# Policy Planning to Reduce Greenhouse Gas Emissions in Alabama

## Final Report

**Submitted by**

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# Contents

## Abstract

The overall objective of this project was to develop a program for the mitigation of greenhouse gases for the state of Alabama. The project was funded in part by the U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, State and Local Outreach Program. Phase 1, the development and preparation of a state greenhouse gas (GHG) inventory for the baseline year 1990 from major anthropogenic sources, was completed in the Spring of 1995, and has been published as "Inventory of Alabama Greenhouse Gas Emissions and Sinks: 1990" by the Environmental Institute, College of Engineering, The University of Alabama, Tuscaloosa. Phase 2 developed recommendations for a state action plan to mitigate GHG emissions through the use of an Advisory Panel of stakeholders in Alabama, a Technical Committee composed of University faculty/staff, and public meeting input. The Panel developed and ranked options for reducing GHG emissions. Tax-related options were introduced and analyzed for economic effect by the Technical Committee, but none of these options were acceptable to the Panel on principle and to the Technical Committee based on negative economic effect. Finally, the Panel and the Technical Committee grouped and combined the highest-ranking options into five groups containing a total of 20 options. These recommendations are presented in this final report for consideration by the appropriate Alabama State agencies. A companion volume for this project is available with additional details.

**The greenhouse effect and greenhouse gases**

The greenhouse effect is a natural phenomenon, illustrated in Figure 1. The sun emits radiation to the earth. Approximately one-third of this radiation is reflected by the earth and the atmosphere back to space, while the remainder is absorbed by the earth's surface, warming it. The earth absorbs solar radiation and then emits thermal (infrared) radiation back to space. The incoming solar radiation and the out-going reflected radiation are short-wave radiation, whereas the out-going thermal radiation is long-wave radiation. Approximately 99 percent of the atmosphere is composed of gases which are transparent either to the incoming solar radiation or to the outgoing thermal radiation. But a few gases, which comprise the remaining one percent of the atmosphere, are not transparent to the outgoing long-wave thermal radiation. They absorb some of the thermal radiation and re-emit it both outward into space and downward to the earth. The effect of this is to warm the earth's surface and the lower atmosphere. As a result, the earth surface becomes warmer than it would otherwise be. This phenomenon, which is similar to the phenomenon occurring in a horticultural greenhouse, is known as the greenhouse effect. The gases trapping heat are called greenhouse gases.

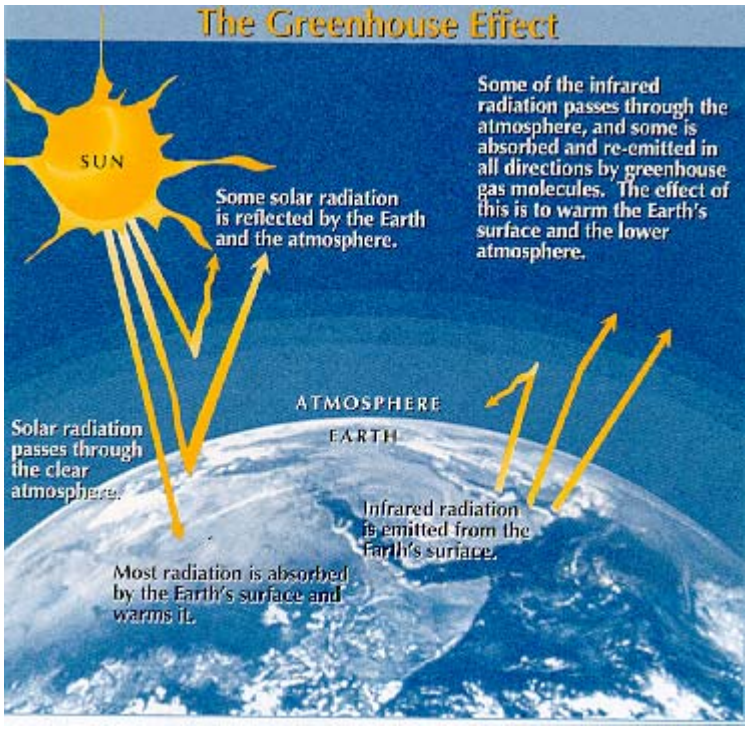



Figure 1. The Greenhouse Effect.
Source: EPA 1997

The primary natural greenhouse gases are water vapor ($H_2O$), carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), and tropospheric ozone ($O_3$). Without these greenhouse gases and the resulting greenhouse effect, the earth surface temperature would be $55^0$ F ($31^0$C) lower than it is today. The heat-trapping property of these gases maintains a global climate hospitable to all plants, animals, and human life.

