UTAH GREENHOUSE GAS EMISSIONS

Estimates for 1990 and 1993

by

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and

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FOREWORD

The most casual observer of current events cannot fail to notice the media's increasing attention devoted to the problem of greenhouse gas emissions. Accounts of its possible effects occupy our evening news and grace the editorial pages of our local newspapers. Indeed, barely a month passes without a story of new research confirming suspicions that, in fact, human activity contributes measurably to the Earth's warming. Seemingly, with each new report, yet another heart in the scientific community is won over and the public's interest is heightened.

It is in the spirit of this growing consensus that the Division of Air Quality (DAQ) and the Office of Energy and Resource Planning (OERP) undertake this inventory of greenhouse gas emissions in the state of Utah. This effort marks the state's initial step in the identification and documentation of the natural and anthropogenic (human caused) sources of greenhouse gases. Albeit a seemingly basic task, this undertaking is critical for it will establish the baseline data against which competing policy decisions and costs of mitigation strategies may be compared.

This multi-phase study is a joint effort among several agencies both state and federal. As such, the authors of this and successive reports must extend their gratitude to the many individuals who have supported this research effort. First and foremost, the state of Utah respectfully acknowledges the financial and institutional support of the EPA, without which this study would not be possible.

The Division of Air Quality and the OERP also wish to thank the many members of their staff who have contributed to this report as well as several state agencies including the Department of Agriculture, the Division of Plant Industry, the Department of Natural Resources, and the Department of Transportation. The authors would also like to extend their gratitude to the many utilities and private sector firms who have provided state agencies with the data described in this report.

Executive Summary

This report provides a comprehensive inventory of greenhouse gas emissions for Utah. The greenhouse gases included are the four primary greenhouse gases emitted as a result of human activity. These are carbon dioxide, methane, nitrous oxide and ozone-depleting compounds (primarily chlorofluorocarbons).

Emissions of these gases are estimated for 1990 and 1993. Emissions were estimated by using the methodologies given in the EPA *State Workbook.*

The second phase will evaluate current and potential policies to reduce greenhouse gas emissions, including the estimated cost of implementing those policies. The results of phase one will be used as a basis for completing phase two of the study.

Table 4 provides the results of the emissions inventory. For the sake of simplicity, the 1993 levels will be referred to throughout the report. On a ton per year basis, Utah produced slightly more than 64 million tons of greenhouse gases. Carbon dioxide from fossil-fuel combustion accounts for over 62 million of this total, followed by limestone use, cement production, and limestone production. Aside from nominal amounts of CO_2 released from soda ash processing, forestry and land use changes account for most of the remaining sources of carbon gases.

Methane represents the next largest fraction of greenhouse gases at 409,554 tons. Underground coal mines are responsible for over half of the emissions from this category, followed by domestic animals. Oil and gas consumption and methane from landfills account for most of the remainder. Nitrous oxide, associated with fertilizer use, registered only 450 tons.

Due to the presence of coal burning power plants, Millard and Emery counties produce the largest portion of greenhouse emissions in the state. Salt Lake county, the most densely populated county in the state, produces the third largest amount of emissions in Utah. Counties containing underground coal mines (Emery, Sevier and Carbon) release the most methane. While an almost insignificant source of emissions, fertilizer-based nitrous oxide is distributed among the middle and northern counties.

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Introduction

A. Purpose of the Greenhouse Gas Study

This study is intended to provide a set of methodologies to estimate the emissions of greenhouse gases using a formal set of guidelines to characterize these emissions in the state of Utah. Compiling an emissions inventory is a critical first step toward developing policies and strategies to mitigate greenhouse gas emissions and to assess the various options available for responding to the effects of climate change.

B. Greenhouse Gases and Climate Change

The climate of the earth is affected by changes in radiative forcing attributable to several sources including the concentrations of radiatively active (greenhouse) gases, solar radiation, aerosols, and albedo.[1] Greenhouse gases in the atmosphere are virtually transparent to sunlight (shortwave radiation), allowing it to pass through the air and to heat the Earth's surface. The Earth's surface absorbs the sunlight and emits thermal radiation (longwave radiation) back to the atmosphere. In turn, the atmosphere emits thermal radiation both outward into space and downward to the Earth, further warming the surface. This process, known as the "greenhouse effect," enables the Earth to maintain enough warmth to support life. Indeed without this natural process, our planet would be approximately 55°F colder than it is today. However, increasing concentrations of these greenhouse gases are projected to result in increased average temperatures, with the potential to warm the Earth to a level that could disrupt the activities of today's natural systems and human societies.

The British Meteorological Office and the University of East Anglia reported that 1995 was the warmest year since consistent record keeping began in 1856. The 5-year period from 1991 through 1995 was also documented as the warmest on record. This finding is considered particularly troubling, since the Earth benefited from cooler temperatures for nearly two years after the 1991 eruption of Mt. Pinatubo, the volcano located in the Philippines. The Goddard Institute, analyzing a different set of global weather data, also determined that 1995 was the warmest year ever but could not conclude that it was significantly warmer than 1990.

It is now generally accepted that the Earth is being warmed by human activities, in particular greenhouse gas emissions from the burning of fossil fuels. Carbon dioxide emissions were reported to be 1,430 million metric tons of carbon in 1994 for the United States. Of this, energy consumption contributed 1,396 million metric tons of carbon, while other industries accounted for

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[1] Albedo is the fraction of light or radiation that is reflected by a surface or a body. For example, polar ice and cloud cover increase the Earth's albedo. "Radiative forcing" refers to changes in the radiative balance of the Earth (i.e., a change in the existing balance between incoming and outgoing radiation). This balance can be upset by natural causes, such as volcanic eruptions as well as by anthropogenic activities, for example greenhouse gas emissions.

about 34 million metric tons. World carbon emissions in 1994 were approximately 6,000 million metric tons and it is anticipated that the growth of China will significantly increase global carbon emissions.

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), and ozone (O_3).[2] Some human-made compounds, including chlorofluorocarbons (CFCs) and partially halogenated fluorocarbons (HCFCs), their substitutes hydrofluorocarbons (HFCs), and other compounds such as per fluorinated carbons (PFCs), are also greenhouse gases. In addition, there are photochemically important gases such as carbon monoxide (CO), oxides of nitrogen (N_2O), and non-methane volatile organic compounds (NMVOCs) that, although not considered greenhouse gases per se, contribute indirectly to the greenhouse effect. These are commonly referred to as "tropospheric ozone precursors," because they influence the rate at which ozone and other gases are created and destroyed in the atmosphere.[3]

Although CO_2, CH_4, and N_2O occur naturally in the atmosphere, their recent atmospheric buildup appears to be the result of anthropogenic activities. The buildup has altered the composition of the earth's atmosphere, and possibly will affect future global climate. Since 1800, atmospheric concentrations of carbon dioxide have increased about 25 percent, methane concentrations have more than doubled, and nitrous oxide concentrations have risen approximately eight percent (IPCC, 1992). Furthermore, beginning in the 1950s until the mid-1980s, when international concern over CFCs grew, the use of these gases increased nearly 10 percent per year. The consumption of CFCs is declining quickly as these gases are phased out under the *Montreal*

[2] Ozone exists in the stratosphere and troposphere. In the stratosphere (about 12.4 - 31 miles above the Earth's surface), ozone provides a protective layer shielding the Earth from ultraviolet radiation and subsequent harmful health effects on humans and the environment. In the troposphere (from the Earth's surface to about 6.2 miles above), ozone is a chemical oxidant and major component of photochemical smog. Most ozone is found in the stratosphere, with some transport occurring to the troposphere (through the tropopause, i.e., the transition zone separating the stratosphere and the troposphere) (IPCC, 1992).

[3] For convenience, all gases discussed in this document are generically referred to as "greenhouse gases," although the reader should keep in mind the distinction between actual greenhouse gases and photochemically important trace gases.

Protocol of Substances that Deplete the Ozone Layer.[4] Use of CFC substitutes is expected to grow substantially.

Despite these increases, it is impossible at this juncture to predict with certainty the timing, magnitude, or regional distribution of any climatic change. Uncertainty about the climatic role of oceans and clouds as well as the climate feedback from oceans, clouds, vegetation, and other factors make it difficult to predict the exact amount of warming that a given level of greenhouse gases, such as doubled CO_2 concentration, would cause and the rate at which any climate change would occur.

If the predicted level of climate change occurs (an average global temperature change between 1.5 and 4.5°F by 2050 (IPCC, 1992), however, the areas most vulnerable to this disruption include forests, fisheries, coastal zones, agriculture, water resources, energy demand and supply, air quality, and human health. Potential impacts on these sectors include: loss of tree species and reduced land area of healthy forests resulting from drier soils or increased pestilence and disease; reduced shellfish productivity; increased annual demand for electricity for summer cooling thereby increasing the need for total generating capacity; water use conflicts, as water availability declines and demand for water, such as for irrigation and power plant cooling, increases; and increased air pollution, as air quality is directly affected by weather variables such as higher temperatures which speed reaction rates among chemicals in the atmosphere, causing higher ozone pollution and urban smog (Smith and Tirpak, 1989).

Drastic cuts in emissions would be required to stabilize atmospheric composition. Because greenhouse gases remain in the atmosphere for decades to centuries, merely stabilizing emissions at current levels would allow the greenhouse effect to intensify for more than a century. For example, emissions of carbon dioxide might have to be reduced by 50 to 80 percent to hold current concentration constant. While it is not possible to stabilize greenhouse gas concentration immediately, implementation of measures to reduce emissions would decrease the risk of global warming, regardless of the uncertainties about the response of the climate system (Lashof and Tirpak, 1990).

