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**Agriculture & Forestry Technical Work Group
Policy Option Descriptions, June 20, 2006
For TWG Call #9 (June 27, 2006)**

NOTES:

Document format: This revised format for policy descriptions and results is consistent with format that we will be using as an appendix to the final CCAG report.

Yellow highlights: These indicate comments or changes to the policy option write-ups since the last CCAG meeting. Please review these carefully.

Data gaps: Data gaps and uncertainties have been listed within the text for each option.

Policy overlaps: The TWG will need to note areas where policies overlap and potentially impact the quantification of benefits and costs. This issue will be addressed during the TWG Call#9.

F-1 Forest and Rangeland Protection from Developed Uses

Option Category: Quantified

Policy Description: Reduce the rate at which existing forest and rangeland are cleared and converted to developed uses.

Policy Design:

- **Goal levels:** Reduce by 50 percent the total acres of forestland expected to be lost from land clearing and converted to developed uses over the project period.
- **Timing:** Policy initiation by 2010; 30% reduction achieved by 2012; 50% reduction achieved by 2020; no net loss achieved by 2030, continuing through 2050.
- **Parties:** County governments, New Mexico Environment Department, Forest Legacy program (NM EMNRD), Natural Lands Protection program (NM EMNRD), private non-profit land trusts. Forest protection accomplished through acquisition of conservation easements and fee title by public and private conservation organizations. The NM Land Conservation Incentive program provides tax relief for landowners who donate conservation easements to private non-profit land trusts.
- **Other:** Criteria for land protection have been established by existing public land protection programs such as the federal/state Forest Legacy program and the federal Grassland Reserve Program. Private land trusts may have different criteria.

Implementation method(s):

i. *Information and education/ Research and development*

(1) Development of a carbon sequestration assessment program that would assess and assign carbon sequestration value to the state's natural, working agricultural (see Option #A8), as well as native prairie and grasslands. This carbon sequestration map and ancillary data could support a variety of GHG reduction policies, including: establishment of property tax incentives for carbon sequestration on natural lands (#2 above); identification of high priority lands for carbon protection; and acquisition of natural lands by utilities/other large CO2 emitters needing to offset emissions in a carbon-restricted economy.

ii. *Technical assistance—Mechanism (4) under Funding Mechanisms below would enhance technical assistance from DFA for Transfer of Development Rights programs.*

iii. *Funding mechanisms and or incentives*

The following mechanisms may be appropriate to decrease the rate at which natural lands are converted to developed use:

(1) Enhancement of incentives for placement of no-development easements on private land through the Land Conservation Incentives Act – possibly through establishment of

limited-term carbon sequestration leases whose cost is linked to the “carbon sink” value of natural lands.

(2) Establishment of an “Agricultural/Conservation Land Reserve” that would establish a pool of permanently protected forest, agricultural or other conserved lands. This can be accomplished through either a mandatory or voluntary reserve, though applications to enter or exit the reserve are voluntary under both mechanisms. Owners of natural/agricultural land would be given a choice: 1) opt into the land reserve now, and maintain low property taxes (or qualify for reduced taxes), or 2) opt out of the land reserve, and be assessed property taxes at closer to the “developable” rate. Once the land base in the ALR has been established, no property can be removed from the ALR without transferring an equivalent property into the Reserve.

(3) Creation of a state “Grassland Reserve Program” that would establish County and State tax incentives for private landowners who voluntarily maintain native (untilled) prairie or grassland, and who have enrolled their land in the federal Grassland Reserve Program.

(4) Enhancement of the existing statewide Transfer of Development Rights (TDR) program which allows purchase and trade of development rights between high density and low density areas to conserve open space, agricultural land and forest land on the margins of growing urban areas. Devoting additional staff and funding to the existing program within the Dept of Finance and Administration.

iv. *Voluntary or negotiated agreements/ Market based mechanisms*

Creation of “Efficient Home Mortgages” program that would expand upon the established Location Efficient Mortgage model (found in Chicago, Seattle, and Los Angeles), offering low down payments, low interest rates and flexible qualification criteria e.g. “grossing up” the household income for individuals interested in purchasing eligible “efficient properties”. These would be programs offered by the private sector/financial and lending institutions involving a voluntary offering and participation.

v. *Codes and standards*

State level planning to encourage/enable “Transit Oriented Development”, creating communities where easily accessible public transit augments living, working and recreation needs reducing rapid growth into undeveloped land on the margins of communities, reducing vehicle miles traveled.

vi. *Reporting*

Mechanism (1) under Information and Education would enable reporting from the agricultural and forestry sectors, widening market participation in a carbon restricted economy

vii. *Administrative/ Funding/ Codes/ Market Based Mechanisms*

Development of a state-based, comprehensive “Road Pricing Policy” including measures

such as pay-as-you-drive insurance, weight-distance road user fees, congestion pricing, high occupancy toll lanes, etc. Each of these measures would generate revenue for road maintenance, reduce congestion and vehicle miles traveled.

Related Policies/Programs in place: Natural land protection is currently accomplished at the state level through acquisition of conservation easements and fee title by the NM EMNRD (through the Forest Legacy Program) and by private non-profit conservation organizations such as the Santa Fe Conservation Trust. The NM Land Conservation Incentive program provides tax relief for landowners who donate conservation easements to qualifying private non-profit land trusts.

Types(s) of GHG Benefit(s):

- **CO₂:** Carbon savings occur when live carbon stocks (trees, shrubs, and some soil organic carbon) are protected from clearing and the associated decay or combustion of cleared biomass. Carbon losses are offset to some extent by the portion of harvested biomass that is converted to durable wood products (carbon storage in product use), and for that portion converted to renewable energy and displaces fossil energy use that otherwise would be used. Because conversion of forest and rangeland to developed land uses typically is permanent, replacement biomass does not grow back on the site to previous levels to offset removals of live biomass and soil carbon (i.e., to the levels that existed during forest/rangeland use).
- **CH₄:** New research indicates that about four percent of the carbon storage benefit of live forests is offset by methane release. Methane can be released from land filled biomass under anaerobic conditions.
- **Black Carbon:** Emissions of black carbon (soot) result from combustion of biomass from open burning during land clearing, but the heating effect is likely to be offset by the large amount of organic material that is also emitted during biomass combustion.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** 0.1, 0.2
- **Net Cost per MtCO₂e:** \$13

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** The number of acres that moved from forested land and rangeland to developed uses between 1982 and 1997 was obtained from the USDA Natural Resource Inventory (NRI). Based on comparison of rangeland acreage from NRI and pinyon-juniper acreage from USDA Forest Service, it was determined that roughly 20% of rangeland is pinyon-juniper. For the purposes of this analysis, pinyon-juniper is considered forested land. Forest carbon stock per acre data values were calculated from 1997-1999 USDA Forest

Service carbon stock and acreage data (the latest data available).¹ The above-ground forest carbon density average for NM was estimated to be 28.5 MtC/1,000 acres, and the below-ground density was estimated at 9.7 MtC/1,000 acres (below ground density represent soil organic carbon only). Cost data for conservation easements on forested lands was obtained from the New Mexico Forest Legacy Program and the Nature Conservancy.^{2 3} The mid-point in the range of estimates for purchasing conservation easements was \$1,960/acre.

- **Quantification Methods:** The annual rate of loss from the NRI data was determined to be 3,880 acres/yr (combined forest and rangeland based on loss rates from 1982-1997). The rangeland acreage was adjusted to reflect the amount of pinyon-juniper forest on these lands (20% of rangeland in the NRI was estimated to be pinyon-juniper forest). Reducing the loss rate by 50% yields 1,900 acres/yr protected. Assumptions regarding carbon losses due to development are: for each acre lost to development, 10,000 sq ft (0.23 acre) loses 100% of soil carbon; the remainder of that acre loses 25% of soil carbon; 90% of above ground carbon is lost. The number of acres saved per year was multiplied by the loss of carbon on these acres to estimate carbon savings. Carbon savings were then converted to CO₂e. Costs were estimated by multiplying the acreage saved per year by the cost of conservation easements shown above.
- **Key Assumptions:** Some rangeland carbon estimates are not currently included in forest carbon estimates due to data limitations; however, “nonstocked” and “pinyon-juniper” forest stands as defined by FIA include many lands classified as “rangeland” by NRI. Forecasted carbon stock measurements from 2002 to 2020 are based on extrapolations of past trends from 1982-2002 and assume a static continuation of all land cover and land use dynamics during that period. Implementation mechanisms are assumed to be “growth neutral” to avoid offsetting development impacts, i.e. land protection does not result in land clearing in other areas (also referred to as “leakage”).

Key Uncertainties:

- **Benefits:** The rate at which live biomass stocks would have declined beyond business as usual due to forest health and forest fire risks may be significant. The rate of offsetting development effects from land protection may be sensitive to the design of policy implementation tools.
- **Costs:** Cost savings from avoided land clearing costs (not quantified in this assessment) may be contingent on regulatory acceptance of alternative land development approaches, such as conservation design or cluster development.

Contributing Issues, if applicable:

- **Human and social issues**

¹ Jim Smith, USDA Forest Service, personal communication with S. Roe, CCS.

² Bob Sivinski, NM Forest Legacy Program, personal communication with H. Lindquist, CCS, June, 2006.

³ Bob Findling, The Nature Conservancy, personal communication with H. Lindquist, CCS, June, 2006.

- Protection of working lands for sustainable wood products use, recreation, cultural and natural heritage.

- **Environmental issues**

- Environmental asset protection, including watersheds (water quality and quantity, biological diversity, wildlife and air quality).

- Reduced transportation emissions from increased location efficiency.

- **Economic issues**

- Reduced costs of infrastructure and services for dispersed or low density development.

- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

F-2a Forest Health and Restoration – Residential Lands

Option Category: Quantified

Policy Description: Manage sustainable thinning or biomass reduction from residential forestlands (intended to address fire and forest health issues), so that harvested biomass is directed to wood products and renewable energy instead of open burning or decay. Residential forested areas are primarily located at the fringe of development and are often referred to as the wildland-urban interface (WUI).

Policy Design:

- **Goal levels:** A goal of expanding the usage rates of biomass extracted from forested residential lands for wood products and/or energy production **to 50%** is recommended. The TWG recognizes that 100% biomass utilization is not achievable due to access to the material or to efficient methods of transporting the material to processors/end users.
- **Timing:** Begin ramp up in 2007 and reach full yearly implementation by 2012 and continue through at least 2020.
- **Parties:** State Forest Service (NM Energy Minerals and Natural Resources Department),

NM Public Regulation Commission, City/County Governments, Private Industry.

- **Other:** For the purposes of estimating GHG benefits and costs, biomass is assumed to be utilized for the production of commercial steam/space heat or residential space heat. As stated above, other end uses (electricity generation, liquid fuels, durable wood products) should also be targeted by this policy.

Implementation method(s):

i. Funding mechanisms or incentives/Market based mechanisms

The following mechanisms function to increase the rate at which the by-products of forest thinning at the wildland-urban interface are used to create wood products (e.g. building materials and furniture) or to generate renewable energy:

- (1) Provide tax incentives to reduce the capital costs of biomass energy production, including electricity generation and heating of residences and public buildings. This could include tax reductions in state sales tax for a wide variety of biomass-related equipment, including but not limited to biomass harvesting/collection equipment, biomass gasification equipment, biomass electricity generation equipment, and high efficiency wood pellet stoves. Gross receipts exemptions for biomass generation facilities, project construction and related equipment and materials are also recommended.
- (2) Establish utility “Buyback Rates” for “Feed-in-Tariffs” for biomass derived energy where utilities offer a standard rate for which they purchase biomass generated energy (electricity and/or heat). This program could be structured in a similar fashion to PNM’s existing solar energy buyback program, where they purchase the renewable energy credits from customer owned solar projects for 13 ¢/kWh for 10 years and apply those credits to their RPS requirements. Buyback rates for biomass projects in other regions of the country generally range from 6-7 ¢/kWh.
- (3) Expand the NM Renewable Energy Tax Credit by lowering the eligible threshold capacity from 10 MW down to 1 MW as well as expanding the classification of corporate taxpayers and including general income taxpayers.

ii. Codes and standards

- a. Increase efficiency standards for wood burning equipment and appliances (e.g. wood burning furnaces and stoves).
- b. Expand existing net-metering regulations to enable projects up to 2 MW in size to net-meter at retail energy rates.