Carbon monoxide (CO), nitrogen oxides ($NO_x$), and non-methane volatile organic compounds (NMVOC's) are defined as photo-chemically important gases. Although they themselves can not trap heat in the atmosphere, these gases can indirectly contribute to the greenhouse effect through their photochemical reactions in the atmosphere with other substances. For example, carbon monoxide enhances concentrations of methane and tropospheric ozone through chemical reactions with atmospheric constituents such as the hydroxyl radical ($OH^-$) that would otherwise assist in destroying methane and tropospheric ozone. In addition, carbon monoxide will eventually oxidize to carbon dioxide.

## Change of Greenhouse Gas Concentrations in the Atmosphere and Potential Global Warming

Through much of the earth's history, greenhouse gases in the atmosphere have been in a natural balance, that is, the greenhouse gas concentrations in the atmosphere have remained about constant. Analysis of air bubbles trapped in ice-cores indicates that the carbon dioxide concentration in the atmosphere has remained relatively stable at about 280 ppmv (parts per million by volume) over the last several thousand years, but it has increased rapidly since the industrial revolution. Since this increase has followed closely by the increase of carbon dioxide emissions from fossil fuel, it is believed that human activities are responsible, at least to some degree, for this increase. In addition to carbon dioxide emissions, significant methane, nitrous oxide, chlorofluorocarbons (CFC's) and photochemically important gases have also been emitted from man-made sources since the industrial revolution, thereby increasing the greenhouse gas concentrations in the atmosphere. Although it is uncertain to what degree the anthropogenic emissions have affected the greenhouse gas concentrations in the atmosphere, it is certain that the greenhouse gas concentrations in the atmosphere have increased since the industrial revolution. Table 1 presents the change of greenhouse gas concentrations in the atmosphere since the pre-industrial period (the average over several centuries before 1750).

As shown in Table 1, carbon dioxide concentration in the atmosphere has increased since the pre-industrial period by 27 percent, methane by 145 percent, nitrous oxide by 17 percent and CFC-12 by 503 percent. The rising concentrations indicate the greenhouse gas emissions have become increasingly larger than can be accommodated by natural removal processes. With the increase of worldwide population and energy

consumption, anthropogenic greenhouse emissions will be increased further. Therefore, the increase of greenhouse gas concentrations in the atmosphere in the future is expected to continue. This may lead to an increase in the average earth surface temperature. Examination of the record of earth surface temperatures indicates that the average earth surface temperature has increased during the last 100 years (see Figure 2). Projection of the trends of greenhouse gas emissions suggest that the atmospheric carbon dioxide concentration may double its pre-industrial value by the middle of the next century, leading to an average earth surface temperature increase of $1.5^0$ C to $3.5^0$ C by 2100.

Table 1
Changes of Greenhouse Gas Concentrations in the Atmosphere

| | $CO_2$ (ppmv) | $CH_4$ (ppbv) | $N_2O$ (ppbv) | CFC-12 (pptv) |
|---|---|---|---|---|
| Pre-industrial concentration | 280 | 700 | 275 | 0 |
| Concentration in 1992 | 355 | 1714 | 311 | 503 |
| Increased percentage | 27% | 145% | 17% | 503% |

Note: 1 ppmv = 1 part per million by volume
1 ppbv = 1 part per billion by volume
1 pptv = 1 part per trillion by volume

Source: Intergovernmental Panel on Climate Change (IPCC). 1994. Radiative Forcing of Climate Change: The 1994 Report of the Scientific Assessment Working Group of IPCC: 17, Table 3. Cambridge University Press, Cambridge.