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[4] Recognizing the harmful effects of chlorofluorocarbons and other halogenated fluorocarbons on the atmosphere, many governments signed the *Montreal Protocol on Substances that Deplete the Ozone Layer* in 1987 to limit the production and consumption of a number of these compounds. As of June 1994, 133 countries had signed the *Montreal Protocol*. The United States furthered its commitment to phase out these substances by signing and ratifying the Copenhagen Amendments to the Montreal Protocol in 1992. Under these amendments, the United States committed to eliminating the production of all halons by January 1, 1994, and all CFCs by January 1, 1996.

C. International, National, and State Actions

Scientific consensus that the threat of climate change is real has triggered a wave of responses by governments at the international, national, and state levels. For example, since the mid-1980s, the United States has taken an active role in fostering international cooperation and furthering research into understanding the causes and effects of climate change. Initially, the United States worked with technical experts from over 50 countries and the Organization for Economic Cooperation and Development (OECD) to develop methods for estimating emissions and uptake of greenhouse gases. This cooperative effort supported the charge of the Intergovernmental Panel on Climate Change (IPCC), a committee jointly established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) in 1988 to assess scientific information related to climate change issues. These activities culminated in the compilation of a set of internationally accepted methods for conducting national emission inventories, the *IPCC Guidelines for National Greenhouse Gas Inventories: Vols 1-3* (IPCC, 1994).

In June 1992, the United States further demonstrated its concern about climate change by joining with 154 other nations at the United Nations Conference on Environment and Development in signing the Framework Convention on Climate Change (FCCC). Later, in October 1992, the United States became the first industrialized nation to ratify the treaty, which came into force on March 21, 1994. The FCCC commits signatories to stabilizing anthropogenic greenhouse gas emissions to "levels that would prevent dangerous anthropogenic interference with the climate system." To facilitate this, Article 4-1 requires that all parties to the FCCC develop, periodically update, and make available to the Conference of Parties, national inventories of anthropogenic emissions of all greenhouse gases not controlled by the *Montreal Protocol*, using comparable methodologies to fulfill its obligation under the FCCC, the U.S. government published the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1993* (U.S. EPA, 1994) and the *U.S. Climate Action Report* (U.S. Government, 1994).[5]

At the national level, the Clinton Administration developed and published the *Climate Change Action Plan* (CCAP, Clinton and Gore, 1993) to assist the United States in meeting its obligation under the FCCC - to return greenhouse gas emissions to 1990 levels by the year 2000. The *Climate Change Action Plan* promotes the development and expansion of approximately 50 initiatives that span all sectors of the economy and focus on reducing emissions of greenhouse gases in a cost-effective manner. These initiatives call for cooperation between government, industry, and the public, and since they are primarily voluntary in nature, are designed for rapid

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[5] The *Climate Action Report* represents the first formal U.S. communication under the FCCC as required by Articles 4.2 and 12 and describes the current U.S. program. The report neither identifies additional policies or measures that might ultimately be taken as the United States continues to move forward in addressing climate change, nor serves as a revision to the *Climate Change Action Plan*. It is intended to identify existing policies and measures, and assist in establishing a basis for considering future actions.

implementation. Also, the U.S. Department of Energy has recently released a set of draft guidelines for entities to report voluntarily their reductions of greenhouse gas emissions and fixation of carbon, achieved through any measure. The guidelines serve several purposes such as: 1) providing a database of information for entities seeking to reduce their own greenhouse gas emissions; 2) establishing a formal record of emissions and emission reductions and carbon sequestration achievements; and 3) informing the public debate regarding future discussions on national greenhouse gas policy.

At the state level, the U.S. EPA's Climate Change Division, State and Local Outreach Program, has been working with states to assist them in: 1) identifying their greenhouse gas emission sources and estimating their overall contribution to radiative forcing; 2) assessing the areas of the state that are most vulnerable to climate change; and 3) developing state-specific greenhouse gas mitigation strategies. In November 1992, the Climate Change Division published the original version of this document, *State Workbook: Methodologies for Estimating Greenhouse Gas Emissions* (U.S. EPA, 1992). As part of the next phase of the State and Local Outreach Program, the Climate Change Division will publish the *States Guidance Document: Policy Planning to Reduce Greenhouse Gas Emissions* (forthcoming). In addition to these activities, the National Governor's Association Task Force on Global Warming has proposed more than 20 strategies, consistent with international goals, for responding to the threat of global warming (NGA, 1991). Also, the Council of State Governments' Global Change Task Force has published a plan that recommends 30 ways for Northeastern states to reduce emissions of greenhouse gases (Environmental Information Networks, Inc., 1944a).

D. The Role of the States

States will need to consider a variety of issues, ranging from mass transit to reforestation, and from the recycling of wastes to the reduction of energy use, in order to develop climate change policies that reduce emissions of greenhouse gases while maintaining economic growth and development. Many states have already begun to address these issues. Examples include: a California law calling for the California Energy Commission to study the potential impact of climate change on the state's energy supply/demand, economy, environment, and agricultural and water resources; a Connecticut law establishing a broad range of energy conservation measures; the program focused on the reduction of CO_2 emissions by the Energy Division of the Minnesota Department of Public Service; and, an Oregon law requiring the Oregon Department of Energy to develop strategies for reducing greenhouse gas emissions (Silbiger and Gongring, 1992 and Environmental Information Networks, Inc., 1994b).

There are several reasons why states can significantly affect their emissions of greenhouse gases. First, state governments hold direct regulatory authority over the sources of more than half of all CO_2 emissions: gas and electric utilities. Second, states also determine the acceptability of building specifications and land-use planning, thereby affecting emissions from the residential, commercial, and transportation sectors. Third, states also have jurisdiction over determining regulations concerning the use and recycling of paper, glass, and plastic products, the management of municipal solid wastes (and consequently methane emissions), and the promotion of energy savings from secondary manufacturing. Finally, many states currently regulate forestry practices on non-federal lands.

A wide variety of policy options are available that have the technical potential to reduce greenhouse gas emissions. Many appear to be consistent with other economic, development, environmental, and social goals. One such policy includes identifying and implementing opportunities for cost-effective energy improvements. For example, efficiency investments that pay for themselves over the life of the equipment, through reduced energy costs, suggest that the accompanying reduction in carbon dioxide emissions may be essentially a cost-free by-product of a more efficient economy.[6] Efficiency improvements can also reduce emissions of other pollutants, improve economic competitiveness, and enhance U.S. environmental quality, energy independence, capturing and reusing methane from landfills and coal mines, and increasing afforestation and reforestation efforts are other possible policy options with multiple benefits.

Policymakers and planners will need to design policies and strategies to deal with the uncertainties of climate change, the potentially significant impacts climate change could have on their region's natural resources, and ways to reduce emissions of greenhouse gases to help curb climate change.[7] This requires a three-step process: 1) an assessment of the vulnerability of resources to climate change impacts; 2) an evaluation of adaptation options; and 3) an evaluation of mitigation options.

Assessing the vulnerability of a state or region to climate change impacts involves estimating a range of regional climate change scenarios. After vulnerability assessments have been completed, a state can weigh its vulnerabilities against the economic, environmental, and social changes in rainfall and temperature, water conservation, forest health and production, and protection of biological diversity. The efficient implementation of these policies can best be achieved through the establishment of priorities among suggested anticipatory options (U.S. EPA, 1991).

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[6] According to the National Academy of Science report "Policy Implications of Greenhouse Warming Mitigation Panel" NAS Press, 1991, as quoted by Richard Kerr, "the most cost-effective measures for reducing emissions involve increasing the energy efficiency of residential and commercial buildings and activities, vehicles, and industrial processes that use electricity." (*Science*, Vol 252, 21 June 1991, p. 252).

[7] Adaptation options will be necessary in the future if current and planned capabilities are found to be insufficient to address the adverse impacts of climate change. Under these options falls the debate over anticipatory versus reactive measures. Reactive measures are those which are made as climate change impacts occur, anticipatory measures are made before climate change impacts are felt. Crucial to this debate is the analysis of the economic, environmental, and social costs and benefits of any suggested option (U.S. EPA, 1991).

Considerable uncertainty exists, however, regarding the economic and social costs and benefits associated with preventive measures to combat the potential effects of climate change and strategies to mitigate greenhouse gas emissions. Some estimates show that the costs associated with stabilizing greenhouse gas emissions will range anywhere from zero to six percent of the U.S. GNP (Manne and Richels, 1989), while a National Academy of Sciences panel has concluded that the potential exists to reduce greenhouse gas emissions in the United States by 10 to 40 percent of 1990 levels at a very low cost and possibly a net savings (NAS, 1991). The actual costs and benefits of alternative mitigation and adaptation strategies in an individual state will, of course, depend on the particular sources of emissions, currently available technologies, and the vulnerability of the agricultural, forestry, energy, and other important sectors in that state.

