Baseline Greenhouse Gas Emission Profile and Forecast

Prepared for the

LA PLATA COUNTY

Community Development Department

April 3, 2008

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Executive Summary

In 2006, the La Plata County Board of County Commissioners approved a resolution supporting the U.S. Mayors Climate Protection Agreement. The agreement urges federal and state governments to:

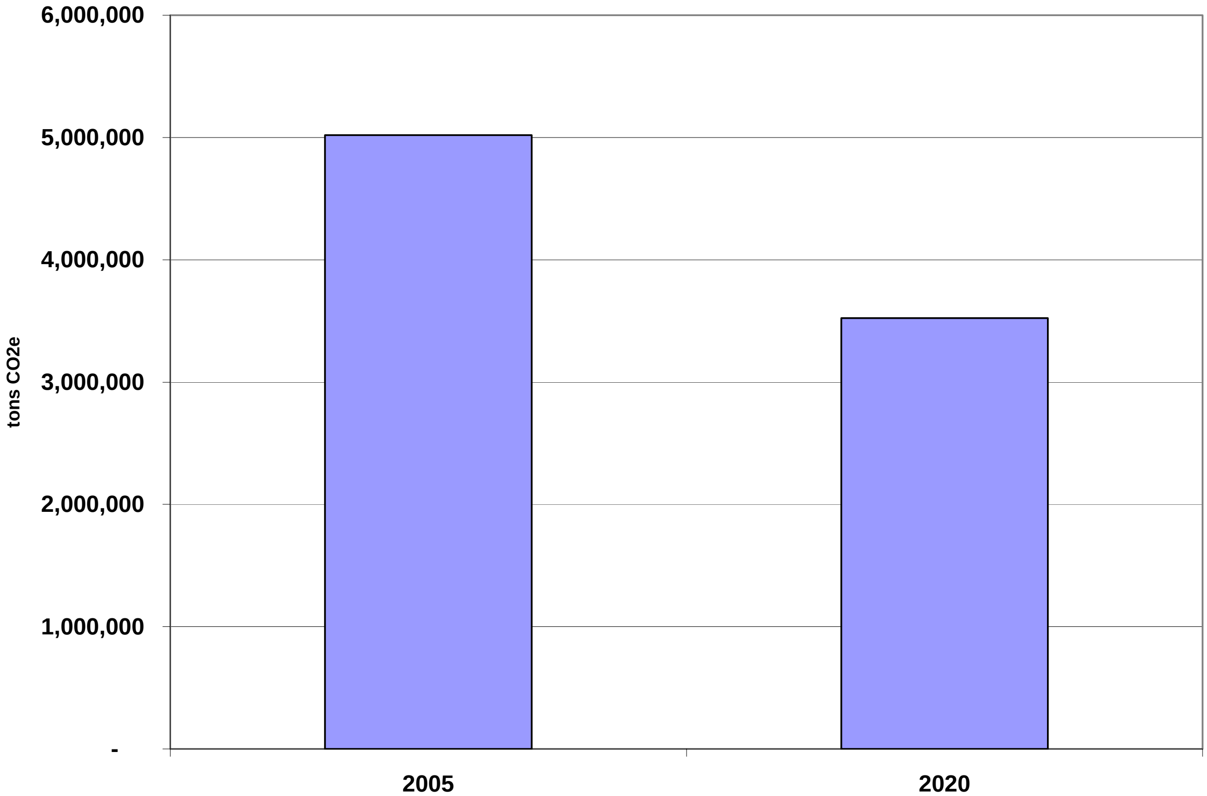
> ...enact policies and programs to meet or beat the target of reducing global warming pollution levels to 7 percent below 1990 levels by 2012, including efforts to: reduce the United States' dependence on fossil fuels and accelerate the development of clean, economical energy resources and fuel-efficient technologies such as conservation, methane recovery for energy generation, waste to energy, wind and solar energy, fuel cells, efficient motor vehicles, and biofuels.

During the fall of 2007, La Plata County took the first step outlined in the Agreement by commissioning an inventory of greenhouse gas emissions in the County. This report conveys the results of the inventory and forecasting effort that will form the foundation for the County to set realistic reduction targets and create an action plan that addresses local opportunities for emissions reductions.

The following emission sources are included in this inventory:

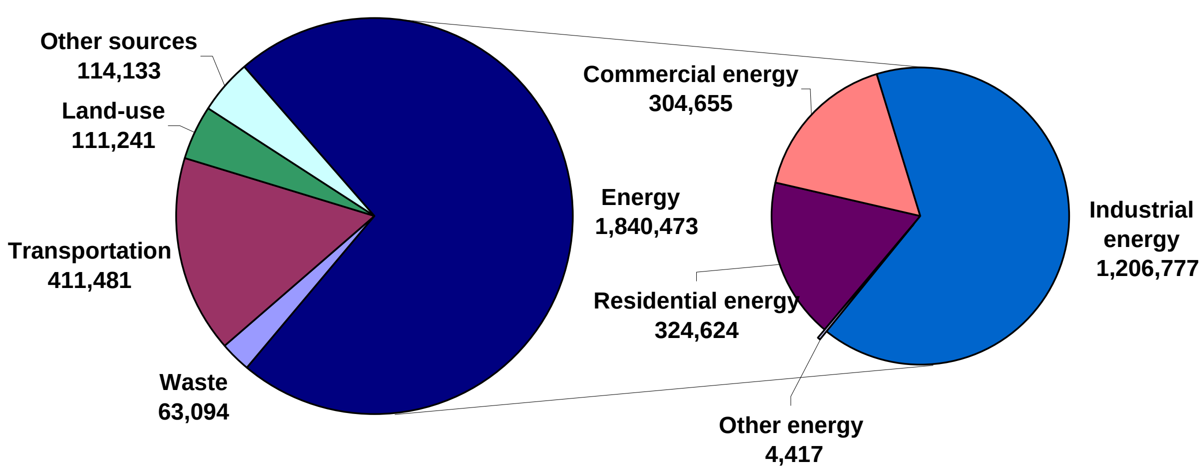
- Electricity consumption
- Natural gas consumption
- Other stationary fuel combustion
- On-road vehicle transportation
- Aviation activity
- Rail transportation
- Solid waste disposal
- Wastewater treatment
- Medical waste incineration
- Land-use activities and land-use change (e.g., livestock, agricultural and forest management, development)
- Coal mining
- Non-road vehicle and equipment use
- Refrigerant losses
- Natural gas production

Based on data for the baseline year of 2005, La Plata County's total greenhouse gas (GHG) emissions from the above sources are estimated to be 5,019,511 tons of carbon dioxide equivalent (tCO_2e). As the figure below indicates, these emissions are forecasted to decrease to 3,523,633 tCO_2e by 2020. The decrease in emissions is driven by reduced production in the natural gas industry. Over the same period, emissions from all other activities in the community are anticipated to grow from 1,333,645 tCO_2e to 2,058,387 tCO2e.



Total County GHG Emissions 2005 and 2020

The contributions to the County's total emissions from each source category, excluding direct emissions of natural gas and entrained carbon dioxide from the natural gas production industry, are broken down in the figure below.



County GHG Emissions by Source and Sector, tCO_2e

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Acknowledgements

Thank you to all of the stakeholders from utilities, governments, and local organizations that have contributed their time to introduce and share the nature of La Plata County, compile data, review results, and bring this inventory to realization.

The stakeholders in this inventory process consisted of a group of about 20 individuals that participated in three meetings to identify emissions sources, suggest available data sources and contacts, confirm methodologies, and review inventory results.

A subset of the stakeholders group also participated in a presentation of the preliminary results of this inventory to an audience at the Focus the Nation event hosted by Fort Lewis College on January 31st, 2008.

In addition to the stakeholders group, numerous individuals from organizations throughout the County willingly answered questions and compiled the data that was used to complete this inventory.

1.0 Methodology

The following sections outline the emissions sources and the geographical and temporal boundaries that are used in this baseline greenhouse gas (GHG) emission profile. The general approach to the inventory also is described. The final section provides definitions of units and terminology frequently used in the document.

1.1 Sources, Jurisdictional Boundaries, Sectors, Temporal Boundaries

In preparing an emissions profile for La Plata County, the approach was to identify and determine emissions for all the major source categories in the County with less attention on relatively small emissions sources that offer less opportunity for emissions reductions. The following emission sources were considered in this inventory:

- Electricity consumption
- Natural gas consumption
- Propane consumption
- Other stationary fuel combustion
- On-road vehicle transportation
- Aviation
- Rail transportation
- Solid waste disposal
- Wastewater treatment
- Medical waste incineration
- Land-use activities and land-use change (e.g., livestock, agricultural and forest management, development)
- Coal mining
- Non-road vehicle and equipment use
- Refrigerant losses
- Natural gas production
- Exported electricity generation
- Cement production

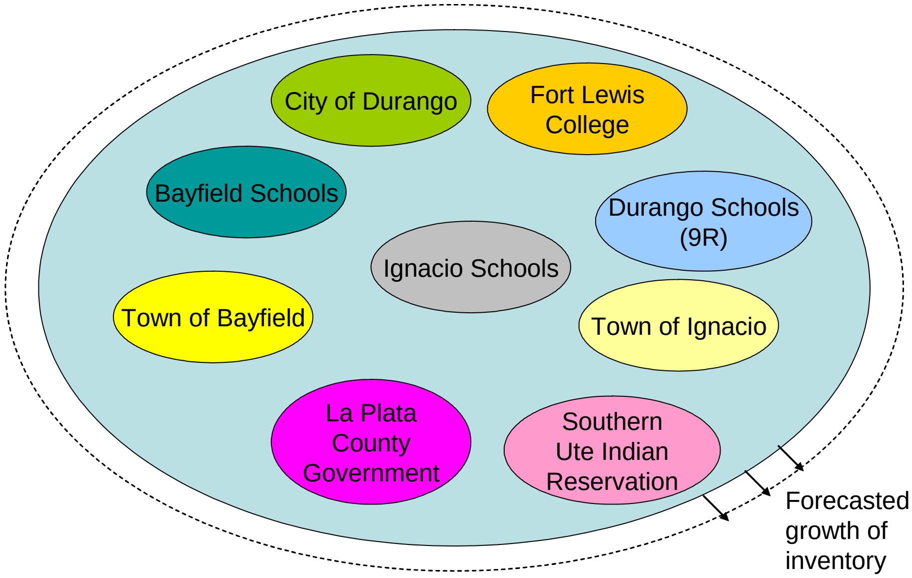

Figure 1. Inventory Components

Figure 1 depicts the overall structure of the emission profile. In this depiction, the light blue region represents the total County emissions from all of the sources listed above. The emissions from these sources are described in Section 2.0.

To better understand the contribution by local governments and entities (e.g., City of Durango, Fort Lewis College) to the inventory, and thus the capacity for direct action within the operations of these entities, an attempt was made to isolate the emissions for entities from which data could be obtained. These results are described in Section 3.0.

In the interest of further isolating emission sources, those emissions that can be directly attributed to residential, commercial, or industrial sectors also are identified. Emissions from electricity and natural gas consumption can be attributed to these sectors based on available data as related in Section 2.1.

The historic datum for this baseline inventory was established as 2005. The year 1990 has been the preferred choice and facilitates ready comparison to the targets established by Kyoto and the U.S. Mayors Climate Agreement. However, more reliable and accurate data were found to be available in recent years. This corresponds to the direction of newer climate agreements, such as the Western Climate Initiative, which are selecting later years (e.g., 2005) for baselines. Wherever possible, data from the year 2005 were used in this inventory.

A forecast of future emissions in La Plata County also was developed and is presented in Section 4.0. This forecast demonstrates the implications of meeting certain reduction targets, such as those laid out by the U.S. Mayors Climate Agreement.

1.2 General Approach and Tools

GHG emission inventories are rarely, if ever, based on direct measurement of emissions. Instead, emissions are estimated based on accepted models and methodologies. This inventory prioritized emissions estimates based on data pertaining to actual activities in La Plata County (e.g., electricity consumed) over modeled data. However, in some cases the results of modeling are the only option upon which to base a calculation (for example, determining emissions from on-road vehicle transportation requires modeling the number of vehicle miles traveled [VMT]).

This inventory draws on well reviewed and accepted methodologies from the Intergovernmental Panel on Climate Change, the Environmental Protection Agency (EPA), and those implemented in Local Governments for Sustainability's (ICLEI's) Clean Air and Climate Protection (CACP) software.

The CACP software tool is used to calculate the basic inventory components and accommodates unique emissions to provide an overall inventory accounting. The CACP software is well suited to La Plata County's application for the following reasons:

- Available to La Plata County as a member of ICLEI
- Focuses on fundamental carbon intensive areas with readily available data sources
- Easy for County staff or other organizations maintaining the inventory to learn and use
- Supported by well developed documentation
- Accepted methodology embedded in software
- Subject to ongoing software updates from ICLEI, making it less likely to become outdated when compared to a proprietary tool
- Ongoing support available from ICLEI
- Built-in capacity for reduction measurement within tool

For emission sources not covered directly by the CACP tool, custom spreadsheets have been developed. These tools and associated data were documented and provided to the County as part of this project for ongoing inventory maintenance. The results from these tools have been entered into CACP using the *Other* emissions category such that CACP produces a single coherent inventory.

The purpose of this report is to convey the approaches used and the results of the inventory. Therefore, it is not burdened with excessive details of methodology. Full documentation of data sources, emission factors, methodologies, and results can be found in the CACP tool and accompanying spreadsheets. Appendix C is targeted at the audience that will be maintaining the inventory and describes the general structure of the inventory, including directory structure, data sources, spreadsheets, and how they are coordinated into a cohesive inventory.

1.3 Included Greenhouse Gases, Terminology, and Units

Included Greenhouse Gases

The CACP tool is designed to incorporate emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), the fundament GHGs included in this inventory. It also supports more obscure GHGs, such as chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs).

Terminology and Units

The following terminology is used throughout this report and should be clarified from the outset.

- The terms inventory and profile will be used interchangeably to refer to the results of this baseline profile.
- GHG emission refers to the release of CO_2, CH_4, or any other GHG to the atmosphere.
- All units presented in the body of this report are short tons (1 short ton = 2,000 pounds).

The units of carbon dioxide equivalent (CO_2e) are used to normalize the global warming potential of the various GHG.

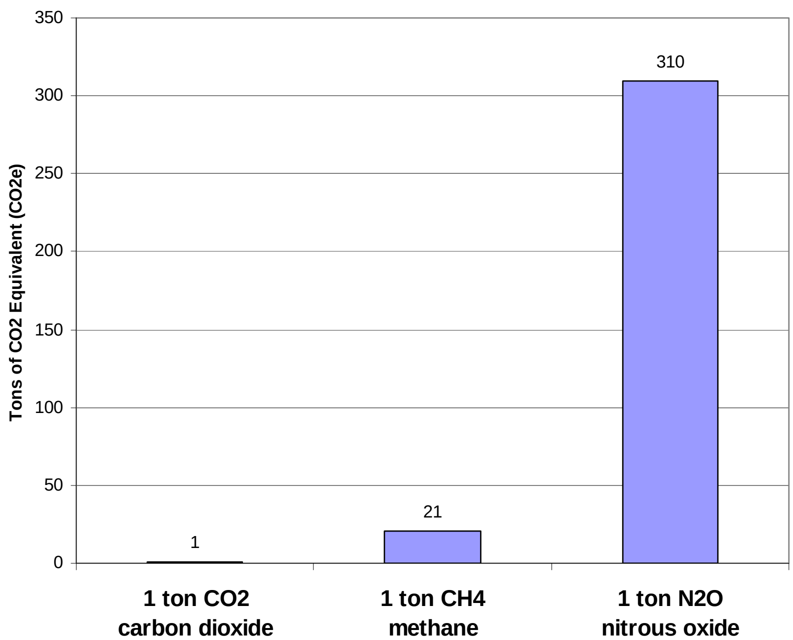

Figure 2. Units of GHG Representation

As portrayed in Figure 2, the emission of 1 ton of N_2O has a global warming potential (GWP) 310 times larger than that of the emission of 1 ton of CO_2. Similarly, the emission of 1 ton of CH_4 has a GWP 21 times that of CO_2. To avoid confusion between emissions of the different types of gases and their respective GWPs, all emissions are reduced to the common unit of CO_2e. Thus, the emission of 1 ton of N2O is expressed as the emission of 310 tons of CO_2e. Tons of CO_2e will be labeled as tCO_2e.

2.0 Aggregate County Emissions

La Plata County's total GHG emissions in 2005 are estimated to be 5,019,511 tCO_2e. As Figure 3 indicates, these emissions are forecasted to decrease to 3,523,663 tCO_2e in 2020. The reduction in emissions is driven by decreased production by the natural gas industry.

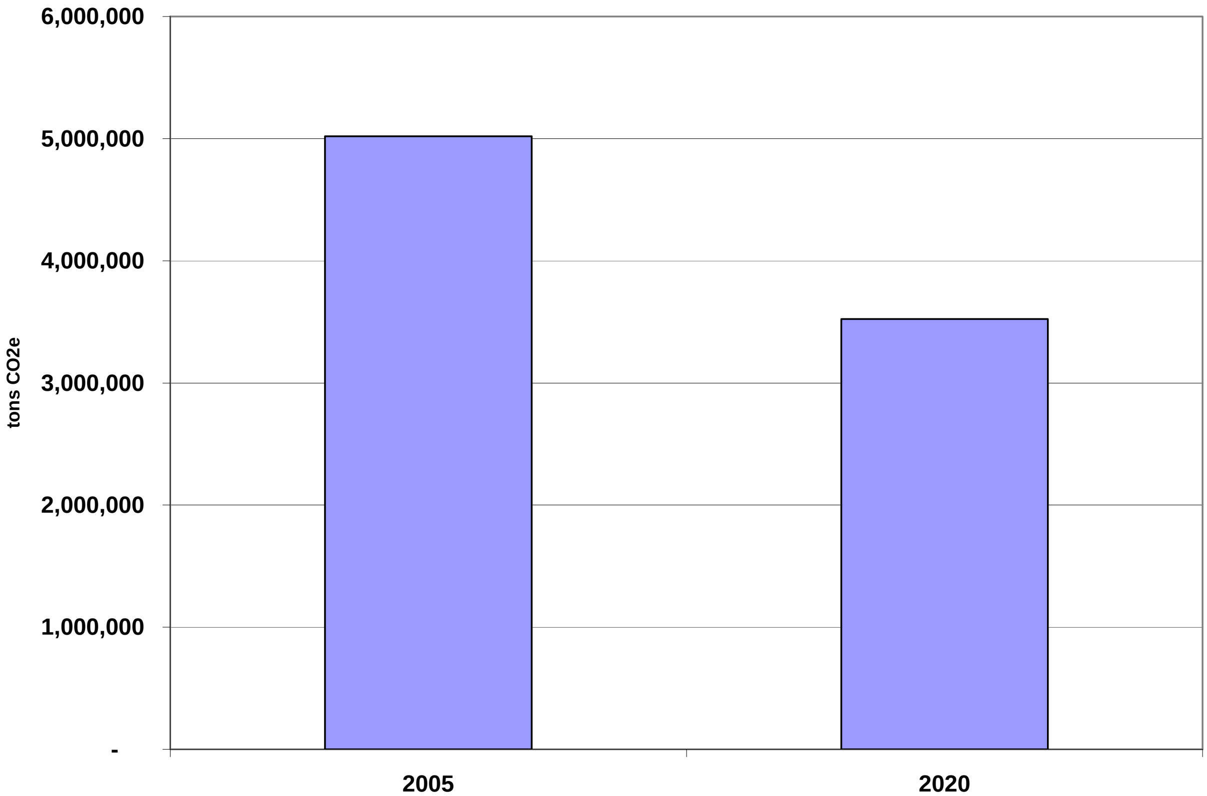

Figure 3. Total County GHG Emissions 2005 and 2020

La Plata County's emissions are considered, for the purpose of this report, in three segments:

- **Segment A:** Natural gas production industry emissions of methane, entrained carbon dioxide, and the remainder of carbon dioxide emissions from energy use (e.g. primarily transportation fuels) not covered in Segment B: 2,479,000 tCO_2e
- **Segment B:** Industrial energy use, electricity and natural gas combustion, based on utility and regulatory data: 1,207,000 tCO_2e
- **Segment C:** GHG emissions due to all other activities in the County: 1,334,000 tCO_2e

Total emissions, as expressed in Figure 3, include all three Segments. For the remainder of this report, unless otherwise indicated, references to *total emissions* or the *La Plata*

County inventory will include only Segments B and C. More detail on Segment A emissions is provided in Section 2.5.

The contributions to the County's total emissions of 2,540,422 tCO_2e (Segments B and C), from each source category, are broken down in Figure 4. The following sections will elaborate on the approach and results for each of these source categories.

