DRAFT

Maine Greenhouse Gas Action Plan Development Process

Agriculture Greenhouse Gas Reduction Options

May 27th, 2004

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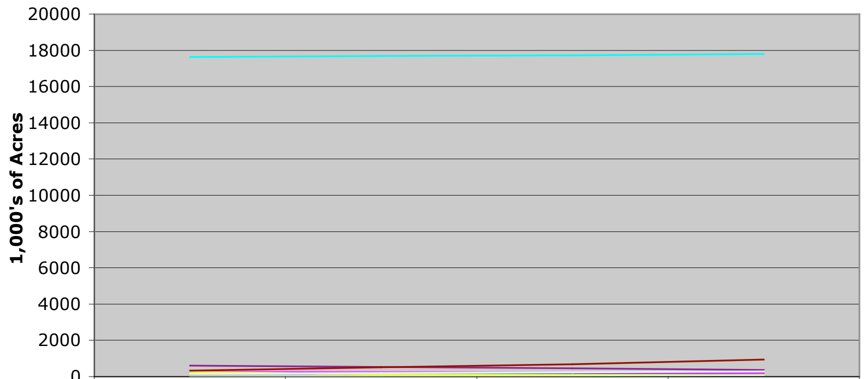
Inventory and Baselines

Figure 1 below shows historical and projected land cover change in Maine from the Natural Resource Inventory (NRI) from 1982-2020, using work group forecast assumptions. Wetlands are not included as a separate category and are embedded partially in the forest and agriculture categories. A simple linear extrapolation of historical trends in agricultural land from 1997 to 2010 and 2020 would show a complete loss of pasture in Maine and a very step decline of cultivated cropland. These trends were considered unlikely by the working group, and an alternate baseline method was constructed with the following assumptions:

- Conversion of forestland and other natural lands to urban land continues at a historical rate (196,000 acres over 15 years)
- Conversion of pasture to other uses occurs at one percent per year consistent with working group assumptions on livestock animal units (slower than historical rates of 142,000 acres per year that result in total loss of pasture land by 2010)
- Conversion of noncultivated cropland to other uses occurs at the historical rate (30,000 acres per 15 years)
- Conversion of cultivated cropland to other uses drops to zero after reaching a base acreage of 150,000 acres (slower than historical rates of 78,000 acres over 15 years that result in base acreages of 87,400 acres by 2010 and 35,400 acres in 2020)

Figure 1.

Maine Land Cover 1982-2020 (NRI, WG Adjusted)



	1982	1997	2010	2020
Cropland, cultivated	233	155	150	150
Cropland, noncultivated	288	258	232	212
Pastureland	265	123	107	99
Forest Land	17640	17691	17736	17804
Minor Land Cover/uses	610	537	474	376
Urban Land	332	528	697	956
Federal Land (cover/use not recorded)	168	207	241	293
Conservation Reserve Program	0	30	55	95