E. Global Warming Potential (GWP)

When discussing greenhouse gases in a policy context, especially when attempting to estimate the costs and benefits of greenhouse gas emission reduction strategies, it is useful to have some means of estimating the relative effects of each greenhouse gas on radiative forcing of the atmosphere over some future time horizon, without performing the complex and time-consuming task of calculating and integrating changes in atmospheric composition over the period. In short, an index is needed that translates the level of emissions of various gases into a common metric in order to compare the climate forcing effects without directly calculating the changes in atmospheric concentrations (Lashof and Tirpak, 1990). This information can then be used for calculation of the cost-effectiveness of reductions (e.g., CO_2 emissions compared to CH_4 emissions).

A number of approaches, called Global Warming Potential (GWP) indices, have been developed in recent years. These indices account for the direct effects of growing concentrations of carbon dioxide, methane, chlorofluorocarbons, nitrous oxide, hydorfluorocarbons, and per fluorinated carbons in the atmosphere on radiative forcing. They also estimate indirect effects on radiative forcing due to emissions which are not themselves greenhouse gases, but lead to chemical reactions that create other greenhouse gases. These emissions include carbon monoxide, nitrogen oxides, and non-methane volatile organic compounds, all of which contribute to formation of tropospheric ozone, which is a greenhouse gas (Lashof and Tirpak, 1990).

This report follows the methodology used by the IPCC (IPCC, 1992). However, there is no universally accepted methodology for combining all the relevant factors into a single global warming potential for greenhouse gas emissions. In addition to the IPCC, there are several other noteworthy attempts to define a concept of global warming potential, including Lashof and Ahuja (1990), Rodhe (1990), Derwent (1990), WRI (1990), and Nordhaus (unpublished).

The concept of the global warming potential, as developed by the IPCC, is based on a comparison of the radiative forcing effect of the concurrent emissions into the atmosphere of an equal quantity of CO_2 and another greenhouse gas. Each gas has a different instantaneous radiative forcing effect. In addition, the atmospheric concentration attributable to a specific quantity of each gas declines with time. In general, other greenhouse gases have a much stronger instantaneous radiative effect than does CO_2; however, CO_2 has a longer atmospheric lifetime and a slower decay rate than most other greenhouse gases. Atmospheric concentrations of certain greenhouse gases may decline due to atmospheric chemical processes, including latitudinal and temporal variations that make it impossible to quantify how certain gases may indirectly affect the climate. Due to these uncertainties over indirect effects, these concentrations have not been included in the GWP of each gas at this time (IPCC, 1992). Only the ability of gases to directly affect radiative forcing is included here.[8]

Table 1. Global Warming Potentials for Various Greenhouse Gases (Direct Effects Only)

Trace Gas	GWP (100 years)	Indirect Effect
Carbon Dioxide	1	none
Methane [a]	11/22	positive
Nitrous Oxide	270	uncertain
CFC-11 [b]	-	uncertain
CFC-12 [b]	-	uncertain
CFC-113 [b]	-	uncertain
CFC-114 [b]	-	uncertain
HCFC-22 [b]	-	uncertain
HFC-134a	1,200	positive
HFC-23	10,000	positive
HFC-152a	150	positive
PFCs	5,400	positive
CO	-	positive
NO	-	uncertain
NMVOCs	-	positive

[a] The direct GWP of methane is 11, however, the indirect effects of methane are considered comparable in magnitude to direct effects, therefore a GWP of 22 is recommended for use on this document.

[b] Although CFCs and related compounds have very large direct GWPs, their indirect effects are believed to be negative and could significantly reduce the magnitude of their direct effects (IPCC, 1992). Given the uncertainties surrounding the net effect of these gases, no GWP has been provided at this time.
Source: IPCC, 1992

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[8]The one exception is methane, which has a direct GWP of 11. The indirect effects of methane are considered comparable in magnitude to the direct effects. A GWP of 22 is used in this document (IPCC, 1992). Using a GWP of 22 for methane is consistent with the GWP used in the *Climate Change Action Plan* (Clinton and Gore, 1993), and follows the suggestion of the International Negotiating Committee's (INC) 9th Session that requests indirect effects of greenhouse gases be included where applicable. The magnitude of the indirect effects of other gases are either zero or uncertain and are not recommended at this time.

Following this convention, the GWP is defined as the time-integrated commitment to climate forcing from the instantaneous release of one kilogram of a trace gas expressed relative to that from one kilogram of carbon dioxide. The magnitude of the GWP is sensitive to the time horizon over which the analysis is conducted (i.e., the time over which the integral is calculated). For example, Table 1 summarizes the GWPs of key greenhouse gases assuming a 100-year time horizon. The assumed integration period defines the time period over which the radiative effects of the gas are measured. These GWPs indicate, for example, that one kilogram of nitrous oxide emissions is estimated to have approximately 270 times the direct impact on radiative forcing as one kilogram of carbon dioxide for a 100-year time horizon. If a 500-year time horizon is assumed, nitrous oxide is estimated to have 170 times the impact on radiative forcing compared to an equivalent amount of carbon dioxide. The difference between the values for 100 years and 500 years incorporate the differences in atmospheric lifetime.

For the discussion included in this document, the GWPs presented in Table 1 for a 100-year time horizon are used to convert all greenhouse gases to a CO_2 equivalent basis so that the relative magnitudes of different quantities of different greenhouse gases can be readily compared. There is nothing unique about this time horizon. It is sufficient that many of the atmospheric processes currently thought to affect concentrations can be considered without weighing long-term impacts on atmospheric processes.

Using the GWPs presented in Table 1, the relative contribution of each greenhouse gas to global warming for any greenhouse gas emission estimates can be calculated. For example, in Table 2, U.S. contributions to global warming by the primary greenhouse gases are represented using U.S. emission estimates for the year 1990 based on conversion to a CO_2-equivalent basis using 100-year GWPs.

Table 2. U.S. Greenhouse Gas Emissions and Sinks: 1990 (10^6 metric tonnes C)

CO_2 Emissions	CO_2 Sinks	CH_4	N_2O	HFC/PFC	Net Emissions
1352	-119	162	30	19	1444

Source: U.S. EPA, 1994

The GWP will be an important concept for states in determining the relative importance of each of the major emission sources and in developing appropriate mitigation strategies.

F. The Inventory Process

Before a state can effectively develop policies to reduce gas emissions and respond to climate change, it needs to identify its anthropogenic emissions and estimate the contribution of these emission sources to overall radiative forcing. The methodologies presented in this workbook have been adopted from the *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 1994)[9] and the *Inventory of U.S..Greenhouse Gas Emissions and Sinks: 1990-1993* (U.S. EPA, 1994). In many cases, the methodologies presented are consistent with the *IPCC Guidelines*, however, for emission sources considered to be major sources in the United States, the IPCC default methodologies have been expanded and more comprehensive U.S.- specific methods are provided. These instances include energy consumption, forest sinks, and some methane sources. It is suggested that if a state has access to state- or region-specific emissions factors, or has the ability to take on-site emission measurements at various sources, then the state should pursue these options.

While these methods provide a solid foundation for the development of a more detailed comprehensive emission inventory, they have several strengths and weaknesses. First, there are uncertainties associated with some of the emission coefficients presented. Some of the current emissions coefficients, such as those for CO_2 from energy-related activities and cement processing are considered accurate. For other categories of emissions, a lack of data or an incomplete understanding of how emissions are generated limits the scope or accuracy of the emission coefficients. For certain categories, emission coefficients are given as a specified range to reflect the associated uncertainty. Where applicable, specific factors affecting the accuracy of the estimates are discussed.

Secondly, while the methodologies provided in the *IPCC Guidelines* and the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* represent baseline methodologies for a variety of source categories, many of these methodologies are still being refined. The uncertainties associated with calculating greenhouse gas emissions are both qualitative and quantitative. The methods provided reflect current best scientific understanding. Efforts need to be made to improve existing methodologies and data collection activities, so that the methodologies and data are consistent with one another and so that they allow states to estimate emissions with greater ease, certainty, and consistency.

Regardless of the methodologies or estimation techniques a state may decide to use, the key to a sound emissions inventory is documentation of the activity data and emissions factors being used. This includes information on derivation and clear definitions of activities. Any emissions inventory that is not accompanied by sound documentation is unverifiable. Without clear documentation of the methods employed and data used, it will be impossible to refine and improve the accuracy of greenhouse gas inventories. States may also, at some point, want to

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[9] Discussions of inventory methods can be found in *Estimation of Greenhouse Gas Emissions and Sinks: Final Report from the OECD Experts Meeting*, 18-21 February 1991 (August 1991). The report documents baseline inventory methodologies for a variety of source categories, which have subsequently been further refined based on recommendations provided at an IPCC sponsored experts workshop held in Geneva, Switzerland in December 1991 and at an OECD/Netherlands-sponsored workshop in Amersfoort, Netherlands in February 1993. The proceedings from these meetings, the Final Report (OECD, 1991), as well as several other international meetings, form the basis for the current *IPCC Guidelines*.

compare their inventories with other states, or pool statistical data in a regional inventory. This can only be done if emissions are estimated using comparable and consistent methods with data that are understandable and verifiable.

Results

Estimates of Utah greenhouse gas emissions for all gases and anthropogenic emission sources are found in Table 4. In both these broad categories, emissions totaled 64,183,747.43 tons per year. On a ton per year basis, carbon dioxide accounts for nearly all of the emissions, followed by methane (409,553.51) and less than 1,000 tons of nitrous oxides.

Of all categories, fossil fuel consumption is the primary source of Utah's greenhouse emissions. Combustion of fossil fuels in stationary and mobile sources (electric utility, industry, and transportation) represents 97 percent of all greenhouse sources. In the case of electric power generation, Utah's power plants produce over 95 percent from bituminous coal, which accounts for 62 percent of all fossil fuel related carbon.