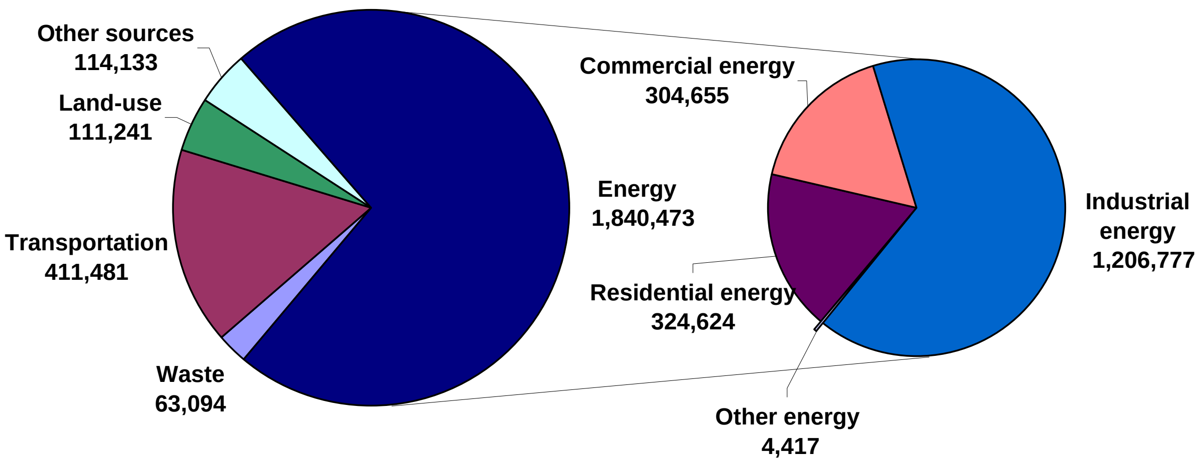

Figure 4. County GHG Emissions by Source and Sector

2.1 Energy

Energy consumption through electricity use, natural gas combustion, and other stationary fuel use represented 72% of the emissions inventory, the single largest source category. Unique among the source categories, data were available to support dividing these emissions among the three major sectors of residential, commercial, and industrial (RCI) use. The residential and commercial sectors each account for 12% while the industrial sector contributes 47% of the total inventory. Most of the industrial energy consumption is attributed to the natural gas production industry.

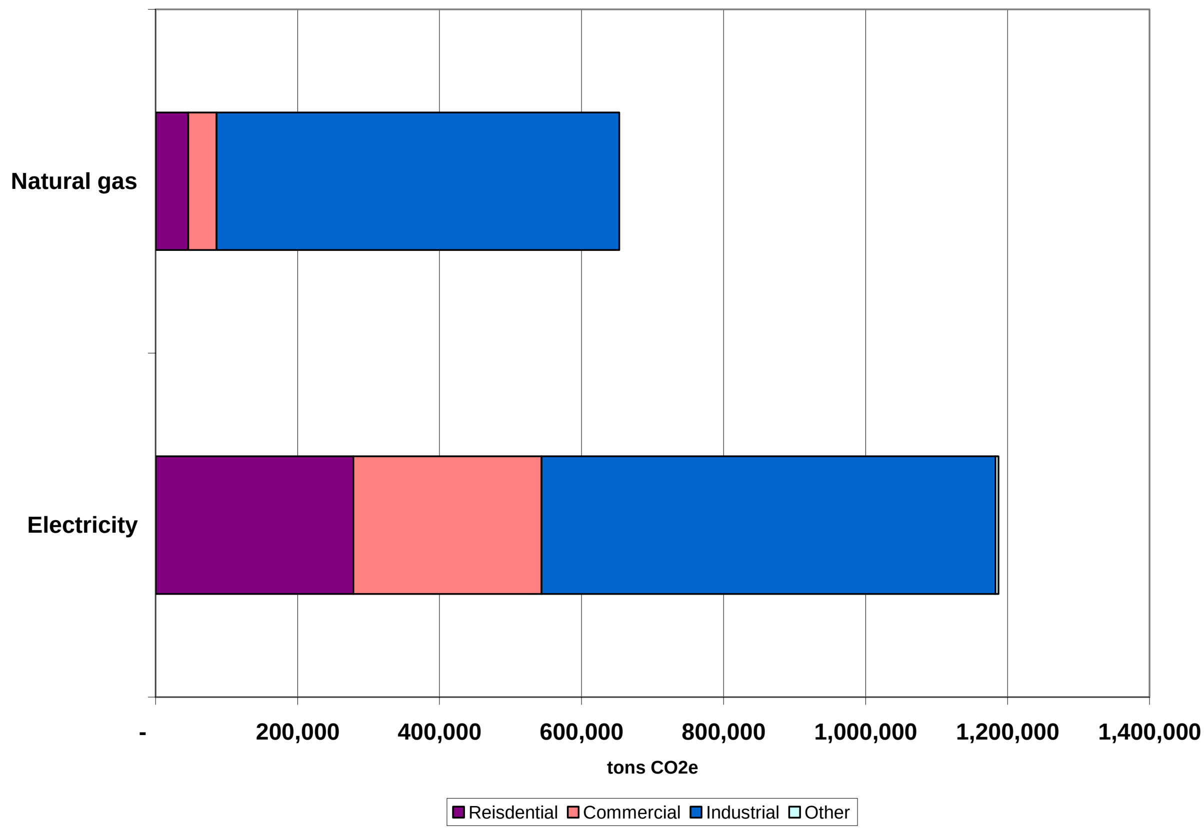

Figure 5. County Emissions From Energy Use by Sector

Electricity

GHG emissions from electricity consumption are indirect, occurring at the source of the electricity generation, but are attributed to the consumer of the energy. Emissions from La Plata County's electricity consumption were 1,110,932 tCO_2e, 43.7% of the total inventory. As indicated in Figure 5, residential and commercial electricity use each contributed about 25% of electricity emissions and industrial use contributed the remaining 50%.

Emissions from electricity generation are calculated using an emission factor that accounts for the mix of resources used to generate the electricity and the particular GHG emission rates of those resources. For the La Plata County inventory, a factor for Tri-State G & T from the EPA's eGRID database was applied. The calculation of emissions was carried out using CACP, and details of the methodology can be found in that software's documentation.

Electricity consumption data were provided by the La Plata Electric Association (LPEA), a cooperative and the sole electricity provider in the County, and included segregation of RCI uses. These data also included minor electricity uses, such as street lighting, re-sales, and irrigation, which are categorized as *Other* in Figure 5 and constituted less than 1% of emissions due to electricity consumption. LPEA indicated that its Green Power program was not well established in 2005, thus it is assumed that none of the electricity consumed in the County in that year was from renewable sources, aside from hydroelectric and other renewable energy sources already included eGRID factor.

Natural Gas

GHG emissions from natural gas consumption are direct, occurring at the site when the gas is combusted for uses such as heating. Emissions from La Plata County's natural gas consumption were 725,071 tCO_2e, 28.5% of the total inventory. As indicated in Figure 5, residential and commercial natural gas use each contributed about 5% of natural gas emissions and industrial use contributed the remaining 88%.

Emissions from natural gas consumption are calculated using an emission factor that accounts for the regional gas quality or heat content. For the La Plata County inventory, a factor from the 1605 Voluntary GHG Emissions Reporting Guidelines produced by the Department of Energy was applied. The calculation of emissions was carried out using CACP, and details of the methodology can be found in that software's documentation.

Natural gas consumption data and heat content were provided by Atmos Energy, SourceGas and the Southern Ute Indian Tribe Utilities Division for residential, commercial, and a very small portion of industrial uses. The remainder of the industrial natural gas consumption data was provided by the Air Pollution Control Division, Stationary Sources Program, at the Colorado Department of Public Health and Environment.

Propane

Similar to natural gas, GHG emissions from propane consumption are direct, occurring at the site when the gas is combusted for uses such as heating. Emissions from La Plata County's propane consumption have not been calculated as part of this inventory because data could not be obtained within the timeframe of this project to support the calculation. Numerous contacts were made with local and regional distributors as well as national providers with no substantive response. It is anticipated, given the limited service area of natural gas providers, that propane will contribute a similar magnitude of emissions as the residential and commercial sectors of natural gas to the County's inventory. The CACP tool supports the calculation of emissions from propane should these data become available for future revisions of the inventory.

Other Stationary Fuel Combustion

Other stationary fuel combustion includes direct emissions resulting from the consumption of fuels other than natural gas or propane by stationary equipment for purposes such as heating and generating energy. Emissions from stationary fuel use are predominately captured under industrial natural gas use above, but a small quantity of diesel also was combusted, resulting in 53 tCO_2e, 0.002% of the total inventory.

Emissions from this diesel consumption are calculated using an emission factor from the 1605 Voluntary GHG Emissions Reporting Guidelines produced by the Department of Energy. The calculation of emissions was carried out using CACP, and details of the methodology can be found in that software's documentation.

Other stationary fuel combustion data were provided by Air Pollution Control Division, Stationary Sources Program, at the Colorado Department of Public Health and Environment.

2.2 Transportation

Transportation activities in La Plata County, including on-road vehicle travel, aviation, and trains, representing 16% of the emissions (the second largest source category) of the La Plata County inventory.

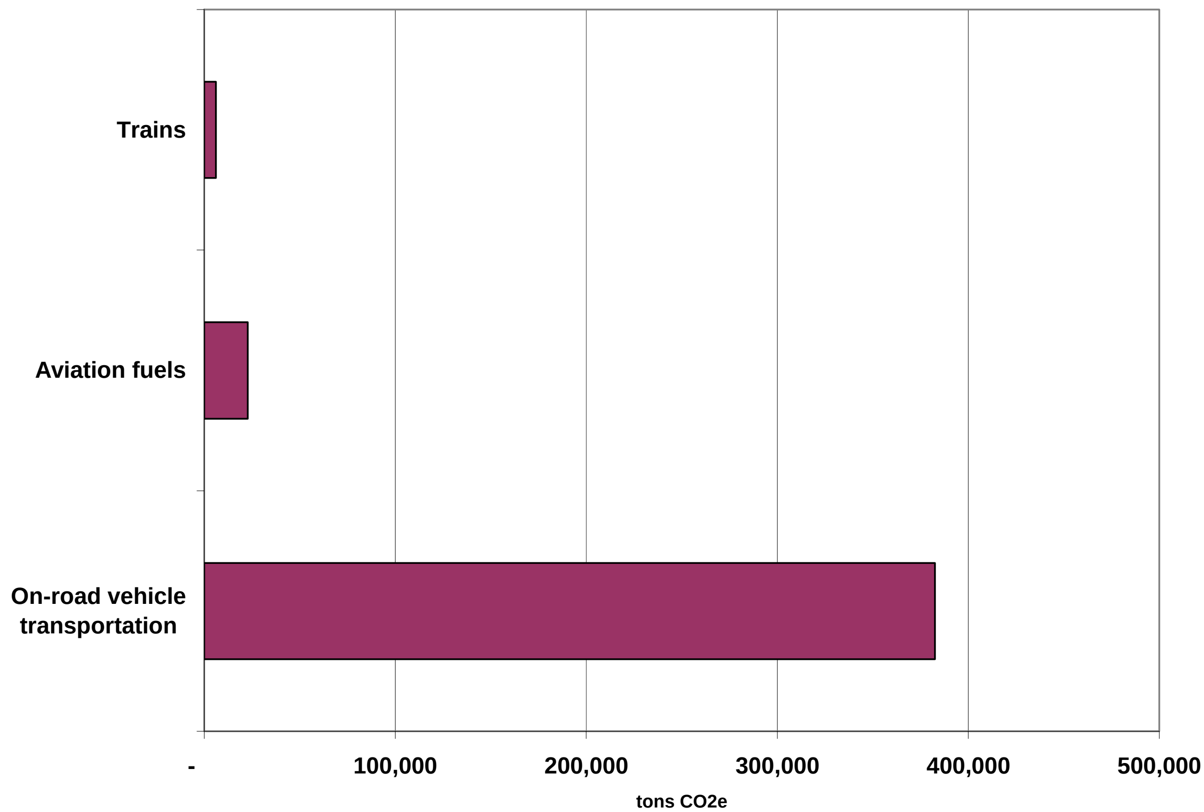

Figure 6. County Emissions From Transportation

On-road Vehicle Transportation

GHG emissions from on-road vehicle travel are direct, occurring at the tailpipe as the result of fossil fuel combustion in the vehicle's engine. These vehicles include cars, light and heavy trucks, and transit buses. Emissions from on-road vehicle travel in La Plata County were 382,616 tCO_2e, 15.1% of the total inventory. As indicated in Figure 6, on-road vehicle travel accounts for a majority of the emissions from transportation activities.

Emissions from on-road vehicle travel are calculated using average fleet fuel economies and composition of vehicle types from the Energy Information Administration and Tellus. These factors allow the conversion of total VMT to an estimated quantity of fuel consumed, which is converted to GHG emissions using factors from the EPA. The calculation of emissions was carried out using CACP, and details of the methodology can be found in that software's documentation.

The La Plata County Community Development Department provided the results of VMT modeling from transportation planning efforts to support the calculation of emissions from on-road vehicle travel. The County's model includes state highways, arterials, and collectors at the County and municipal level. Most minor local roads are not included in the model.

Aviation

GHG emissions from aviation activities are direct, occurring at the aircraft's engine as a result of fossil fuel combustion. Emissions from aviation activities to, from, and within La Plata County were 22,755 tCO_2e, 0.9% of the total inventory. As indicated in Figure 6, aviation contributes a fairly small quantity of transportation-related emissions.

The calculation of emissions from aviation activities is not directly supported by the CACP software. For this reason, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Tier 1 approach for Civil Aviation were applied. This approach accommodates calculating emissions based on average emission rates and the quantity of aviation fuels consumed. The Guidelines provide emission factors for aviation gasoline and jet fuel.

Emissions from aviation activities raise some accounting challenges since many flights cross County boundaries and the burden of these emissions ultimately is shared with the origin/destination city of the flight. Obviously, the emissions from these aircraft do not occur solely in La Plata County but also in flight to and from the origin/destination city. However, these emissions are fairly attributed to the County and the origin/destination city, not the transit space between, as a consequence of the presence of airline service between the two locations.

The Durango-La Plata Airport and Animas Airpark provided quantities of aviation gasoline and Jet A that were used to refuel aircraft at each airfield. Therefore, the emissions quantity represents the total emissions of aircraft leaving airfields located in La Plata County.

Rail

GHG emissions from rail travel are direct, occurring at the train's exhaust as a result of fossil fuel consumption. Emissions from train travel in La Plata County were 6,110 tCO_2e, 0.2% of the total inventory. As indicated in Figure 6, train travel accounts for a minority of transportation-related emissions.

The only rail activity in the County is the primarily passenger service of the Durango & Silverton Narrow Gauge Railroad (D&SNGR). Emissions from the coal consumed by this train are calculated using an emission factor from the 1605 Voluntary GHG Emissions Reporting Guidelines produced by the Department of Energy. The calculation of emissions was carried out using CACP, and details of the methodology can be found in that software's documentation.

The D&SNGR provided the quantity of coal combusted per trip from Durango to Silverton. The number of annual trips of the train was calculated based on schedules available on D&SNGR's website. These factors were combined to determine the total annual volume of coal combusted by the train. Any fuel use in idling that is not included in the quantity per trip provided by D&SNGR is assumed to be negligible compared to the quantity combusted under load.

2.3 Land-use Activities

The Brendle Group acknowledges Mark Easter, Steve Williams, Amy Swan, and Keith Paustian of the Natural Resource Ecology Lab, Colorado State University, Fort Collins, Colorado, for their work on the land-use component of this inventory.

Land-use and land-use change activities in La Plata County, including livestock, biomass combustion, manure management, development, agriculture, and fertilizer application, represented 4% of the emissions (the third largest source category) of the La Plata County inventory.

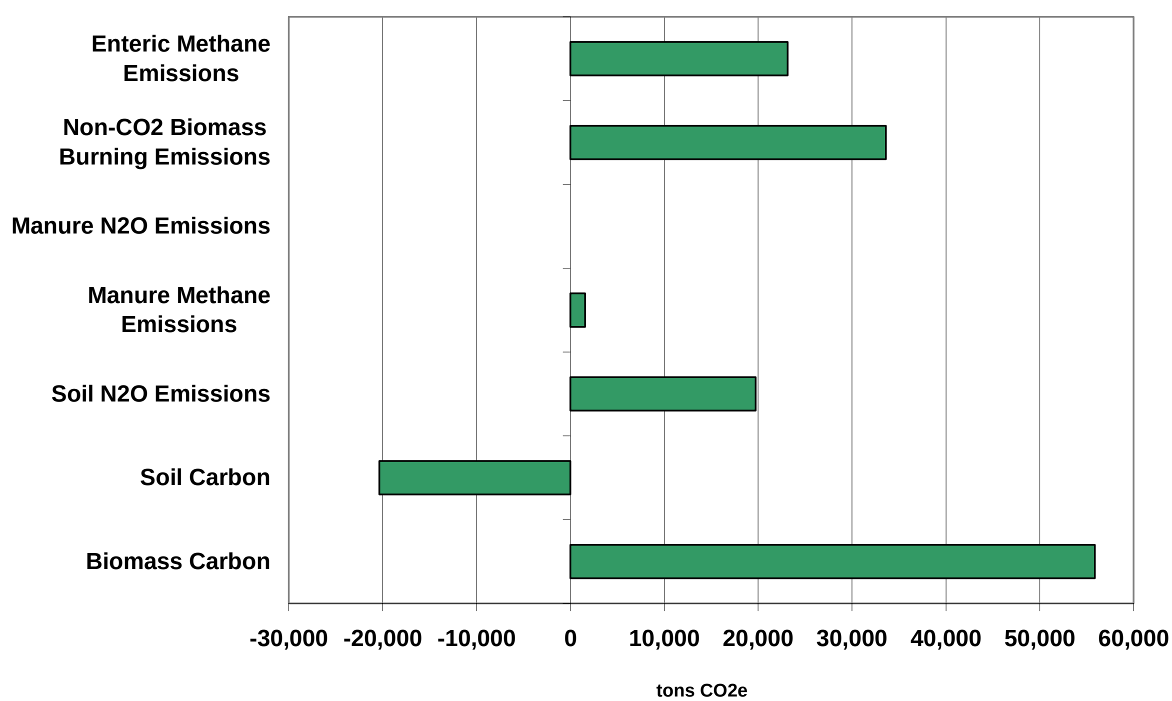

Figure 7. County Emissions From Land-use and Land-use Changes

Enteric Methane Emissions

Methane from enteric fermentation comes from the digestion of feed by animals. Beef cattle and horses are the two most significant sources of enteric methane in La Plata county, accounting for 72% and 19% of 2006 emissions, respectively (USDA National Agriculture Statistics Service 2007a, IPCC 2006).

Non-CO_2 Biomass Burning Emissions

The IPCC method provides calculations for non-CO_2 emissions from biomass burning from four greenhouse gases: methane, nitrous oxide, carbon monoxide, and nitrogen oxides. These emissions result from wood combustion during slash burning from timber harvest and land clearing, fuelwood burning, and wildfire.

Manure N_20 Emissions

The major source of manure nitrous oxide is from manure captured and stored at confined animal feeding operations (CAFOs). La Plata County has few livestock managed in CAFOs, hence there are no significant manure nitrous oxide emissions to report (USDA National Agriculture Statistics Service 2007ab).

Manure Methane Emissions

Methane emissions from manure is highly dependent upon the way in which manure is stored and/or processed (IPCC 2006). Manure left in pasture/range/paddock systems or stored in dry lots releases relatively little methane, whereas manure captured from dairies, feedlots, and other types of confined animal feeding operations (CAFOs) emit substantially more methane compared with equivalent numbers of livestock kept in pasture/range/paddock systems.

Soil N_20 Emissions

Emissions from Soil Nitrous Oxide in La Plata County come from direct and indirect emissions from four major sources, as follows:

- Nitrogen fertilizers sold within the county and applied for agriculture and landscaping (USEPA 2007).
- Manure nitrogen left by livestock on soils in pastures, on rangeland, within paddocks, and in other manure management categories where the manure is not collected and stored or handled otherwise (USDA National Agriculture Statistics Service 2007a).
- Direct emissions from crop residues (USDA National Agriculture Statistics Service 2007b).
- Sewage sludge applied to soils within the county (Mike Sharp, personal communication).

Soil Carbon

Soil organic carbon consists of organic matter that has been taken up by plants during photosynthesis, and then decomposed into the soil after the plant died or plant material fell onto the soil.

Biomass Carbon

Biomass carbon consists of carbon stored in the woody tissues of trees and shrubs, including both above and below ground. Examples in La Plata County include high elevation spruce-fir forests, mid elevation ponderosa pine and aspen forests, and low elevation scrub oak and pinyon-juniper woodlands and sagebrush steppe. Biomass carbon is lost when woody vegetation is cleared and burned or left to decompose on the site. Common examples from La Plata County include clearing forest land for single-family home construction, industrial development, or housing subdivisions, and clearing sagebrush steppe for oil and gas development.