Related Policies/Programs in place: Current residential/municipal fire risk and forest health initiatives oriented toward density reduction include the multi-agency National Fire Plan, Western Governors Association 10-Year Comprehensive Strategy for Implementation of the National Fire Plan, federal Collaborative Forest Restoration Program, NM Forest and Watershed Health Restoration Plan, the federal FIREWISE program, various FEMA programs for fire risk

mitigation on private residential lands, and the establishment of the NM Forest and Watershed Restoration Institute, and many other local, state and federal initiatives too numerous to list.

Current programs designed to increase market use of small diameter trees for energy and wood products include various Department of Energy and USDA Forest Service grant programs, Collaborative Forest Restoration Program, and others. Various incentives exist to promote the development of renewable energy in New Mexico, including the Renewable Portfolio Standard, which requires that 10% of IOU energy supplied to in-state consumers come from renewable sources by 2011. This requirement grants a 2x credit multiplier to biomass related projects and has established a Reasonable Cost Threshold of (6-8 ¢/kWh) for biomass projects. Any subsequent tax credits will better enable biomass projects utilizing forest and agricultural waste to compete within this arena. Currently, there exists a NM production tax credit (PTC) for large scale renewable projects 10 MW in capacity and greater, as well as compensating tax deductions for biomass equipment. Additionally, the state enables net-metering at retail rates of renewable projects 10 kW in capacity and smaller.

Types(s) of GHG Benefit(s):

- **CO₂:** Carbon savings occur when live and dead carbon stocks (trees, shrubs) that otherwise would decay or burn in the forest, or be left for decay and or open burning following harvest, are harvested and converted to: 1) durable wood products that store carbon; 2) to low embedded energy wood building materials that substitute for high embedded energy conventional building materials (steel and concrete); or 3) to renewable energy that displaces fossil energy use. Sustainable management ensures that replacement biomass grows back to the maximum extent on thinned sites to offset removals of live biomass.
- **CH₄:** New research indicates that about four percent of the carbon storage benefit of live forests is offset by methane release. Methane can be released from land filled biomass under anaerobic conditions.
- **Black Carbon:** Emissions of black carbon (soot) result from combustion of biomass from open burning of land clearing, but the heating effect may be offset by the large emissions of organic material associated with biomass combustion.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** 0.2, 0.2
- **Net Cost per MtCO₂e:** \$-21

Data Sources, Methods and Assumptions (for quantified actions):

Benefits and costs were estimated by assuming that all of the biomass energy would be utilized in commercial/municipal boilers or residential space heating equipment (e.g. pellet stoves). Benefits are estimated by quantifying the CO₂e reduced by offsetting an equivalent amount of energy from natural gas combustion. However, it should be noted that this policy supports all

beneficial energy uses of biomass.

- **Data Sources:** CCS obtained data on both mechanical and fire treatments conducted in NM from 2001 – 2006.¹ These data contained information on treatments that had occurred on both wildland-urban interface (WUI) lands and non-WUI lands. The WUI lands are those considered to be residential areas applicable to this option. The average acres treated during these years was used as the starting point for analysis. The average carbon stocking on NM forestlands was taken from the USFS data that underlie the AZ Inventory & Forecast (i.e. USFS FIA). Estimates of the fraction of biomass to be removed in WUI and non-WUI areas were taken from an assessment by a researcher at Colorado State University.² A reduction in basal area of 42% associated with an “Intermediate Restoration Level” was selected for WUI lands. The reduction in basal area was assumed to be representative of a reduction in biomass density. The cost of producing pelletized fuel (\$134/ton) was taken from a Canadian study.³
- **Quantification Methods:** The amount of biomass removed during forest health projects was calculated by multiplying the annual acres treated by the above ground carbon density and the treatment fraction (0.42). CCS assumed that 50% of the biomass from both mechanically-treated and fire-treated areas would be diverted to energy use (pelletized fuel for space heat for the purposes of this analysis). The heat content associated with the diverted biomass was then used to estimate the equivalent amount of natural gas offset (with no adjustment for potential differences in energy efficiency between gas-fired and pellet-fired equipment). Emissions from this offset natural gas were quantified as the benefit of this option. No effort was made to quantify the embedded energy (and CO₂e) associated with biomass diversion (e.g. CO₂e associated with transport of biomass, pelletizing, and product transport). These were not considered since the life-cycle emissions associated with natural gas production and delivery were not included. The cost savings for this policy were estimated as the costs for offsetting the natural gas.
- **Key Assumptions:** Current use of forest biomass from treatment projects is essentially zero. Historical treatment areas are representative of future treatment programs and are the only source of forest biomass. The average NM forest carbon density is representative of areas requiring treatment (areas requiring treatment could be stocked at levels higher than the state average). Energy diversion (50%) and treatment levels selected for analysis are representative of those to be achieved in future practice. The cost of producing and distributing pelletized fuel is representative of what can be achieved in NM.

Key Uncertainties:

- **Benefits:** The market demand for new supplies of wood products and renewable energy is dynamic and not likely to fully absorb all new supply sources without support from policies that expand the market and, potentially, establish preferential treatment of these products in comparison to conventional supplies. The rate of biomass replacement growth in thinned stands is likely to be less than full due to ecological barriers (precipitation) and forest health issues, but the exact rates of replacement are estimated based on expert field judgment. The increased carbon sequestration potential of thinned stands has not been incorporated into this

assessment.

- **Costs:** Future production cost reductions for wood product development and biomass energy recapture technologies are likely to fall with market expansion and “learning by doing” but are difficult to estimate at this time. Demand for biomass energy products is likely to remain strong and continue to grow with increasing fossil fuel costs (e.g. recent surge nationally in residential pellet stoves).

Contributing Issues, if applicable:

- **Human and social issues**
 - Protection of residential and or municipal lands from fire risk.
- **Environmental issues**
 - Environmental asset protection, including watersheds, wildlife and air quality. Lower air emissions occur from energy utilization, as compared to open burning.
- **Economic issues**
 - Expansion of markets for industrial producers of sustainable wood products and renewable energy use. Creation of New Mexico jobs in the associated forestry management industries.
- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

F-2b Forest Health and Restoration – Other Lands

Option Category: Quantified

Policy Description: Increase sustainable thinning of biomass for ecological restoration of forests, and direct the harvested wood and wood waste to wood products and renewable energy. This policy focuses on areas beyond the WUI (other areas). However, much of the background material developed for Option F-2a is applicable to this option.

Policy Design:

- **Goal levels:** A goal of expanding the usage rate of biomass extracted from forested non-

residential lands for wood products and/or energy production **by 50%** is recommended. The TWG recognizes that 100% biomass utilization is not achievable due to access to the material or to efficient methods of transporting the material to processors/end users.

- **Timing:** Begin ramp up in 2007 and reach full yearly implementation by 2012 and continue through at least 2020.
- **Parties:** USFS, plus the additional parties listed in the applicable section under Option F-2a.
- **Other:** For the purposes of estimating GHG benefits and costs, biomass is assumed to be utilized for the production of commercial steam/space heat or residential space heat. As stated above, other end uses (electricity generation, liquid fuels, durable wood products) should also be targeted by this policy.

Implementation method(s): See discussion under Option F-2a.

Related Policies/Programs in place: Current residential/municipal fire risk and forest health initiatives oriented toward density reduction include the multi-agency National Fire Plan, Western Governors Association 10-Year Comprehensive Strategy for Implementation of the National Fire Plan, federal Collaborative Forest Restoration Program, NM Forest and Watershed Health Restoration Plan, the federal FIREWISE program, various FEMA programs for fire risk mitigation on private residential lands, and the establishment of the NM Forest and Watershed Restoration Institute, and many other local, state and federal initiatives too numerous to list.

Current programs designed to increase market use of small diameter trees for energy and wood products include various Department of Energy and USDA Forest Service grant programs, Collaborative Forest Restoration Program, others.

Types(s) of GHG Benefit(s):

- **CO₂:** Carbon savings occur when live and dead carbon stocks (trees, shrubs) that otherwise would decay or burn in the forest are harvested and converted to: 1) durable wood products that store carbon; 2) to low embedded energy wood building materials that substitute for high embedded energy conventional building materials (steel and concrete); or 3) to renewable energy that displaces fossil energy use. Sustainable management ensures that replacement biomass grows back to the maximum extent on thinned sites to offset removals of live biomass.
- **CH₄:** New research indicates that about four percent of the carbon storage benefits of live forests is offset by methane release. Methane can be released from land filled biomass under anaerobic conditions.
- **Black Carbon:** Emissions of black carbon (soot) result from combustion of woody biomass from open burning of land clearing, but the heating effect may be offset by the cooling effect of this particular type of black carbon.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** 0.45, 0.45
- **Net Cost per MMtCO₂e:** \$-21

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** See discussion under F-2a above.
- **Quantification Methods:** See discussion under F-2a above. For non-WUI lands, a treatment fraction of 0.21 was selected (“Fuels Reduction” level of restoration). This led to a 21% reduction in biomass (and carbon) density on the treated acres. Otherwise, the methods used to estimate benefits and costs are the same as the WUI areas under F-2a.
- **Key Assumptions:** See discussion under F-2a above.

Key Uncertainties:

- Benefits: See discussion under F-2a above.
- Costs: See discussion under F-2a above.

Non GHG issues, if applicable:

- **Human and social issues**

Protection of working lands and associated industries for sustainable wood products use, recreation, cultural and natural heritage.

- **Environmental issues**

Environmental asset protection, including watersheds, wildlife and air quality. Lower air emissions occur as a result of energy utilization, as compared to open burning.

- **Economic issues**

Expansion of markets for industrial producers of sustainable wood products and renewable energy use. Creation of New Mexico jobs in the associated forestry management industries.

- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-1 Manure Digesters or Other Energy Utilization

Option Category: Quantified

Policy Description: Reduce CH₄ emissions from livestock manure through the use of manure digesters or other energy capture technologies installed at dairies. Gas captured from the manure digesters is used to create heat or electricity, which offsets fossil fuel-based energy production and associated CO₂ and black carbon emissions.

Policy Design:

- **Goal levels:** By 2050, 75% of the dairy and feedlot population shall be participating in either an on-site manure digester/generator facility or as part of a centralized digester/generator facility located in high density CAFO regions of the state, i.e. Mesquite, Portales, Roswell, Las Cruces, Clayton, Clovis, Hobbs/ Lovington, Artesia, Albuquerque/Belen/Socorro.
- **Timing:** Head of dairy cattle affected from 2006-2020, including head of cattle affected in 2010 and 2020. Number in 2050, based on projected growth rate of 1.2% per year.
 - 2010 – 15% of total dairy cattle (64,500 out of 430,000)
 - 2020 – 35% of total dairy cattle (169,400 out of 484,000)
 - 2050 – 75% of total dairy cattle (519,000 out of 692,000)
- **Parties:** NM Environment Department (currently regulates NM dairy impacts on air and water—nitrate saturation), NM Energy Minerals and Natural Resources Department for incentives for biomass energy production, New Mexico State Engineer, NM Department of Agriculture.
- **Other:**

Implementation method(s):

- Information and education – materials and talks throughout state from EMNRD/ NMDA/ NMED on opportunities for farmers
- Technical assistance – technology/ implementation assistance from EMNRD (1 FTE)
- Funding mechanisms and or incentives – (with market based mechanisms vi.), increase eligible equipment to receive tax compensating tax deduction, gross receipts tax deduction for biomass related equipment, agricultural grant program for clean energy development
- Voluntary and or negotiated agreements – commitments from NM agricultural leaders, partnerships between dairies and utilities
- Codes and standards – air standards and permitting for GHG emissions (NMED)

- Market based mechanisms (above)
- Pilots and demos – memorial/ state funding for partnerships between universities and industry
- Research and development – necessary R&D for dry waste/ open corral feedlots, thermophilic plug flow digesters in southwest
- Reporting – as a NM industry generating GHGs
- Regulatory – net-metering, interconnection standards, special buy-back rates for biomass kWh or biomass RECs

Related Policies/Programs in place:

- Pending/Pilot Projects:
 - The Dairy Producers of NM with the Pecos Valley Biomass Coop have submitted permit application to the Chaves County Commission and received a \$250,000 grant from the State for a centralized digester for 25,000 head outside of Roswell, piping methane into PNM's main trunk line.
 - La Mesa Digester Pilot Project with NMSU to process 5,000 tons of manure/year (1,500 kWh/yr), implementing bi-phasic digester technology for dry climate/open corral facilities.
 - Microgy has submitted a permit application to the Chavez Co. Commission for a 12,000 head digester project.
 - An area on the outskirts of Roswell has been zoned to accommodate large digester operations.
- NM Clean Energy Grants Through NMEMNR, no monies appropriated in 2006, though seeking recurring revenue stream beginning 2007
- NM Biomass Equipment and Materials Compensating Tax Deduction: offsets state compensating (sales) tax on equipment and materials for landfill gas, biomass, municipal solid waste, CHP/Cogeneration, hydrogen, anaerobic digestion, ethanol, methanol, biodiesel, and microturbines.
- Federal: State Technologies Advancement Collaborative, Value-Added Grants Program, USDA Renewable Energy and Energy Efficiency Section 9006 Grants, USDA NRCS and EQIP Grants, CIG Awards.