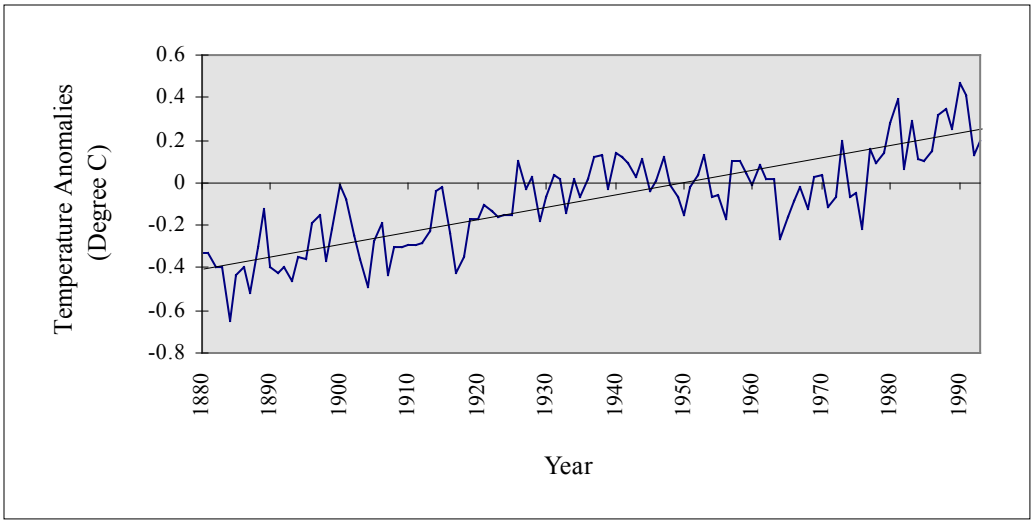



Figure 2. Global Temperature Anomalies from Instrumental Surface Air Temperature Records Since 1880.
Source: Wilson, H. and J. Hansen. 1994. In Trends '93: A Compendium of Data on Global Change: 612-3. ORNL/CDIAC-65. Carbon Dioxide Information Analysis Center, Oak Ridge, Tennessee. September 1994.

The increase in the average earth surface temperature may cause changes in climate around the world, thereby affecting significantly the global environment. Some of the potential impacts of global climate change are: sea level rise and coastal flooding; changes in precipitation patterns; change in yield of crops; loss of some ecosystems; migration of forests; increased air pollution; high incidence of pestilence and disease; and increased demand for water and electricity. However, uncertainties exist about climate change and the resulting impacts, because the earth's climate is the result of a complex system driven by many factors, such as solar radiation, thermal radiation, volcanic activity, evaporation from oceans and vegetation and others, and interactions among these factors are not yet well understood. Nevertheless, the majority of scientists agree that the rising concentrations of greenhouse gases in the atmosphere will eventually result in higher temperatures, with the potential to warm the earth to a level that could disrupt the activities of today's natural systems and human societies, though there is much less agreement about the timing, magnitude, or regional distribution of any climatic change.

## The Concept of Global Warming Potential

The concept of Global Warming Potential (GWP) has been developed to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. Carbon dioxide was chosen as the "reference" gas by IPCC. The Global Warming Potential (GWP) of a greenhouse gas is the ratio of global warming, or radiative forcing, from one unit of a greenhouse gas to one unit of carbon dioxide over a given period of

time. For example, that the GWP for methane is 24.5 over a period of 100 years means the ability of one pound of methane to trap heat in the atmosphere is 24.5 times as great as that of one pound of carbon dioxide over this period of time. The GWP for a greenhouse gas depends on its instantaneous radiative effect and its lifetime in the atmosphere. For example, methane has stronger instantaneous radiative effect but a shorter lifetime than does carbon dioxide. As its concentration will decline with time, its ability to trap heat also will decrease with time. So, given a different period of time, the ability of methane to trap heat in the atmosphere compared with carbon dioxide is different. Thus, the GWP for a greenhouse gas varies with different periods of time given except for carbon dioxide. Moreover, the GWP's for greenhouse gases have been revised by IPCC based on results from the on-going study of these gases. Table 2 shows the latest estimates (IPCC 1994) of lifetimes and the GWP's for different greenhouse gases.