See Appendix A for additional detail on the land-use component of the inventory.

2.4 Waste

Waste disposal activities in La Plata County, including solid waste landfilling, wastewater treatment, and medical waste incineration, represented 2% of the emissions (the fourth largest of the major source categories) of the La Plata County inventory.

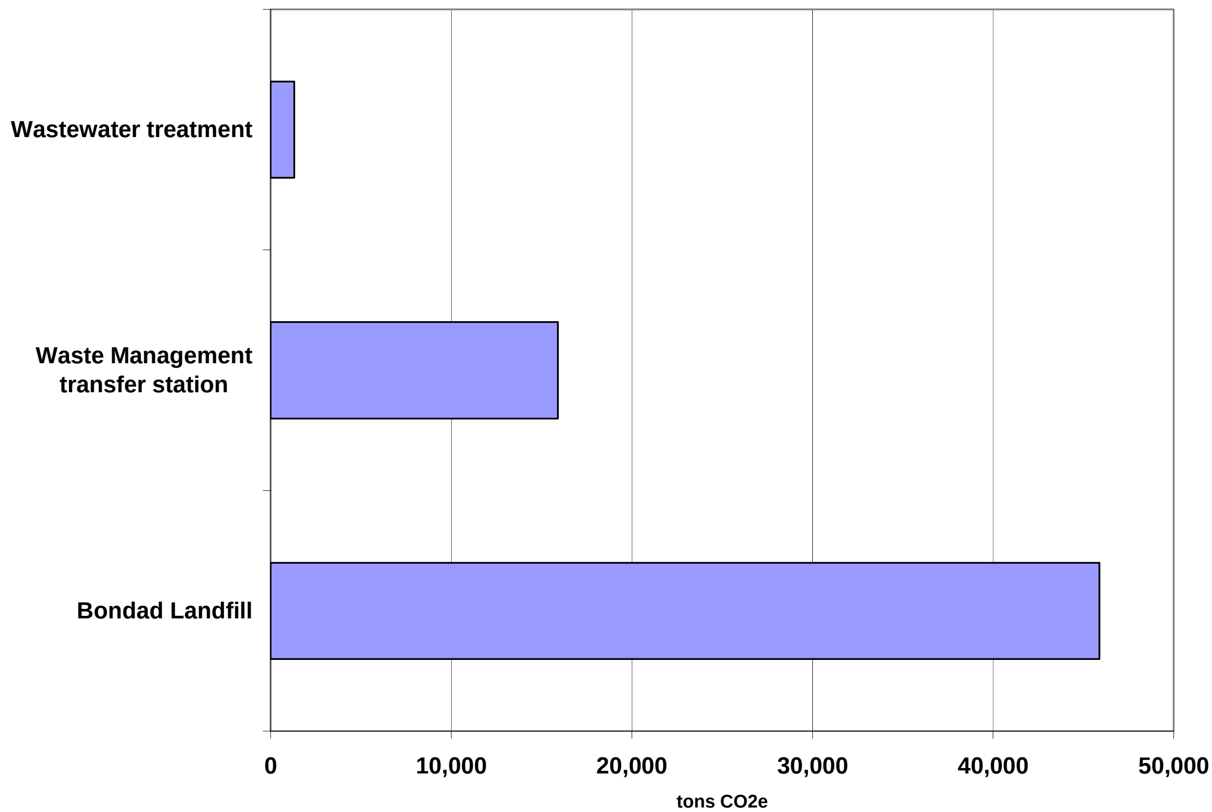

Figure 8. County Emissions From Waste Disposal

Solid Waste

GHG emissions from solid waste disposal are direct and occur as a result of material decomposition at the landfill. Emissions from solid waste disposal in La Plata County were 61,784 tCO_2e, 2.4% of the total inventory. As indicated in Figure 8, committing solid waste to landfills accounts for the majority of solid waste emissions in the County.

Emissions from disposal of solid waste are calculated using emission factors from the EPA's Waste Reduction Model (WARM). National averages for the material characterization of municipal solid wastes were applied. The calculation of emissions was carried out using CACP, and details of the methodology can be found in that software's documentation.

The following solid waste disposal sites and related data sources were considered in this inventory:

- La Plata County Recycling Center, Bondad Landfill – Volume of waste disposed from Colorado Department of Public Health and Environment; no waste characterization available; no methane capture

- City of Durango-owned, Waste Management-operated transfer station – Waste Management transfers solid waste to New Mexico landfills; provided volume per day maximum for solid waste flow; no waste characterization available
- City of Durango (Van Dahl) Landfill – Weight of organics used primarily for capping the old landfill was provided by the City of Durango; contributes little or no emissions
- Florida River Land Treatment Site – Site operated by BP that captures contaminated soil; site is less than 1 acre and has no apparent emissions sources
- Closed landfills – No evidence of methane monitoring at closed landfills and hence no basis on which to calculate emissions

Wastewater Treatment

GHG emissions from wastewater treatment are constituted by direct methane releases or carbon dioxide produced when the methane is captured and either flared or combusted in boilers. Emissions from wastewater treatment in La Plata County were 1,307 tCO_2e, 0.1% of the total inventory. As indicated in Figure 8, wastewater treatment accounts for a small minority of the waste disposal-related emissions.

Emissions from the wastewater treatment process require little calculation since they are based on the volumes of methane and/or carbon dioxide that are directly emitted.

The City of Durango provided volumes of methane flared and combusted in boilers. The carbon dioxide resulting from the combustion of the methane was then calculated. Based on discussions with the Colorado Department of Public Health and Environment, it was determined that the numerous other wastewater treatment facilities and aeration ponds that exist in La Plata County were likely to produce negligible emissions, if data were even available to quantify the emissions, particularly considering that the contribution of the larger City of Durango facility was very small relative to the total inventory.

Medical Waste Incineration

Medical waste incineration includes direct emissions resulting from the combustion process. Emissions from medical waste incineration resulted in 3 tCO_2e, 0.0001% of the total inventory. Medical waste incineration is a negligible source category and is only included because the data were readily available.

Emissions from incinerating medical wastes are calculated using emission factors from WARM. Emissions were calculated using CACP, and details of the methodology can be found in that software's documentation.

Medical waste incineration data were provided by Air Pollution Control Division, Stationary Sources Program at the Colorado Department of Public Health and Environment.

2.5 Other Sources

The *other sources* category encompasses those emissions that are not easily accommodated in the main source categories in the inventory. These emissions include direct methane releases from coal mining, non-road vehicle and equipment operation, and losses from refrigeration systems. Other sources in La Plata County represented 4% of the emissions in the La Plata County inventory.

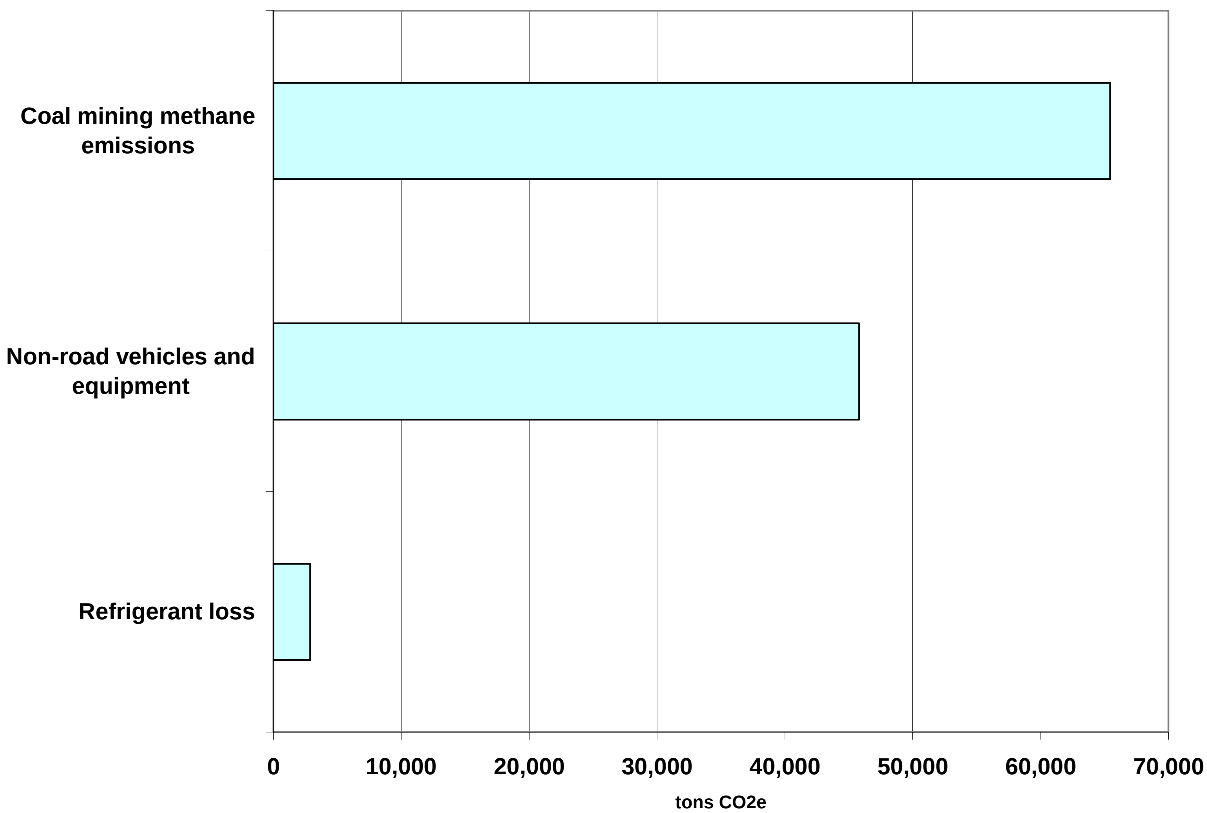

Figure 9. County Emissions From Other Sources

Coal Mining

GHG emissions from coal mining are predominately the result of direct methane emissions through an underground mine's ventilation system. Emissions from coal mining methane in La Plata County were 65,433 tCO_2e, 2.6% of the total inventory. As indicated in Figure 9, coal mining methane emissions accounted for the majority of other source emissions.

The CACP software does not directly support the calculation of emissions from coal mining activity, so the 2006 IPCC Guidelines for National Greenhouse Gas Inventory's methodology was considered as an alternative. Unfortunately, this methodology requires mine-specific ventilation data that were not forthcoming from the mines in La Plata County, state agencies, or the Mine Safety and Health Administration. Therefore, in an approach consistent with the State of Colorado's inventory, an emission factor based on quantity of coal produced from the Energy Information Administration was applied.

The quantity of coal produced in La Plata County was determined from a Colorado Mineral and Energy Industry Activities Report produced by the Colorado Geological Survey.

Non-road Vehicles and Equipment

GHG emissions from non-road vehicles and equipment include fossil fuel combustion related to a variety of activities, including the following:

- Recreational vehicles, such as all-terrain vehicles and snowmobiles
- Logging equipment, such as chain saws
- Agricultural equipment, such as tractors
- Construction equipment, such as graders and back hoes
- Industrial equipment, such as fork lifts, airport grounds equipment, and sweepers
- Residential and commercial lawn and garden equipment, such as leaf and snow blowers
- Recreational and commercial marine vessels, such as power boats

Emissions from these activities in La Plata County were 45,815 tCO_2e, 1.8% of the total inventory. As indicated in Figure 9, these activities were a significant contributor to other source emissions.

The CACP software does not directly support the calculation of emissions from these activities and other data to support the calculation were not readily available. Therefore, the EPA's NONROAD2005 Model was employed to estimate these emissions. The NONROAD2005 Model includes the following data sets, with resolution to the sub-county level:

- Equipment population for base year, distributed by age, power, fuel type, and application
- Average load factor expressed as average fraction of available power
- Available power in horsepower
- Activity in hours of use per year
- Emission factor with deterioration and/or new standards

For details on the NONROAD2005 Model, see that software's documentation.

Refrigerant Losses

Chlorofluorocarbon (CFC) based refrigerant gases used in air conditioning and refrigeration systems also are GHGs. It is common to exclude these gases from a GHG inventory because they are regulated by the Clean Air Act and currently are in the process of being phased out. However, an estimate is included here so that the magnitude of the remaining impact of the replacement refrigerants (hydrocholorofluorocarbons such as HFC-134a) can be understood.

In the course of normally operating cooling equipment, some of these gases will be emitted to the atmosphere (e.g., through leaks). GHG emissions from these losses in La Plata County are estimated to be less than 2,885 tCO_2e, 0.1% of the total inventory.

The CACP software does not directly support the calculation of emissions from operating refrigeration equipment, so an estimate was made based on loss rates from the EPA's Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance. The Protocol suggests three approaches to calculating emissions from refrigeration systems, all of which require detailed information on the equipment and/or the flux of refrigerants in equipment installation, maintenance, and decommissioning. Since those data could not be obtained within the scope of this project, the estimation was made based on commercial square footage in the County.

It is assumed that commercial air conditioning equipment is the largest user of refrigerants in the County, and the La Plata County Assessor provided total commercial square footage. Assumptions were made for the quantity of cooling per square foot, the quantity of refrigerant gas required to supply that cooling, and the refrigerant gas installed. Despite the likely overestimate resulting from assuming that 100% of the commercial square footage is cooled, the emissions from this source category are still very small.

Natural Gas Production

The Brendle Group acknowledges Richard Heede of Climate Mitigation Services, Snowmass, Colorado, for contributing the GHG emissions estimate for the natural gas production industry in La Plata County.

In 2006, the natural gas production industry in La Plata County produced 437 billion cubic feet (Bcf) of natural gas from 2,886 operating wells. This amounts to 35% of Colorado's production and 2.3% of US marketed production. This natural gas is produced chiefly by coal bed methane recovery from the Fruitland Formation.

There are a number of sources of GHG emissions from the natural gas production process:

1. Methane sources include routine operations, fugitive releases, field operations, pipelines, flares, and other process releases estimated to be 1,282,168 tCO_2e (Segment A)

2. Carbon dioxide from industry use of natural gas, diesel fuel, electricity, and in some cases steam (electricity and natural gas accounted for in Segment B at 1,206,777 tCO_2e, remaining sources included in Segment A at 188,553 tCO_2e)
3. Carbon dioxide vented from produced natural gas. Natural gas, while principally methane, also contains entrained CO_2, sometimes in high concentrations, as is apparently the case in the San Juan Basin, and especially from coal bed methane, such as the Fruitland Formation. The New Mexico section of the Fruitland Formation has a CO_2 content exceeding 17 percent. These emissions are estimated at 1,008,330 tCO_2e (Segment A)

Using emissions rates developed for the neighboring San Juan Basin in New Mexico, the emissions for the La Plata County natural gas production industry were estimated as shown in Figure 10. *It should be emphasized that these results are preliminary estimates.* As better data specific to La Plata County become available, the estimate of La Plata County's industry emissions is likely to be substantially improved.

As a result of the uncertainty in these calculations, the Segment A emissions depicted in Figure 10 (e.g. methane, some CO_2 from combusted fuels, and CO_2 vented) have been excluded from the total inventory as was discussed at the beginning of Section 2.0. However, a majority of CO_2 emissions from combusted fuels, Segment B, are confirmed by utility and regulatory records and included in the inventory. These emissions are indicated in red in Figure 10 and are equivalent to the industrial electricity and natural gas use discussed in Section 2.1.

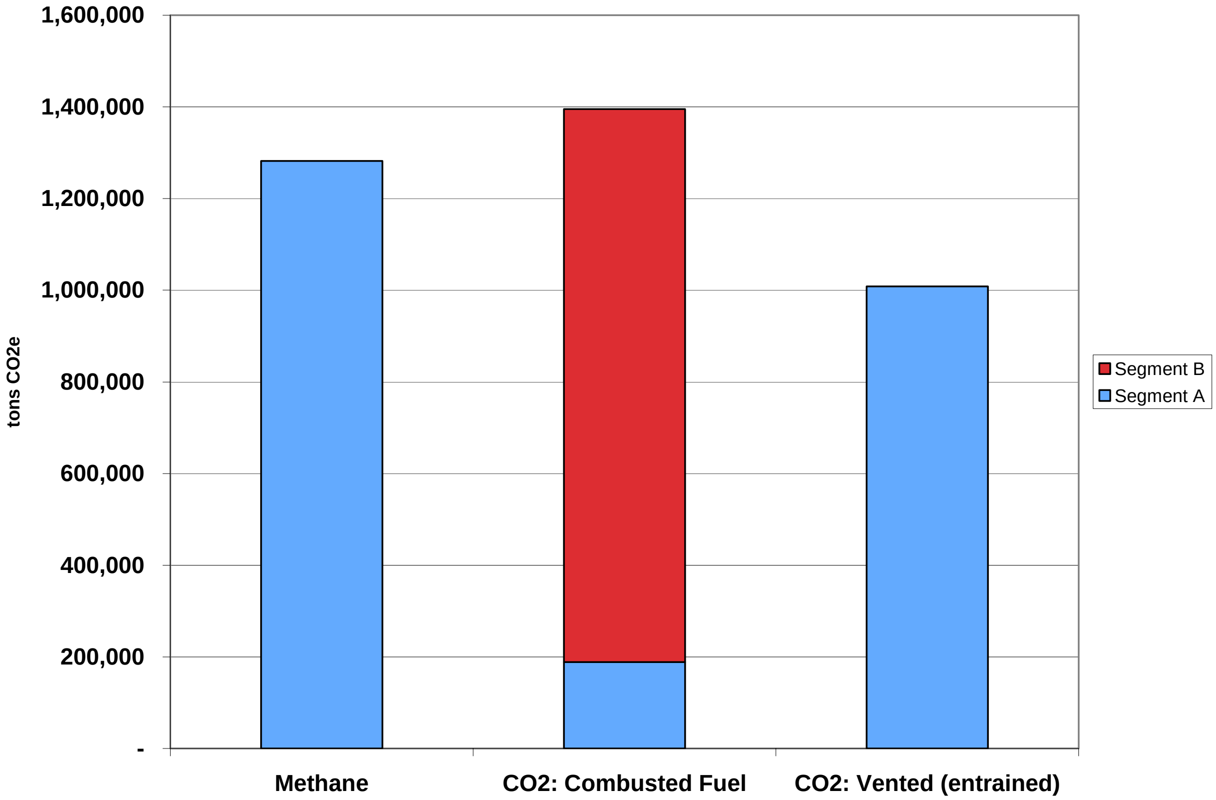

Figure 10. County Emissions from Natural Gas Production
(Units in Figure 10. are English tons which differ from the units of metric tonnes used in Appendix B)

Some of the uncertainties that might be resolved as additional data are made available are described below:

- Entrained CO_2 content (currently assumed equal to New Mexico portion of basin at 17%)
- Practice of CO_2 re-injection for enhanced oil recovery
- Demonstration of lower fuel use rates
- Implementation of best practices and/or mitigation options recommended by Four Corners Air Quality Task Force

See Appendix B for additional detail on the emissions estimate for the natural gas production industry.

Exported Electricity

GHG emissions from electricity generated in La Plata County, even if it is exported and consumed elsewhere, also might be included in this inventory. A review of the EPA's eGRID electric power system database indicates that there is no significant GHG-producing electrical generation in the County. This was confirmed by reviewing the Four Corner's Air Quality Task Force Four Corners Area Generating Units summary.

Cement Production

Cement production is a common and GHG intense industrial process. The Colorado Mineral and Energy Industry Activities report indicates that no significant cement production occurs in La Plata County.

3.0 Jurisdictional Emissions

To better understand the contribution by local governments and entities within the inventory, efforts have been made to identify the emissions of these groups.

Recognizing some gaps in the obtained data, the contribution was still relatively small at 2.1% of the total inventory.

Table 1. Emissions from Local Governments and Entities

Local Government or Entity	tCO_2e	Source Categories Included
Town of Bayfield	-	No data obtained.
Bayfield School District	-	No data obtained.
City of Durango	13,320	Electricity, natural gas, propane, fleet vehicles (excluding police cars), wastewater treatment.
Durango School District	13,257	Electricity, natural gas, propane, solid waste, fleet vehicles.
Fort Lewis College	16,897	Electricity, natural gas, fleet vehicles, fertilizer application, animal agriculture, solid waste generation, composting, faculty/staff/student commuting.
Town of Ignacio	650	Electricity, natural gas, fleet vehicles, streetlights.
Ignacio School District	-	No data obtained.
La Plata County Government	9,843	Electricity, natural gas, propane, stationary diesel, fleet vehicles.
Southern Ute Indian Tribal Government	1,646	Fleet vehicles and equipment, propane at wastewater treatment plant.