Types(s) of GHG Benefit(s):

- CO₂: Use of methane captured in manure digesters to generate electricity displaces fossil fuel use and associated CO₂.
- CH₄: Manure digesters collect and combust the CH₄ produced from anaerobic decomposition during manure storage.

- **Black Carbon:** Use of methane captured in manure digesters to generate electricity displaces fossil fuel use and associated BC emissions.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** 0.35, 0.90 (dairies); 0.0003, 0.0009 (feedlots)
- **Net Cost per MMtCO₂e:** \$4 (dairies); \$994 (feedlots)

Data Sources, Methods and Assumptions (for quantified actions):

• **Data Sources:** Data from the GHG inventory & forecast report on methane emissions and dairy/feedlot populations were used as the starting point. Dairy populations were projected from 2004 levels at a growth rate of 1.2% per year. Feedlot populations were assumed to remain constant at 2004 levels. Methane emissions at feedlots are much lower than those at dairies due to the differences in manure management and storage at these different operations. Consistent with the policy design, manure digesters are assumed to be implemented at dairies and feedlots covering 15% of the state population by 2010 and 35% by 2020. By 2050, 75% of the dairy and feedlot cattle population is assumed to be covered.

For each facility that installs a manure digester or other energy capture/utilization technology, it is assumed that 75% of the methane emissions are collected (due to inefficiencies in the manure collection process). This methane is converted to electricity using a heat rate of 17,100 Btu/kW-hr.⁴ The annual kW-hrs produced were used to estimate both the costs offset (through avoided electricity consumption), as well as GHGs offset (from grid power). The 2012 and 2020 grid power emission factors were taken from the NM GHG Inventory & Forecast Report (2.01 lb CO₂e/kW-hr and 1.81 lb CO₂e/kW-hr, respectively).

The CO₂e reduction benefits were calculated as the sum of the methane emissions reduced, plus the GHG offset from grid-based power. Costs were estimated using data on capital costs from EPA’s Methane to Markets report⁵ and a recent dairy manure digester application in central California. These data indicate a range of capital costs from about \$190 to \$450 per head. An annual operating cost of \$38/head was also estimated from the central California project.⁶ An electricity offset cost of \$0.04/kW-hr was also used. High and low annualized costs were estimated using the high and low estimates of capital costs. The reported costs for the policy are based on the mid-point of these estimates. A 15-year project life was assumed along with a 5% interest rate to determine the capital recovery factor.

- **Quantification Methods:** See discussion above under data sources.

⁴Leonard Bull, Animal and Poultry Waste-to-Energy, PowerPoint presentation, North Carolina State University, http://www.cals.ncsu.edu/waste_mgt/waste%20to%20energy.pdf, accessed June 2006.

⁵http://www.methanetomarkets.org/resources/ag/docs/animalwaste_prof_final.pdf, accessed March 2006.

⁶Williams, Douglas, Valley Air Solutions, presentation “Joseph Gallo Farms Dairy Manure Digester”, January 18, 2006.

- **Key Assumptions:** Most applications of manure digesters in the U.S. have been done at dairies with liquid (slurry) manure management systems. For livestock operations that manage manure primarily in a dry solid form, there could be major differences in energy technology selected (e.g. for solid manure, biomass gasification might be a better alternative). These different technology choices could carry higher or lower costs than those used here for anaerobic lagoon digesters combined with an engine and electricity generator. A cost estimate provided by a TWG member⁴ suggested that capital costs for a biomass gasification plant could have similar capital cost on a per head basis as an anaerobic digester facility (about \$190/head for a regional plant serving about 20,000 head). CCS believes that the range of costs considered in this analysis represents, on the low end, manure energy projects implemented for a group of farms (e.g. regional digesters/energy plants) to high end costs, where the digester/energy plant is implemented at a single facility.

Key Uncertainties: See Key Assumptions above. The costs associated with anaerobic digester/energy plant application at AZ dairies and their representativeness to the energy technology actually selected. Different energy utilization technologies can produce different energy products (electricity, steam, heat, liquid fuels). While each type of project will have GHG benefits, the level of benefit will vary. Anaerobic digester technology was chosen here only as an example of manure energy utilization technologies to be promoted by this policy.

Non GHG issues, if applicable:

- **Human and social issues**
 - Provides odor control, particularly for facilities near urban areas (Portales, Las Cruces, Roswell, Albuquerque Area).
 - Reduces pathogen load, controls flies, reduces fine dust and reduces the spread of weed seeds.
- **Environmental issues**
 - Reduces water quality problems and provides solution for managing nutrients (nitrate saturation occurs in many areas with high dairy density), VOC emissions.
 - Reduces of fossil fuel-based energy consumption.
- **Economic issues**
 - Produces electricity and/or heat production for on-site use on farm or opportunity to sell energy, keeping energy dollars within that community if farm is locally owned.
 - Turns a waste product that is costly to dispose of into a value added product such as bedding, compost and energy,
- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-2 Biomass Feedstocks for Electricity of Steam Production

Option Category: Not Quantified

Policy Description: Displace fossil fuel usage through the use of agricultural waste (e.g., pecan waste, other crop residue) as a feedstock for electricity or steam production.

Policy Design:

- **Goal levels:** Utilize 25% of agricultural waste by 2012, 50% by 2020, and 75% by 2050.
- **Timing:** see above.
- **Parties:**
- **Other:**

Implementation method(s):

- i. Information and education: X
- ii. Technical assistance: X
- iii. Funding mechanisms and or incentives: X. Monetary incentives may be needed to encourage the first pilot facility for using crop byproduct to generate electricity, steam or fuel for space heating.
- iv. Market based mechanisms: X.
- v. Pilots and demos: X. Some interest has been directed to the implementation of a small electrical generation facility in southern New Mexico using manure and pecan waste as the fuel. Interested parties should encourage development of this facility as a pilot plant through incentive grants.
- vi. Research and development: X. Research directed at: determining the impact of reducing crop residues on subsequent cropping systems and soil erosion; and on maximizing the BTU output of mixed fuel sources (e.g. pecan shells and manure).

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

- **CO2:** Savings occur as a result of displacing fossil fuel use in the production of electricity or steam.
- **CH4:** Reductions are likely in situations where residue is currently burned on-site (pecan waste) due to more efficient methods of combustion associated with energy use. These benefits were not quantified.
- **N2O:** Not applicable (savings only occur if it can be demonstrated that biomass combustion produces less N2O than fossil-based combustion)
- **HFC's, SFC's:** Not applicable
- **Black Carbon:** Potential for a reduction in BC emissions to the extent that coal-based combustion is offset. These benefits were not quantified.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO2e):** 0.93, 1.87
- **Net Cost per MtCO2e:** -\$18

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Estimated biomass byproducts for primary crops are provided in Table 1 below. New Mexico's agricultural crops are concentrated in only a few regions of the state. Availability of irrigation water (surface or ground) limits the state's agriculture to several regions along the Rio Grande and Pecos rivers and the northwestern region of Farmington. Due to adequate groundwater availability, the Estancia Valley (central) and the eastern region of the state also have principal farming areas. In general, the eastern side of the state has the largest concentration of croplands.

Availability of combustible byproduct estimates may be lower than those printed in other sources. Amounts included in the table below account for irrigation methods and for a 50% harvestable product rather than 100% (grain crops). Estimates for pecan related byproducts are derived from a percentage of the acres pruned in a single year and a percent of the nuts shelled instate.

Combustible Agricultural Byproduct and Feasibility of Use from Principal NM Crops

| Crop | Acres (1,000) | Major Production Area | Byproduct Available (Tons) | Feasibility ³ |
|-----------------|---------------|---------------------------|----------------------------|--------------------------|
| Wheat (Dryland) | 217 | Eastern /North Western | 75,950 ¹ | Low |

| | | | | |
|---------------------|----|----------|----------------------|--------|
| Wheat (Irrigated) | 83 | Eastern | | Low |
| Sorghum (Dryland) | 75 | Eastern | 120,350 ¹ | Low |
| Sorghum (Irrigated) | 17 | Eastern | 42,750 ¹ | Low |
| Corn | 58 | Eastern | 21,930 ¹ | Low |
| Pecans (wood) | 33 | Southern | 156,600 ¹ | Low |
| Pecans (shell) | - | Southern | 4,752 ² | Low |
| | | | 2,640 ² | Medium |

1. Result from adjusted Kansas State University crop residue index based on production of grain.

2. Unpublished measured amounts from New Mexico State University.

3. Availability of product for other uses not currently incorporated in a producer's practices (no financial incentive).

Feasibility index represents the practicality of using a specific byproduct for space heating or electrical generation. National Resource Conversation Service policies increased minimum tillage practices, soil moisture conservation requirements, improvements to soil structure, grazing benefits, and added costs to harvest all contribute to the indexes associated with grain crops. The classification as an "agricultural byproduct" does not preclude beneficial use by a producer. With respect to pecan prunings, the largest wood is removed by firewood contractors with the remaining branches pushed to the end of the orchard and burned or chipped in the orchard and allowed to decompose. Labor constraints dictate the handling and movement of branches be conducted by machine. Due to the potential labor associated with handling tree branches or investment by producers for chippers, the feasibility of using pecan wood for the generation of electricity, steam, or space heat is low without financial incentives for the producer. New Mexico has one large pecan sheller located in Las Cruces. As a byproduct of the shelling process, pecan shells are trucked from the plant back to orchards for placement on farm roads to reduce dust or as a soil amendment to the orchards. The trucking and ease of handling of shells elevates their Feasibility Index to "medium".

The limited amount and seasonal availability of pecan waste and other agricultural crop byproducts necessitate their coupling with other combustible agricultural byproducts and some financial incentives to offset increased costs associated with their harvest and loss of on-farm benefits, if they are to be incorporated in the production of electricity, steam or space heat. Due to the limited quantities and seasonal availability, the TWG estimated benefits for using the residue to produce pelletized fuel for use in commercial/municipal boilers or residential space heaters (e.g. pellet stoves). Pellet stoves, in particular, have shown a recent surge in popularity in the United States due to the recent increase in fossil heating fuels. However, the technical feasibility of pelletizing each of the crop residues produced in NM requires additional study.

Cost information on pelletizing agricultural residues was taken from a Canadian study (\$134/ton).⁵ The energy content of pelletized agricultural residue was taken from the same source, while the energy content for pelletized wood (for assessing pecan residue) was taken from a pellet stove manufacturer.⁶ The cost of natural gas was taken from the U.S. Energy Information Administration (\$12.20/MMBtu) and represents the current average of commercial and residential costs.

- **Quantification Methods:** Estimates of the energy content for switchgrass pellets (19.3 MMBtu/ton for crop residues) and wood pellets (16.4 MMBtu/ton for orchard trimmings) were used to estimate the total energy that could be generated by producing biomass pellets. The amount of CO₂e generated from the combustion of an equivalent amount of natural gas was estimated using the residential natural gas emission factor (116.7 lb CO₂e/MMBtu) minus the biomass emission factor (14.96 lbsCO₂e/MMBtu). No adjustments were made for the potential differences in efficiencies between the natural gas-fired and biomass-fired equipment. The GHG benefit was estimated as the difference in CO₂e produced by combusting the pelletized fuel versus an equivalent amount of natural gas.
- **Key Assumptions:** The estimates of available future supplies of biomass residue assume no change from current levels. The energy content and pelletizing costs for NM crop residue were assumed to be the same as for an analysis of pelletized switchgrass conducted in Canada. There are no technical issues associated with pelletizing residue from any of the principal NM crops.