In addition to the coal burned for consumption in Utah, considerable quantities of power are generated within the state's borders and wheeled to or exchanged with other states. Nearly 4.5 million tons of carbon are produced for power sales and exchange contracts with customers in California and elsewhere.

Carbon dioxide is also associated with other non-energy sectors in the economy including limestone use (834,397.56 tons), cement production (493,788.20 tons), limestone production (368,431.9 tons), and nominal amounts released in soda ash production (415 tons). Juab, Millard, and Morgan counties are responsible for most of the carbon releases related to these activities.

Forest and land use changes may either add or subtract from the carbon dioxide inventory, depending on the relationship between harvest and growth. In 1993, this category accounted for a negative value (35,566.72). Sevier, San Juan, Sanpete and Millard counties are the primary areas in which these fluctuations are found. Of note, Utah does not produce greenhouse gas emissions from rice fields.

The second most important category of greenhouse gas emissions is methane. A distant second from carbon dioxide, this gas accounts for 409,553.51 tons or 4.2 million tons of equivalent of carbon dioxide. Emissions from underground coal mines in Emery, Sevier, and Carbon counties represent over half the total (213,114.23 tons), followed by domestic animals which accounts for 74,000 tons distributed evenly across the state. Oil and gas processing emissions, registering just over 60,000 tons, are found along the Wasatch Front. Albeit rather small in measure, the Wasatch Front is also largely responsible for methane emissions due to landfill leaks and wastewater treatment.

In the category of carbon released from fossil-fuel combustion natural gas, which is mostly methane, is ranked second to bituminous coal. Used in industrial, commercial and residential sectors, natural gas represents 12 percent of total emissions relating to fossil fuel combustion. Petroleum, used primarily for transportation, contributes significant amounts of carbon. Motor gasoline represents 13 percent of total carbon in this category, followed by distillate fuel oils and kerosene (J-type) which together equal eight percent of the total. These emissions are generally associated with economic activity along the Wasatch Front as well.

Nitrous oxide emissions in Utah are estimated at 450.73 tons or 129,000 tons of carbon dioxide equivalent. These emissions are linked to fertilizers used in farming lands in Box Elder, Salt Lake, Utah, and Cache counties.

It is important to note that greenhouse gas emission estimates vary in terms of accuracy. For example, carbon dioxide measurements are most accurate in the case of power plant combustion. Estimates from the transportation sector are less accurate given the variability in engine efficiencies across a wide range of vehicles of different year and make. As a result, estimates are drawn from an average emissions factor based on gasoline tax records. Finally, because of sampling problems, the least accurate measurements involve the calculation of emissions from domestic animals, fertilizer applications, and land use changes.

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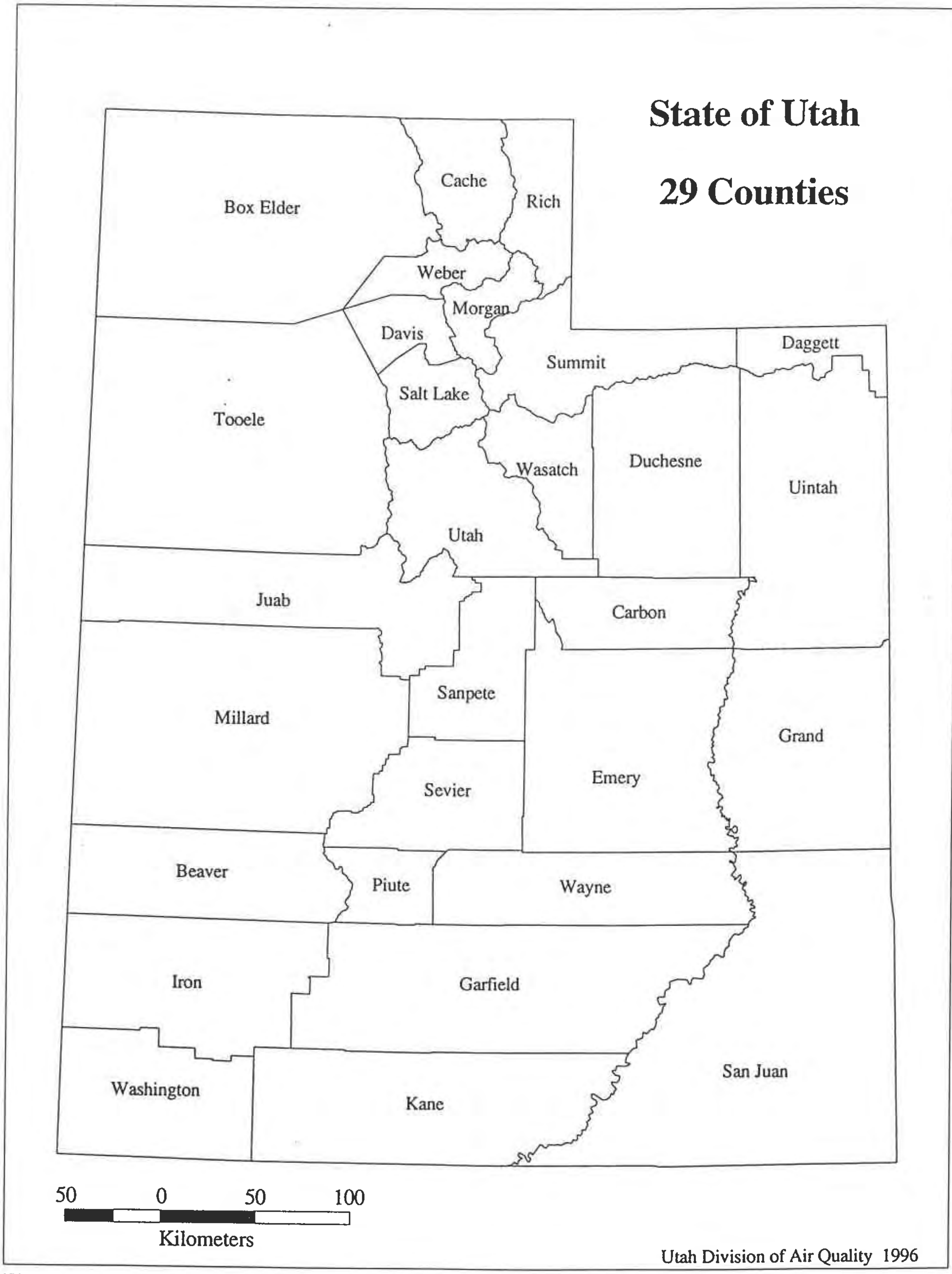
State of Utah
29 Counties
Box Elder
Cache
Rich
Weber
Morgan
Davis
Summit
Daggett
Salt Lake
Tooele
Duchesne
Wasatch
Uintah
Utah
Juab
Carbon
Sanpete
Millard
Grand
Sevier
Emery
Beaver
Piute
Wayne
Iron
Garfield
San Juan
Washington
Kane
50 0 50 100
Kilometers
Utah Division of Air Quality 1996

Figure 1

State of Utah Greenhouse Gas Inventory 1990

Greenhouse Gases (CO_2, CH_4, N_2O) and Photochemically Important Gases (CO, NO_x)