4.0 Emission Forecast

To facilitate the County in setting realistic reduction targets for GHG emissions and to understand those goals in the context of targets set by other entities, it was necessary to develop a forecast for the emissions inventory. The following sections describe the approach used in developing the forecast, the implications of various emissions reductions targets for the County, and the role of the inventory in measuring future progress toward targets.

4.1 Growth Rates

To forecast emissions in the County from the baseline year of 2005 through 2020 requires making assumptions about the growth rate of emissions in each source category. Existing forecasts are applied where available. Otherwise, a review of recent trends was conducted and a conservative growth rate was applied. Table 2 summarizes the annual growth rates applied to each source category.

Table 2. Emission Growth Rates by Source Category

Source Category	Annual Percentage Growth Rate	Justification
Residential energy (electricity, natural gas, propane)	2.36-3.08%	Household growth forecast for Region 9 from Colorado State Demography Office, varies annually between the indicated values.
Commercial energy (electricity, natural gas)	2.36-3.30%	Job growth forecast for La Plata County from Colorado State Demography Office, varies annually between the indicated values.
Industrial energy (electricity, natural gas)	(14.0)-(3.4)%	This source category is likely dominated by natural gas production. Preliminary results from an evaluation of reserves in La Plata County indicate decreased production in the future, varies annually between the indicated values.
Other stationary fuel combustion	(14.0)-(3.4)%	Assumed to be industrial use. See above.
On-road vehicle transportation	3.03%	Average growth rate in Colorado Department of Transportation Vehicle Miles Modeling for La Plata County from 2001-2006.

Source Category	Annual Percentage Growth Rate	Justification
Aviation	2.36-3.08%	Assumed to be driven by population and therefore most influenced by residential growth. See above.
Rail transportation	-	Assumed to be fairly constant.
Solid waste disposal	7.29%	Average growth rate in volume of waste delivered to Bondad Landfill from 2002-2006 based on reporting to Colorado Department of Public Health and Environment.
Wastewater treatment	2.36-3.08%	Assumed to be driven by population and therefore most influenced by residential growth. See above.
Medical waste incineration	2.36-3.08%	Assumed to be driven by population and therefore most influenced by residential growth. See above.
Land-use activities		
Biomass carbon	Unpredictable and highly variable, but likely to increase	Insect infestations are likely to increase risk of wildfire, though the extent cannot be estimated at this time.
Soil carbon	Remain stable, then gradually increase	Soil carbon losses will primarily be from land development in agricultural lands. Soil carbon levels on CRP lands will stabilize. Long-term funding for restoration of additional grassland on degraded lands is unpredictable.
Soil N_2O emissions	-2%	Agricultural census indicates a long-term decrease in livestock populations and dryland farming.
Manure methane emissions	-2%	Agricultural census indicates a long-term decrease in livestock populations.
Manure N_2O emissions	-2%	Agricultural census indicates a long-term decrease in livestock populations.

Source Category	Annual Percentage Growth Rate	Justification
Non-CO_2 biomass burning emissions	Unpredictable and highly variable, but likely to increase	As with Biomass Carbon, insect infestations are likely to increase risk of wildfire, though the extend cannot be estimated at this time.
Enteric methane emissions	-2%	Agricultural census indicates a long-term decrease in livestock populations.
Coal mining	2.92%	Average production growth rate for 2005-2006 from Colorado Mineral and Mineral Fuel Activity Reports.
Non-road vehicle and equipment use	2.36-3.30%	Predominantly construction and mining equipment emissions and therefore assumed to be driven by commercial growth rates. See above.
Refrigerant losses	2.36-3.30%	Predominantly commercial sources, therefore assumed to be driven by commercial growth rates. See above.
Natural gas production	(14.0)-(3.4)%	Average growth of natural gas production from 1999-2006 from Colorado Oil & Gas Conservation Commission. Studies are in progress to forecast the future production of the natural gas fields and will likely improve on this growth rate.

Source Category	Annual Percentage Growth Rate	Justification
Animas-La Plata Project	-	The Animas La Plata pumping project, if served by the regional electric grid, would generate approximately 72,000 tCO_2e once it reaches full capacity. However, this project is to be served electricity by the Western Area Power Administration (WAPA). WAPA's resource mix is comprised of hydroelectric power and therefore does not contribute additional emissions. Based on consultation with the United States Bureau of Reclamation.

4.2 Forecast

Applying the annual percentage growth rates described in Table 2 to the inventory's source categories yields the forecast by segment depicted in Figure 12. In 2005, La Plata County's total GHG emissions were estimated to be 5,019,511 tCO_2e. As the figure indicates, these emissions are forecasted to decrease to 3,523,663 tCO_2e by 2020 due to reduced production by the natural gas industry. Furthermore, while the majority of County emissions in 2005 are the result of natural gas production, declining production in that industry and continued growth in other County activities reverses that balance by 2020.

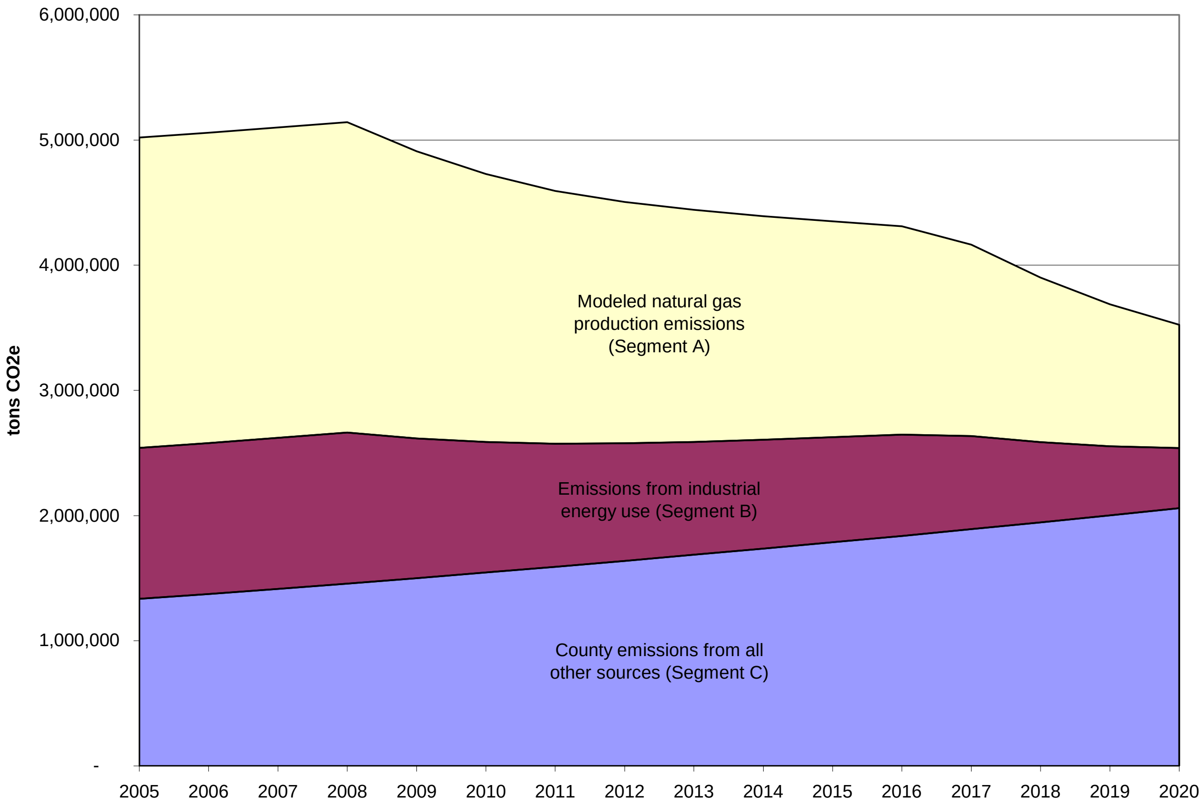

Figure 11. County Emissions Forecast 2005-2020, by Segment

4.3 Path to Emission Targets

Numerous collaborations and regions throughout the world are inventorying their GHG emissions and setting reduction targets. These reduction targets unify communities around a common goal and provide a context for developing appropriate strategies to achieve GHG reductions. A few relevant targets, as depicted in Figure 12, are presented below, as well as the implications for the County should it choose to adopt one of these targets. Only emission Segments B and C are included in calculating these target paths.

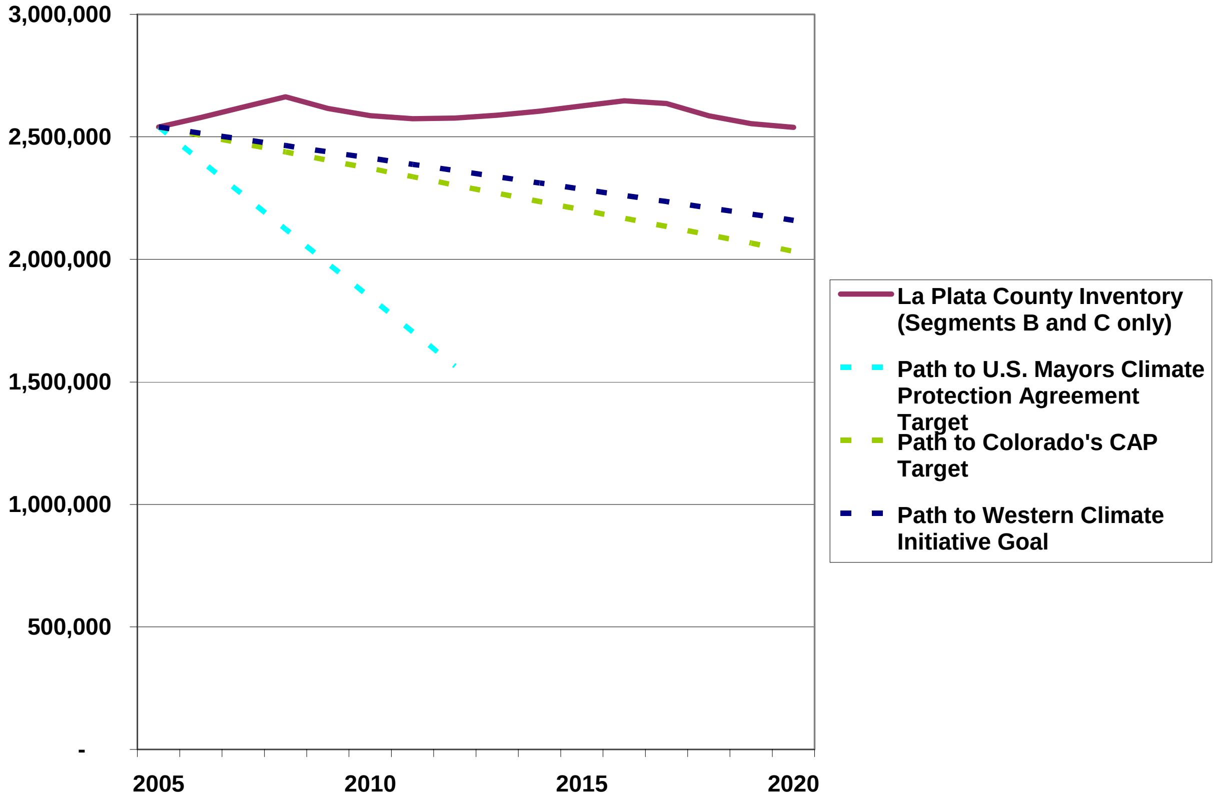

Figure 12. County Emissions and Paths to Potential Targets 2005-2020

U.S. Mayors Climate Agreement

In 2006, the La Plata County Board of County Commissioners approved a resolution supporting the U.S. Mayors Climate Protection Agreement. The Agreement urges federal and state governments to take action to meet or beat the target of reducing GHG emissions to 7 percent below 1990 levels by 2012.

The County's GHG emissions in 1990 were estimated by determining per capita emissions in 2005 and applying those per capita rates to the County's population in 1990.

To achieve this reduction target, the County would need to reduce emissions in 2012 to approximately 1,565,000 tCO_2e. This represents a reduction of 39% over projected emissions in 2012, as shown in Figure 12.

Colorado Climate Action Plan

The Colorado Climate Action Plan was recently released by Governor Bill Ritter Jr. and sets an interim target of reducing Colorado's emissions to 20 percent below 2005 levels by 2020.

To achieve this reduction target, the County would need to reduce projected emissions in 2020 to approximately 2,032,000 tCO_2e. This represents a reduction of 19.9% over projected emissions in 2020, as shown in Figure 12.

Western Climate Initiative

In 2007, the Western Climate Initiative was launched by the Governors of Arizona, California, New Mexico, Oregon, and Washington to collaborate in developing regional strategies to address climate change.

The Initiative has established a goal of reducing emissions by 15 percent below 2005 levels by 2020.

To achieve this reduction target, the County would need to reduce projected emissions in 2020 to approximately 2,159,000 tCO_2e. This represents a reduction of 14.9% over projected emissions in 2020, as shown in Figure 12.

4.4 Measuring Progress Toward Emission Targets

The role of the inventory in measuring progress toward emission targets is often misunderstood. Annual variations in the inventory caused by weather, changes in the economy, fluctuations in commercial/industrial production, and other factors generally create a level of uncertainty that will obscure the impact of most individual GHG reduction activities. Only a concerted, community-wide effort across many source categories taken in aggregate will produce the magnitude of reductions that will be readily discerned at the inventory level.

Often, a hybrid approach is applied that maintains an updated inventory as well as estimating the GHG reduction impacts on a measure-by-measure basis. A frequently updated inventory helps identify trends in County emissions that may impact the outcome of an adopted target and will, if concerted efforts at reduction take place, reveal progress toward that target. Simultaneously, the aggregated impacts of individual measures that the County adopts to achieve emission reductions should be tracked in order to more directly measure the success of the many strategies that will likely comprise a successful climate action plan. The CACP tool is designed to accommodate ongoing updates of the inventory as well as to track common GHG reduction measures.

5.0 Equivalencies and Benchmarks

The concept of a GHG emissions inventory (these many thousands or millions of tCO_2e) is quite abstract. To place these emissions in some context, it can be helpful to illustrate with equivalencies that are more easily visualized. At a presentation of the results of this inventory, one member of the audience asked, "Just how big is a ton of carbon dioxide? If I were to put it on a football field, how deep would the gas be?" One ton of CO_2 gas would cover the football field at a depth of approximately 4.5 inches, assuming normal atmospheric pressure and temperature. La Plata County's entire inventory stacked on top of a football field would be approximately 180 miles high. This is approximately the altitude at which the Space Shuttle orbits.

Another way to provide context for GHG emissions is to make comparisons to other communities and regions. As Figure 13 indicates, La Plata County's emissions are higher than those for other communities in the region, probably largely due to industrial energy consumption. This figure is provided for illustrative purposes only. The methodologies and boundaries drawn for the comparison inventories are not necessarily equivalent to those used in this inventory. Therefore, this is not a comparison of apples to apples.

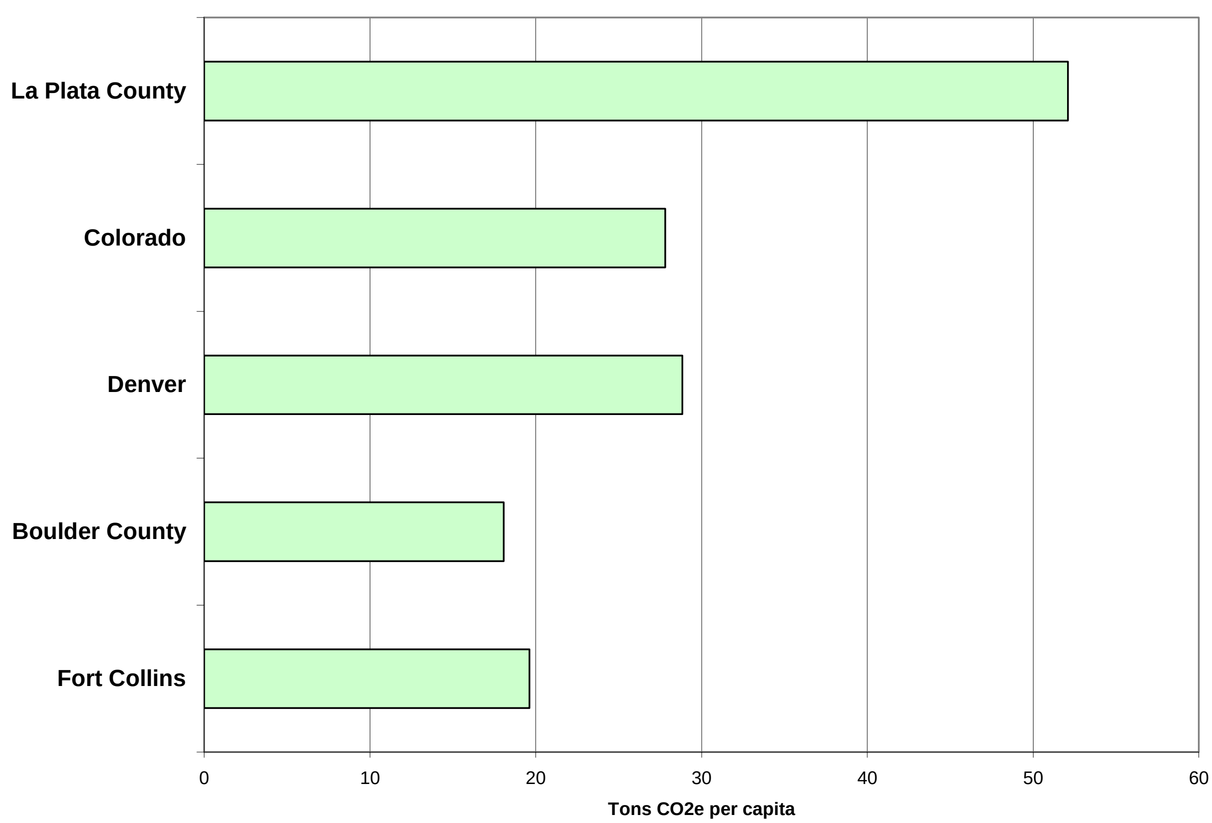

Figure 13. Per Capita Emissions of Various Regions
(Note: Use caution in direct comparison. Inventories produced with varying methodologies and boundaries.)

Appendix A: La Plata County Land-use Greenhouse Gas Emissions

The Brendle Group acknowledges Mark Easter, Steve Williams, Amy Swan, and Keith Paustian of the Natural Resource Ecology Lab, Colorado State University, Fort Collins, Colorado, for their contribution of the following report on greenhouse gas emissions from land-use and land-use change in La Plata County.

Greenhouse Gas Emissions Inventory from Land Use, Land Use Change, and Agriculture in La Plata County, Colorado, 1990-2006

Prepared by:

Mark Easter, Steve Williams, Amy Swan, and Keith Paustian
Natural Resource Ecology Laboratory
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Fort Collins, CO 80523-1499

February 27, 2008

Introduction

This report summarizes greenhouse gas emissions from land use, land use change, and agriculture for La Plata County, Colorado, from 1990 through 2006. We utilized the Intergovernmental Panel on Climate Change (IPCC) method (IPCC 2006) to complete a tier 2 analysis in several source categories, and a tier 1 analysis in others. The availability of data was the primary factor determining whether a tier 2 analysis was possible.

The IPCC greenhouse gas inventory method is well documented; however we try to provide details of the calculations and techniques where we hope they may be helpful. The principal emissions we estimate are from carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). We also estimate emissions from carbon monoxide (CO), and nitrogen oxides (NO_x) in source categories where biomass was burned.

The IPCC method classifies regions into specific climate, soil, and land use classes, and then defines specific calculations and default emissions factors that may be applied to these classes to calculate emissions. A Tier 1 analysis uses the IPCC default equations and factor values throughout. A Tier 2 analysis uses improved calculation techniques and region- or country-specific emission factor values in the calculations.

The method classifies the climate in La Plata County into three climate regions: boreal moist, cold dry, and cold moist. There is little or no land use change in the boreal moist climate region, so no calculations were done for that region. Soils in La Plata County are classified according to the method into four major types: bare rock, water, wetlands, and high activity clay mineral. There has been little significant land use change or activities in the bare rock and water categories, so our analysis is limited to wetlands (of which there are less than 1000 acres in the county) and high activity clay mineral soils, which constitute the majority of the rest of the county.