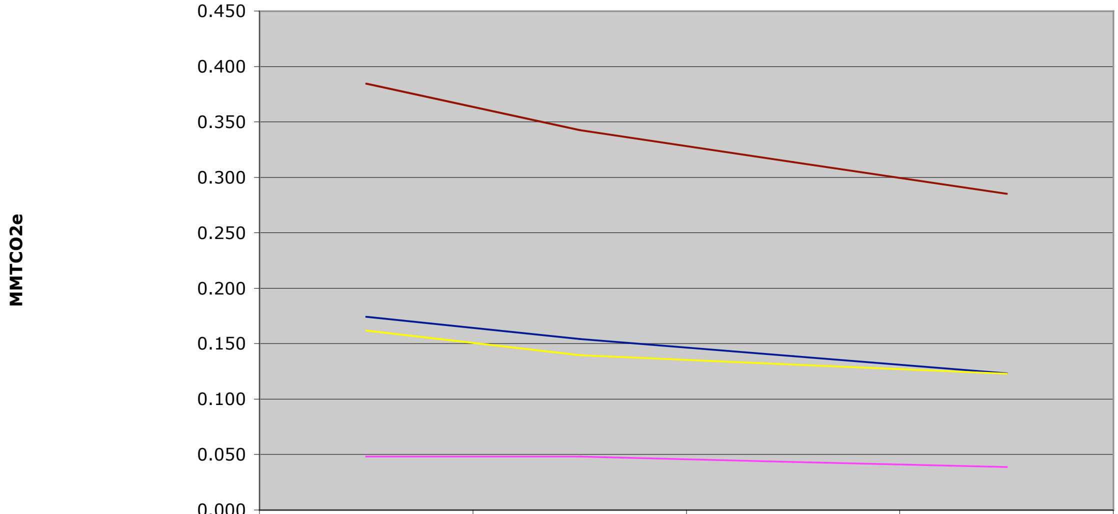
Years

Figure 2 below shows historical and projected agricultural greenhouse gas emissions for Maine from 1990-2020 using the EPA inventory tool with working group forecast assumptions. This includes carbon dioxide, methane and nitrous oxide. Enteric fermentation, manure management and soil carbon are included, but rice the categories of rice cultivation and agricultural residue burning showed no data for Maine and were excluded. Forecasted emissions from 1997 to 2010 and 2020 were developed using similar assumptions as indicated for NRI land cover data above, as follows:

- Methane emissions from enteric fermentation declined at one percent per year consistent with working group assumptions on animal units
- Methane and nitrous oxide emissions from manure management (fertilizer management of agricultural soils) declined at one percent per year consistent with working group assumptions on animal units
- Soil carbon losses declined at a rate of 0.6 percent per year consistent with the combined rate of acreage decline for cultivated and non cultivated cropland, and pasture.

Figure 2.

Maine Agriculture Baselines (EPA, WG Adjusted)