Table 2
The Lifetimes and the GWP's for the Selected Greenhouse Gases

| Greenhouse gases | Lifetime (years) | Global Warming Potential* (Time Horizon, years) | | |
|---|---|---|---|---|
| | | 20 | 100 | 500 |
| $CO_2$ | (50-200)# | 1 | 1 | 1 |
| $CH_4$ | (12-17)+ | 62 | 24.5 | 7.5 |
| $N_2O$ | 120 | 290 | 320 | 180 |
| CFC-12 | 102 | 7900 | 8500 | 4200 |
| HCFC-22 | 13.3 | 4300 | 1700 | 520 |

* The typical uncertainty for the GWP's is ± 35 percent relative to the $CO_2$ reference.
\# No single lifetime for $CO_2$ can be defined because of the different rates of uptake by different sink processes.
\+ This has been defined as an adjustment time which takes into account the indirect effect of methane on its own lifetime.
Source: IPCC. 1994. Radiative Forcing of Climate Change: The 1994 Report of the Scientific Assessment Working Group of IPCC: 17, Table 3, 28, Table 5. Cambridge University Press, Cambridge.

The GWP's for greenhouse gases used in this study are from EPA's State Workbook and are in the same range as those estimated by the IPCC (Table 2). They are: 22 for methane and 270 for nitrous oxide. The selected time horizon for these GWP's is 100 years.

## 1990 Alabama greenhouse gas emissions

Greenhouse gas concentrations in the atmosphere, such as carbon dioxide, methane, and nitrous oxide, have been increasing since the industrial revolution. It is believed that man-made sources of greenhouse gases are, at least to some degree, responsible for this increase. Since this increase may result in a potential global warming, thereby significantly affecting the global climate and environment, worldwide efforts are being made to study anthropogenic greenhouse gas emissions. This study quantified the anthropogenic greenhouse gas emissions in Alabama in 1990 using the U.S. Environmental Protection Agency's recommended or alternative methodologies. Alabama anthropogenic greenhouse gas emissions and sinks from 17 sources were studied. 1990 Alabama total anthropogenic greenhouse gas emissions and sinks were estimated to be 41.84 and 5.91 million tons of carbon equivalent respectively, or 153.42 and 21.66 million tons of carbon dioxide equivalent. As a result, the net total greenhouse gas emissions were estimated to be 35.93 million tons of carbon equivalent or 131.76 million tons of carbon dioxide equivalent. Table 3 presents the summary data for each source category including stationary and mobile combustion on a full molecular basis and in terms of $CO_2$-equivalent and carbon equivalent. Total emissions are given excluding biomass fuels according to U.S. EPA recommendations. These emissions do not include the major sinks from forest management. Net total emissions include the credit for sinks, while still excluding biomass fuels. Table 4 shows the data with stationary and mobile combustion excluded. Fossil fuel combustion is the major source of emissions, representing approximately 79 percent of all emissions. Coal mining and landfills are two other significant emission sources, representing approximately 10 and 6 percent of the total emissions respectively. Forests in Alabama represent the major sink, offsetting approximately 14 percent of the total emissions. In terms of greenhouse gas emissions by gas, carbon dioxide represents the majority of the emissions, accounting for approximately 77 percent; methane and nitrous oxide represent the remaining 22 and 1 percent respectively. On a per capita basis, Alabama is a high emission state. Alabama's emission rate is 8.8 tons of carbon or 32.3 tons of carbon dioxide equivalent per capita in 1990, compared to the national per capita average of 6.4 tons of carbon or 23.4 tons of carbon dioxide equivalent. The high emission rate is attributed to higher emissions than the national average from fossil fuel combustion, from coal mining, and from landfills in Alabama. The complete emissions report, *Inventory of Alabama Greenhouse Emissions and Sinks: 1990,* is included in the companion document to this report.