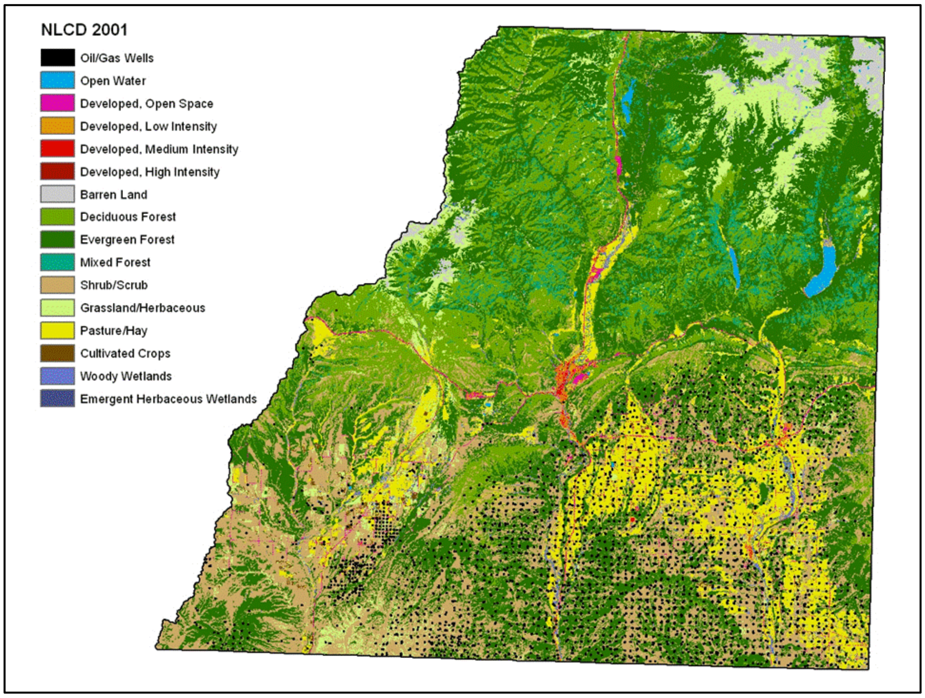
Figure 1 shows the Land Cover datasets (Homer *et al.* 2004, Vogelmann *et al.* 2001) and soil-climate combinations (IPCC 2006) that we used in the analysis.

Emissions by IPCC Source Category

Biomass Carbon Loss

Biomass carbon consists of carbon stored in the woody tissues of trees and shrubs, including both above and below ground. Examples in La Plata County include high elevation spruce-fir forests, mid elevation ponderosa pine and aspen forests, and low elevation scrub oak and pinyon-juniper woodlands and sagebrush steppe. Note that the IPCC method does not generally include the easily-decomposable, non-woody grasses and forbs that grow in these ecosystems as part of the biomass carbon inventory, since non-woody vegetation carbon stocks generally do not accumulate from year to year, in contrast to woody vegetation carbon stocks.

Biomass carbon is lost when woody vegetation is cleared and burned or left to decompose on the site. Common examples from La Plata County include clearing forest land for single-family home construction, industrial development, or housing subdivisions, and clearing sagebrush steppe for oil and gas development. We assumed that nearly all of woody material cleared for these purposes was either bulldozed and left to decompose on the site (in the case of sagebrush steppe, scrub oak, or pinyon-juniper



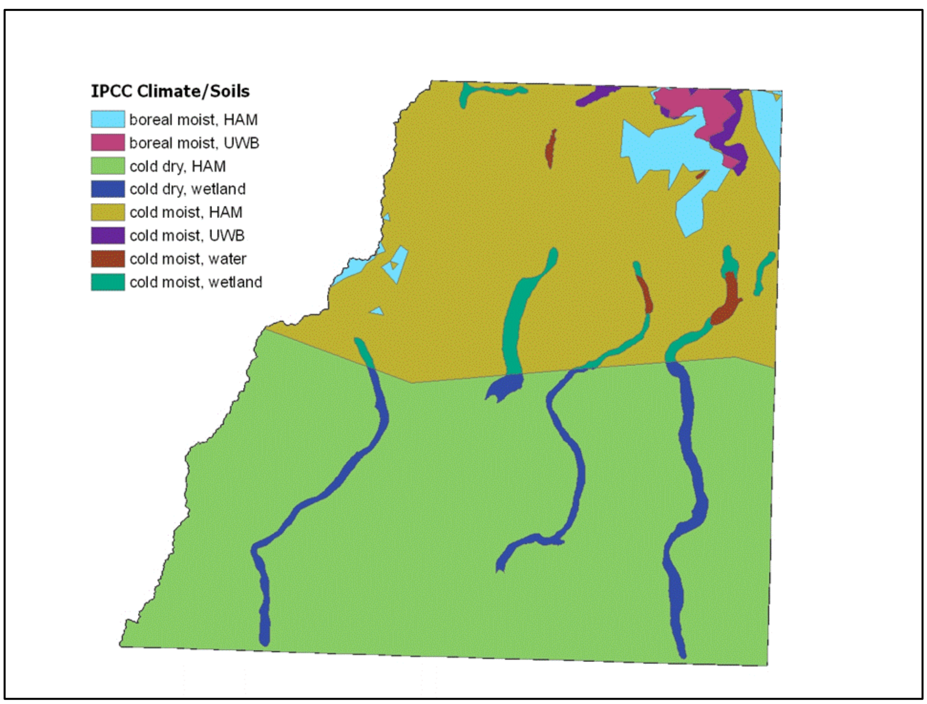


Figure 1. NLCD land use dataset (top) and IPCC climate-soil combinations (bottom) for La Plata County, Colorado.

Woodlands) or was cut, piled, and burned on site or later as fuel wood in the case of forest land cleared development.

Biomass carbon stocks were compiled from several sources (Tinker and Knight 2000, Fahnstock and Agee 2003, Ryan and Waring 1993, Ojima unpublished data). Table 1 shows typical biomass stocks for forest, woodland, and steppe ecosystems in La Plata County.

Table 1. Estimated carbon stocks for woody vegetation in La Plata County.

Vegetation Class	Biomass carbon (CO_2eq tons/acre)
sagebrush steppe	3.3
pinyon-juniper woodland	12.6
scrub oak woodland	14.2
aspen forest	22.6
ponderosa pine/Douglas fir forest	31.8
lodgepole pine forest	120.6
spruce-fir forest	163.3

Emissions from Biomass Carbon loss were divided into five major categories: forest harvest, fuel wood gathering, wildland fire, oil and gas development, and land development. We consider the analysis for Biomass Carbon Stocks to be Tier 2 (IPCC 2006).

Statistics for Forest harvest and fuel wood gathering were derived from data provided by the San Juan Public Lands Center.

Biomass losses from insect infestations were not calculated as part of this study. Accurate aerial inventories of infested stands have been conducted for the county, indicating that tens of thousands of acres of woodland and forest lands have likely been affected (Aguayo, personal communication, and USDA Forest Service 2007). Unfortunately, the intensity of the infestations has not been recorded, and associated tree death and decomposition rates are unknown. It is likely that at least some of the affected forests will burn in wildfires (Aguayo personal communication, Romme personal communication) and hence the biomass loss should be estimated from the fire events.

Statistics for wildland fire were provided by the Colorado State Forest Service under an interagency cooperating agreement (Aguayo, personal communication). We used the following wildland fire area estimates:

- For the Missionary Ridge fire of 2002, we assumed the fire covered approximately 72,000 acres (Dallison, Personal Communication), roughly equally divided between mid- and high-elevation forest vegetation classes.
- Fires since 1990 were assumed to cover approximately 2750 acres per year, roughly equally divided between forest vegetation classes within the county.

Statistics for oil and gas development were derived from the Northern San Juan Basin Coal Bed Methane Project (2007) and from personal communications with Brett Sherman, La Plata County. Each new coal bed methane well or support facility was assumed to require permanent removal of 2 acres of vegetation for the well pad and nearby infrastructure requirements, plus a new service road twenty feet wide traversing eighty acres.

Statistics for land development were derived from the National Land Cover Dataset for 2001 (Homer *et al.* 2004, Vogelmann *et al.* 2001, Figure 1). We utilized descriptions of developed land classes described in the dataset to estimate the total area of land developed between early settlement in the 20th century and 2001. From this total number of developed acres, we estimated the total biomass loss from conversion of native vegetation to development. The accumulated biomass loss from settlement to 1990 totaled approximately 167,000 tons CO_2eq. The accumulated biomass loss from settlement to 2006 totaled approximately 257,000 tons CO_2eq. La Plata County grew at a population growth rate of 2.67% between 1990 and 2006, so we estimate additional loss rates of 2.67% of 257,000 tons CO_2eq, or approximately 6,800 tons/yr CO_2eq in 2006.

Land development was divided into five major development classes:

- Commercial/industrial/transportation, requiring removal of 100% of all woody vegetation and disturbing 100% of the soil.
- High density urban, requiring removal of 80% of woody vegetation and disturbing 80% of the soil.
- Medium density urban/suburban, requiring removal of 60% of woody vegetation and disturbing 60% of the soil.
- Low density suburban/exurban, requiring removal of 30% of woody vegetation and disturbing 30% of the soil.
- Developed open space, which removed approximately 90% of the woody vegetation and disturbing 90% of the soil.

Data describing forest growth and reforestation were not available for the county, hence biomass carbon sequestration rates from forest growth and reforestation could not calculated. If forest harvest practices are conducted at sustainable rates using sustainable methods, and post-harvest reforestation efforts succeed and burned areas successfully regenerate as the vegetation types preceding the fire, one may assume that forest harvest, wildfire, and regrowth are in equilibrium over the centuries-long time scale that these processes operate.

Estimated emissions from biomass carbon stocks are shown in figure 2.

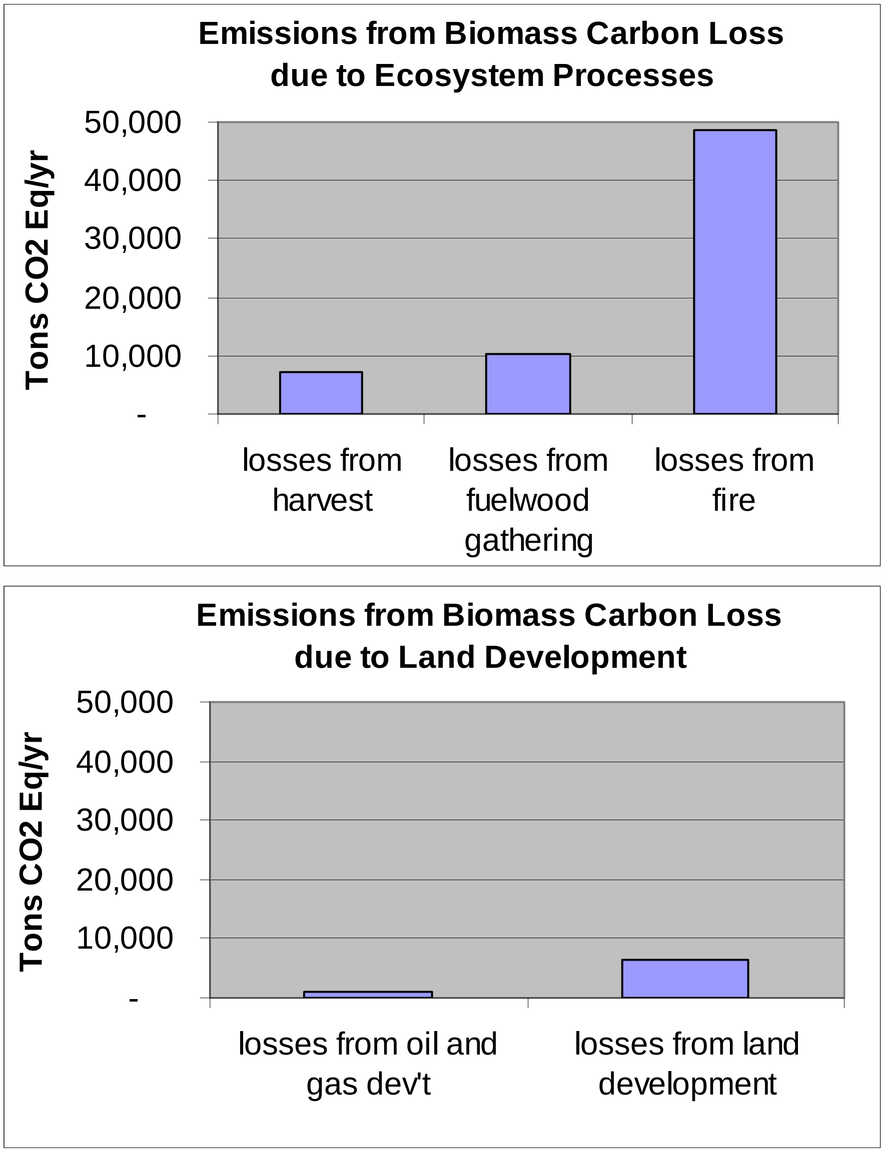


Figure 2. Emissions from biomass carbon stocks for La Plata County, Colorado. The upper chart shows the estimated forest biomass carbon lost from timber harvest, fuelwood gathering, and wildfire from 1990-2006. Note that if forest regrowth is sufficient to replace the biomass loss from harvesting, fuelwood gathering, and fire, carbon emissions will be offset over time by carbon sequestered through forest growth. The lower chart shows the annual estimated biomass carbon losses from land development for new construction and oil and gas development.

Estimated biomass carbon stock emissions on a per-acre basis from land development activities are shown in Table 2.

Table 2. Estimated biomass carbon stock emission rates (tons CO2eq/acre) for land development activities by vegetation class in La Plata County, CO.

Vegetation Class	Commercial /Industrial /Transport-ation	High Density Urban	Medium Density Urban /Suburban	Low Density Suburban /Exurban	Developed Open Space
sagebrush steppe	3.3	2.7	2.0	1.0	3.0
pinyon-juniper woodland	12.6	10.0	7.5	3.8	11.3
scrub oak woodland	14.2	11.4	8.5	4.3	12.8
aspen forest	22.6	18.1	13.6	6.8	20.4
ponderosa pine/Douglas fir forest	31.8	25.5	19.1	9.5	28.6
lodgepole pine forest	120.6	96.5	72.4	36.2	108.5
spruce-fir forest	163.3	130.6	98.0	49.0	147

Estimated biomass carbon stock emissions on a per-acre basis from wildland fire are shown in Table 3. Biomass carbon loss rates from wildland fire were derived from multiple sources (IPCC 2006, Tinker and Knight 2000, Ryan and Waring 1993, Fahnstock and Agee 1983). We assume a 16% biomass carbon loss rate from wildland fire. Loss rates are likely higher in sagebrush steppe vegetation, but could vary in all vegetation classes by region, slope, and aspect.

Table 3. Estimated biomass carbon stock emission rates (tons CO2eq/acre/yr) from wildland fire by vegetation class in La Plata County, CO.

Vegetation Class	Wildland Fire Loss Rate (tons/acre)
sagebrush steppe	0.5
pinyon-juniper woodland	2.0
scrub oak woodland	2.3
aspen forest	3.6
ponderosa pine/Douglas fir forest	5.1
lodgepole pine forest	19.3
spruce-fir forest	26.1

Estimated biomass carbon stock emissions on a per-wellhead and per-facility basis from oil and gas development are shown in Table 4. Oil and gas development occurs in three major vegetation classes in La Plata County (sagebrush steppe, gamble oak woodland, and pinyon-juniper woodland), with the majority on agricultural lands and sagebrush steppe. Biomass carbon stock emissions from agricultural land converted to oil and gas development are assumed to be zero as little or no agricultural land in La Plata County produces crops from perennial, woody vegetation. These estimates assume a total of approximately 2.5 acres of land is developed for each producing well head or support facility. This analysis assumes that woody vegetation on site during well head development and road construction is bulldozed or cut, and either piled and burned or left on site to decompose.

Table 4. Estimated biomass carbon stock emission rates (tons CO2eq/acre/yr) from oil and gas development by vegetation class in La Plata County, CO.

Vegetation Class	Loss Rate (tons/well head or facility)
sagebrush steppe	8.4
pinyon-juniper woodland	31.4
scrub oak woodland	35.6

Soil Carbon Loss

Soil organic carbon consists of organic matter that has been taken up by plants during photosynthesis, and then decomposed into the soil after the plant died or plant material fell onto the soil. La Plata County is divided into two major climate regions with two major soil types affected by land use management practices, shown in Table 5 (IPCC 2006).

Table 5. Soil carbon stocks and loss rates from newly developed lands in La Plata County, CO. * The IPCC method estimates soil carbon emissions from land use change to occur for 20 years, after which soil carbon stocks stabilize to a new equilibrium level. ** Soil carbon content in wetland soils is very high, but variable. Emission rates in wetland soils are assumed to be constant at 0.45 tons/acre/yr for decades into the future.

Climate Region	Soil Type	Soil carbon stock (tons/acre)	Soil carbon loss rate (tons/acre/yr) *
Cool Temperate, Dry	High Activity Clay Mineral	22.3	0.225
Cool Temperate, Dry	Wetlands	**	0.45

Cool Temperate, Moist	High Activity Clay Mineral	42.4	0.425
Cool Temperate, Moist	Wetlands	**	0.45

Soil carbon is sequestered in soil when organic matter inputs to soil are increased, such as when agricultural land is converted to grassland, dryland agriculture is converted irrigated lands, or when soil disturbance ceases or is reduced, such as conversion from intensive tillage to reduced or no tillage agricultural methods.

Soil carbon is lost when soil is disturbed, such as when grassland, woodland, or forestland is plowed under to grow crops, or when organic matter inputs to the soil are reduced or cease altogether, such as when land is cleared for development or for oil and gas wells.

The IPCC method is designed to measure soil carbon stock changes resulting from land use change. The principal land use change processes occurring in La Plata County are as follows:

- Dryland agricultural land is converted to exurban/suburban/urban development.
- Agricultural land is converted to oil and gas development.
- Agricultural land or forestland, woodland, or shrubland is converted to oil and gas development.
- Forestland, woodland, or shrubland is converted to exurban/suburban/urban development.

We consider our analysis for soil carbon emissions to be Tier 1 (IPCC 2006).

The IPCC method predicts that carbon stocks in soils under developed land uses (commercial and residential or oil and gas development) would be virtually the same as carbon stocks in soils under dryland agriculture practiced in La Plata County. The most significant changes occur when mid and high elevation forest land is developed for commercial or residential buildings. Figure 3 summarizes these findings.

The greatest potential for soil carbon sequestration comes from conservation reserve program (CRP) lands (approximately 21,000 tons CO_2eq/yr). The CRP program began in 1987, and CRP contracts in La Plata reached their current acreage of about 12,000 acres by the early 1990's. The benefits of soil carbon sequestration are real, but soil carbon stabilizes at a new equilibrium rate after two to three decades (IPCC 2006). These CRP lands will reach their maximum soil carbon stock value in the next decade, after which no additional soil carbon sequestration on these lands is likely.

The greatest additional potential for additional soil carbon sequestration in La Plata County is in restoring native grasslands or shrublands. Degraded pasture, rangeland, cropland, or developed lands are good candidates for grassland restoration. Based on NRCS statistics and the NLCD land conversion rates, we estimate there are roughly 10,000 – 15,000 acres of land in La Plata County that would yield soil carbon sequestration rates similar to that from the CRP program if restored to native grassland.

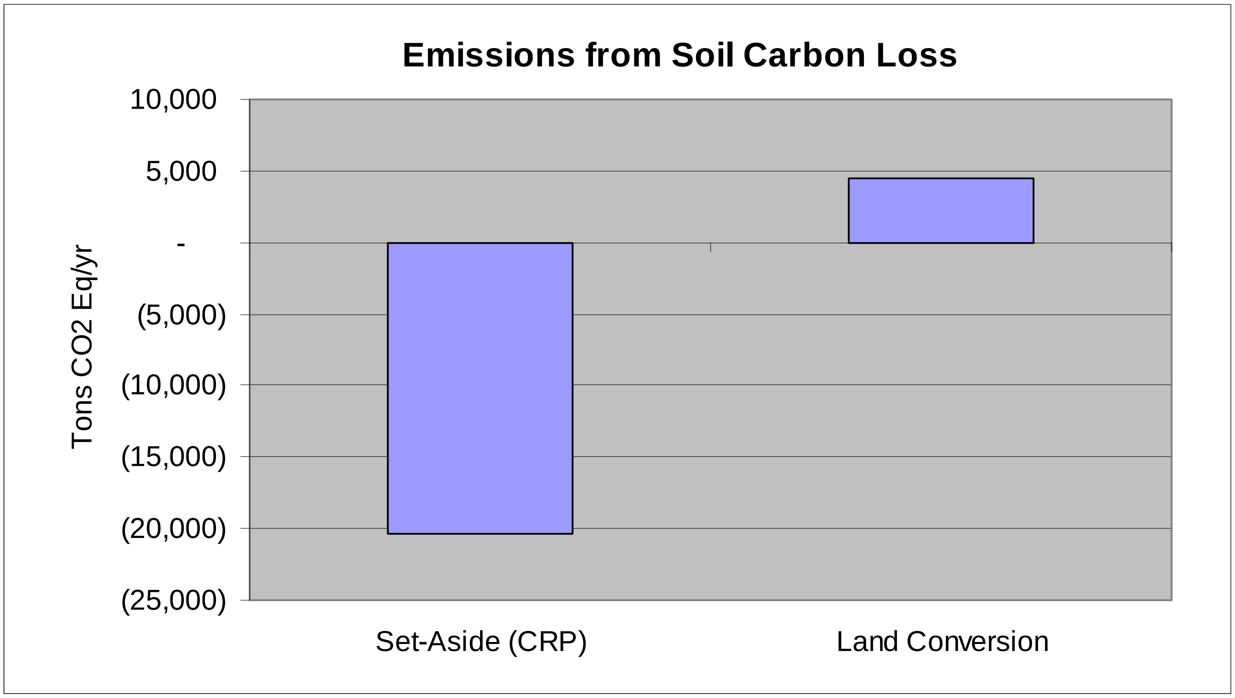


Figure 3. Emissions (Sequestration) from soil carbon. Note that CRP lands in La Plata County have a net sequestration rate, whereas land conversion to developed uses is a net emitter of carbon.