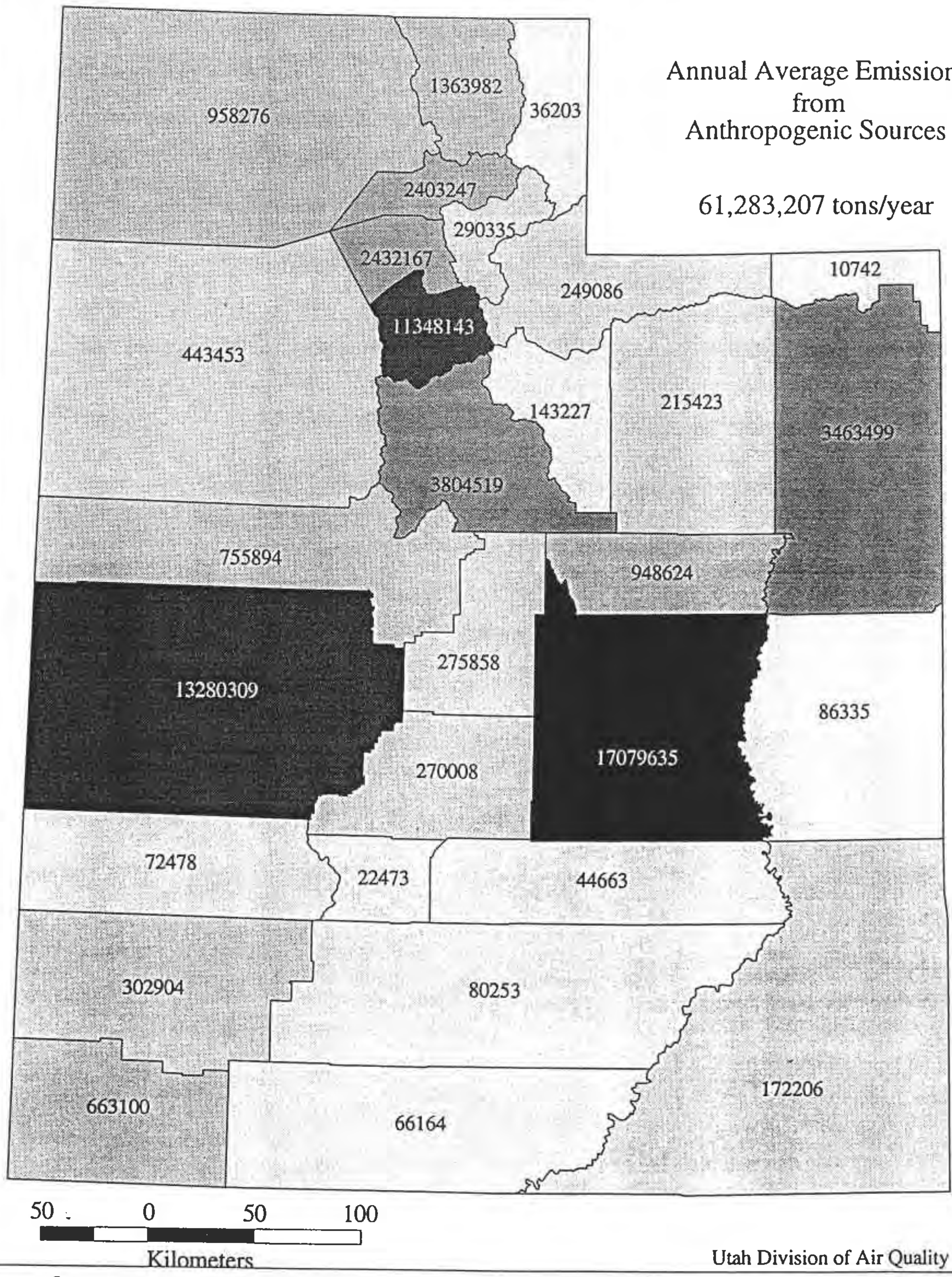

Figure 2

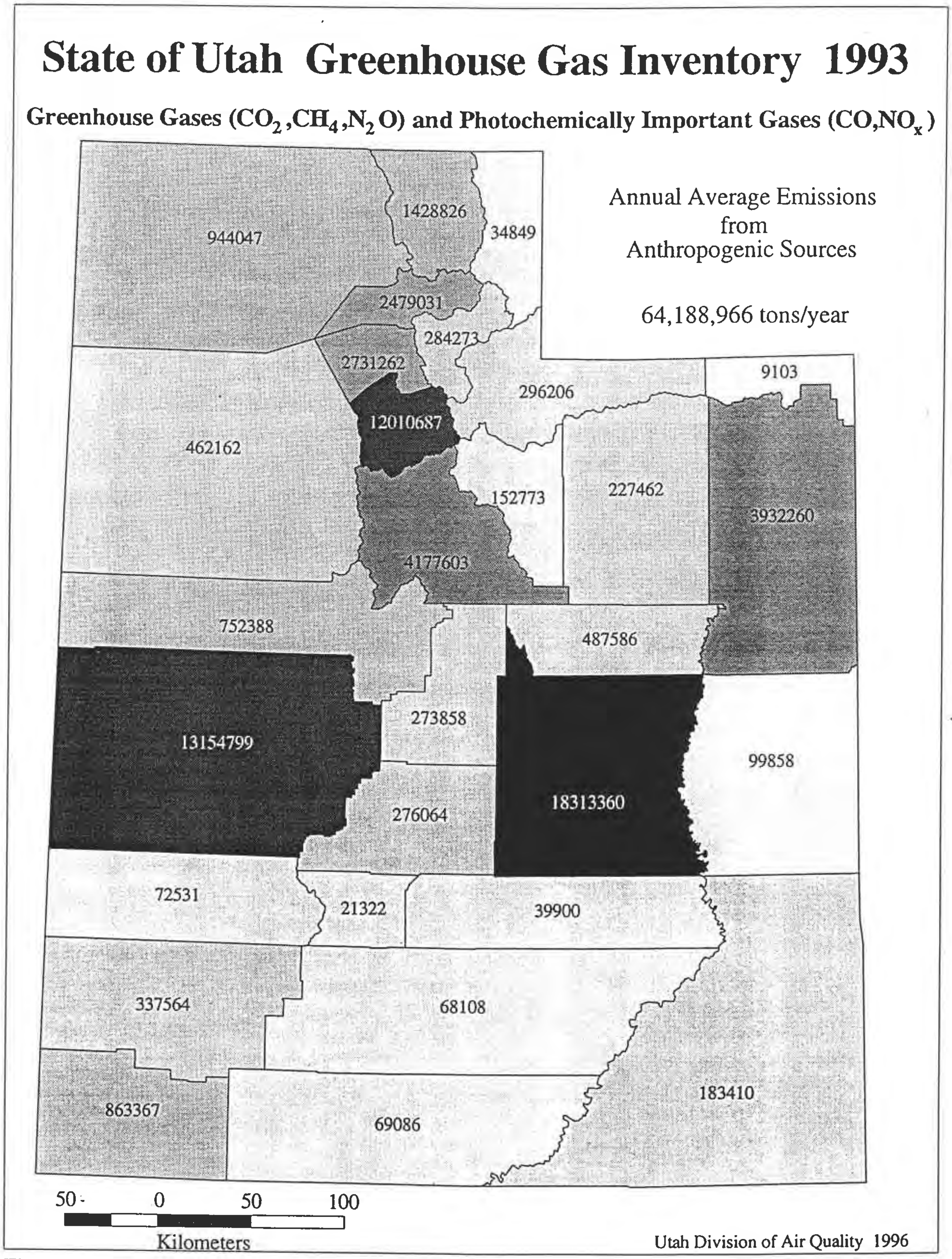
State of Utah Greenhouse Gas Inventory 1993
Greenhouse Gases (CO_2, CH_4, N_2O) and Photochemically Important Gases (CO, NO_x)
Annual Average Emissions from Anthropogenic Sources
64,188,966 tons/year
1428826
34849
944047
2479031
284273
2731262
9103
296206
12010687
462162
152773
227462
3932260
4177603
752388
487586
273858
13154799
99858
18313360
276064
72531
21322
39900
337564
68108
183410
863367
69086
50 0 50 100
Kilometers
Utah Division of Air Quality 1996

Figure 3

Table 3 Total Greenhouse Gas Emissions 1990

Tons/Year

County	Landfills CH_4	Underground Coal Mines CH_4	Fertilizer Use N_2O	Limestone Use CO_2	Cement Production CO_2	Lime Production CO_2	Soda Ash CO_2	Forestry and Land Use Change CO_2
Beaver	20.22		2.51				0.58	-940.39
Box Elder	148.33		93.51				4.38	-162.45
Cache	5,824.22		36.39				8.46	-2315.11
Carbon	5,659.38	18,964.10	1.82				2.42	-312.07
Daggett	3.29		0.69				0.08	739.76
Davis	11,734.58		9.94				1.51	-618.05
Duchesne	45.78		13.11				22.56	956.86
Emery	36.52	157,998.18	2.05				1.23	-2336.28
Garfield	16.59		0.00				0.47	10550.96
Grand	30.13		0.00				0.79	-573.99
Iron	75.06		4.42				2.51	2546.43
Juab	23.43		3.18	339,196.00	315,499.72		0.70	-434.96
Kane	18.26		0.02				0.62	1286.05
Millard	44.35		17.11	348,939.80		286,525.00	1.35	-2455.64
Morgan	19.99		6.31		193,897.02		0.66	-171.54
Piute	5.68		0.25				0.15	-1347.76
Rich	7.50		0.00				0.21	-524.69
Salt Lake	13,753.18		84.80				87.37	-689.82
San Juan	49.02		0.65				1.51	-4112.58
Sanpete	62.22		7.31				1.95	-3983.40
Sevier	59.80	36,151.95	2.54				1.85	-4642.94
Summit	48.74		7.44				1.88	-1856.40
Tooele	105.35		21.31	36,530.56		31,400.00	3.20	-1298.56
Uintah	80.42		20.59				2.66	1177.61
Utah	6,428.80		65.81	40,376.71			31.93	-1364.50
Wasatch	35.67		1.29				1.21	-1250.22
Washington	5,687.45		6.49				5.89	4207.87
Wayne	8.80		0.96				0.26	287.40
Weber	6,204.43		11.99				19.08	-642.65
Statewide Total	56,237.22	213,114.23	422.49	765,043.07	509,396.74	317,925.00	207.50	-10281.06