Key Uncertainties: Technical feasibility of converting agricultural residues from all principal NM crops to pelletized fuel or other energy source. The TWG recognizes that there could be continued expansion of the dairy industry in NM, which could affect the availability of residue in the future (e.g. as acres devoted to wheat are converted to alfalfa). The pecan industry could also see continued growth leading to additional residue supplies. However, the estimates of available future supplies of biomass residue assume no change from current levels. CO₂e emissions associated with the processing (chipping, pelletizing) and transporting of pelletized fuel were not incorporated into the benefits assessment (the embedded CO₂e associated with offset natural gas or propane was also not included). Cost information taken from a Canadian study might not be representative of production costs from all types of NM crop residues.

Non GHG issues, if applicable:

- **Human and social issues**
- **Environmental issues:** Lower emissions of criteria and toxic air pollutants than those associated with the open burning of residues.
- **Economic issues**
- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-3 Ethanol Production

Option Category: Quantified

Policy Description: Provide incentives for the production of ethanol from crops, agricultural waste, or other materials (forest treatment biomass, municipal solid waste). Use of the ethanol will offset fossil fuel use (gasoline). Different incentive programs will be needed for crop (starch-based) ethanol production versus agricultural waste (cellulosic) ethanol production processes.

Policy Design:

- **Goal levels:** Align in-state production with TLU ethanol renewable fuels goals of 20% of NM gasoline consumption by 2012 and 40% of gasoline consumption by 2030. Based on the NM I&F report, current ethanol usage in reformulated gasoline is 7.7% of gasoline by volume. To meet the policy goals, significant increases in ethanol production will be needed. Current ethanol production in the state is 30 million gallons/year (MMgal/yr).⁷ Due to the current production methods (starch-based) and primary U.S. geographic production regions (mid-western states), significant GHG benefits will only occur when the ethanol is produced and consumed within NM.

Measured increases in corn, sorghum, and other grains should be achievable and will supplement ethanol production from starch in New Mexico. However, any increase in grain production will have to be balanced by demand on water resources and input of petroleum chemical based products (fertilizers, herbicides, pesticides) needed to increase grain production in addition to increased ethanol processing capacity. While this policy is meant to be technology neutral, due to the production issues and higher GHG benefits, cellulosic ethanol production is the most likely technology to produce the quantities of ethanol required.

Increased use of agricultural wastes (e.g. wood products, corn stover) for conversion to ethanol should be achievable in the next few years (e.g. enzymatic processes). Required research and development for economical and efficient conversion processes of cellulose to ethanol are also required (e.g. pilot scale commercial plants), but should be available through federally funded programs. With current ethanol wholesale pricing, conventional cellulosic production technology (acid hydrolysis) has been shown to be profitable.

- **Timing:** By 2012, 221 MMgal/yr additional production capacity will be needed using any ethanol production technology (achieves the 20% renewable goal). By 2020, the TWG estimates that an additional 338 MMgal/yr will be needed to get to the 25% renewable goal (halfway to the 30% goal in 2030). The TWG recommends promoting the establishment of both starch-based and cellulosic production facilities to meet these production goals, using

feedstocks produced in state (to reduce the embedded energy costs associated with feedstock transport).

- **Parties:** New Mexico Department of Agriculture (NMDA), New Mexico Agricultural Extension Services (NMAES), and New Mexico Energy, Minerals, and Natural Resources Department would be the lead agencies.

- **Other:**

Implementation method(s):

i. Information and education

NMDA and NMAES would develop guidance for grain growers to convert current crops to ethanol-compatible crops and practices to grow these crops.

NM Energy, Minerals, and Natural Resources would provide guidance on plant capacities and ethanol production and use in the state and nation.

ii. Technical assistance

Technical assistance on conversion of cellulose to ethanol will be required but should be available from programs named in the Energy Policy Act of 2005.

iii. Funding mechanisms and or incentives/Market based mechanisms

(1) Expect private investment (e.g., Abengoa and others) and federal and state tax incentives to produce ethanol from cellulose and starch crops.

(2) Create a NM production tax credit for the creation of renewable fuels (to include sustainable starch based-ethanol, cellulosic ethanol, renewable based hydrogen) on a per gallon gasoline equivalent output basis.

(3) Enable gross receipts tax exemptions on construction/ production of renewable fuels facilities.

(4) Recognize the need for renewable fuels consumption incentives (as outlined by the TLU TWG. These could include a sliding scale “fee-bate” program to incentivise low emissions/flex fuel ready vehicles in the market at the time of purchase. Also, an exemption of vehicle registration fees for low emissions/flex fuel vehicles to incentivise increased ethanol ready vehicles in the market.

iv. Codes and standards

As outlined by the TLU TWG, establish a NM based Renewable Fuels Standard (RFS) that would mandate by 2009, 12% of all fuel use (10% ethanol, 2% biodiesel) in New Mexico would be replaced by biofuels, rising to 20% by 2012, 30% by 2030, and 40% by 2040. Government vehicle alternative fuel use should provide a model for the state to follow.

v. Pilots and demos

Provide state funding for first cellulosic ethanol facility in NM to become operational by 2009.

vi. Research and development

As above, additional research on cellulose conversion to ethanol is needed to improve the economics of different conversion processes (e.g. cost of enzymes to break down cellulose). At current prices (\$2.70/gallon or more for wholesale ethanol) assessments of cellulosic ethanol production in NM have been shown to be cost effective.⁸

No additional research and development, outside of efficiency gains (both crop production and starch conversion), expected for current ethanol conversion of starch.

Related Policies/Programs in place: New Mexico currently has production capacity of approximately 30 million gallons of ethanol in 2005 from a single production plant. This production capacity ranks 17th in the nation compared to 21 states that produce ethanol. National ethanol production was about 3.4 billion gallons in 2004 whereas, 140 billion gallons of gasoline was produced in the same year.

The proposed policy action is to provide incentives for the production of ethanol from crops or agricultural waste. Use of the ethanol will offset fossil fuel use (gasoline) and will provide a new market for corn and other grains as well as agricultural wastes. Increasing New Mexico ethanol production capacity from the current 30 million gallons annually will be also needed to meet new federal production goals. For conversion of starch (grains) to ethanol, the federal Energy Policy Act of 2005 calls for a 7.5 billion gallon capacity nationally by 2012. In addition, New Mexico should have a role in new Energy Policy Act programs to market 1 billion gallons of ethanol from cellulose (ag/forestry/municipal waste) conversion by 2015.

Albuquerque currently requires that E10 be available during the winter months (Nov-Feb). Also, New Mexico currently provides compensating tax exemptions for renewable fuels, and alternative fuel vehicles are exempt from the state excise (sales) tax.

Types(s) of GHG Benefit(s):

- CO₂: Emissions are reduced by offsetting the use of petroleum-derived gasoline and diesel. In order to assess the CO₂ benefit, energy requirements of producing ethanol from starch and cellulose need to be compared to the energy requirements of producing gasoline.
- Black Carbon: While differences in BC emissions between gasoline and ethanol-blended gasoline are likely to be negligible, a small gain from reduced particulate emissions could be realized by conversions of fuel to blended ethanol/gasoline.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG reduction potential in 2012, 2020 (MMtCO₂e):** 1.26, 1.92
- **Net Cost per MtCO₂e:** \$154

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Production volumes for each year are based on forecasted gasoline consumption (from the NM Inventory & Forecast), current ethanol production in the state, and the volume of gasoline to be offset in each year. Costs for all ethanol production are based on estimates for cellulosic technology.⁹ The current in-state production is 30 MMgal/yr.¹⁰ Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Lab study.¹¹ These emission factors incorporate the GHG emissions during the entire life-cycle of fuel production (e.g., extraction, transport, refining, distribution, and consumption for gasoline; crop production, feedstock transport, processing, distribution, and consumption for ethanol). These life-cycle emission factors are referred to as well-to-wheels emission factors.

Cost information on cellulosic ethanol production plants in NM was provided by a TLU work group member.³ Based on a variety of feedstocks, the current production cost is estimated to be \$1.30/gallon.

- **Quantification Methods:** Well-to-wheels CO₂e emission factors from a recent General Motors/Argonne National Laboratory Study were used to estimate the benefits of offsetting conventional gasoline with enough ethanol produced in state to fulfill the policy goals. Well-to-wheels emission factors take into account the energy required to produce, process, and transport each fuel type (i.e., starting with the oil well for gasoline and the crop for starch-based ethanol). These emission factors are output from Argonne National Lab’s GREET Model. For the purposes of this analysis, ethanol production is assumed to occur using cellulosic ethanol technology, which has higher life-cycle GHG benefits than starch-based ethanol production. For comparison purposes, benefits associated with starch-based ethanol would be about 25% of those estimated for cellulosic ethanol.

To meet the goals of this policy option, the following ethanol production volumes were estimated:

| Year | Production Needed (MMgal/yr) |
|------|------------------------------|
| 2012 | 221 |
| 2020 | 338 |
| 2050 | 1,035 |

Costs were estimated by multiplying the production volume in each year by the estimated cost of cellulosic ethanol production (\$1.30/gal).

- **Key Assumptions:** These include – the bulk of future ethanol production occurs using cellulosic technology (benefits occur with starch-based production, but the benefit decreases

with increasing starch-based production); the life-cycle emission factors are accurate for in-state ethanol production (these were developed at the national level; potentially the benefits could be even higher, since the embedded energy in feedstock transport is lower); current cost estimates for cellulosic ethanol production are accurate and not expected to change considerably over the policy period (thru 2020); current ethanol prices will not fall substantially to the point of making near term cellulosic plants economically infeasible.

Key Uncertainties:

Ethanol production life-cycle emission factors, cellulosic ethanol production costs, the amount of starch-based versus cellulosic ethanol production.

Non GHG issues, if applicable:

- **Human and social issues**
- **Environmental issues**
 - Gasoline-ethanol blends may increase or decrease emissions of some criteria and toxic air pollutants.
 - Environmental impacts of increased production of grains for ethanol need to be assessed and compared to benefit in decreased gasoline production and use.
- **Economic issues**
 - Ethanol production increases from starch may require additional water use and/or additional input of petroleum based products (fertilizers and herbicides) that may make the increased production more expensive.
 - Increased ethanol production could provide new markets for grains grown in New Mexico as long as critical resources (water) were not impacted disproportionately.
- **Political and regulatory issues**

Feasibility Issues, if applicable: The current wholesale ethanol pricing makes starch-based and cellulosic ethanol plants very attractive. A sharp drop (e.g. below \$1.90/gallon) could have a strong negative effect on private investment.

Monitoring needs: Monitor grain crop production and conversion to ethanol, compare against state and federal guidelines on ethanol production.

Monitor agricultural wastes available and actually used to produced ethanol.

Key Assumptions:

1. Sufficient research and development will be completed and implemented for efficient cellulose conversion to ethanol by 2010. Current pricing of ethanol will not fall dramatically to the point of upsetting the economics of existing cellulosic technology.

2. Increased production of grains will result in increased income for New Mexico grain farmers.
3. Increased grain production will not negatively impact water, land resources and will not result in net increase of petroleum products used to provide the offset.

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-4 Nutrient Management

Option Category: Quantified

Policy Description: Between 0.2% and 3% of applied nitrogen in agricultural fields is estimated to be lost as N₂O directly from soil emissions. These N₂O emission rates are directly related to the rates, placement, and timing of applied fertilization. The challenge is to reduce total application of nitrogen without reducing yields or total production.

Agronomic practices that tighten the coupling between soil nitrogen availability and crop growth will improve nutrient use efficiency and reduce the likelihood that nitrogen will escape as N₂O, leach as nitrate into groundwater systems, or be transported to surface water systems. Better synchronization of nutrient applications with active crop needs can be achieved with improved nutrient management. The development and promotion of '*nutrient management guidelines and strategies*' along with support for enhanced extension and outreach of these guidelines can increase adoption of improved nutrient planning and practices, leading to both lower N₂O emissions and lower fertilizer costs.