Soil Nitrous Oxide

Emissions from Soil Nitrous Oxide in La Plata County come from direct and indirect emissions from four major sources, as follows:

- Nitrogen fertilizers sold within the county and applied for agriculture and landscaping (USEPA 2007).
- Manure nitrogen left by livestock on soils in pastures, on rangeland, within paddocks, and in other manure management categories where the manure is not collected and stored or handled otherwise (USDA National Agriculture Statistics Service 2007a).
- Direct emissions from crop residues (USDA National Agriculture Statistics Service 2007b).
- Sewage sludge applied to soils within the county (Mike Sharp, personal communication).

Direct emissions are from nitrogen that is converted directly to nitrous oxide at the time it is applied or before it is sorbed onto soil particles or taken up by plants or soil microbes. Indirect emissions come from nitrogen that volatilizes into gaseous form and is re-deposited in dry or wet form elsewhere nearby, and then converted into nitrous oxide, or nitrogen that leaches into surface waters or groundwater and is then converted into nitrous oxide.

We consider our analysis for Soil Nitrous Oxide to be Tier 1 (IPCC 2006). Figure 4 shows the total soil nitrous oxide emissions from all sources in 1990 and 2006. The reduction seen over this time period is due to the major reduction in dryland agriculture (from approximately 25,000 acres in 1990 to about 2,500 acres in 2006), and from a small reduction in livestock populations during that time. Irrigated hay and pasture acreage has remained relatively constant during that time, and it continues to receive significant nitrogen fertilizer applications (USDA National Agricultural Statistics Service 2007ab, and Cindy Dvergtsen, Personal Communication).

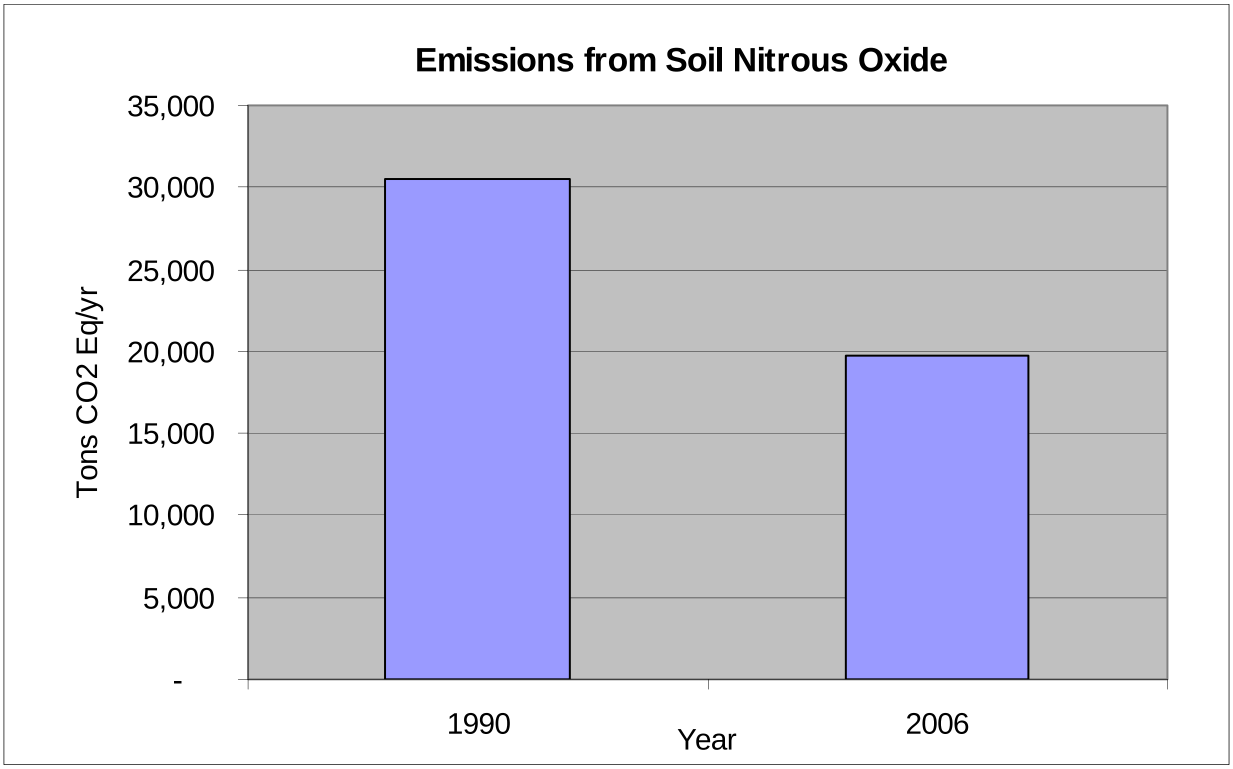


Figure 4. Total Emissions from Soil Nitrous Oxide in La Plata County, Colorado.

Table 6 shows the emissions from individual sources for 2006.

Table 6. Soil Nitrous Oxide emissions from various sources in La Plata County, Colorado.

Sub Source Category	2006 Emissions (tons CO_2eq/yr)
Nitrogen fertilizers	2,682
Manure in pasture/range/paddock, and other manure sources	11,591
Crop Residues	5,142
Sewage Sludge applied to soils	317

Manure Methane

Methane emissions from manure is highly dependent upon the way in which manure is stored and/or processed (IPCC 2006). Manure left in pasture/range/paddock systems or stored in dry lots releases relatively little methane, whereas manure captured from dairies, feedlots, and other types of confined animal feeding operations (CAFOs) emit substantially much more methane compared with equivalent numbers of livestock kept in pasture/range/paddock systems.

We consider our analysis for Manure Methane to be Tier 1 (IPCC 2006). Figure 5 shows the 1990 and 2006 estimates of manure methane emissions.

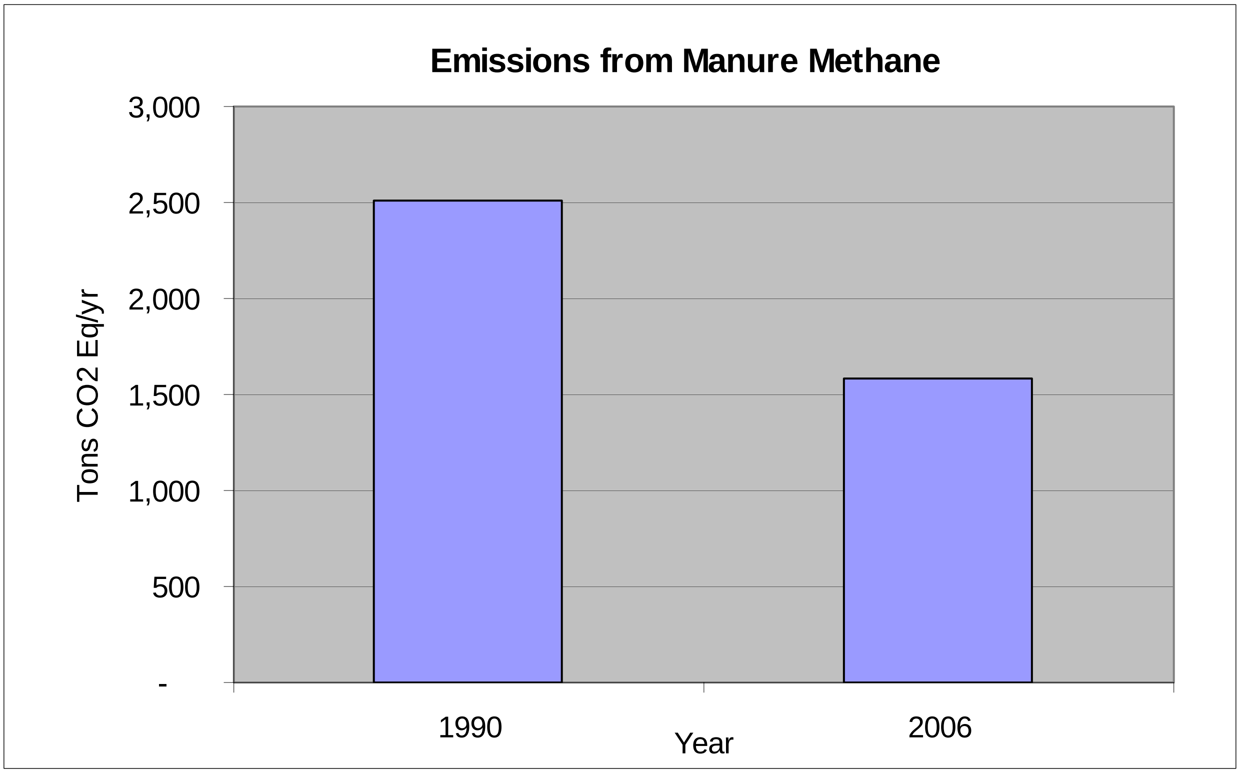


Figure 5. Emissions from manure methane in La Plata County, Colorado. The main source of the reduction is a ~80% reduction in dairy cattle and a ~30% reduction in beef cattle over this time period.

Manure Nitrous Oxide

The major source of manure nitrous oxide is from manure captured and stored at confined animal feeding operations (CAFOs). La Plata County has few livestock managed in CAFOs, hence there are no significant manure nitrous oxide emissions to report (USDA National Agriculture Statistics Service 2007ab).

Biomass Burning, Non-CO_2 Emissions

The IPCC method provides calculations for non-CO_2 emissions from biomass burning from four greenhouse gases: methane, nitrous oxide, carbon monoxide, and nitrogen oxides. These emissions result from wood combustion during slash burning from timber harvest and land clearing, fuelwood burning, and wildfire. We consider our analysis of biomass burning, non-CO_2 emissions to be Tier 1 (IPCC 2006). Figure 6 shows the total methane (CH_4) and nitrous oxide (N_2O) from these activities.

Carbon monoxide and NOx emissions are precursors to carbon dioxide and nitrogen oxide, respectively, however no global warming potential (GWP) is described in the method for these gases. We estimate emissions carbon monoxide and NOx emissions for 2006 at 3,291 and 55 tons/yr, respectively.

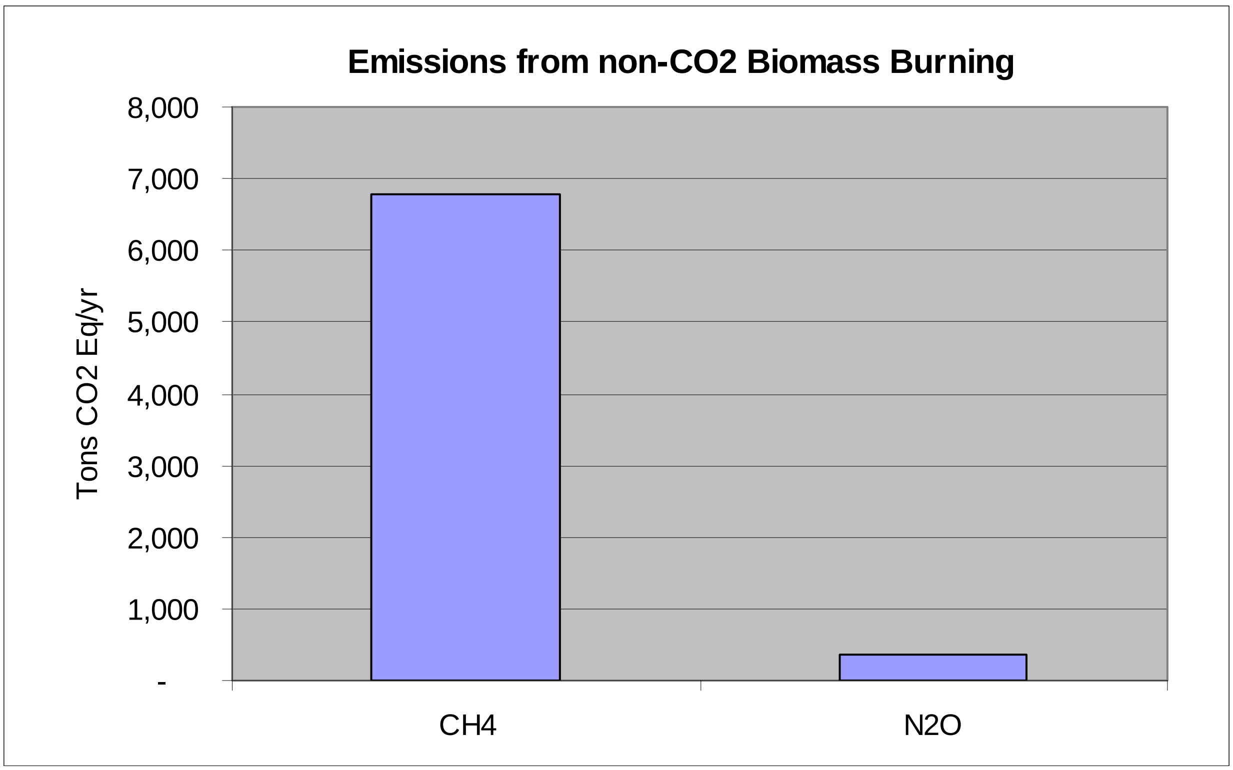


Figure 6. Estimated Non-CO_2 emissions from biomass burning in La Plata County, CO in 2006. Emissions are from timber harvesting, land conversion, fuelwood burning, and wildfire.

Enteric Methane

Methane from enteric fermentation comes from the digestion of feed by animals. Beef cattle and horses are the two most significant sources of enteric methane in La Plata county, accounting for 72% and 19% of 2006 emissions, respectively (USDA National Agriculture Statistics Service 2007a, IPCC 2006).

We consider our analysis of enteric methane emissions to be Tier 1 (IPCC 2006). Enteric methane emissions in La Plata County for 1990 and 2006 are shown in Figure 7.

The emissions reductions over that time are largely from reductions in dairy and beef cattle in the county over that period.

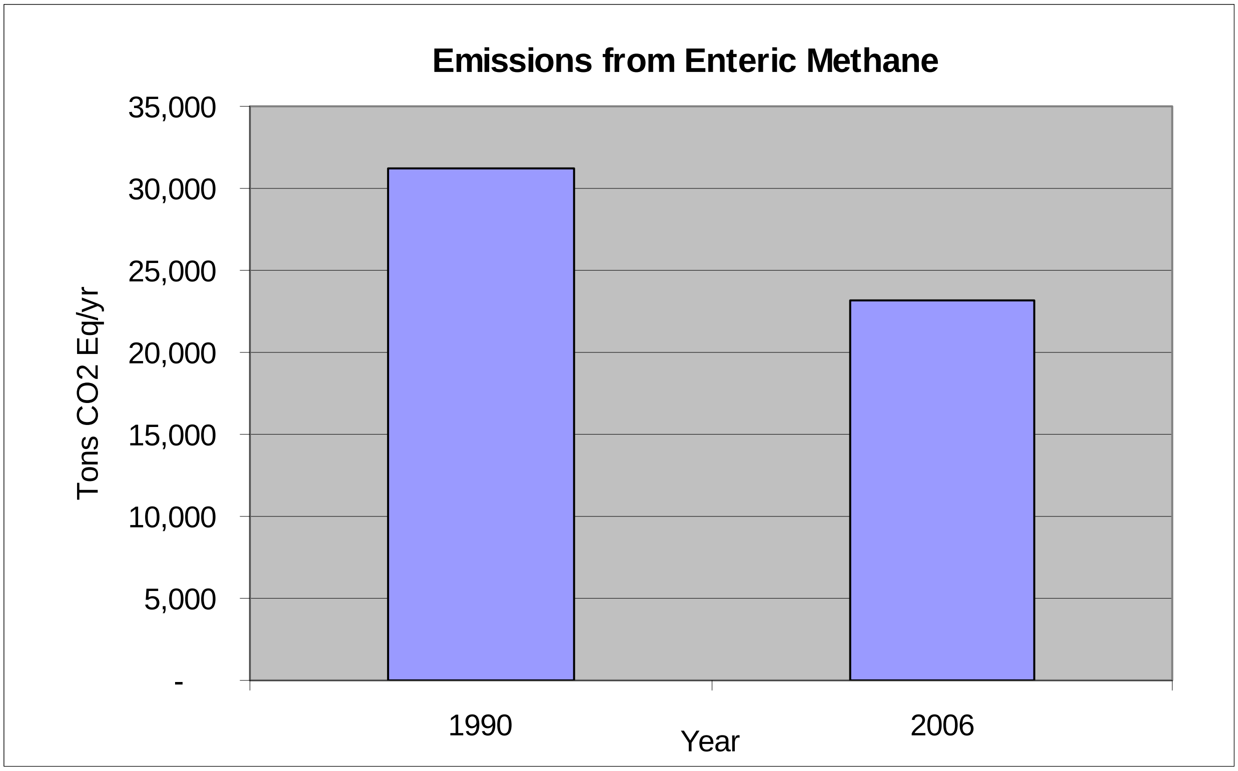


Figure 7. Enteric fermentation emissions in La Plata County, Colorado.

Missionary Ridge Fire

Under equilibrium conditions, some portion of the Southern Rocky Mountain ecoregion burns every year, while other areas regenerate and grow back after fires in previous years. The forests and rangelands of the Southern Rocky Mountains are a vast, diverse mosaic of forest types and age classes distributed broadly over a large region, and they are constantly in flux. If one were to add up all of the carbon and nitrogen stored in these forests over a fixed area, one would likely find it remains relatively constant over a period of centuries to millennia (Harmon, ME 2001, Turner *et al.* 1995ab, Barbour and Billings 1988).

This equilibrium condition was perturbed by fire suppression and other land management activities in the 20th century, as well as more recent climate changes (Schimel *et al.* 2001). Forest managers worry that fuel buildup and insect and disease infestations in Southern Rocky Mountain Forests will lead to large, mostly uncontrollable fires like the Missionary Ridge Fire of 2002 near Durango, CO. If the forest types that preceded the fire regenerate in the same places or roughly in the same proportions as before the fire, and stable ecosystem processes are restored, one may assume that the greenhouse gas balance of the forest will persist over a period of several centuries as the forest regrows and accumulates carbon and nitrogen (IPCC 2006).

If, however, forest vegetation types substantially change, or rangeland encroaches on the lower elevation areas of the fire, we will know that the ecosystem balance has been disrupted by the fire and subsequent regeneration conditions. And by extension, the greenhouse gas balance of the region will have been disrupted as well. We are unable to assess the magnitude and direction of any potential change at this time, and hence we are unable to assess how the Missionary Ridge fire fits into the larger picture of the greenhouse gas balance for the region.

Three principal greenhouse gases emitted during wildfire are carbon dioxide, nitrous oxide, and methane. We assumed that the fire was roughly equally divided between the mid and high elevation forest types found in the area of the fire, and that approximately 16% of the total biomass present before the fire burned in the fire (IPCC 2006, Tinker and Knight 2000, Ryan and Waring 1983, Fahnstock and Agee 1983). We estimate total emissions in CO2 equivalents from the fire to be approximately 1,340,000 tons. Figure 8 shows the balance of estimated emissions from the three greenhouse gases.