County	Agricultural Burning $CH_4+CO+N_2O+NO_x$	Wastewater Treatment CH_4	Nitric Acid Manufacturing NO_x	Oil & Gas CH_4	Fossil Fuels CO_2	Domestic Animals CH_4	Manure Management CH_4	County Total
Beaver		3.92		191.27	70,598.11	2,524.20	77.37	72,477.78
Box Elder	139.99	29.81		1,454.43	949,477.11	6,860.16	231.08	958,276.34
Cache		57.57		2,809.24	1,351,319.81	5,826.08	415.50	1,363,982.17
Carbon		16.50		804.92	920,230.87	3,238.25	17.41	948,623.59
Daggett		0.57		27.89	9,604.65	359.50	5.64	10,742.09
Davis		153.53		7,491.30	2,413,309.22	31.99	53.08	2,432,167.09
Duchesne		10.29		502.08	213,342.89	412.80	116.98	215,423.34
Emery		8.41		410.43	16,920,862.95	2,607.25	44.68	17,079,635.44
Garfield		3.23		157.40	69,125.09	370.73	28.88	80,253.35
Grand		5.39		262.99	85,778.74	822.04	8.62	86,334.70
Iron		17.07		832.81	296,721.83	2,650.06	53.96	302,904.15
Juab		4.74		231.11	99,517.37	1,827.92	24.82	755,894.03
Kane		4.21		205.21	63,460.23	1,171.23	17.70	66,163.52
Millard		9.23		450.27	12,643,080.84	3,577.93	118.79	13,280,309.04
Morgan		4.53		221.15	91,682.97	1,286.18	3,387.48	290,334.75
Piute		1.02		49.81	22,308.27	1,422.09	33.13	22,472.64
Rich		1.43		69.73	31,857.91	4,723.64	67.59	36,203.33
Salt Lake		594.52		29,008.85	11,303,997.08	1,210.76	96.13	11,348,142.88
San Juan		10.29		502.08	173,614.34	2,109.18	31.73	172,206.20
Sanpete		13.31		649.51	273,987.31	4,780.79	338.90	275,857.91
Sevier		12.58		613.65	234,370.14	3,322.66	116.09	270,008.32
Summit		12.82		625.60	247,586.11	2,585.72	74.37	249,086.29
Tooele		21.80		1,063.92	372,908.64	2,659.25	37.94	443,453.42
Uintah		18.13		884.61	3,456,673.49	4,557.07	84.51	3,463,499.08
Utah		217.23	514.00	10,599.39	3,742,760.27	4,630.33	259.22	3,804,519.19
Wasatch		8.25		402.46	142,461.62	1,513.05	53.18	143,226.51
Washington		40.10		1,956.50	649,387.41	1,780.69	27.38	663,099.79
Wayne		1.76		85.67	41,839.68	2,395.78	42.21	44,662.53
Weber	139.99	129.85		6,335.72	2,388,803.90	2,112.59	132.09	2,403,246.99
Statewide Total	279.99	1,412.07	514.00	68,900.00	59,280,668.84	73,369.91	5,996.46	61,283,206.46

Table 4 Total Greenhouse Gas Emissions 1993

Tons/Year

County	Landfills CH4	Underground Coal Mines CH4	Fertilizer Use N2O	Limestone Use CO2	Cement Production CO2	Lime Production CO2	Soda Ash CO2	Forestry and Land Use Change CO2
Beaver	20.72		3.55				1.11	-1255.70
Box Elder	156.95		91.42				8.47	-157.34
Cache	6,010.41		43.32				16.92	-2242.23
Carbon	5,825.01	18,964.10	1.95				4.60	-327.52
Daggett	3.09		0.72				0.16	-585.48
Davis	12,142.79		14.00				45.80	-594.75
Duchesne	47.13		9.74				2.93	-757.29
Emery	36.81	157,998.18	2.99				2.31	-2452.02
Garfield	17.21		0.00				0.93	1094.38
Grand	33.52		0.00				1.67	-602.49
Iron	81.17		7.70				5.29	264.17
Juab	24.79		3.57	343,537.92	308,321.36		1.38	-276.80
Kane	19.12		0.02				1.21	133.41
Millard	44.58		22.12	394,318.01		325,186.25	2.60	-3279.07
Morgan	21.57		6.26		185,466.84		1.37	-166.20
Piute	5.90		0.54				0.30	-1799.73
Rich	7.66		0.00				0.40	-508.19
Salt Lake	14,230.66		89.90				172.76	-664.21
San Juan	48.59		1.26				2.91	-4316.31
Sanpete	67.20		8.29				4.02	-4142.70
Sevier	62.03	36,151.95	4.78				3.65	-6199.86
Summit	56.23		9.53				4.38	-1798.00
Tooele	113.22		21.31	35,073.28		43,245.65	6.25	-1257.94
Uintah	85.66		19.63				5.25	-931.13
Utah	6,663.36		67.50	61,468.35			64.70	-1132.60
Wasatch	38.51		1.25				2.49	-795.68
Washington	5,866.24		5.94				13.05	436.49
Wayne	8.96		0.96				0.49	-629.60
Weber	6,403.90		12.50				37.58	-622.35
Statewide Tota	**58,143.01**	**213,114.23**	**450.73**	**834,397.56**	**493,788.20**	**368,431.90**	**415.00**	**-35566.72**

County	Agricultural Burning CH4+CO+N2O+NOx	Wastewater Treatment CH4	Nitric Acid Manufacturing NOx	Oil & Gas CH4	Fossil Fuels CO2	Domestic Animals CH4	Manure Management CH4	County Total
Beaver		4.08		162.34	70,811.73	2,692.82	90.64	72,531.29
Box Elder	133.63	31.11		1,237.03	936,391.68	5,920.40	233.67	944,047.03
Cache		62.15		2,470.78	1,416,596.37	5,461.84	406.73	1,428,826.30
Carbon		16.90		672.09	460,987.09	1,423.68	17.84	487,585.75
Daggett		0.57		22.73	9,054.59	601.52	5.10	9,103.00
Davis		168.23		6,688.44	2,711,430.95	1,307.69	58.63	2,731,261.79
Duchesne		10.78		428.58	222,175.97	5,415.18	128.87	227,461.89
Emery		8.49		337.67	18,155,189.62	2,181.13	54.95	18,313,360.13
Garfield		3.43		136.37	64,717.04	2,102.74	35.69	68,107.79
Grand		6.12		243.48	99,603.45	565.61	7.08	99,858.45
Iron		19.44		772.74	334,074.48	2,286.50	52.97	337,564.45
Juab		5.06		201.30	99,319.35	1,224.12	26.06	752,388.10
Kane		4.45		176.95	67,671.55	1,060.20	18.98	69,085.89
Millard		9.56		379.88	12,434,309.63	3,680.49	124.63	13,154,798.67
Morgan		5.02		199.68	97,609.60	1,073.78	55.52	284,273.44
Piute		1.10		43.83	21,808.23	1,229.68	32.57	21,322.43
Rich		1.47		58.44	30,655.33	4,548.09	85.54	34,848.74
Salt Lake		634.54		25,227.68	11,969,371.36	1,500.97	123.21	12,010,686.89
San Juan		10.70		425.33	184,749.40	2,453.85	34.56	183,410.28
Sanpete		14.78		587.67	272,879.01	4,079.50	360.00	273,857.78
Sevier		13.39		532.44	242,370.30	2,996.37	129.44	276,064.50
Summit		16.09		639.62	295,067.19	2,142.98	68.26	296,206.28
Tooele		22.95		912.35	382,203.91	1,784.48	36.54	462,162.00
Uintah		19.27		766.25	3,928,313.43	3,883.27	98.85	3,932,260.48
Utah		237.65	504.00	9,448.23	4,095,430.96	4,552.52	297.97	4,177,602.64
Wasatch		9.15		363.64	151,836.28	1,269.40	48.43	152,773.47
Washington		47.94		1,905.91	853,392.13	1,663.94	35.12	863,366.76
Wayne		1.80		71.43	38,578.80	1,823.23	43.90	39,899.96
Weber	133.63	138.02		5,487.13	2,464,906.68	2,413.07	121.23	2,479,031.38
Statewide Tota	**267.26**	**1,524.24**	**504.00**	**60,600.00**	**62,111,506.13**	**73,339.06**	**2,832.97**	**64,183,747.57**

Table 5 CO2-Equivalents (Global Warming Potential) 1990

Tons/Year

County	Landfills CH4	Underground Coal Mines CH4	Fertilizer Use N2O	Limestone Use CO2	Cement Production CO2	Lime Production CO2	Soda Ash CO2	Forestry and Land Use Change CO2
Beaver	444.93		677.78				0.58	-940.39
Box Elder	3,263.34		25,246.72				4.38	-162.45
Cache	128,132.92		9,826.61				8.46	-2315.11
Carbon	124,506.34	417,210.20	491.20				2.42	-312.07
Daggett	72.38		187.34				0.08	739.76
Davis	258,160.73		2,682.87				1.51	-618.05
Duchesne	1,007.06		3,540.16				22.56	956.86
Emery	803.54	3,475,959.96	554.67				1.23	-2336.28
Garfield	364.94		0.73				0.47	10550.96
Grand	662.75		0.00				0.79	-573.99
Iron	1,651.26		1,194.01				2.51	2546.43
Juab	515.45		859.61	339,196.00	315,499.72		0.70	-434.96
Kane	401.77		4.48				0.62	1286.05
Millard	975.73		4,618.97	348,939.80		286,525.00	1.35	-2455.64
Morgan	439.76		1,704.41		193,897.02		0.66	-171.54
Piute	125.04		68.13				0.15	-1347.76
Rich	165.03		0.11				0.21	-524.69
Salt Lake	302,570.05		22,897.17				87.37	-689.82
San Juan	1,078.35		175.37				1.51	-4112.58
Sanpete	1,368.84		1,974.09				1.95	-3983.40
Sevier	1,315.63	795,342.90	685.56				1.85	-4642.94
Summit	1,072.35		2,007.52				1.88	-1856.40
Tooele	2,317.74		5,752.77	36,530.56		31,400.00	3.20	-1298.56
Uintah	1,769.24		5,558.17				2.66	1177.61
Utah	141,433.69		17,767.36	40,376.71			31.93	-1364.50
Wasatch	784.85		347.41				1.21	-1250.22
Washington	125,123.89		1,751.86				5.89	4207.87
Wayne	193.70		259.45				0.26	287.40
Weber	136,497.53		3,237.61				19.08	-642.65
Statewide Total	1,237,218.83	4,688,513.06	114,072.14	765,043.07	509,396.74	317,925.00	207.50	-10281.06
Percent of CO2-Equivalen	1.76%	6.68%	0.16%	1.09%	0.73%	0.45%	0.00%	-0.01%