Table 3
1990 Alabama Greenhouse Gas Emissions and Sinks by Source/Gas
(Stationary and Mobile Combustion Included)

| Source | Gas | Emissions (tons, on a full molecular basis) | GWP | Emissions (tons, $CO_2$-equivalent) | Emissions (tons, C-equivalent) | % of total emissions |
|---|---|---|---|---|---|---|
| Fossil fuel combustion | | | | 121,084,041 | 33,022,920 | 79% |
| Fossil fuel combustion | $CO_2$ | 119,936,525 | 1 | 119,936,525 | 32,709,961 | 78% |
| Fossil combustion (stationary) | | | | 455,548 | 124,240 | 0% |
| | $CH_4$ | 4,456 | 22 | 98,035 | 26,737 | 0% |
| | $N_2O$ | 1,324 | 270 | 357,513 | 97,504 | 0% |
| | $NO_X$ | 394,772 | - | | | |
| | CO | 139,312 | - | | | |
| | NMVOC | 6,457 | - | | | |
| Fossil combustion (mobile) | | | | 691,969 | 188,719 | 0% |
| | $CH_4$ | 5,214 | 22 | 114,717 | 31,287 | 0% |
| | $N_2O$ | 2,138 | 270 | 577,251 | 157,432 | 0% |
| | CO | 946,201 | - | | | |
| | $NO_X$ | 167,180 | - | | | |
| | NMVOC | 160,730 | - | | | |
| Biomass fuel combustion | $CO_2$ | 4,074,259 | 1 | 4,074,259 | 1,111,162 | 3% |
| Coal mining | $CH_4$ | 720,881 | 22 | 15,859,380 | 4,325,285 | 10% |
| Natural gas and oil systems | $CH_4$ | 37,933 | 22 | 834,523 | 227,597 | 1% |
| Industrial processes | $CO_2$ | 2,887,584 | 1 | 2,887,584 | 787,523 | 2% |
| Domestic livestock | $CH_4$ | 107,709 | 22 | 2,369,605 | 646,256 | 2% |
| Manure management | $CH_4$ | 47,512 | 22 | 1,045,269 | 285,073 | 1% |
| Fertilizer use | $N_2O$ | 2,236 | 270 | 603,675 | 164,639 | 0% |
| Forest management and land-use change | | | | (21,660,218) | (5,907,332) | -14% |
| | $CO_2$ | (21,641,936) | 1 | (21,641,936) | (5,902,346) | -14% |
| | $CH_4$ | (170) | 22 | (3,734) | (1,018) | 0% |
| | $N_2O$ | (54) | 270 | (14,548) | (3,968) | 0% |
| Landfills | $CH_4$ | 393,751 | 22 | 8,662,528 | 2,362,508 | 6% |
| Municipal wastewater treatment | $CH_4$ | 3,300 | 22 | 72,594 | 19,798 | 0% |
| **Total emissions** | | | | **153,419,301** | **41,841,628** | **100%** |
| ( All Sources, excluding sinks and biomass fuels) | $CO_2$ | 122,824,211 | 1 | 122,824,211 | 33,497,512 | 80% |
| | $CH_4$ | 1,320,757 | 22 | 29,056,652 | 7,924,541 | 19% |
| | $N_2O$ | 5,698 | 270 | 1,538,439 | 419,574 | 1% |
| | $NO_X$ | 561,952 | - | - | - | - |
| | CO | 1,085,513 | - | - | - | - |
| | NMVOC | 167,186 | - | - | - | - |
| **Net total emissions** | | | | **131,758,981** | **35,934,268** | **100%** |
| ( All Sources, including sinks but excluding biomass fuels) | $CO_2$ | 101,182,173 | 1 | 101,182,173 | 27,595,138 | 77% |
| | $CH_4$ | 1,320,587 | 22 | 29,052,918 | 7,923,523 | 22% |
| | $N_2O$ | 5,644 | 270 | 1,523,891 | 415,607 | 1% |
| | $NO_X$ | 561,952 | - | - | - | |
| | CO | 1,085,513 | - | - | - | |
| | NMVOC | 167,186 | - | - | - | |