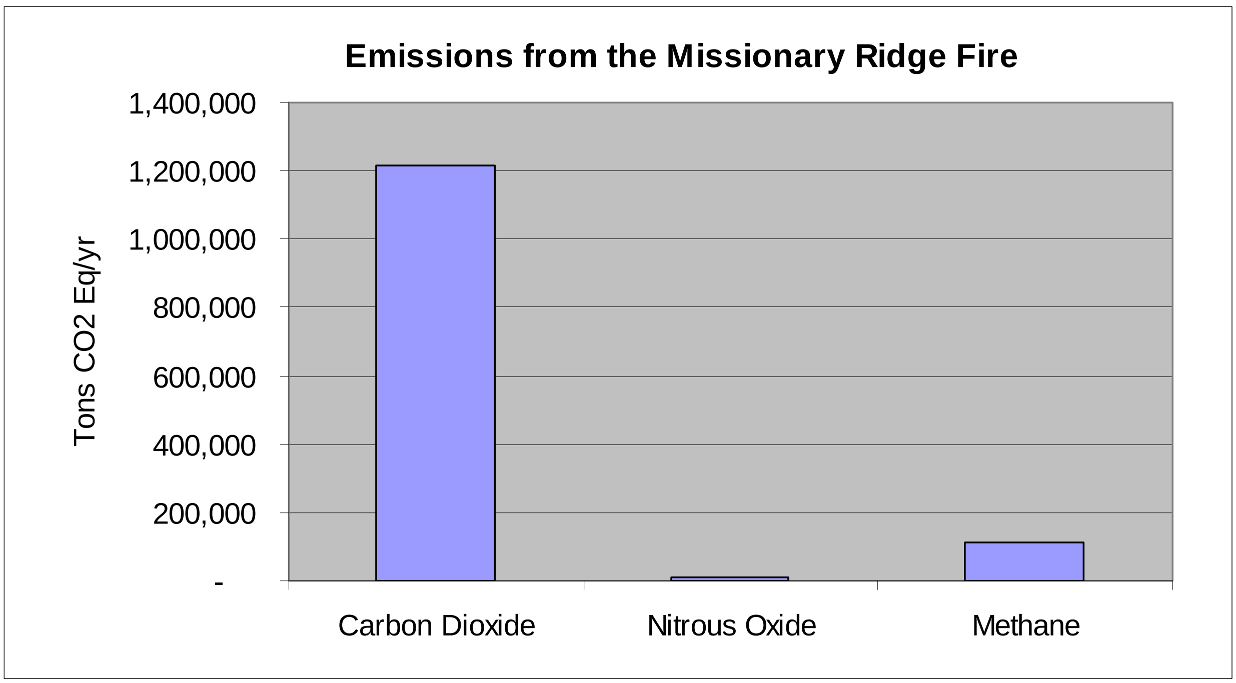


Figure 8. Emissions from the 72,000 acre Missionary Ridge Fire of 2002 near Durango in La Plata County, Colorado.

Summary

We estimate the 2006 total emission from land use, land use change, and agriculture in La Plata County to be approximately 111,000 tons CO_2eq/yr. The seven different IPCC source categories for this total are shown in Figure 9. Note that forest biomass carbon sequestration rates (unknown at this time) may reduce biomass carbon loss substantially.

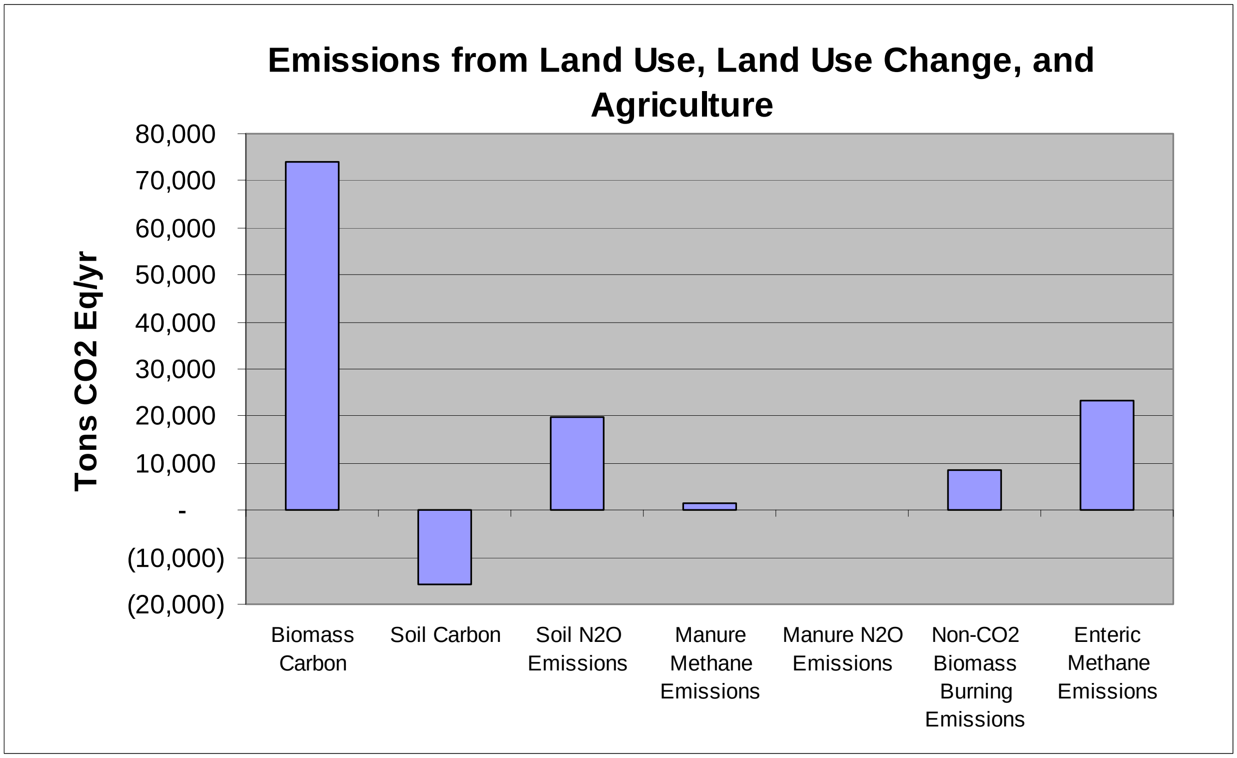


Figure 9. Estimated total emissions from land use, land use change, and agriculture for 2006 in La Plata County, Colorado.

Table 7 describes the likely emission growth rates for the next decade for each of the source categories.

Table 7. Projected emission rates changes for La Plata County, Colorado under a Business as Usual scenario.

Source Category	Annual % change	Justification
Biomass Carbon	Unpredictable and highly variable, but likely to increase	Insect infestations are likely to increase risk of wildfire, though the extent cannot be estimated at this time.
Soil Carbon	Remain stable, then gradually increase	Soil carbon losses will primarily be from land development in agricultural lands. Soil carbon levels on CRP lands will stabilize. Long-term funding for restoration of additional grassland on degraded lands is unpredictable.
Soil N_2O	-2%/yr	Agricultural census indicates a long-term decrease in livestock populations and dryland farming.

Manure Methane	-2%/yr	Agricultural census indicates a long-term decrease in livestock populations.
Manure N_2O	-2%/yr	Agricultural census indicates a long-term decrease in livestock populations.
Non-CO_2 Biomass Burning	Unpredictable and highly variable, but likely to increase	As with Biomass Carbon, insect infestations are likely to increase risk of wildfire, though the extend cannot be estimated at this time.
Enteric Methane	~-2%/yr	Agricultural census indicates a long-term decrease in livestock populations.

La Plata County's greatest Land Use opportunities for reducing greenhouse gas emissions are as follows:

- Apply nitrogen fertilizers on cropland, pasture, hay land, and developed lands to recommended quantities based on a yearly soil test. Use best management practices to reduce runoff and leaching. Utilize nitrification inhibitors and use subsurface applicators where possible. Utilizing all of these techniques can reduce nitrous oxide emissions from fertilizer by more than half.
- Ensure that future confined animal feeding operations (CAFOs) operated within the county avoid using open lagoons for manure storage, or utilize methane digesters in concert with enclosed storage if lagoons are used.
- Utilize forest biomass as a renewable and sustainable source for heating and energy production where possible. Sustainable use of the resource may be achieved when biomass harvest techniques minimize soil disturbance and retain vegetation cover, and where forest regrowth keeps pace with forest removal rates. Additional study would be necessary to determine the full extent of this potential.
- Restore existing degraded lands to native grassland and/or shrubland where possible.
- Grow crops using no tillage or minimum tillage techniques.
- Grow oilseed crops or other biomass crops on soils currently utilized for annual crop production.
- Avoid plowing or otherwise disturbing existing grasslands, rangeland, and irrigated hayland or pasture.

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Appendix B: La Plata County Natural Gas Industry Greenhouse Gas Emissions Estimate

The Brendle Group acknowledges Richard Heede of Climate Mitigation Services, Snowmass, Colorado, for his contribution of the following greenhouse gas emissions estimate for the natural gas production industry in La Plata County.

The following report is a preliminary estimate based on the best available data from the natural gas production industry in the San Juan Basin, New Mexico. As better data become available, the estimate of La Plata County's industry emissions is likely to be substantially improved.

Note that emissions quantities expressed in this appendix and in the body of the *La Plata County Natural Gas Industry Greenhouse Gas Emissions Estimate* are in metric tons and thus not expressed in the same units as the emissions in English tons in the remainder of this document.

NOTE: LA PLATA COUNTY IS WORKING WITH THE LA PLATA COUNTY ENERGY COUNCIL TO ESTABLISH FURTHER PROTOCOL AND METHODOLOGY FOR AN ON-GOING DATA COLLECTION PROGRAM THAT IS AIMED TO REDUCE GREENHOUSE GAS EMISSIONS RELATIVE TO THE OIL AND GAS INDUSTRY.

AT THIS TIME LA PLATA COUNTY HAS AGREED TO SUSPEND THE ADDITION OF THE NATURAL GAS INDUSTRY GREENHOUSE GAS EMISSIONS ESTIMATE WITH RESPECT TO THE DESIRE FOR BOTH THE COUNTY AND THE LA PLATA COUNTY ENERGY COUNCIL TO DERIVE ESTIMATES THAT MORE ACCURATELY REFLECT THE BEHAVIOR OF THE NATURAL GAS INDUSTRY IN LA PLATA COUNTY.

IF ANYONE SHOULD HAVE ANY QUESTIONS REGARDING THIS EFFORT PLEASE CONTACT:

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or e-mail at auneej@co.laplata.co.us

La Plata County Natural Gas Industry Greenhouse Gas Emissions Estimate, 2006

Report to The Brendle Group in Support of the La Plata County Inventory

By Richard Heede

Climate Mitigation Services

19 February 2008

Climate Mitigation Services

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to La Plata Board of County Commissioners for their commitment to climate stewardship

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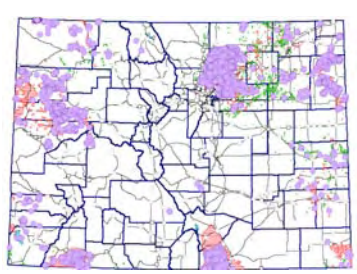
Note on units: Metric units are used throughout this report, except in cases of common US units, e.g., gas production in billion cubic feet (Bcf). One metric tonne = 1.1023 short tons. Methane is expressed in CO_2equivalent terms (CO_2e) at $21xCO_2$.



www.cdphe.state.co.us/ap/down/O&G07AssessOct.pdf

Cover: Rules Hill & Vosburg Pike area northwest of Bayfield. Google satellite image.

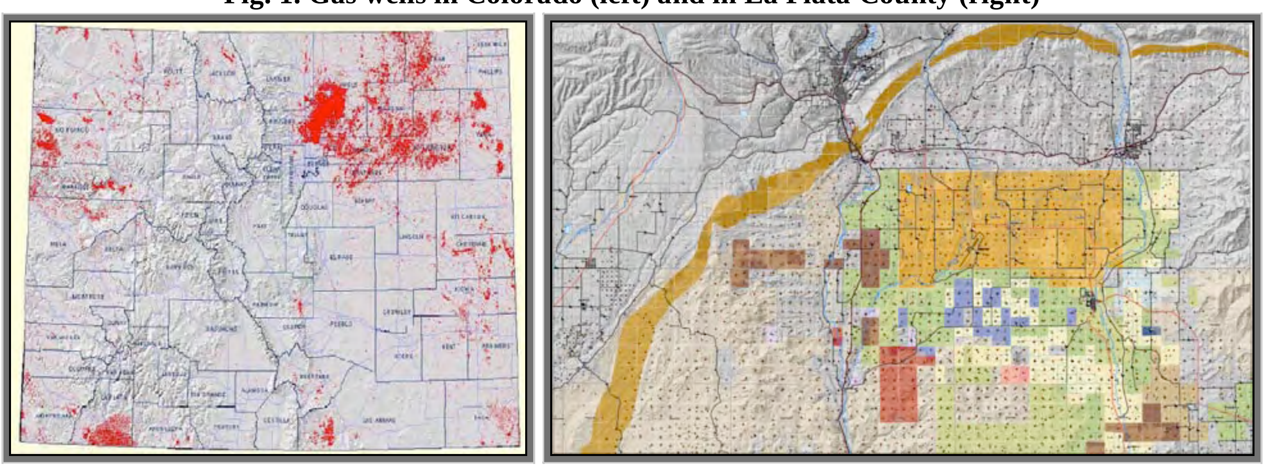
La Plata gas industry GHG emissions: methodology and results

Introduction

Gas industry operators in La Plata County produced 437 billion cubic feet (Bcf) of natural gas in 2006 from 2,886 operating wells. This equals 35 percent of Colorado's natural gas production totaling 1,233 Bcf and 2.3 percent of US marketed production totaling 19,338 Bcf. La Plata production was chiefly from the shallower Fruitland Formation from which coal bed methane (CBM) is recovered. A minor quantity of crude oil (30,048 bbl) was also produced in La Plata County in 2006, although amounting to 0.13 percent of Colorado's total oil production.

Climate Mitigation Services (CMS) was commissioned by The Brendle Group to estimate emissions of carbon dioxide and methane from the gas industry in La Plata county. The Brendle Group was awarded the contract with La Plata Community Development Dept to inventory all major direct and indirect sources of greenhouse gas emissions from energy consumption, energy production, land use, wastewater treatment plants, landfills, and other sources in or attributable to the county. These sources include consumption of transportation fuels (gasoline, diesel, and jet fuel), combustion of natural gas and propane for residential heating or industrial uses, and power plants supplying electricity to the homes, businesses, and industries operating within the county.

Fig. 1. Gas wells in Colorado (left) and in La Plata County (right)



Left: Colorado gas wells, CDPHE (2007), slide 5. Right: La Plata County gas wells, La Plata County GIS.

No estimates of gas industry greenhouse gas (GHG) emissions in La Plata County have been published to date, although criteria pollutants such as NOx and ozone are monitored and reported. Neither the State of Colorado Oil and Gas Conservation Commission (COGCC) or the State's Dept of Public Health & Environment's Air Pollution Control Division requires reporting of methane and carbon dioxide, and neither agency has estimated GHG emissions from the state's energy industries. Awareness of the issue of climate change has lead to efforts to identify and quantify company, municipal, and individual and household GHG emissions. However, the results of any Plata County operator's efforts to quantify emissions that may be underway are not yet publicly available.

Major gas industry GHG emissions sources

There are three principal categories of emissions sources pertinent to the natural gas industry.

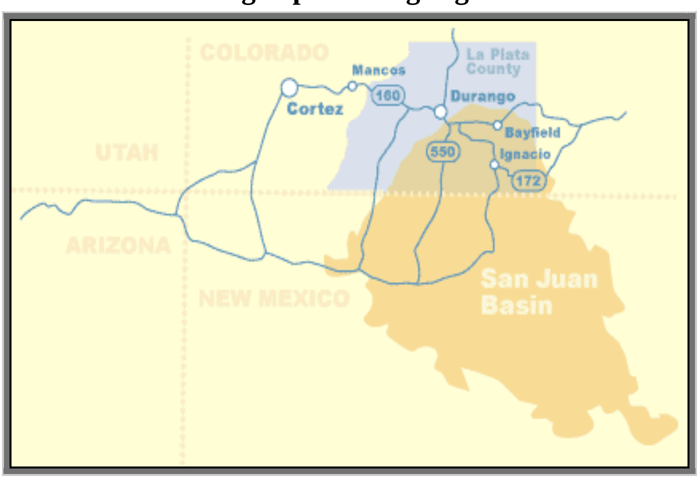
1. Methane sources include routine operations, fugitive releases, field operations, pipelines, pneumatic device vents, gas-oil separation plants (GOSPs), Kimray pumps, dehydrator vents, centrifugal and reciprocal compressors, internal combustion engines, seals, flanges, meters, pipeline leaks, upsets, incomplete flaring, and so forth.
2. Carbon dioxide from industry use of natural gas, diesel fuel, electricity, and (in some cases) steam.
3. Carbon dioxide vented from produced natural gas. Natural gas, while chiefly methane, also contains entrained CO_2, sometimes in high concentrations, as is apparently the case in the San Juan Basin, and especially from coal bed methane such as the Fruitland Formation. The New Mexico section of the Fruitland Formation has a CO_2 content exceeding 17 percent. CMS has been unable to verify the concentration of entrained CO_2 in La Plata's produced gas.

Methodology

Estimating emissions from an industry as complex as natural gas production across several producing formations and dozens of operating companies in varying stages of production cannot be reliably estimated from the ground up without in-depth data from the industry. CMS inquired about company emissions estimates, but none have been published.

The Center for Climate Strategies (CCS) completed a statewide inventory of Colorado emissions sources in 2007, including the oil, gas, and coal mining industries. Although industry methane emissions were estimated using EPA's State Greenhouse Gas Inventory Tool (SGIT), neither carbon dioxide emissions from fuel combustion nor entrained CO_2 were estimated for Colorado. CCS did quantify gas industry CO_2 emission in its 2006 New Mexico state inventory.

Fig. 2. Map of the San Juan Basin gas-producing region of New Mexico and Colorado.



Source: La Plata County Energy Council, Inc., www.energycouncil.org/

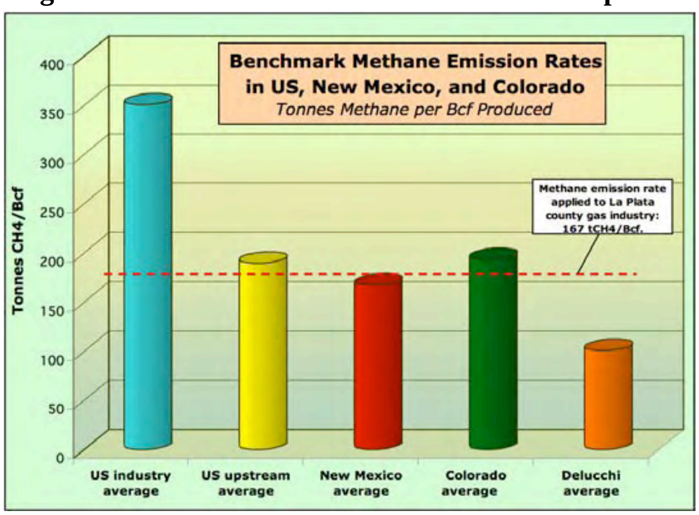
While not as accurate as industry-provided data that includes all relevant emissions sources, a commonly used estimation method in state, regional, and corporate inventories is to apply relevant emission *rates* per unit of gas produced. CMS calculated benchmark emissions rates of CO_2 and methane per Bcf of annual production for several pertinent producing regions. Emission rates were computed for New Mexico (especially the San Juan Basin shared with and underlying La Plata county; Fig. 2), the State of Colorado, and compared to a range of US domestic gas industry as analyzed by Kirchgessner, US EPA, Delucchi, CMS, and others.

CMS elected to use emission rates in New Mexico as the model for La Plata County gas industry emissions for three principal reasons: 1) it is based significantly on emissions rates for the San Juan Basin, 2) the emission rates were substantially based on industry-provided data, and 3) the NM inventory included all major sources of gas industry emissions sources — entrained CO_2, fuel combustion, and methane — that CMS wanted to include in the present La Plata inventory.

CMS analyzed the methods and results of the gas industry estimate for New Mexico that detailed useful data on emission rates for various stages of production, processing, transportation and storage, and distribution. This industry data complements and supports the results of the New Mexico gas industry emissions estimate in the Center for Climate Strategies (2006) *New Mexico Greenhouse Gas Inventory.*[1] Since La Plata and New Mexico produce gas from the shared San Juan Basin's Fruitland and Dakota Formations, the emission rates in New Mexico can reasonably be assumed to be applicable to La Plata. Future research and the availability of gas industry data specific to La Plata can be expected to revise the present CMS gas industry emissions estimate, especially as material differences across the San Basin and operator practices come to light.

The New Mexico emission rate is 167 tonnes of methane per billion cubic feet of gas produced (tCH_4/Bcf). The CO_2 emission rate is 6,590 tCO_2/Bcf. The benchmark methane emission rates evaluated by CMS are shown in Fig. 3. The combined methane and carbon dioxide emission rate (at CH_4 GWP of 21xCO_2) of the "best" (median) estimate is 7,649 tCO_2e/Bcf, which equates to 13 percent of hypothetical full combustion of the produced natural gas (see Fig. 7).[2]

Fig. 3. Benchmark methane emission rates compared.



Recognizing that the gas industry in La Plata *may* emit carbon dioxide and methane at lower rates than New Mexico (see "Caveats and Uncertainties"), CMS reduces the combined emission rate by 24.3 percent and 48.6 percent for in the "best" and "low" estimates, respectively. CMS

[1] This industry data was used by CCS in developing the NM gas industry emissions estimates and there are no material differences between the two sources. See CCS (2006), Appendix D, Table D-13 for summary data. CMS bases its La Plata gas industry emissions in the CO_2 and methane emission rates developed for New Mexico.