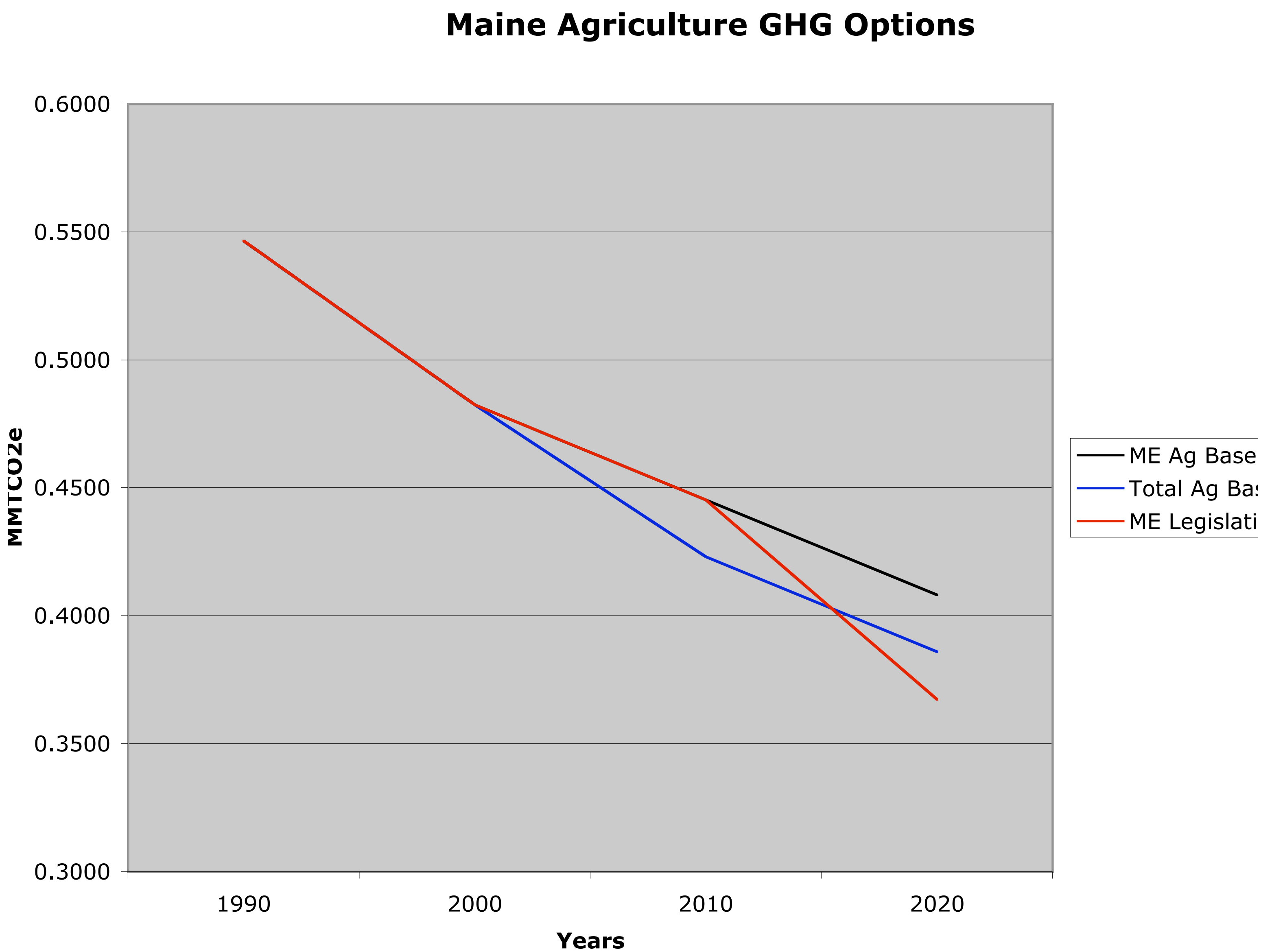


	1990	2000	2010	2020
Enteric Fermentation	0.174	0.154	0.139	0.124
Manure Management	0.048	0.048	0.044	0.039
Ag Soils	0.162	0.140	0.131	0.123
TOTAL	0.385	0.343	0.314	0.285

Year

Estimated GHG Savings & Costs

Policy Action	GHG savings 2010 (MMTCO2e)	GHG savings 2020 (MMTCO2e)	Cost Effectiveness ($MTCO2e)
Biodiesel and/or Ethanol for Farm Equipment	0.0002	0.0002	$323-1797
Nutrient Management – Organic And Synthetic	0.0016	0.0016	$0-?
Conservation Tillage/No Till	0.0091	0.0091	$2.10-27.90
Increase Cover Crops/Rotations Of High Organic Matter Crops	0.0015	0.0015	$2.10-27.90
Agricultural Land Preservation	0.0028	0.0028	TBD
Organic Farming	0.0030	0.0030	$2.10-27.90
Support Local Farming/Buy Local	0.0040	0.0040	TBD
Total	0.0222	0.0222	


Maine Agriculture GHG Options
0.6000
0.5500
0.5000
0.4500
0.4000
0.3500
0.3000
MMTCO2e
1990
2000
2010
2020
Years
ME Ag Base
Total Ag Ba
ME Legislati

Biodiesel or Ethanol Fuel for Farm Equipment

Policy Description: Incentives to expand qualification and use of lower carbon fuels with biomass additives.

BAU Policy/Program: Two pilot programs exist for biodiesel in Maine: 1) the Chewonki Foundation has a small-scale demonstration pilot underway; and 2) a cooperative exists in Hancock County to promote use of biodiesel through existing equipment. Neither program has a significant rate of market penetration at present. L.L. Bean Company recently began testing of B20 in its fleet with purchases of biodiesel from a plant owned by Frontier Energy in South China, Maine. A graduate program at USM is exploring establishment of a biodiesel fund to support fuel needs of campus VIP fleets. The Alternative Fuels Data Center (http://www.afdc.doe.gov/refuel/state_tot.shtml) lists three biodiesel fueling locations in Maine.

Estimated GHG Savings and Costs:

Variable	Data
Acres Soybeans	5,000
Bushels Soybeans	190,000
Gallons Biodiesel	135,714
MMTCO2 Displaced	0.0012
MMTCO2 Displaced - high life cycle	0.0002
MMTCO2 Displaced - low life cycle	-0.0005
Costs per gallon	$2.84
Cost per MTCO2e - no life cycle	$323.46
Cost per MTCO2e - high life cycle	$1,797.01

Key Uncertainties:

- Acres of soybeans economically available for biodiesel production in Maine
- Life cycle emissions rates
- Price per gallon in Maine

Notes:

- Potential GHG lifecycle impacts from renewable fuels vary widely due to farming practices and crop choice:
    - **Recent biodiesel data shown a range of +18% to - 221% net GHG impacts.** Biodiesel is potential high in terms of GHG emissions due to the nitrogen fixation ability of soybeans, which causes N_20 releases during harvest. An alternative crop (rapeseed), improved farming practices (low

till) or shifting current soybean crops (from feed to fuel) would mitigate this GHG impact.[1]

