fossil fuel use; shelterbelts; and soil and water management.

Following a thorough review of the literature, the author developed Table 1 showing the associated GHG reductions and the major co-benefits for the above agricultural practices; only those benefits listed in the literature were included. Because all practices have drawbacks (and these vary for the operation and location of the farm), only major disadvantages are presented. It is recognized that the table is far from exhaustive, but rather highlights major agricultural practices, the numerous opportunities for GHG reductions and co-benefits across a range of sub-sectors.

2 Conclusions

Based on the analysis in Table 1, it might be useful for producers to consider a GHG activity portfolio at different timescales—in the near term and in the long term. Some practices might be undertaken in short order, and at very little cost with multiple benefits: for example, improved soil management practices or crop rotation on forest soils. Over the longer term, farmers might employ low-cost changes in crop and livestock practices.

For many producers, these low-cost, climate-friendly practices may make good financial sense. Other farmers may, however, find that climate-friendly practices (particularly high-cost practices, such as afforestation or biofuels) do not make financial sense, and would therefore increase such practices only if financial inducements were available. Farmers might adopt new practices if payments were large enough to cover direct costs (e.g. the cost of new equipment, loss in profits caused by crop switching, etc.) and indirect costs (e.g. six years may be needed to successfully switch from conventional tillage to no-till) (Pew Center on Global Climate Change 1999).

Table 1: Agricultural practices that reduce greenhouse gases (GHGs) and generate co-benefits.

Practice	Description	GHG Reduction	Co-Benefit	Disadvantage
Soil management		-C sequestration -reduces N_2O emissions	-reduces compaction -reduces erosion -reduces particulates -reduces runoff -protects water quality -increases biodiversity	
Fertilization management (e.g. fertilizer selection; and controlled release fertilizers)	-accounts for all nutrient sources -fertilization according to a nutrient management plan that matches nutrient input to crop needs -uses nutrients that maximize uptake -places fertilizer in close proximity to roots -prevents build-up of nutrients in upper horizons of soil	-C sequestration	-increases yield -increases uniformity -reduces compaction -reduces erosion	-large portions of applied N (up to 50%) may leach into the environment
Manure management		-amount of N_2O emitted from manured soils depends on type of manure, N content, method and rate of application, and soil properties		
Safe storage	-until conditions right for application	-reduces CH_4 and N_2O emissions	-reduces risk of contaminated runoff	
Covered manure		-reduces CH_4 and N_2O emissions	-reduces ammonia -reduces particulates	

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Table 1: Continued.

Anaerobic digestion		-reduces CH_4 if energy consumed	-cost competitive -improves nutrient manageability -reduces pathogens -controls odours -provides energy	
Lower temperature		-reduces CH_4 emissions		
Aerate manure during decomposition		-most of the C will be released as CO_2 rather than as CH_4		
Application	-apply to land as soon as possible -avoid winter application -place manure efficiently -apply only as much as needed -use variable rates of application to reflect differences in soil fertility	-reduces CH_4emissions -C sequestration -reduces N_2O emissions	–value of $4-$20/ton in first year of application -increases organic matter -decreases particulates -increases yield -increases uniformity -reduces nutrient leaching (especially ammonia which can be toxic to fish at high concentrations)	
Conservation tillage	-crops are grown with minimal cultivation of the soil	-substantial increase in soil C' -reduces N_2O emissions	-improves productivity -reduces erosion -reduces pesticide loss -reduces excessive runoff -less time and energy	-may increase leaching potential
Crop management Remove land permanently from cultivation		-one of the fastest ways to restore soil C'	-reduces erosion -reduces particulate matter	-cost
Reduced summer fallow		-C sequestration (but less than those continuously cropped)		-requires weed control -enhances erosion -returns little residue to soil

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Table 1: Continued.

Adding organic material	-practices that favor higher photosynthesis -e.g. -using higher yielding crop varieties -using crops that keep all residues in fields	-C sequestration	-improves crop nutrition -improves soil quality -reduces particulates -reduces water stress	
Cover crops		-C sequestration -N fixation when legumes are used	-adds residue to soil -improves soil structure reduces particulate matter -acts as sink for nutrients -reduces excess soil nitrate -acts as weed control -reduces wind erosion -reduces damage to plants -reduces runoff -conserves water quality -increases biodiversity	
Grow woodlots/ Grow short-rotation woody crops		-C sequestration	-increases farm income -controls erosion -treats agricultural and community waste	
Agro-forestry	-an intense land management system that optimizes the benefits created when trees and shrubs are combined with crop and livestock production	-C sequestration	-increases crop production -improves efficiency -improves economic gain -improves soil quality -improves water quality -increases biodiversity	
Keep residues on soil surface		-C sequestration	-reduces erosion -reduces particulate matter -returns N annually to soil	
Convert crop residues to products with a long life (e.g. fibre-board)		-reduces C	-new products	

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Table 1: Continued.

Avoid burning residues		-burning increases C to atmosphere as CO_2	-reduces smoke and soot -reduces particulates	
Animal Management Improve grazing management		-C sequestration (amount of gain is unclear, and will depend on many factors, including initial soil content, etc.)	-reduces soil erosion -improves air and water quality –increases plant diversity	
Improve feed quality	-diets that increase the rate of digestion reduce CH_4 emissions -e.g. add oils -e.g. alter the type of bacteria in rumen -e.g. feed easily digestible feed grains, legumes, and silage	-reduces CH_4	-increases growth -raises profitability -reduces manure production -reduces N level in manure -reduces ammonia, which contributes to secondary formation of particulates	
Minimize amount of bedding		-reduces CH_4		
Shelterbelts		-C sequestration	-increases crop yields in fields adjacent to shelterbelts -hay and pasture yields increase with shelterbelts -provides diversification opportunities (e.g. fruit and maple syrup production) -controls erosion -reduces particulate matter -traps nutrients and prevents them from entering waterways -creates favourable micro-climates -protects plants from physical injury -protects animals from winter winds, and reduces stress on herds; as a result, cattle require less energy and feed to keep warm -in summer, provides cool shade and protection from hot winds -can anchor stream banks -can stabilize eroding gullies -provides wildlife habitat -reduces odours, and creates aesthetically pleasing landscapes	

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Table 1: Continued.

Water management	-by irrigation or by using water more efficiently	-C sequestration	-increases yields -reduces energy use -improves water quality	
Restore wetlands		-C sequestration	-restored wetlands can remove 90-100% of suspended solids, 90-100% of biochemical oxygen demand, 65-100% of total phosphorous, and 80-90% of total nitrogen from runoff -sustains many ecosystems	-increases CH_4
Reduce fossil fuel use		-reduces CO_2	-reduces CO, NO_x, $SO_{x,\ and}$ particulates -improves environmental and human health	
Grow crops that provide an alternative energy source		-fossil fuel substitution -reduces CH_4, CO_2, and N_2O		
Insulate farm buildings to reduce energy consumption		-reduces CO_2		-reduces cost
Reduce making and transporting fertilizers		-reduces CO_2		-reduces cost
Dry crops in the field, which reduces energy use		-reduces CO_2		-reduces cost
Maintain engines in efficient running order		-reduces CO_2		-reduces cost
Source: Compiled from the references on pages 8-10.				

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