Policy Design:

- **Goal levels:** Measured reductions in total fertilizer use (on a per acre basis) – and consequently in the N₂O and nitrate flux from agricultural soils – are achievable with improved nutrient management and adoption of specific nutrient management strategies (as described below). An initial policy goal is proposed that aims to reduce excessive fertilization by reducing average annual per acre nitrogen fertilizer use by 10% by 2020.
- **Timing:** ½ % incremental reduction from 2006 levels in each year from 2006-2015 and 1% incremental reductions from 2015-2020.
- **Parties:** New Mexico Department of Agriculture (NMDA) in conjunction with the New Mexico Agricultural Cooperative Extension Service (NMCES) would be lead agencies.
- **Other:**

Implementation method(s):

- Information and education
 - a. NMDA and NMCES would develop fertilization guidance for each major New Mexico crop.
 - b. NMCES would promote adoption through county extension agents and regional workshops.
 - c. NMDA would monitor progress and performance toward goal through direct questioning of nutrient management practices during annual NASS survey of state farmers.

Related Policies/Programs in place:

- Currently the only annually tracked measure of nutrient usage by the NMDA is ‘fertilizer shipped into New Mexico’ – in 2003 this amount was estimated to be 63,844 tons of nitrogen materials (this figure is gross weight and is not adjusted for nitrogen composition of various materials such as anhydrous ammonia, urea, ammonium sulfate etc.).

Types(s) of GHG Benefit(s):

- N₂O: Savings occur through the reduction in the use of nitrogen fertilizers that lead to N₂O emissions. N₂O is produced naturally by microbial processes in the soil. Application of synthetic nitrogen and organic fertilizers leads to increased emissions by augmenting the microbial processes.
- CO₂: Reduced rates of fertilizer application could reduce total CO₂ emissions that result from fertilizer manufacture and application – assuming that manufacturing levels are consequently reduced i.e., production is not shifted onto other buyers.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** 0.004, 0.012
- **Net Cost per MtCO₂e:** -\$46

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** The amount of nitrogen fertilizer shipped into New Mexico was obtained from the USDA’s National Agricultural Statistics Service (NASS; http://www.nass.usda.gov/nm/nmbulletin/07_04.pdf). The nitrogen content of each fertilizer came from the Arizona Department of Agriculture (<http://www.azda.gov/ESD/UFTRSCodes.pdf>). Costs for the five fertilizers with the highest

usage rates were obtained from the USDA's Economic Research Service (ERS).¹² The average of these costs was used for the less used fertilizer types.

- **Quantification Methods:** The reduction in nitrogen applied to NM soil was estimated by multiplying the amount of fertilizer shipped into NM by the nitrogen content (%) of each fertilizer type by the percent reduction for that year. The reduction in nitrogen was estimated using the method from EPA's SGIT. The reduction in nitrogen was multiplied by 90% to estimate the amount of unvolatilized nitrogen not emitted as NH₃ or NO_x. The amount of nitrogen emitted as N₂O was estimated as 1.25% of the unvolatilized nitrogen.

Costs were estimated as the sum of fertilizer savings (negative cost); costs for soil testing; costs for staff, overhead, and travel; and guidance document preparation costs. Soil testing would be required for each crop field once every 4 years. The number of fields was estimated as 11,416 (856,166 harvested acres divided by 75 acres per field). The cost for each soil test was estimated to be \$10. Costs for 2 FTEs of additional staff, overhead, travel, lab, and associated costs was estimated at \$250,000 per year, and preparation of guidance documents was assumed to be \$75,000 in the first year.¹³

- **Key Assumptions:** The amount of nitrogen shipped into New Mexico in a particular year was assumed to accurately reflect the usage of fertilizer on New Mexico fields in that year. This amount of fertilizer shipped into the state is also assumed to cover all agricultural nitrogen fertilizer consumption in the state.

Key Uncertainties:

- **Benefits:** Difficult to measure and monitor adoption rates and management effectiveness of nutrient management guidelines. Measures such as 'fertilizer shipped into New Mexico' is a very crude and unreliable performance measure but is the only one presently available to proxy and estimate for total nitrogen use within the State.
- **Costs:** Soil testing costs can range from \$5-\$15 per sample. Nutrient management guidance documents could be prepared based on existing research for most major crops, perhaps at a cost of \$50,000-\$75,000. Printing and distribution would likely add to this cost. Extension training and regional workshop costs would also add some cost and could vary significantly depending on scope, frequency, and other factors.

Contributing Issues, if applicable:

- **Human and social issues**
- **Environmental issues**
 - More efficient use of nitrogen fertilizer reduces potential for runoff and leaching into surface- and ground-waters that diminish water quality.
- **Economic issues**
 - More efficient use of fertilizer could reduce farm operating costs with lower purchases of applied materials; however, there may be increased costs associated

with required activities such as soil testing and monitoring.

- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-5 Manure Management

Option Category: Quantified

Policy Description: Reduce N₂O emissions from daily spread and other land application of dairy and feedlot cattle manure through the use of better application methods. These application methods are designed to reduce contact of manure nitrogen with air (lowering the rate of denitrification) and the amount of manure nitrogen loss via leaching and runoff.

Reduce CH₄ emissions from dry manure storage by promoting composting of these wastes.

Policy Design:

- **Goal levels:** Implement composting and land application improvements at dairies and feedlots representing 25% of dry manure storage and treatment processes by 2012 and 90% by 2020.
- **Timing:** see goal levels identified above.
- **Parties:**
- **Other:**

Implementation method(s):

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** TBD
- **Net Cost per MtCO₂e:** TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** There are little data available on the reductions of N₂O associated with different manure application methods. Most previous studies have focused on reductions in NH₃ (ammonia) emissions, increased nitrogen uptake by crops, or lower nitrogen runoff. CCS identified one source of information that suggested that subsurface application of manure could lower nitrogen oxide (NO) emissions, but actually raise N₂O emissions.⁷

The reduction in CH₄ from composting was assessed by comparing emission factors for stockpiling and composting. The emission factor for manure stockpiling (0.0035 kg CH₄/kg volatile solids) was taken from EPA's SGIT. Manure contains about 10% volatile solids,¹⁴ so the emission factor converts to 0.00035 kg/kg manure. An emission factor for composting was taken from a report on emissions from composting operations.¹⁵ The reported emission factor was 2.23 lb CH₄/ton of material for 80% manure, 20% digested biosolids. This emission factor converts to 0.0011 kg CH₄/kg manure; which is higher than the emission factor for manure stockpiling. Additional study is needed to determine the relative CH₄ reduction benefit of composting manure. It is also not clear whether there could be an N₂O benefit or dis-benefit from composting relative to stockpiling (increasing oxygen availability could conceivably increase the rate of N₂O production).

The increased cost of composting over stockpiling was obtained from the University of Nebraska Agricultural Research and Development Center.¹⁶ Costs were listed as: \$1.25/ton for turning beef feedlot manure and \$2.25 to \$4.75/ton for spreading, based on labor charges of \$10/hour, tractor rental charges of \$19.50/hour, \$30/hour for a loader and operator, \$.60/ton for spreader use, \$1/mile for truck usage, and \$.50/ton for use of the compost turner. It was assumed that the same costs would apply to stockpiling except for turning; therefore, the cost difference was assumed to be \$1.25/ton.

- **Quantification Methods:** Due to the lack of available data, benefits and costs for reductions in N₂O associated with different manure application methods were not quantified.

CH₄ emission reductions achieved through the adoption of manure composting at beef cattle feedlots were also not estimated due to a lack of information on the relative benefits of manure composting.

- **Key Assumptions:** Beef cattle populations were assumed to remain static at the 2004 level. Other assumptions are discussed under Data Sources and Quantification Methods above.

Key Uncertainties: The major uncertainty is the emission factor for manure compost. Emissions can vary due to factors such as type and amount of bedding material composted with the manure.

Non GHG issues, if applicable:

- **Human and social issues**
- **Environmental issues**

- **Economic issues**
- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-6 Conservation Tillage/No-Till

Option Category: Not Quantified

Policy Description: The amount of carbon stored in the soil can be increased by the adoption of conservation tillage. Reducing mechanical soil disturbance reduces the oxidation of soil carbon compounds and allows more stable aggregates to form. In addition to soil carbon benefits, conservation tillage has numerous co-benefits including reduced wind and water erosion, reduced fuel consumption and improved wildlife habitat.

Other management practices such as decreased summer fallow or an increase in winter cover crops could also affect soil carbon levels; however opportunities for significant implementation for these practices in NM were not identified.

Policy Design:

- **Goal levels:** Program goal of bringing 650,000 acres of cropland into new management practices (conservation tillage or no till).
- **Timing:** 650,000 acres of cropland brought into no till management practices from 2007-2015; 1,300,000 acres total by 2025.
- **Parties:** Local Agricultural Extension Offices or USDA Soil Conservation Service Field Offices.
- **Other:**

Implementation method(s):

- **Information and education-** NM Extension and NRCS Field Offices have educational programs in place to encourage farmers to adopt conservation tillage practices.
- **Technical assistance-** There is sufficient technical assistance available in the Extension Service and NRCS Field Offices and in farmer groups.

- **Funding mechanisms and or incentives-** Conservation Security Program incentives provide financial incentives to adopt conservation tillage, however, the funding to extend CSP to cover all cropland is currently lacking.
- **Voluntary and or negotiated agreements–** participation in federal conservation programs is voluntary.
- **Market based mechanisms-** Some NGOs are attempting to organize demonstration projects to deliver carbon sequestration benefits to global markets. The slow rate of accumulation of soil carbon and the uncertainty associated with dryland farming will limit the attractiveness of New Mexico based projects to private sector investors. However, federal programs, particularly the Conservation Security Program, are intended to expand to cover all eligible land and to provide incentives for adoption of management practices such as conservation tillage.
- **Pilots and demos-** Currently, there is a need to support Pilot projects to demonstrate the technical (measurement, monitoring and verification) feasibility of private sector projects in the state.
- **Research and development-** Improved measurement (direct estimates of soil carbon), monitoring (estimates of acres under different tillage regimes) and verification (model integration of direct measurement estimates and acres of adoption) are required to reduce the uncertainties to an acceptable level.
- **Reporting-** The U.S. DOE Voluntary Greenhouse Gas Emission Reduction Reporting System (1605b) is currently structured to accept conservation tillage as an emission reducing practice.

Related Policies/Programs in place: Currently, there are about 275,000 acres in conservation tillage. There are no financial incentives to adopt. The Conservation Security Program rewards farmers financially for implementing conservation tillage. CSP is currently limited to less than 5% of New Mexico cropland, but should be expanding over the next decade to include the majority of land.

Types(s) of GHG Benefit(s):

- **CO₂:** Reducing tillage and soil disturbance slows the breakdown of plant material on the soil surface and in the root zone, accelerating the microbial processes that stabilize carbon and protecting carbon from oxidation, inhibiting the release of carbon back into the atmosphere. Depending on how the adoption of conservation tillage affects the overall crop production process, additional CO₂ reductions can occur through lower fossil fuel consumption in farm equipment.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO₂e):** 0.06, 0.13

- **Net Cost per MMtCO₂e:** TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** An estimate of the amount of diesel fuel saved by converting to no-till farming (3.5 gal/acre) was obtained from the Conservation Tillage Information Center.¹⁷ A diesel fuel emissions factor was obtained from EPA's SGIT [8.37 MtCO₂e/1000 gal (including CO₂, CH₄, and N₂O emissions)]. A soil carbon sequestration rate for adoption of conservation tillage practices of 0.11 ton CO₂/acre/yr (0.075 ton C/ha/yr) was provided by a member of the TWG.¹⁸
- **Quantification Methods:** The soil carbon sequestration rate cited above was applied to the acres adopting no-till practices to estimate the amount of carbon sequestered as a result of this program. Soil is assumed to continue sequestering carbon for up to 20 years after no-till is adopted.⁷ The amount of diesel fuel emissions avoided was estimated by applying the amount of diesel fuel saved and the diesel fuel emission factor.
- **Key Assumptions:** Assumptions regarding adoption of conservation tillage practices are based entirely upon the funding and implementation of federal conservation programs such as the Conservation Security Program. If these programs are funded in the 2007 and 2012 Farm Bills, it is assumed that approximately one-half of the eligible acres will be converted to conservation tillage by 2015 (10 years) and the remaining one-half will be converted over the following 10 years. Experience has shown that once conservation tillage is adopted, there is little return to conventional tillage. A further assumption is that there is year-to-year consistency in the application of tillage practices.