County	Agricultural Burning CH4+CO+N2O+NOx	Wastewater Treatment CH4	Nitric Acid Manufacturing NOx	Oil & Gas CH4	Fossil Fuels CO2	Domestic Animals CH4	Manure Management CH4	County Total	Percent of CO2-Equivalen
Beaver		86.24		4,207.88	70,598.11	55,532.30	1,702.21	132,309.64	0.19%
Box Elder		655.78		31,997.40	949,477.11	150,923.52	5,083.78	1,166,489.57	1.66%
Cache		1,266.63		61,803.19	1,351,319.81	128,173.76	9,140.91	1,687,357.19	2.40%
Carbon		362.92		17,708.15	920,230.87	71,241.54	383.04	1,551,824.60	2.21%
Daggett		12.57		613.65	9,604.65	7,908.91	124.14	19,263.49	0.03%
Davis		3,377.67		164,808.51	2,413,309.22	703.79	1,167.76	2,843,594.01	4.05%
Duchesne		226.38		11,045.68	213,342.89	9,081.56	2,573.45	241,796.60	0.34%
Emery		185.05		9,029.40	16,920,862.95	57,359.52	983.01	20,463,403.06	29.15%
Garfield		70.97		3,462.73	69,125.09	8,156.09	635.39	92,367.37	0.13%
Grand		118.58		5,785.83	85,778.74	18,084.87	189.55	110,047.12	0.16%
Iron		375.50		18,321.80	296,721.83	58,301.34	1,187.23	380,301.90	0.54%
Juab		104.20		5,084.52	99,517.37	40,214.26	545.93	801,102.81	1.14%
Kane		92.53		4,514.70	63,460.23	25,767.11	389.29	95,916.78	0.14%
Millard		203.02		9,906.04	12,643,080.84	78,714.51	2,613.38	13,373,123.01	19.05%
Morgan		99.72		4,865.36	91,682.97	28,295.87	74,524.50	395,338.73	0.56%
Piute		22.46		1,095.80	22,308.27	31,285.96	728.77	54,286.83	0.08%
Rich		31.44		1,534.12	31,857.91	103,920.15	1,486.99	138,471.27	0.20%
Salt Lake		13,079.48		638,194.67	11,303,997.08	26,636.63	2,114.83	12,308,887.47	17.54%
San Juan		226.38		11,045.68	173,614.34	46,401.94	698.00	229,128.97	0.33%
Sanpete		292.85		14,289.25	273,987.31	105,177.34	7,455.81	400,564.04	0.57%
Sevier		276.68		13,500.27	234,370.14	73,098.53	2,554.03	1,116,502.64	1.59%
Summit		282.07		13,763.26	247,586.11	56,885.89	1,636.24	321,378.93	0.46%
Tooele		479.70		23,406.32	372,908.64	58,503.45	834.63	530,838.46	0.76%
Uintah		398.85		19,461.43	3,456,673.49	100,255.46	1,859.25	3,587,156.16	5.11%
Utah		4,779.04		233,186.51	3,742,760.27	101,867.28	5,702.92	4,286,541.22	6.11%
Wasatch		181.46		8,854.07	142,461.62	33,287.08	1,169.95	185,837.43	0.26%
Washington		882.15		43,043.07	649,387.41	39,175.16	602.41	864,179.72	1.23%
Wayne		38.63		1,884.78	41,839.68	52,707.27	928.60	98,139.77	0.14%
Weber		2,856.65		139,385.92	2,388,803.90	46,476.91	2,906.06	2,719,541.00	3.87%
Statewide Total		31,065.60		1,515,800.00	59,280,668.84	1,614,137.98	131,922.06	70,195,689.76	100.00%
Percent of CO2-Equivalent		0.04%		2.16%	84.45%	2.30%	0.19%	100.00%	

Table 6 CO2-Equivalents (Global Warming Potential) 1993

Tons/Year

County	Landfills CH4	Underground Coal Mines CH4	Fertilizer Use N2O	Limestone Use CO2	Cement Production CO2	Lime Production CO2	Soda Ash CO2	Forestry and Land Use Change CO2
Beaver	455.83		957.89				1.11	-1255.70
Box Elder	3,453.00		24,684.37				8.47	-157.34
Cache	132,229.06		11,695.62				16.92	-2242.23
Carbon	128,150.24	417,210.20	526.58				4.60	-327.52
Daggett	68.04		194.06				0.16	-585.48
Davis	267,141.32		3,780.12				45.80	-594.75
Duchesne	1,036.84		2,629.56				2.93	-757.29
Emery	809.75	3,475,959.96	807.53				2.31	-2452.02
Garfield	378.72		0.36				0.93	1094.38
Grand	737.55		0.83				1.67	-602.49
Iron	1,785.75		2,079.01				5.29	264.17
Juab	545.31		963.26	343,537.92	308,321.36		1.38	-276.80
Kane	420.59		5.57				1.21	133.41
Millard	980.75		5,971.44	394,318.01		325,186.25	2.60	-3279.07
Morgan	474.61		1,690.19		185,466.84		1.37	-166.20
Piute	129.78		144.93				0.30	-1799.73
Rich	168.50		0.00				0.40	-508.19
Salt Lake	313,074.59		24,273.53				172.76	-664.21
San Juan	1,069.05		340.04				2.91	-4316.31
Sanpete	1,478.48		2,237.71				4.02	-4142.70
Sevier	1,364.61	795,342.90	1,291.08				3.65	-6199.86
Summit	1,237.10		2,572.60				4.38	-1798.00
Tooele	2,490.84		5,754.23	35,073.28		43,245.65	6.25	-1257.94
Uintah	1,884.43		5,300.41				5.25	-931.13
Utah	146,593.94		18,224.84	61,468.35			64.70	-1132.60
Wasatch	847.20		336.69				2.49	-795.68
Washington	129,057.26		1,603.14				13.05	436.49
Wayne	197.20		258.10				0.49	-629.60
Weber	140,885.81		3,374.63				37.58	-622.35
Statewide Tota	1,279,146.15	4,688,513.06	121,698.30	834,397.56	493,788.20	368,431.90	415.00	-35566.72
Percent of CO2-Equivale	1.75%	6.43%	0.17%	1.14%	0.68%	0.51%	0.00%	-0.05%

County	Agricultural Burning CH4+CO+N2O+NOx	Wastewater Treatment CH4	Nitric Acid Manufacturing NOx	Oil & Gas CH4	Fossil Fuels CO2	Domestic Animals CH4	Manure Management CH4	County Total	Percent of CO2-Equivale
Beaver		89.84		3,571.48	70,811.73	59,242.00	1,994.01	135,868.19	0.19%
Box Elder		684.52		27,214.69	936,391.68	130,248.69	5,140.81	1,127,668.89	1.55%
Cache		1,367.22		54,357.24	1,416,596.37	120,160.42	8,948.12	1,743,128.74	2.39%
Carbon		371.90		14,785.94	460,987.09	31,320.96	392.57	1,053,422.56	1.44%
Daggett		12.57		500.01	9,054.59	13,233.55	112.16	22,589.66	0.03%
Davis		3,701.08		147,145.78	2,711,430.95	28,769.07	1,289.88	3,162,709.26	4.34%
Duchesne		237.16		9,428.71	222,175.97	119,133.87	2,835.23	356,723.00	0.49%
Emery		186.85		7,428.68	18,155,189.62	47,984.95	1,208.87	21,687,126.50	29.75%
Garfield		75.46		3,000.05	64,717.04	46,260.20	785.14	116,312.28	0.16%
Grand		134.73		5,356.51	99,603.45	12,443.45	155.78	117,831.48	0.16%
Iron		427.60		17,000.26	334,074.48	50,303.00	1,165.25	407,104.80	0.56%
Juab		111.39		4,428.64	99,319.35	26,930.67	573.28	784,455.75	1.08%
Kane		97.91		3,892.92	67,671.55	23,324.49	417.50	95,965.14	0.13%
Millard		210.21		8,357.27	12,434,309.63	80,970.81	2,741.76	13,249,769.67	18.17%
Morgan		110.50		4,392.92	97,609.60	23,623.19	1,221.33	314,424.34	0.43%
Piute		24.26		964.30	21,808.23	27,052.99	716.60	49,041.66	0.07%
Rich		32.34		1,285.73	30,655.33	100,057.93	1,881.85	133,573.89	0.18%
Salt Lake		13,959.85		555,009.04	11,969,371.36	33,021.33	2,710.61	12,910,928.87	17.71%
San Juan		235.36		9,357.28	184,749.40	53,984.61	760.22	246,182.56	0.34%
Sanpete		325.19		12,928.77	272,879.01	89,748.98	7,919.96	383,379.42	0.53%
Sevier		294.64		11,713.75	242,370.30	65,920.22	2,847.70	1,114,948.97	1.53%
Summit		353.94		14,071.64	295,067.19	47,145.56	1,501.74	360,156.15	0.49%
Tooele		504.86		20,071.73	382,203.91	39,258.61	803.84	528,155.25	0.72%
Uintah		424.01		16,857.40	3,928,313.43	85,431.98	2,174.72	4,039,460.49	5.54%
Utah		5,228.22		207,860.98	4,095,430.96	100,155.49	6,555.31	4,640,450.19	6.37%
Wasatch		201.22		8,000.12	151,836.28	27,926.82	1,065.55	189,420.69	0.26%
Washington		1,054.64		41,929.91	853,392.13	36,606.77	772.68	1,064,866.07	1.46%
Wayne		39.52		1,571.45	38,578.80	40,110.99	965.85	81,092.79	0.11%
Weber		3,036.33		120,716.81	2,464,906.68	53,087.62	2,666.99	2,788,090.11	3.82%
Statewide Total		33,533.29		1,333,200.00	62,111,506.13	1,613,459.22	62,325.27	72,904,847.37	100.00%
Percent of CO2-Equivalent		0.05%		1.83%	85.20%	2.21%	0.09%	100.00%	