- **Cellulosic-based ethanol reduces GHG emissions by up to 80% vs. gasoline.** Current research at NREL as elsewhere indicates the potential for converting a variety of feed stocks, including corn stalk or stover (as well as those plants listed above), into low-GHG renewable fuels.[2]

References:

L.L. Bean Biodiesel announcement:
http://www.afdc.doe.gov/documents/altfuelnews/7_1states.html

USM Biodiesel Initiative: http://www.megreencampus.com/USMbiodisel.html

[1] Source: National Renewable Energy Laboratory (NREL) and Delucci et al.
[2] Source: Argonne National Laboratory's GREET model

Nutrient Management

Policy Description: Improve efficiency of fertilizer application. A portion of nitrogen applied to the soil is subsequently emitted as N_2O (a GHG); therefore, a reduction in the quantity of fertilizer applied or measures that improve uptake can reduce N_2O emissions. This can be accomplished by substituting organic fertilizer (primarily manure) for synthetic fertilizer, by altering the timing of applications, by altering cover crops and rotational schemes, or by increasing soil testing to improve efficiency (and reduce unnecessary applications).

BAU Policy/Program: Maine passed a Nutrient Management Law in 1998 (7 M.R.S.A. Chapter 747, Nutrient Management Act) that prevents winter manure spreading and requires a nutrient management plan. Maine also has an Agriculture Compliance program that requires plans and implementation of certain best management practices in order to quality for certain support payments. The Environmental Quality Incentives Program (EQIP) was reauthorized in the US Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. The Conservation of Private Grazing Land (CPGL) initiative ensures that technical, educational, and related assistance is provided to those who own private grazing lands. The USDA Conservation Security Program provides security payments to farmers in exchange for adoption of environmentally beneficial best management practices. The Agricultural Management Assistance Program provides cost share payments for land and water conservation to 15 states where federal crop insurance levels have been historically low, including Maine.

Estimated GHG Savings and Costs:

Potatoes BMP: Alter nitrogen application by applying 40 pounds initially, then waiting six to eight weeks for second application of 80 pounds as opposed to applying 120 pounds at the outset. Assume that 50 percent of current acreage of 65,000 acres uses traditional methods, and that 25 percent of the total acreage could be brought into the new application practice (16,500 acres) at a savings of 40 pounds per acre of fertilizer that will be fully incorporated by crops and not applied in excess (660,000 pounds nitrogen saved).

<u>Using the EPA Inventory Tool:</u>

Maine Potato growers could potentially reduce losses of 294,835 kg N as synthetic fertilizer during the calendar year 2005.

294,835 kg N x (1 – 0.1) = 265,351 kg unvolatilized N/yr

Convert emissions to N_2O-N using the 0.0125 emission factor, and then to units of N_2O using the molecular weight ratio, 44/28.

265,351 kg N/yr x 0.0125 N_2O-N/N x 44/28 = **5212.26 kg N_2O per year**

5212.26 kg N_2O = 5.74 tons N_2O x 310 Global Warming Potential (GWP) = **1779.4 tons CO2e per year**

Variable	Data
Acres brought into new BMP annual	16,500
Pounds fertilizer saved per acre annual	40
Pounds fertilizer saved total annual	660,000
MTN2O saved per year	5.20
MTCO2e saved per year	1614.2
MMTCO2e saved per year	0.0016
Cost per MTCO2e saved per year (assumed to be economical)	$0

Key Uncertainties:

- Acreage that can be brought into new BMP
- Cost per acre of new BMP

Conservation Tillage/No-Till

Policy Description: Practices that result in less disruption of the soil or increase organic content through carbon deposition can increase the carbon content (stock) of soil or reduce its rate of loss (flow) to the atmosphere.

BAU Policy/Program: A variety of support programs exist to encourage conservation tillage or no till agriculture. Maine has an Agriculture Compliance program that requires plans and implementation of certain best management practices in order to quality for certain support payments. The Environmental Quality Incentives Program (EQIP) was reauthorized in the US Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. The Conservation of Private Grazing Land (CPGL) initiative ensures that technical, educational, and related assistance is provided to those who own private grazing lands. The USDA Conservation Security Program provides security payments to farmers in exchange for adoption of environmentally beneficial best management practices. The Agricultural Management Assistance Program provides cost share payments for land and water conservation to 15 states where federal crop insurance levels have been historically low, including Maine.