Key Uncertainties:

- Funding for federal conservation programs in the 2007 and 2012 Farm Bills.

Non GHG issues, if applicable:

- **Human and social issues**
- **Environmental issues**
 - Reduced tillage increases plant cover on the soil surface and reduces wind and water erosion.
 - Crop residue helps hold moisture in the soil and improves water quality by preventing runoff.
- **Economic issues**
 - Reduced tillage saves labor, fuel (and associated emissions), and machinery wear that would be spent tilling the land.
 - Increased carbon content of the soil increases infiltration, water and nutrient

holding capacity and improves productivity of cropland.

- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-7 Convert Agricultural Lands to Grasslands or Orchard

Option Category: Not Quantified

Policy Description: Increase carbon sequestration in agricultural land by converting marginal land used for annual crops to permanent cover (grassland/rangeland or orchard). Also, prevent the loss of soil carbon in the future associated with cropland currently in the Conservation Reserve Program (CRP). Adopt mechanisms to either keep these cropland acres in the CRP or prevent them from either returning to conventionally tilled production or to suburban/urban development.

Policy Design:

- **Goal levels:** The TWG found that there was not much potential to convert additional marginal agricultural land to permanent cover beyond what is already being handled in the CRP. Focus was instead placed on policy that would assure that acres coming out of the CRP in future years would not return to production using conventional tillage practices or to suburban/urban development. The goal of the policy is to assure that no soil carbon associated with the acres coming out of the CRP program is lost during the policy period. Based on discussions with the USDA, 145,000 acres in the CRP program will not be extended beyond 2010.
- **Timing:** By 2010, adopt policies to assure no loss of soil carbon from acreage coming out of the CRP program (e.g. no return to conventional tillage, no suburban/urban development).
- **Parties:**
- **Other:**

Implementation method(s): (provide category from standard CCS list, with details as needed)

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

- CO₂: Loss of carbon to the atmosphere from tillage and fallow land is prevented by keeping cropland currently under permanent cover in the same state (i.e. CRP acres).

Estimated GHG Savings and Costs (for quantified actions):

- **GHG reduction potential in 2012, 2020 (MMtCO₂e):**
- **Net Cost per MtCO₂e:**

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** The U.S. Department of Agriculture Farm Services Agency provides data on acreage expiring from the CRP program.¹⁹ Currently, 599,142 acres are in the CRP. As shown below, most of these acres will expire in 2007:

2006: 4,312
2007: 533,982
2008: 36,884
2009: 12,530
2010: 524
2011: 0
2012: 0
2013: 1037
2014 and beyond: 9,873.

Additional discussions with the USDA indicated that about 145,000 CRP acres statewide will not be extended beyond 2010.²⁰ Most of this acreage exists in Curry, Quay, Roosevelt, and Harding counties (CRP acreage is limited to 25% of cropland per county). While detailed information on existing NM cropland soil carbon levels are not available, data suggest that soil carbon losses during the first 2 years of tillage would be on the order of 15 tons of carbon per acre (50 MtCO₂e/acre).²¹ Estimates for the cost of acquiring agricultural land were also provided during these discussions: range \$350-\$500/acre, depending on proximity to urbanized areas. No data were found on the costs for purchasing conservation easements.

- **Quantification Methods:**

The potential carbon losses (quantified as CO₂e emissions) were estimated by assuming that 50% of the expiring 145,000 CRP acres would return to conventional tillage within the 2010 – 2020 time-frame. The carbon loss factor shown above was multiplied by these acreages to estimate total carbon losses. The estimated annual emissions were estimated by dividing this total by 10 years.

The costs for the policy were estimated by multiplying the mid-range land acquisition cost estimate (\$425/acre) by the amount of CRP acres to be conserved (total CRP acres returning to conventional tilling/development divided by 10). The value of 10 reflects the assumption

that the expiring acreage would be acquired over a 10-year period from 2010 to 2020.

- **Key Assumptions:**

The fraction of expired CRP acres that returns to production with conventional tilling methods or to development (50%). The carbon loss factor is assumed to be representative of the potential losses on expiring CRP acres. The acquisition costs are assumed to be representative; however costs for purchasing conservation easements could be lower.

Key Uncertainties:

See Key Assumptions above.

Non GHG issues, if applicable:

- **Human and social issues**
- **Environmental issues**
 - Restoration of native grassland or forest habitat. Improved water quality and air quality.
- **Economic issues**
- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-8 Reduce Permanent Conversion of Farm and Rangelands to Developed Uses

Option Category: Not Quantified

Policy Description: Reduce the rate at which existing crop and rangelands are converted to developed uses. The carbon sequestered in soils and aboveground biomass is higher in crop and rangelands than in developed land uses. Policies are needed to provide incentives for farm and ranch land preservation.

Policy Design:

- **Goal levels:** These are aligned with the goals of the analogous option for forested lands (F1). Policy initiation by 2010; 30% reduction achieved by 2012; 50% reduction achieved by 2020; no net loss achieved by 2030, continuing through 2050.

- **Timing:** Initiation in 2010 and continuing through 2020.
- **Parties:** Public and private partnerships (private agricultural organizations) with: County planning and zoning entities; State Cooperative Extension Services, New Mexico Department of Agriculture, New Mexico Energy, Minerals and Natural Resources Department; Federal Natural Resource Conservation Service and Farm Service Agency.
- **Other:**

Implementation method(s):

- **Information and education:** NM Extension Service, NRCS Field Offices, land trusts.
- **Technical assistance:** NM Extension Service, NRCS, land trusts
- **Funding mechanisms and or incentives:** Farm Bill, EQIP, CSP and state funding.
- **Voluntary and or negotiated agreements:** Participation in all programs is voluntary.
- **Codes and standards:** County Land Use Development Plans, County zoning ordinances. Tax codes changes will aid in protecting agriculture land to the next generation and slow farmland conversion to other uses.
- **Market-based mechanisms:** Incentive based preservation and payment programs to agriculture producers for advanced protection of pristine and productive agriculture resources and to implement BMPs that result in environmental benefits. Such programs: CRP, CREP, and EQIP. State funding.
- **Pilots and demos:** The NRCS and NM Cooperative Extension Service.
- **Research and development:** Review other states programs such as Idaho Carbon Trading Credits, NM Cooperative Extension Service and NRCS. Review existing local, state and federal policies that result in negative land conversion such as road construction and other infrastructure developments. Review local growth management practices that encourage the development of incompatible land uses and infrastructure services into prime agriculture areas while protecting private property rights and responsibilities.

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

- **CO₂:** Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG reduction potential in 2012, 2020 (MMtCO₂e):** 0.1; 0.2
- **Net Cost per MtCO₂e:** \$62/MtCO₂e

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** The number of acres that moved from cropland, pasture, and rangeland

categories to developed uses between 1982 and 1997 was obtained from the USDA Natural Resource Inventory (NRI). The amount of rangeland assumed to be pinyon-juniper (see Option F1) was subtracted from this data. Agricultural land soil carbon data was taken from a study in *Soil Science* that compiled data for cultivated and uncultivated land with various soil types⁸. Estimates of soil carbon on rangeland in the southwest were obtained from the STATSGO/SSURGO soil organic carbon database.

Costs for agricultural land can vary widely from as low as \$200/acre in rural areas without significant water supply to as much as \$100,000/acre in prime locations with high development potential.⁹ Costs were estimated for this option using a cost of \$2,000/acre for conservation easement. This cost represents the nationwide average determined by the American Farmland Trust.¹⁰

- **Quantification Methods:** The number of acres of cropland/pasture (agricultural land) and rangeland converted to developed uses between 1982 and 1997 was divided by 15 years to give the average number of acres lost each year. The number of acres to be saved in 2010 and 2020 were estimated by multiplying the average rate for 1982-1997 by 20% in 2010 and 50% in 2020. The amount of CO₂ emissions savings were estimated by assuming that for each acre lost to development, 10,000 sq ft (0.23 acre) losses 100% of the soil carbon. The remainder of the acre loses 25% of soil carbon.
- **Key Assumptions:** For each acre of land lost to development, 10,000 sq ft is assumed to lose 100% of the soil carbon. This area represents the area in buildings, streets, and other structures that cover the soil. A loss of 25% of the soil carbon is assumed for the remainder of the acre. These assumptions are based on engineering judgment.

Key Uncertainties: The main areas of uncertainty are the existing soil carbon stocks and the change in soil carbon when land is developed. Additional benefits would be achieved by retaining above ground carbon in preserved rangelands. No data were identified for quantifying these benefits.

Contributing Issues:

- **Human and social issues:** The identification and preservation of agriculture land will protect New Mexico's cultural resources and provide for open space amenity.
- **Environmental issues:** Preservation of agricultural land can reduce suburban sprawl, which decreases transportation-related emissions.
- **Economic issues:**
- **Political and regulatory issues:**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-9 Organic Farming

Option Category: Not Quantified

Policy Description: Increase acres of farmland using organic farming techniques which improve soil quality and eliminate the use of chemical fertilizers and pesticides. CO₂ emissions are reduced because the manufacturing and transportation of chemical inputs have been eliminated. Organic agriculture also increases the organic matter in soil, which increases carbon in the soils. Under some circumstances, with improved soil condition, there can be less irrigation water pumped, which saves on the emissions from energy generation as well as water usage.

Policy Design:

- **Goal levels:** The long-range goal is to increase organic- certified and non-certified- acreage to approximately 80% of total agriculture in the state.
- **Timing:** The current acreage in New Mexico that is certified organic by the New Mexico Organic Commodities Commission at the beginning of 2006 is approximately 50,000 acres, the predominance of which at this time is rangeland for livestock, cattle, and sheep. By 2012, with sufficient support, the acreage could be at least 250,000 acres for transitioning to certified (a 3-year process), and another 250,000 for chemical-free sustainable agriculture. Certified could increase to 500,000 acres or more by 2020 depending on drought impacts and the availability of water.
- **Parties:** NM Department of Agriculture, NM Organic Commodities Commission, Department of Education, in cooperation with federal and non-governmental organizations (such as Quivira Coalition for ranching).
- **Other:**

Implementation method(s):

- Information and education
 - Conduct series of workshops to ensure Extension Agents and other agriculture professionals can teach effectively about how to transition to organic and how to do Carbon Farming (and Carbon Ranching, when appropriate).
 - Combined with the Buy Local Campaign:
 - Establish a requirement for a state teacher's credential to have 1 or 2 courses in the issue of climate change and agriculture and the utilization of school gardens, and nutrition, integrated into standard curricula.

- Expand the existing programs: school gardens (mandatory in California), Farm to School, and Cooking with Kids programs in a schedule that by 2012 includes all public schools and a program to share curricula with volunteer private schools.
 - In high school vocational training, incorporate the expanding opportunities in agriculture, food processing including value-added, and food distribution.
- Technical assistance
 - Mentorship programs like California's that join established organic farmers with conventional farmers can successfully support transitioning.
- Funding mechanisms and or incentives
 - Institutional point system purchasing of state agencies in conjunction with the Buy Local Food program.
 - Transition support- tax breaks and incentives for farmers transitioning to organic systems.
 - Assistance for purchasing approved inputs such as pheromones with bulk buying to reduce user costs.
 - Buy-back programs for safe disposal of existing toxic chemicals.
- Codes and standards
 - For Local Food purchasing, an additional point system supporting a continuum from Integrated Pest Management to non-certified organic to certified organic.
- Market based mechanisms
 - Price premiums for organic are a major driver which can be enhanced by institutional point systems for purchasing.
- Pilots and demos
 - Farm tours on organic farms and mentorship programs.
- Research and development
 - No-till organic research is needed, which could be coordinated with research in other states.
 - Research on the best techniques for organic soils to save water.
- Registry
 - Provide additional support for the New Mexico Organic Commodities Commission to expand promotion and transitional support for certification.