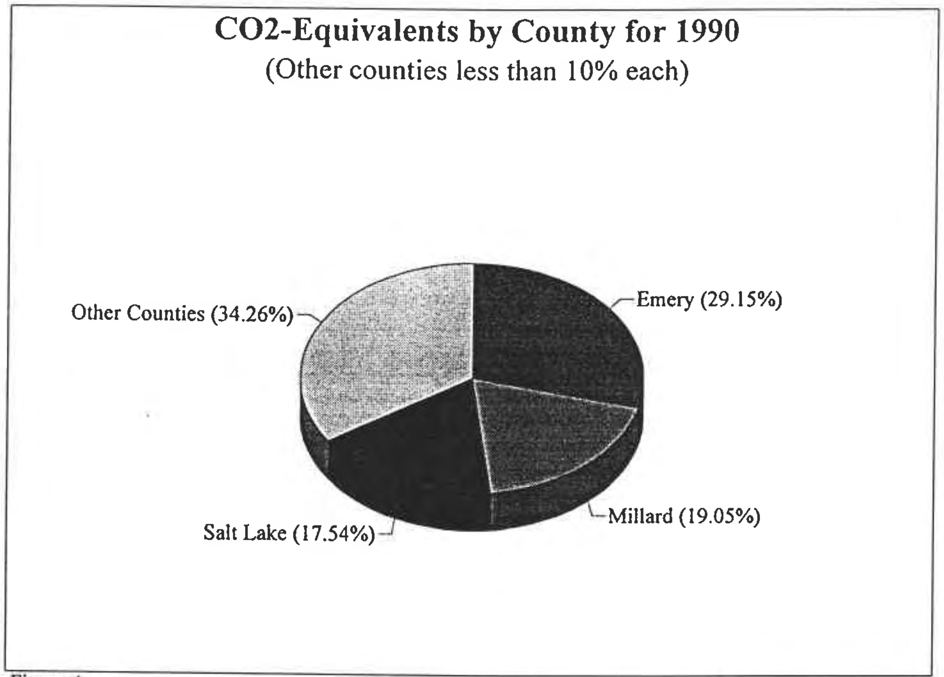

Figure 4

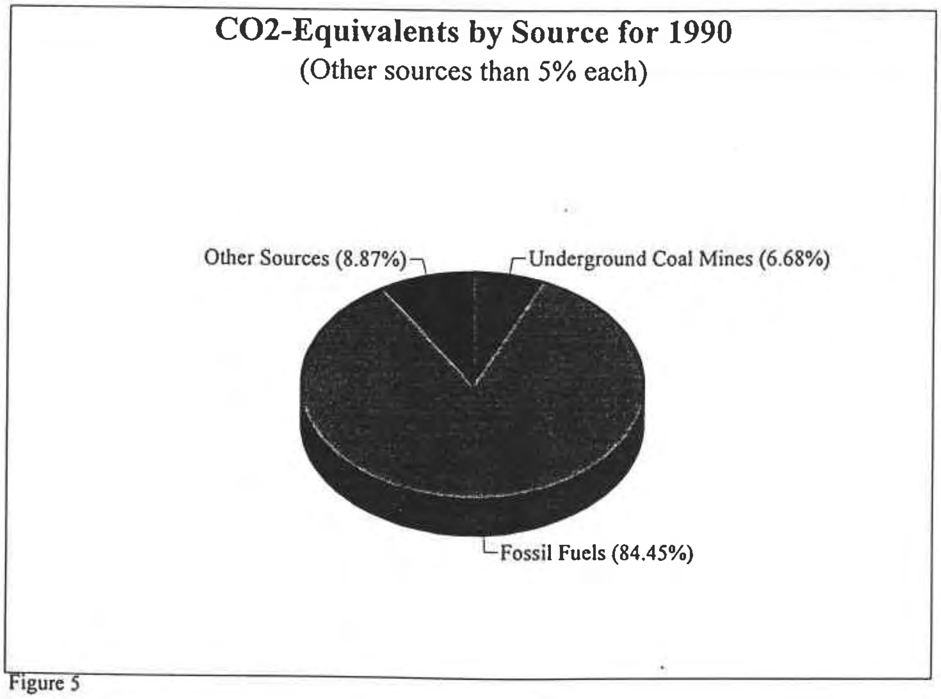

Figure 5

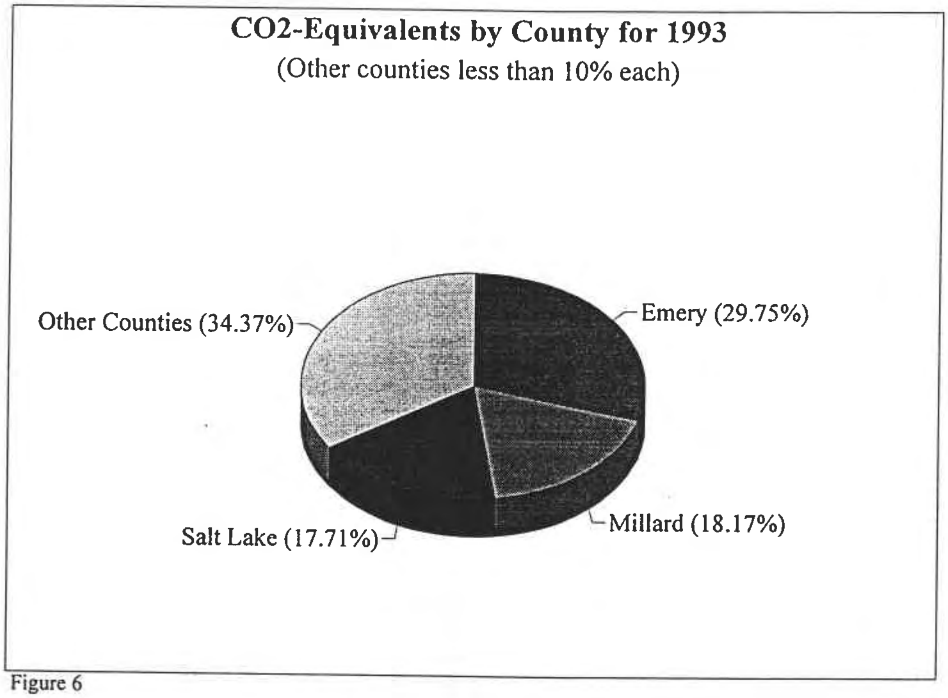

Figure 6

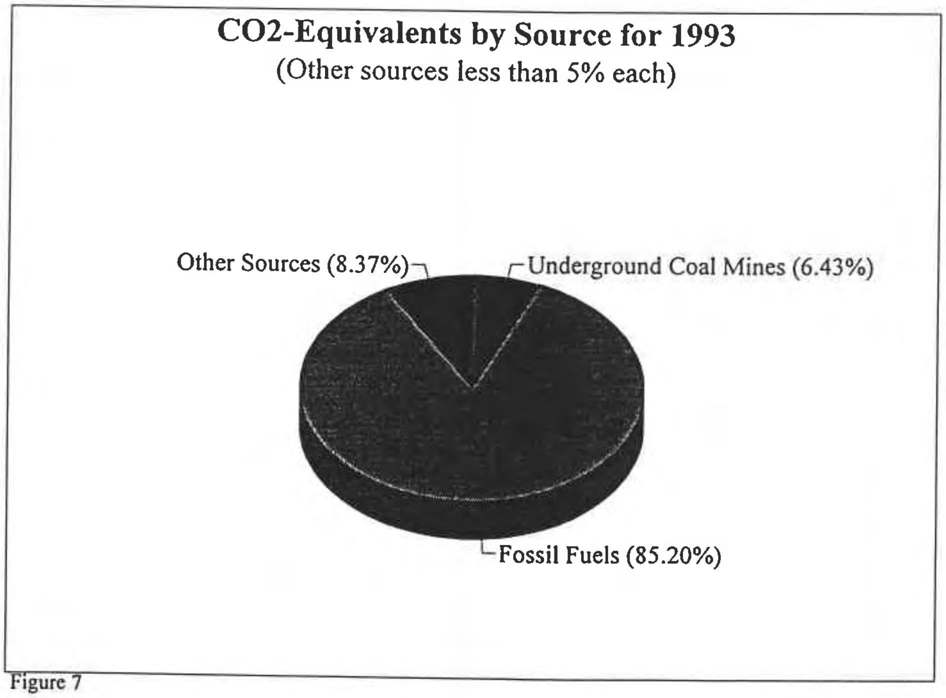

Figure 7