Estimated GHG Savings and Costs:

Variable	Data
Acres of cropland potential for conservation tillage in Maine*	100,000
Potential percent increase in soil organic matter	2.00%
Potential percent increase in organic content	1.75%
Pounds soil per acre	2,000,000
Percent soil organic matter	1.00%
Pounds soil organic matter per acre	20,000
Percent SOM that is Organic Carbon	50.00%
Potential annual rate of SOM increase	2.00%
Pounds OC sequested per acre per year	200
Total lbs OC sequestered per year	20,000,000
MMTCO2e sequestered per year	0.0091
Cost per MTCO2e BMP - low (ERS)	$2.10
Cost per MTCO2e BMP - high (ERS)	$27.90

* Calculations are based on data and assumptions provided by Ivan Fernandez of UM except as otherwise noted.

Key Uncertainties:

- Acreage that can be brought into new BMP
- Type and effectiveness of BMP
- Cost per acre of new BMP
- Retention of soil carbon increases over time

Increase Cover Crops

Policy Description: Increasing the use of cover crops can potentially increase soil carbon content and increase the nitrogen content of soil and reduce fertilizer need. Increased use and length of high organic rotation crops can also increase incorporation of nitrogen and storage of carbon.

BAU Policy/Program: A variety of potential support programs exist. Maine has an Agriculture Compliance program that requires plans and implementation of certain best management practices, including tillage practices, in order to quality for certain support payments. The Environmental Quality Incentives Program (EQIP) was reauthorized in the US Farm Security and Rural Investment Act of 2002 (Farm Bill) to provide a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land. The Conservation of Private Grazing Land (CPGL) initiative ensures that technical, educational, and related assistance is provided to those who own private grazing lands. The USDA Conservation Security Program provides security payments to farmers in exchange for adoption of environmentally beneficial best management practices. The Agricultural Management Assistance Program provides cost share payments for land and water conservation to 15 states where federal crop insurance levels have been historically low, including Maine.

Estimated GHG Savings and Costs:

Variable	Data
Acres of cropland potential (potatoes/clover)	16,500
Potential percent increase in soil organic matter	2.00%
Potential percent increase in organic content	1.75%
Pounds soil per acre	2,000,000
Percent soil organic matter	1.00%
Pounds soil organic matter per acre	20,000
Percent SOM that is Organic Carbon	50.00%
Potential annual rate of SOM increase	2.00%
Pounds OC sequested per acre per year	200
Total lbs OC sequestered per year	3,300,000
MMTCO2e sequestered per year	0.0015
Cost per acre BMP	
Cost per MTCO2e BMP - low (ERS)	$2.10
Cost per MTCO2e BMP - high (ERS)	$27.90

Key Uncertainties:

- Acreage of land that can adopt new BMP

- Type and rotation of cover crop
- Local site and climate effects
- Costs per acre of adopting the BMP

Agricultural Land Conservation

Policy Description: Preservation of agricultural land can retain ability of land to sequester carbon from the atmosphere and reduce transportation emissions by directing growth to more efficient locations.

BAU Policy/Program: A variety of programs that potentially affect land conversion rates exist. The Land for Maine's Future Program (LMFP) was developed in 1987 to protect natural and working lands through financing of easements or fee title; 50 percent of funds must be matched. The USDA Farm and Ranchland Protection Program (FRPP) also provides limited cost sharing for land protection. Maine's Farm and Open Space Tax Law was developed in 1975 to provide tax relief to farm and forestland owners. The Maine Tree Growth Tax Law was enacted to provide property tax relief to owners of woodlots and forestlands. The USDA Farm and Ranch Land Protection Program (FRPP) provides matching funds to help purchase development rights to keep productive farm and ranchland in agricultural uses. The USDA Wetlands Reserve Program is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The Wildlife Habitat Incentives Program (WHIP) is a voluntary program for people who want to develop and improve wildlife habitat primarily on private land. Growth management policies and programs also significantly affect farmland protection, including zoning, property taxation, and infrastructure funding (particularly transportation) as well as private preservation actions by land trust organizations.