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

- CO2: Organic farming reduces emissions of CO2 through the elimination of petroleum-based chemicals that have to be shipped from long distances. Organic farming also sequesters more carbon in the soils than conventional farming. New techniques are being developed for low/no-till organic farming. For every percentage point of organic matter increase, there is substantial increase in soil carbon (i.e. CO2 sequestered).
- N2O: Savings occur through the elimination in the use of petroleum-based fertilizer that leads to emissions from the soils.
- Black Carbon: To the extent that fossil-based diesel fuel is reduced, BC emissions will be reduced.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG potential in 2012, 2020 (MMtCO2e):** 0.6; 0.4
- **Net Cost per MtCO2e:** \$0.54

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Soil organic content (SOC) of 0.017 MMtC/1,000 acres for cultivated southwestern agricultural soils (1.7% SOC content).²² SOC increase for organic cultivation versus conventional tillage is 20%.²³ 500,000 acres to be transitioned to organic cultivation by 2020 (see policy design above). The assumed scheduled to this acreage to transition to organic cultivation is shown below.

| Year | Transitioning Acres | Year | Transitioning Acres |
|------|---------------------|--------------|---------------------|
| 2006 | - | 2014 | 31,250 |
| 2007 | 25,000 | 2015 | 31,250 |
| 2008 | 25,000 | 2016 | 31,250 |
| 2009 | 50,000 | 2017 | 31,250 |
| 2010 | 50,000 | 2018 | 31,250 |
| 2011 | 50,000 | 2019 | 31,250 |
| 2012 | 50,000 | 2020 | 31,250 |
| 2013 | 31,250 | Total | 500,000 |

For cost data, an estimate by Pimentel²⁴ of \$8.90/acre in the difference in revenue between conventional and organic acreage (conventional being higher) was used to estimate the costs of transitioning from conventional to organic practices.

- **Quantification Methods:** Based on existing data, on average SOC content could be increased by 20% by using organic cultivation methods. This increase would take at least several years of organic cultivation to achieve. The total policy benefit was estimated first by multiplying the 500,000 acres by the average SOC content shown above. This value was then multiplied by 20% to estimate the amount of carbon sequestered. This value was then

multiplied by 44/12 to estimate CO₂e sequestered. To estimate benefits occurring in 2012 and 2020, the total program benefit (6.2 MMtCO₂e) was multiplied by the ratio of acreage transitioning in each year to the total program acreage (as shown in the table above).

- **Key Assumptions:** The most important assumption is the 20% average increase in SOC. No data in the scientific literature specific to NM or the U.S. southwest were found use in this assessment. A limited amount of empirical data brought forward by the TWG indicated that increases in SOC much higher than this are possible (e.g. on the order of a 100% increase). Another key assumption is that there are no technical limitations to transitioning 500,000 acres to organic practices. The cost data by Pimentel are also not specific to southwestern agricultural practices.

Key Uncertainties:

As stated in the key assumptions above, SOC increases for organic farming practices holds the largest uncertainty. The amount of acreage that can be transitioned to organic farming and the cost data (revenue differences between organic and conventional practices) is also uncertain. Additional benefits from organic practices have not been quantified due to a lack of data. These include reductions in GHGs associated with the manufacture and transport of synthetic fertilizers, herbicides, and pesticides. There could also be lower water consumption associated with organic practices (and associated GHG emissions for pumping water); however the TWG was unable to find data to demonstrate this benefit.

Contributing Issues:

- **Human and social issues**
 - The values of traditional agriculture in New Mexico can be supported.
- **Environmental issues**
 - The elimination of chemical pesticides and herbicides yields improvements in water quality. The California State Water Resources Control Board conducts programs to convert farmers to organic.
 - Pesticides and herbicides can drift, impacting human health, killing beneficial organisms, and harming wildlife.
- **Economic issues**
 - New Mexico's Secretary of Agriculture has declared that more New Mexico farms need to transition to organic to meet demand. National demand for organic products is growing at rapid rates, with the demand exceeding production. Converting to organic provides increased opportunities for farmers, processors, and distributors of organic products.
 - Organic products garner a premium in the marketplace, and the added income helps farmers be sustainable. In some areas, the only farms that are doing well financially are the organic farms.
 - Carbon sequestration in organic farming improves soil quality, allowing for

better retention of water, critically important under drought conditions.

- With increased prices of fossil fuels, the use of petroleum-based chemical inputs is becoming more expensive. The elimination of petroleum-based inputs will yield an increasing economic advantage over the years.

- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-10 Programs to Support Local Farming/Buy Local

Option Category: Quantified

Policy Description: Today's food has enormous hidden embodied energy in its travel and processing from farm to table in current industrial food systems, typically traveling from one to over five thousand miles. Increasing the percentage of "local food for local people" can reduce significant amounts of fossil fuel use and its associated GHG emissions.

Policy Design:

- **Goal levels:** The amount of local food consumed in New Mexico is estimated to be about 1 percent, and organizers of farmers' markets suggest that 35% of our food could be produced and consumed locally. In the longer range, with some commitment, we could increase this further.
- **Timing:** From today's approximate 1 percent consumption of local food, by the year 2010, we need to build the systems to shift to 8 percent, and to 25% by 2020. Projections to 2050 would depend on the degree that inevitable increased fuel costs forces rises in food prices shipped long distances, and the number and magnitude of extreme weather threats to global and national food supplies. These factors could accelerate the commitment for higher levels of utilization of local farmers' products, possibly leading to 50% or more of New Mexican food being produced and consumed in state.
- **Parties:** NMSU College of Agriculture and Home Economics, and NM Department of Agriculture, NM Department of Education, NM Environment Department, state institutions in cooperation with federal and municipal agencies, and non-governmental groups including Farmers Markets and the Southwest Marketing Network, NM Food and

Agriculture Policy Council, NM Acequia Association, food banks, and the NM Task Force to End Hunger.

- **Other:**

Implementation method(s):

- Information and education
 - Have the Governor do television Public Service Announcement's to promote local food (done previously in California) for the BUY LOCAL FOOD campaign.
 - Establish a requirement for a state teacher's credential to have 1 or 2 courses in the issue of climate change and agriculture and the utilization of school gardens, and nutrition, integrated into standard curricula.
 - Expand the existing programs into a continuous K-12 program: school gardens, Farm to School, and Cooking with Kids programs in a schedule that by 2012 includes all public schools and a program to share curricula with volunteer private schools.
 - In high school vocational training, incorporate the expanding opportunities in agriculture, food processing including value-added, and food distribution.
 - Develop a labeling system for supermarkets to identify local foods that travel less than 500 miles
 - Conduct a campaign with public and private sectors on the benefits and importance of supporting local food systems. Even some churches promote local food.
- Funding mechanisms and or incentives
 - Create compensating or GRT tax credits for corporations purchasing an incremental minimum of local food purchases.
 - Create tax credits for the establishment of local production projects which would phase out over time
 - Support the Farm to Cafeteria program by provide an additional 10 cents per meal for purchasing local fresh fruits and vegetables for at least 2 lunch meals a week
 - Create a program "Safe Local Food for Strong Local Economies" for shorter food chains, integrated with health, education, land-use and transportation agencies which will increase food security, increase food-based businesses which support the local economy, and protect environmental quality
 - Develop urban agriculture projects that utilize composted organic wastes and waste water from the city to grow food produced by students getting credit, local volunteers, offenders assigned to community service, able recipients of food assistance, people wanting their own plots, and farmers. Some cities have three types: people wanting to have a garden plot for home use, for profit CSA's whose members pay, and community gardens that provide food for food banks, shelters, low-income families

and worked by those who have incentives and mandates to help produce food for others.

-Conduct training in season extension, organic soil building, water efficiency, safe pest control, and organic certification.

-Overcome obstacles including providing insurance programs, post-harvesting handling systems, transportation and storage facilities.

- Voluntary and or negotiated agreements

- FARM TO RESTAURANT: Expand the existing program for voluntary commitment from corporations (restaurants, hotels, etc) to buy increasing percentages of local food.

- FARM TO STORE: Work with grocery stores to increase local food purchasing by eliminating price barriers such as slotting fees and by promotional campaigns for local foods. If voluntary arrangements are not successful, regulations should be considered.

- Codes and standards

- BUY LOCAL FOOD CAMPAIGN: The Governor's Executive Order to all state institutions (state buildings/cafeterias, schools, universities, prisons, hospitals, etc.) will be to purchase an increasing amount of local food according to a table for minimum purchases, creating the demand side for local food. The state institution local purchasing needs to, at a minimum, parallel the state goals for increase in local consumption of local food.

- To prepare the local supply side, the Governor shall notify the Board of Regents that building the local food systems is a major priority. A working session with the Board of Regents on climate change and agriculture will initiate the new campaign, setting clear goals. The College of Agriculture and the Department of Agriculture will conduct an assessment of the requirements, define and plan the educational needs. Topics will include carbon farming and carbon ranching methods, and the range of sustainable agriculture, from the initial IPM through to certified organic. Also there will be support for implementing solutions to defined needs such as increased cold storage, allowing improved distribution. Research needs also must be met to assist farmers in improved methods for meeting the new demands.

- Review local, county and state regulations to both add support for local production, processing, storage, distribution and sale of local foods and to remove or adapt barriers to same.

- Pilots and demos

- Expand the existing Farm to Table program to conduct demonstrations projects at schools, colleges and other public facilities promoting local food production and

processing and local food utilization.

- Create an incubator organic farm program to support development of new farmers to replace the current aging farmer population.

- Establish model Urban Agriculture projects based on urban projects in such places as Chicago, Portland, and Missoula, Montana that include greenhouses and utilize treated waste water and composted wastes for waste reduction and reduction of out of state inputs.

- **Research and development**

- Market surveys to facilitate customer demand for increased local food.

- Conduct research to document total miles and energy used for a selection of food products, followed by public education.

- Conduct research to develop systems to better monitor in-state food production & consumption versus imported food.

- **Reporting**

- Assess the need for reporting mechanisms to assess program progress.

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

- CO₂: Savings occur as a result of shorter haul distances and modification of freight modes (air to ground), which would reduce diesel fuel use.
- Black Carbon: Reductions in diesel fuel use result in a reduction in BC emissions.

Estimated GHG Savings and Costs (for quantified actions):

- **GHG reduction potential in 2012, 2020 (MMtCO₂e):** 0.2, 0.6
- **Net Cost per MtCO₂e:** TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Estimates of harvested acres, crop yields, and crop value and production estimates for beef and dairy products were obtained from USDA National Agricultural Statistics Service (NASS). Estimates of state exports were obtained from the USDA Economic Research Service (ERS). U.S. per capita consumption rates were obtained from the ERS Food Consumption (Per Capita) Data System. New Mexico population data were obtained from the New Mexico Bureau of Business and Economic Research.
- **Quantification Methods:** The amount of each crop produced in New Mexico was

estimated using harvested acres and estimates of crop yields per acre (unless the amount produced was already available in NASS data). The amount of each crop consumed in New Mexico was estimated using U.S. per capita consumption rates and the New Mexico population. State export values were reported for commodity class. These values were allocated to each crop based on the crop value for each individual crop compared to the total value for all crops in the commodity class. Export values were then converted from dollars to weight using an estimated price calculated from the crop production value and amount produced for each crop. The amount consumed and exported for each crop was then subtracted from the amount produced to determine how much of the crop was imported. For each imported crop, a likely state of origin was chosen (CA for cabbage, lettuce, sweet corn, cantaloupe, grapes; TX for beef and eggs; WA for apples; and KS for wheat). The estimated amount of imports for each crop and the estimated mileage were then used to estimate ton-miles transported and CO2 emissions. These calculations were repeated for 2010 and 2020 using population projections to estimate future consumption.

- **Key Assumptions:** Transportation emissions were estimated by assuming 23 tons of payload per truck, 6 truck miles per gallon of diesel fuel and 22.4 lb CO2 per gallon of diesel fuel. To estimate miles traveled, food from CA was assumed to travel from Fresno to Phoenix (600 miles), food from OK was assumed to travel from Oklahoma City to Phoenix (1,000 miles), food from ID was assumed to travel from Boise to Phoenix (1,150 miles). The amount of food produced and exported is assumed to remain constant, while consumption is assumed to grow with population.

Key Uncertainties: One uncertainty is the amount of food products leaving the state. State export data from ERS includes only foreign exports. These estimates do not include state-to-state exports. Also, these estimates do not take into account that a large portion of some crops may be shipped out of state when they are in season, and imported into the state when they are not in season. The benefits were quantified at the state level. As such, they do not capture additional GHG benefits where local (e.g. community-level) production and consumption takes place (resulting in addition ton-mile reductions). The quantified benefits could also be conservatively low since the assumptions for out of state produce were based on the nearest likely producer state. Many commodities come from much further away (including foreign countries) and can travel by more energy intensive methods (e.g. air transport). Finally, the assumed transport routes are a single trip from city of origin to Phoenix. Many commodities will make several trips prior to reaching their final point of consumption (e.g. for packaging, storage, processing, etc.). The overall impact of all of the assumptions is that the benefits are underestimated by a large amount.