[2] Hypothetical in that all produced gas is not marketed (some is used in the field, or flared), and does not account for incomplete combustion or non-fuel uses of natural gas. Even so, 13 percent is conservative: Spath & Mann (2000) found 24.9 percent (with a roughly similar boundary definition), Jaramillo et al (2007) suggest 13.6 percent adder for upstream emissions; Delucchi also considers the CMS rate reasonable (personal communication, 21Dec07) considering the high entrained CO_2 content of coal bed methane.

uses the New Mexico emission rates as the basis for the "high" emissions estimate in La Plata, and the "low" estimate is 51.4 percent of the "high" estimate.[3] As a conservatism, CMS uses the average of the "high" and "low" estimates as the preferred estimate when reporting emissions of La Plata's gas industry; in the results section this is referred to as the "best" estimate.

Caveats & uncertainties

The CMS gas industry estimate is certain to be revised when the gas industry responds with credible revisions to the CMS methodology with updated and documented emission rates or monitored emissions covering all relevant GHG sources. Indeed, the industry may release its own comprehensive inventory. The current inventory should be considered a first approximation, and CMS encourages the gas industry in La Plata to help improve the present methodology. It may be the case that gas operators in La Plata county have not yet estimated emissions —even in their own operations. If so, the collaborative interest from the State, the La Plata Board of County Commissioners, and citizens may facilitate fruitful discussions of ways to develop and share such data in due course.

Also, there may be mitigating factors not reflected in the present emissions inventory. The entrained CO_2 content of La Plata's produced gas may be lower than in New Mexico's section of the San Juan Basin, La Plata operators may re-inject the entrained CO_2 (if captured) to enhance oil recovery elsewhere in the county (or export the captured CO_2 to, say, Texas). Or less fuel may be used in field operations, pipelines, and processing plants in La Plata than the New Mexico model suggests. Or La Plata gas operators may be early adopters of many of the emissions reduction measures discussed in the Four Corners Air Quality Task Force report.

On the other hand, the reverse may also be true, and CMS may have under-estimated emissions in La Plata, especially since the emission rates applied to La Plata are ~24 percent lower than the New Mexico model suggests. Regardless, industry review of the present methodology will help improve future gas industry emissions — and may substantially alter the results.

CMS has *not* estimated emissions from the production of crude oil. La Plata's crude oil production (30,048 bbl in 2006) is small compared to its natural gas production, and emissions from oil production are relatively low compared to natural gas.

Results

CMS calculated "low," "best", and "high" emissions for La Plata's gas industry. Gas production in the county totaled 437 Bcf in 2006. Using the actual New Mexico emission rates as the "high" estimate, La Plata emissions total 4.42 million tonnes CO_2e per year ($MtCO_2$e/yr). The "low" estimate is 51.4 percent of the high estimate and totals 2.27 $MtCO_2$e/yr. CMS uses the median "best" estimate when reporting gas industry emissions to The Brendle Group. The median estimate is 75.7 percent of the high estimate and totals 3.34 $MtCO_2$e/yr. The three estimates are shown in Fig. 4, and the "best" estimate of emissions by type is shown in Figs. 5, 6, & Table 1. All computations, details, and cell notes are shown in the PDFs of worksheet in the Appendix.

[3] The "low" estimate is based on the computed rate of U.S. domestic natural gas industry methane emissions plus CO_2 from venting and flaring. This CO_2 rate is known to be low, especially since La Plata's gas production is 89 percent coal bed methane with much higher entrained CO_2. Also, the U.S. venting data is poorly documented (GAO, 2004) and likely underestimated. As a conservatism, CMS applies this rate as the La Plata "low."

Fig. 4. La Plata gas industry emissions: "low," "best," and "high" estimates.

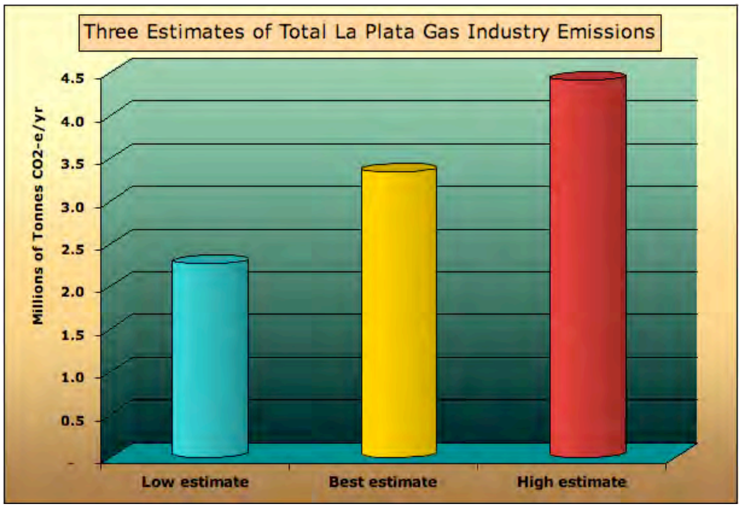


Fig. 5. La Plata gas industry "best estimate" GHG emissions

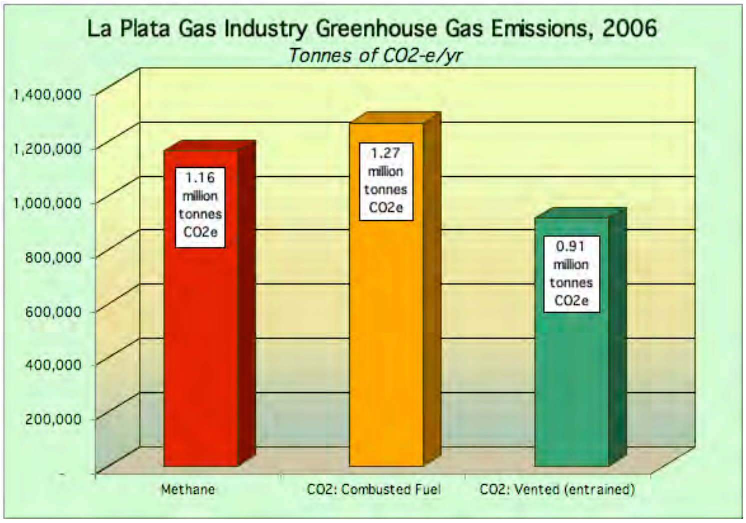


Fig. 6. Emissions by type, in percent

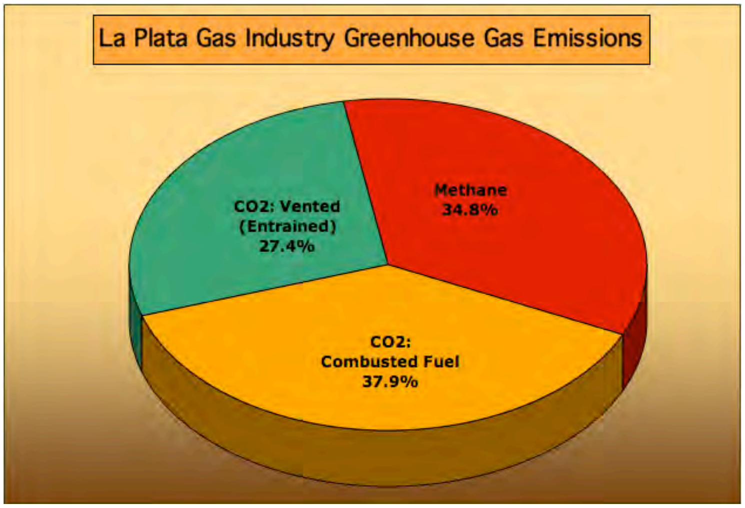
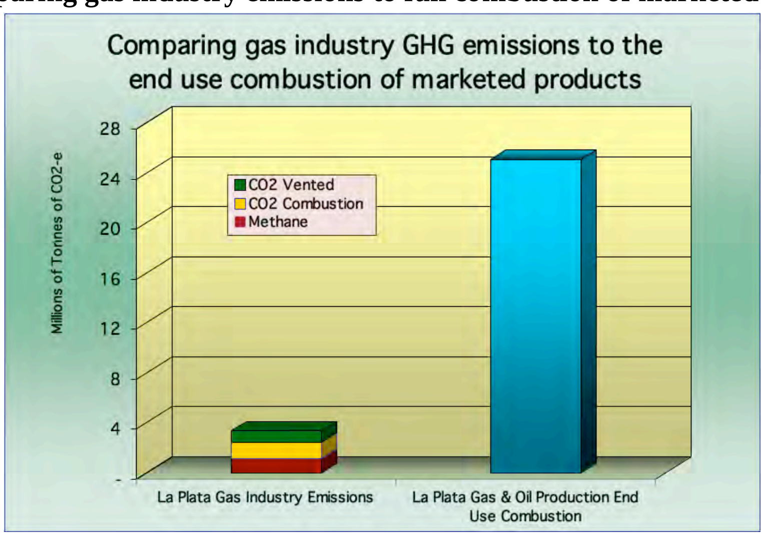


Table 1. La Plata gas industry GHG emissions "best estimate" 2006, in tonnes CO_2e

Industry segment	Carbon Dioxide	Methane	Total
Production	381,786	744,196	1,125,982
Processing	1,324,764	185,820	1,510,584
Transmission	474,036	172,507	646,543
Distribution	negl	60,652	60,652
Total	**2,180,586**	**1,163,175**	**3,343,761**
Emission source	**Carbon Dioxide**	**Methane**	**Total**
Combustion	1,265,835		1,265,835
Vented CO_2	914,751		914,751
Methane		1,163,175	1,163,175
Total			**3,343,761**

CMS estimates that complete combustion of the gas produced and marketed in La Plata County would emit 25 million tonnes of CO_2 emissions (plus a negligible amount [1,308 tonnes CO_2] from combustion of crude oil). Taking the median "best" estimate of 3.34 million tonnes of CO_2e of industry emissions associated with the production and processing and natural gas, the gas industry emissions are equivalent to 13.1 percent of the end-use combustion emissions. This percentage is in line with or below other estimates of ancillary emissions from the upstream production and processing of natural gas.[4]

Fig. 7. Comparing gas industry emissions to full combustion of marketed natural gas.



[4] The combustion of the carbon contained in the fuels produced in La Plata is hypothetical. The calculation is based on marketed production (430 Bcf), does not account for NGL production, assumes full combustion of the end use fuels (whereas liquids are assumed by the EPA and IPCC to be 99 percent combusted, and gas 99.5 percent), and, more importantly, the calculation does not account for non-fuel uses of the marketed products, some of which may be used as pipeline fuel or refineries downstream. Nonetheless, it is a useful comparison of ancillary emissions from gas production detailed in this report and the potential emissions from the fuels produced in La Plata county.

Conclusions

CMS has modeled and estimated carbon dioxide and methane emissions from the operations and facilities of the gas industry in La Plata county. The model is based on official and industry estimates of emissions in New Mexico. CMS has computed emission *rates* per billion cubic feet (Bcf) of natural gas produced in the San Juan Basin underlying northwestern New Mexico and La Plata county. CMS compared New Mexico emission rates of both CO_2 and CH_4 to U.S., Colorado, and other gas industry emission estimates. CMS determined that New Mexico's emission rates are reasonably associated to La Plata, in that both regions have high proportions of coal bed methane with high entrained-CO_2 content. The opportunity exists to articulate and advance further differentiation between industry practice and emission rates in New Mexico and La Plata in future emissions estimates.

CMS calculates La Plata's emissions in the "best" (median) estimate as 24.3 percent lower than the New Mexico model. In the absence of published industry data, county, state, or operator emissions inventories, the CMS methodology is reasonable given the paucity of extant greenhouse gas estimates.

The present result should be considered a first approximation that is likely to be improved in consultation with industry representatives and with the publication of comprehensive industry inventories based on carefully monitored emissions or models built from the field up.

CMS' "best" (median) estimate of total greenhouse gas emissions from the natural gas industry in La Plata county totals 3.34 million tonnes of CO_2 equivalent ($MtCO_2e$) in 2006 (3.69 million tons CO_2e). The "low" estimate is 2.27 $MtCO_2e$, and the "high" estimate is 4.42 $MtCO_2e$.

Arkansas Loop Plant, central La Plata. Photo by Jerry McBride, *Durango Herald*, 30Dec05.

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Chevron's SANGEA™ emissions software package was donated to the American Petroleum Institute in 2004 and is available from API. Inquiries: Karin Ritter, 202-682-8472 or ritterk@api.org

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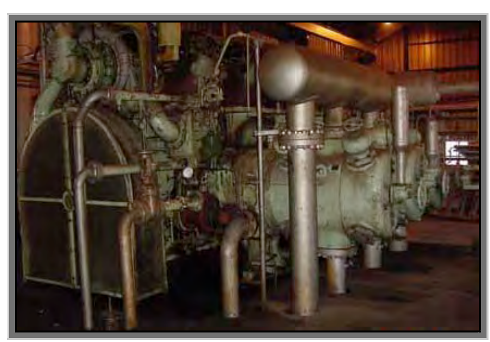

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La Plata gas industry GHG emissions: methodology and results

Report to The Brendle Group in Support of the La Plata Inventory

Richard Heede
Climate Mitigation Services
19 February 2008

Folio of worksheets

N o t e s

Appendix C: Maintenance of the Inventory

Aside from this written report, the La Plata County Inventory deliverable includes a compact disc (CD) containing all the data files, spreadsheets, documentation, and CACP data files necessary for the ongoing maintenance of the inventory. The purpose of this section is to provide a map to orient the maintainer or reviewer of these resources.

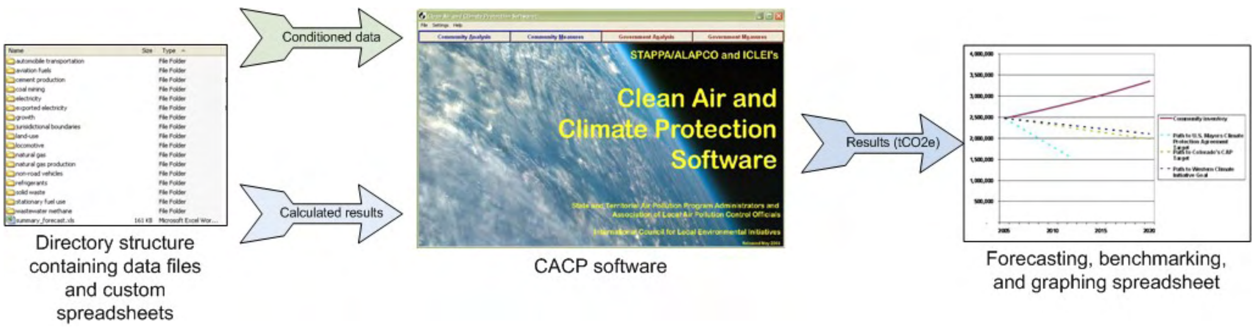

Figure 14. Inventory Data Structure and Flow

The directory structure, at left in Figure 14, includes a directory for each of the source categories or jurisdictional boundaries identified in the inventory. Within each directory are the following files, as appropriate:

- Original raw data file as provided from the source
- Well documented spreadsheet that captures the raw data and conditions them for entry into CACP or, if the particular source category is not supported by CACP, applies the appropriate methodologies to calculate tCO_2e
- Documentation supporting applied methodologies or emission factors

The conditioned data or tCO_2e calculated by the above spreadsheet is subsequently entered into CACP to provide cohesive accounting across all source categories.

The CACP tool, Figure 14 center, is available to ICLEI members for download at http://www.cacpsoftware.org/ . ICLEI may provide access to the tool for additional, non-member, consultants or organizations that support the County in maintaining the inventory. Included on the data CD is a backup of the CACP data file that was used to prepare the inventory. This file can be restored into a newly installed version of the CACP software when the County takes over the inventory.

The CACP tool supports forecasting emissions and generating reports and graphs. However, to achieve greater transparency and flexibility in these activities, the resulting quantities (tCO_2e) from the CACP tool are entered into a spreadsheet (summary_forecast.xls, Figure 14 at right) for forecasting, benchmarking, and generating the graphs found in this document. The reporting and summary features of the CACP tool can still be used when appropriate.

Appendix D: Primary Data Sources

Data Type	Organization	Data Source	Contact Information
Aviation Fuel	Animas Air Park	Delivin Gregg, Gregg Flying Service, Animas Air Park	(970) 247-4632
	Durango-La Plata Airport	Don Brockus, Operations Manager, Durango-La Plata Airport	(970) 382-6079
Cement Production	Colorado Geological Survey	Colorado Mineral and Energy Industry Activities, 2005	http://geosurvey.state.co.us/portals/0/MMF2005.pdf
Coal Mining	Colorado Geological Survey	Colorado Mineral and Energy Industry Activities Report, 2005	http://geosurvey.state.co.us/portals/0/MMF2005.pdf
Electricity	La Plata Electric Association	Larry Day	lday@lpea.coop
Exported Electricity	Four Corners Air Quality Task Force	Four Corners Area Electric Generating Units	http://www.nmenv.state.nm.us/aqb/4C/Docs/4CAQTF_PowerPlant_WorkGroup_FacilityDataTableV10.pdf
Growth	Households	State Demography Office	http://www.dola.colorado.gov/dlg/demog/household_forecast.html
	Jobs	State Demography Office	http://www.dola.colorado.gov/demog_webapps/jobs_cbef
	Transportation	Colorado Department of Transportation	http://www.dot.state.co.us/app_DTD_DataAccess/Statistics/index.cfm?display=true
	Solid Waste	CDPHE - HSRF Year-to-date Cubic Yards Reported	http://www.cdphe.state.co.us/hm/swreport/swreport.htm
	Natural Gas Industry	Preliminary report on natural gas reserves provided by La Plata County	La Plata County
	Coal Mining	Colorado Mineral and Energy Industry Activities Report, 2005	http://geosurvey.state.co.us/portals/0/MMF2005.pdf
Jurisdictional Boundaries	City of Durango	Nancy Andrews, Resource Conservation Coordinator	(970) 375-4830, andrewsnp@ci.durango.co.us
	Town of Ignacio	Balty Quintana – Town Manager	balty@townofignacio.com

Data Type	Organization	Data Source	Contact Information
	Southern Ute Indian Tribal Government	Ethan W. Hinkley and Peter Dietrich, Environmental Programs Division Head, Southern Ute Indian Tribe	ehinkley@southern-ute.nsn.us, pdieth@southern-ute.nsn.us
	La Plata County Government	Barry Perkins, La Plata County	Perkinsjb@co.laplata.co.us
	Fort Lewis College	Marcus Renner, Coodinator, Fort Lewis College Environmental Center	(970) 247-7091, RENNER_M@fortlewis.edu
	Durango School District	Sally Brennan, Staff Accountant, Durango School District	(970) 247-5411 x1429, sbrennan@durango.k12.co.us
Train	Durango & Silverton Narrow Gauge Railroad	Evan Buchanan, Director of Train Operations, D&SNGRR	(970) 385-8828
Natural Gas	Atmos Energy	Kevin Kerrigan, Atmos Energy	(970) 304-2091, Kevin.kerrigan@atmosenergy.com
	Source Gas	Len Mize, SourceGas	(303) 243-3430, Len.Mize@sourcegas.com
	Southern Ute Indian Tribe	Ethan W. Hinkley, Environmental Programs Division Head, Southern Ute Indian Tribe	(970) 563-1035, ehinkley@southern-ute.nsn.us
Non-Road Vehicles	Environmental Protection Agency	EPA NONROAD2005 Model	http://www.epa.gov/otaq/nonrdmdl.htm
On-Road Vehicles	La Plata County	Kyle A. Dalton, Interim Planning Services Manager	(970) 382-6292, DaltonKA@co.laplata.co.us
Refrigerants	La Plata County	Craig Larson, County Assessor	(970) 382-6221
Solid Waste	La Plata Recycling – Bondad	Hazardous Substance Response Act (HSRF) Year-to-date Cubic Yards Reported, 2005	http://www.cdphe.state.co.us/hm/swreport/hsrf2005.pdf
	Waste Management-Durango Transfer Station	Dennis Gallegos, District Manager	(505) 327-6284 x202
	City of Durango - Van Dahl	Nancy Andrews, Resource Conservation Coordinator	(970) 375-4830, andrewsnp@ci.durango.co.us

Data Type	**Organization**	**Data Source**	**Contact Information**
	Florida River Land Treatment Site	Don Mustard	(970) 247-6815
Stationary Fuel Use	Colorado Department of Health and Environment	David Thayer, Air Pollution Control Division, Stationary Sources Program	(303) 692-3187 david.thayer@state.co.us
Wastewater Methane	City of Durango	Jim R. Brandon, Wastewater Treatment Plant Operator	970-375-4896, brandonjr@ci.durango.co.us