Estimated GHG Savings and Costs:

Variable	**Data**
Acres of land cover saved 15 years	60,000
Acres of land cover saved per year	4,000
Housing units affected (1 home per acre average)	4,000
Density increases resulting from land conservation	44.12%
VMT per household before	1,333
VMT per household after	1,267
Gallons fuel reduction per HH from land conservation	186,047
MMTCO2e avoided from land conservation/VMT annual	0.0017
MMTCO2e avoided from land conservation/VMT 2010 (10% of base)	0.0017
MMTCO2e avoided from land conservation/VMT 2020 (20% of base)	0.0017
Soil carbon saved from avoided development MMTCO2e (25% disturbance on new development sites)	0.0011
Total annual carbon savings per acre saved land	0.0028
Total annual carbon costs per acre saved land	TBD

Key Uncertainties:

- Location of saved land relative to existing service areas

- Changes in housing density and location resulting from land savings
- Impact on VMT rates of changes in housing density and proximity
- Degree of soil disturbance per acre from conversion to developed uses
- Soil carbon levels per acre
- Soil carbon emission rates per acre from development

Organic Farming

Policy Description: Organic farming techniques can reduce on-farm energy uses (e.g., reduced tractor use) by reduced tillage (see 3.1) and off-farm energy (e.g., reduced transportation of fertilizer and pesticides).

BAU Policy/Program: About 20,000 acres of farmland in Maine are presently in organic farming out of 155,000 acres of total cultivated cropland. The Maine Organic Farming Association expects this to grow to 30,000 acres by 2010 and then cease to increase. They believe that aggressive public policy could increase this acreage level to 70,000 acres by 2020 (a 40,000 acre increase). Some existing state and federal programs could assist in this effort, including the USDA Resource Conservation and Development (RC&D) program and recently promulgated organic food standards by USDA.

Estimated GHG Savings and Costs:

Variable	Data
Acres of cropland converted - potential	33,500
Potential percent increase in soil organic matter	2.00%
Potential percent increase in organic content	1.75%
Pounds soil per acre	2,000,000
Percent soil organic matter	1.00%
Pounds soil organic matter per acre	20,000
Percent SOM that is Organic Carbon	50.00%
Potential annual rate of SOM increase	2.00%
Pounds OC sequested per acre per year	200
Total lbs OC sequestered per year	6,700,000
MMTCO2e sequestered per year	0.0030
Cost per acre BMP	
Cost per MTCO2e BMP - low (ERS)	$2.10
Cost per MTCO2e BMP - high (ERS)	$27.90

<u>Key Uncertainties:</u>

- Amount of cropland that can be converted to organic farming (the current analysis assumes that all cropland in Maine is under conservation till or cover crop by 2020)
- Soil carbon savings of organic farming
- Reduced fuel use from organic farming
- Costs of converting to and practicing organic farming (above cost figures are based on conservation tillage adoption but not other changes in management)

<u>References:</u>

- Maine organic farmers and gardener's association: http://www.mofga.org/
- Rodale Institute Study: http://www.newfarm.org/depts/NFfield_trials/1003/carbonsequest.shtml

Support Local Farming/Buy Local

Policy Description: Increased purchase of locally grown produce can potentially reduce emissions associated with the transport of agricultural products.

BAU Policy/Program: The purpose of the USDA Resource Conservation and Development (RC&D) program is to accelerate the conservation, development and utilization of natural resources, improve the general level of economic activity, and to enhance the environment and standard of living in designated RC&D areas.

Estimated GHG Savings and Costs:

Gallons of fuel annually saved Iowa/10% policy	8,800,000
Pounds CO2 saved	198,400,000
MMTCO2e reduced from fuel savings	0.09
Iowa population 2003	2,944,062
Maine population 2003	1,305,728
Population adjusted Maine MMTCO2e savings	0.04
Costs per MTCO2e	TBD

Key Uncertainties:

- Percent of food categories that can be shifted to locally grown
- Relative mix of food categories compared to Iowa
- Travel distance of food under present (conventional) circumstances
- Cost of growing food locally vs. elsewhere (as determined by market)
- Incentive system required to make producer and consumer shifts viable

References:

- Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions. Leopold Center for Sustainable Agriculture 209 Curtis Hall Iowa State University Ames, Iowa 50011-1050 Website: http://www.leopold.iastate.edu/