Contributing Issues:

- **Human and social issues**
 - Improved public health from increased consumption of fresh local foods, including a

higher percentage of produce.

- Amplify the benefits to the health of children begun with the Governor's banning of junk food in schools, and the Wellness Policies that have been established.

- Preservation of open spaces utilized for farming.

- Urban agriculture can provide the fewest food miles, provide jobs right next to where people live (no commuting required), take advantage of reusing water (important in droughts), and reusing wastes that have been composted. Vacant city lots, rooftops, and other areas can provide an astonishing amount of food.

- More reliance on local production may reduce the variety of foods available to all consumers throughout the year.

- Under serious drought conditions and/or local/regional climatic variation, supplemental food supplies can be developed for the proportion of food from local sources that are implicated. Urban food production that reuses city water can in some cases provide a buffer.

- Reduction of waste: both when safe solid wastes are composted and return to food producing areas, and when the heavy packaging required for long-distance travel is avoided. Local foods can reuse containers repeatedly.

- **Environmental issues**

- Today's food has enormous hidden embodied energy in its travel and processing from farm to table in current industrial food systems, typically traveling from one to over five thousand miles for food from the United States, and 8,000 miles or more for imported foods. Backhauling- trucks returning empty- can add another 25% to 50% more miles. With only approximately 10% of our foods being fresh produce, the embodied energy from heavily processed, heavily packaged foods is a major contributor to greenhouse gases. Estimates of 20% of total emissions are from our centralized food systems. Local food can not only reduce food miles but also food processing and packaging. Increasing the percentage of "local food for local people" can reduce significant amounts of fossil fuel use and its associated GHG emissions. Local food also increases food security, and can buffer impacts of rising fuel costs and possible fuel shortages.

- New Mexican's spend about \$6 billion dollars for food each year. About 60% is food at home and 40% away from home. Fifty percent of those expenditures are for meat, fresh vegetables, bakery products, and poultry. Cattle represent the second largest source of cash receipts for New Mexico agriculture but only six percent of the beef consumer in the state is slaughtered here. Cattle can travel 3,500 miles in the "chain" from birth to a New Mexico supermarket. Wheat is the major food grain grown in New Mexico yet most of the wheat products are produced out of state. Wheat can travel over 5,000 miles from field to a New Mexico supermarket, when it is flour in a packaged product. Hence, there are substantial CO₂e emissions associated with both fresh and processed food transport, processing, and packaging.

- **Economic issues**

- Increased job opportunities in producing, processing, distributing, and selling food.
- Strengthened local economies and reduction of local dollars leaving the state.
- Increased food security, especially for low-income families who will suffer disproportionately when food prices rise due to extreme weather events and to increased prices for fossil fuels.
- Increased local business opportunities, including for food processing.
- Cost: more reliance on local production may reduce the variety of foods available to all consumers throughout the year.
- Cost: (potential cost): decrease in food security due to local drought conditions and/or local/regional climatic variation—supplemental food supplies and emergency plans must be developed for the proportion of food from local sources.

- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

A-11 Biodiesel Production

Option Category: Not Quantified

Policy Description: Provide incentives for the production of biodiesel from crops or waste vegetable oil. Biodiesel use will offset diesel fuel derived from fossil fuel and will lead to decreased fossil fuel-based CO2 emissions and increased carbon-neutral fuel sources.

Policy Design:

- **Goal levels:** With BAU production very low in the state, increased use of locally-produced biofuels should be relatively easy to attain. Proposed increases in biodiesel production and use are to replace 10% of New Mexico's petroleum diesel consumption by 2010, and increasing to 15% by 2012. A combination of the readily available waste vegetable oil and increased crop production for biodiesel will help meet this schedule. These targets are subject to adjustment based on an analysis of the production capacity of

NM agriculture. Further into the future, the production volume necessary to support the TLU TWG's renewable fuels proposals is targeted. This assumes the need for 30% fossil diesel offset by 2030 and 40% offset by 2040.

- **Timing:** Replace 10% of New Mexico's petroleum diesel consumption by 2010, and increasing to 15% by 2012. The goal for 2030 is 30% of projected fossil diesel consumption and, by 2040, 40% of projected consumption.
- **Parties:**
 - New Mexico Energy, Minerals, and Natural Resources department should lead the evaluation of biodiesel consumption and projections into the 2010, 2012, and 2020 time frames. Energy, Minerals, and Natural Resources should also lead the development of the necessary infrastructure for production and distribution of the locally-produced biodiesel.
 - New Mexico Department of Agriculture (NMDA) and New Mexico Agricultural Extension Services (NMAES) should lead the evaluation of appropriate crops and balance resource use to grow new crops for biodiesel. NMDA and NMAES would also lead the transition to crops for fuel that would be needed to make the proposed plan effective.
- **Other:**

Implementation method(s): (provide category from standard CCS list, with details as needed)

Related Policies/Programs in place:

Types(s) of GHG Benefit(s):

- **CO₂:** CO₂ emissions are reduced by offsetting the use of petroleum-derived diesel fuel. Energy requirements for producing biodiesel need to be compared to the energy requirements of producing fossil fuel diesel to completely assess the CO₂ benefit. Production of biodiesel locally lowers the embedded CO₂e of biodiesel compared to production from out of state vegetable oil suppliers.
- **Black Carbon:** BC emissions could be lower between biodiesel and fossil diesel, based on some recent test data for particulate matter; however, the differences are probably negligible (information on the BC content of particulate emissions from biodiesel combustion might not be available).

Estimated GHG Savings and Costs (for quantified actions):

- **GHG reduction potential in 2012, 2020 (MMtCO₂e):** 0.9; 1.7
- **Net Cost per MtCO₂e:** TBD

Data Sources, Methods and Assumptions (for quantified actions):

- **Data Sources:** Data from the NM Inventory & Forecast was used to quantify the benefits of offsetting fossil diesel consumption with biodiesel produced within the state. Fossil diesel consumption estimates are:

| <u>Year</u> | <u>Amount (1,000 barrels)</u> |
|-------------|-------------------------------|
| 2006 | 11,458 |
| 2010 | 13,194 |
| 2020 | 18,771 |

The policy design calls for 10% of the fossil diesel consumption to be offset by 2010 and 15% by 2012. To achieve the 30% offset by 2030, the estimated offset in 2020 would be 22% (assuming a linear ramp-up for in-state production capacity during the policy period). The CO₂e emission factor used in the inventory and forecast is 10.13 Mt/1,000 gallons.

- **Quantification Methods:** The amount of fossil diesel offset in each year was calculated from the diesel consumption estimates and the fraction to be offset in that year. The fossil diesel offset quantities (biodiesel production quantities) are shown below:

| <u>Year</u> | <u>Amount (1,000 gallons)</u> |
|-------------|-------------------------------|
| 2006 | 0 |
| 2010 | 55,415 |
| 2020 | 170,821 |

The fossil diesel offset quantities were then multiplied by the fossil diesel CO₂e emission factor to estimate the GHG reductions in each year.

- **Key Assumptions:**

Key Uncertainties:

The estimation of benefits does not take into account the lifecycle (e.g. well to wheels) costs and benefits for producing either fossil diesel or biodiesel. These lifecycle costs/benefits would take into consideration the GHGs produced during petroleum extraction, processing, and transport, as well as vegetable oil and alcohol (biodiesel production components) production, processing, and transport.

Contributing Issues:

- **Human and social issues**

- **Environmental issues**
 - Biodiesel is thought to lower emissions of some criteria air pollutants (e.g. sulfur dioxide, nitrogen oxides).
- **Economic issues**
- **Political and regulatory issues**

Feasibility Issues, if applicable:

Status of Group Approval: (Pending or Completed)

Level of Group Support: (Unanimous Consent, Supermajority, Majority, or Minority)

Barriers to consensus (if less than unanimous consent):

¹ J. Roland, USFS, email communication with S. Roe, CCS, 4/26/06. Data from the National Fire Plan Operations and Reporting System (NFORS) database.

² Brett Dickson, CO State Univ.; Data on forest restoration levels provided to George Koch of the AZ AF TWG on 4/05/06; "Intermediate Restoration" level of treatment selected for WUI areas; reduction in basal area assumed to be representative in reduction of above-ground biomass.

³ Based on REAP-Canada presentation (mid-point of 2 values provided for pelletizing wood residue (also representative of costs for pelletizing switchgrass). This value includes costs for transport, pelletizing, bagging and shipping, http://www.reap-canada.com/bio_and_climate_3_2.htm.

⁴ *DPNM Biomass Project Final Report*, prepared by Agri-Energy and the Dairy Producers of New Mexico, 2005.

⁵ Based on REAP-Canada presentation (mid-point of 2 values provided for pelletizing wood residue (also representative of costs for pelletizing switchgrass). This value includes costs for transport, pelletizing, bagging and shipping, http://www.reap-canada.com/bio_and_climate_3_2.htm, accessed May 2006.

⁶ http://www.pelletboiler.com/mh_the_fuels.asp, accessed May 2006.

⁷ Abengoa Bioenergy, Portales. Renewable Fuels Association - <http://www.ethanolrfa.org/industry/locations/>.

⁸ Charles Bensing, Sunbelt Biofuels, personal communication with S. Roe, CCS. Based on conversion of either manure or municipal solid waste feedstocks. These plants are profitable at an ethanol wholesale price of \$1.90/gallon.

⁹ Charles Bensing, Sunbelt Biofuels, personal communication with S. Roe, CCS. Costs based on cellulosic plants in the 7 to 11 MMgal/yr production range. Plants use either manure or municipal solid waste as feedstock. Plants are profitable at ethanol prices of \$1.90/gal (current price is >\$2.70/gal). Costs to produce cellulosic ethanol range from \$1.28 - \$1.40/gal.

¹⁰ Abengoa Bioenergy Plant, Portales, NM, Renewable Fuels Association - <http://www.ethanolrfa.org/industry/locations/>.

¹¹ *Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems— A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions*, General Motors, Argonne National Lab, and Air Improvement Resource, Inc., May 2005.

¹² <http://www.ers.usda.gov/Data/FertilizerUse/Tables/Fert%20Use%20Table%207.xls>.

¹³ Brian Hurd, NMSU Agricultural Economics, personal communication with H. Lindquist, CCS, June, 2006.

¹⁴ Cibrowski, P., “Anaerobic Digestion in the Dairy Industry: Pollution Control Opportunities”, Minnesota Pollution Control Agency, presented at the Air Innovations Conference, August 10, 2004.

¹⁵ SCAQMD, 1996a. Characterization of Ammonia, Total Amine, Organic Sulfur Compound, and Total Non-Methane Organic Compound (TGNMOC) Emissions from Composting Operations, Source Test Report 95-0032/96-0003, conducted at EKO Systems, South Coast Air Quality Management District, January 1996.

¹⁶ University of Nebraska Integrated Farm at ARDC, Composting,
<http://www.ianr.unl.edu/ianr/csas/IF/compost.htm>.

¹⁷ Value obtained from: <http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html>.

¹⁸ Joel Brown, Jornada Experimental Range, U.S. Department of Agriculture, paper prepared for the AF TWG on Terrestrial Sequestration in NM, 2005.

¹⁹ The Farm Services Agency has a website that tracks CRP by state, year and practice and is updated every month:
http://www.fsa.usda.gov/dafp/cepd/crp_statistics.htm.

²⁰ Andrew Ortiz, USDA, personal communication with S. Roe, CCS and C. Abeyta, AF TWG, June 15, 2006.

²¹ Joel Brown, Jornada Experimental Range, U.S. Department of Agriculture, Agriculture Research Service, personal communication with S. Roe, CCS, May 2006.

²² Source: Mann, L.K. 1986. Changes in soil carbon storage after cultivation. *Soil Science* 142(5):279-288.
<http://cdiac.ornl.gov/programs/CSEQ/terrestrial/mann1986/mann1986.html>.

²³ Kimble, JM, R. Lal and R.F. Follett. 2002. *Agricultural Practices and Policies for Carbon Sequestration in Soil*. CRC Press.

²⁴ Pimentel, 2005 (July, 2005 issue of *BioScience*).