Table 4
1990 Alabama Greenhouse Gas Emissions and Sinks by Source/Gas
(Stationary and Mobile Combustion Excluded)

| Source | Gas | Emissions (tons, on a full molecular basis) | GWP | Emissions (tons, $CO_2$-equivalent) | Emissions (tons, C-equivalent) | % of total emissions |
|---|---|---|---|---|---|---|
| Fossil fuel combustion | $CO_2$ | 119,936,525 | 1 | 119,936,525 | 32,709,961 | 79% |
| Biomass fuel combustion | $CO_2$ | 4,074,259 | 1 | 4,074,259 | 1,111,162 | |
| Coal mining | $CH_4$ | 720,881 | 22 | 15,859,380 | 4,325,285 | 10% |
| Natural gas and oil systems | $CH_4$ | 37,933 | 22 | 834,523 | 227,597 | 1% |
| Industrial processes | $CO_2$ | 2,887,584 | 1 | 2,887,584 | 787,523 | 2% |
| Domestic livestock | $CH_4$ | 107,709 | 22 | 2,369,605 | 646,256 | 2% |
| Manure management | $CH_4$ | 47,512 | 22 | 1,045,269 | 285,073 | 1% |
| Fertilizer use | $N_2O$ | 2,236 | 270 | 603,675 | 164,639 | 0% |
| Forest management and land-use change | | | | (21,660,218) | (5,907,332) | -14% |
| | $CO_2$ | (21,641,936) | 1 | (21,641,936) | (5,902,346) | -14% |
| | $CH_4$ | (170) | 22 | (3,734) | (1,018) | 0% |
| | $N_2O$ | (54) | 270 | (14,548) | (3,968) | 0% |
| Landfills | $CH_4$ | 393,751 | 22 | 8,662,528 | 2,362,508 | 6% |
| Municipal wastewater treatment | $CH_4$ | 3,300 | 22 | 72,594 | 19,798 | 0% |
| **Total emissions** | | | | **152,271,785** | **41,528,669** | **100%** |
| ( All Sources, excluding sinks and | $CO_2$ | 122,824,211 | 1 | 122,824,211 | 33,497,512 | 81% |
| biomass fuels) | $CH_4$ | 1,311,086 | 22 | 28,843,900 | 7,866,518 | 19% |
| | $N_2O$ | 2,236 | 270 | 603,675 | 164,639 | 0% |
| **Net total emissions** | | | | **130,611,465** | **35,621,309** | **100%** |
| ( All Sources, including sinks but | $CO_2$ | 101,182,173 | 1 | 101,182,173 | 27,595,138 | 77% |
| excluding biomass fuels) | $CH_4$ | 1,310,917 | 22 | 28,840,166 | 7,865,500 | 22% |
| | $N_2O$ | 2,182 | 270 | 589,127 | 160,671 | 1% |

## Estimated GHG emissions by 2010

Projections of GHG emissions nationally under a "business as usual" scenario range from the Climate Change Action Plan (CCAP, 1993) estimate of 0.7% per year to the current Energy Information Administration (EIA) of 1.4% annually. Actual increases in GHG emissions for the years 1990 to 1995 averaged 1.4% per year, but preliminary 1996 data show an increase of 3.4%, more than double the previous 5-year mean rise.

In Alabama, estimates for future growth range from 0.6% to 1.8% per year for "business as usual" forecasts. Actual increases in GHG emissions due to combustion are estimated at 2.4% per year for the period 1990 to 1994 by EIA, and a complete 1995 inventory is just getting underway at the Environmental Institute.

Goals for future GHG emissions are the subject of current national and worldwide debate. An often stated goal is to reduce GHG emissions to 1990 levels by some time period. The year 2000 was mentioned early in the discussions, but the current U.S. position is the year 2010. Meanwhile the European position is a more aggressive reduction of emissions by 15% or more below 1990 levels by the same time period.

The Alabama Advisory Panel chose not to establish a goal for reduction due to the many uncertainties still at issue in the global warming debate. They further did not specify any action on estimates of reduction of emissions from the proposed options recommended.

## The Alabama Economy

### Employment Trends

Alabama's employment growth rate has remained close to 1 percent since 1996. The failure to register a larger employment increase in 1997 is attributable to several factors. First, employment growth in Alabama was constrained by a lack of available workers in 1997. Second, structural differences between the Alabama economy and the U.S. economy contribute to the state's slower employment growth. Alabama has a relatively larger manufacturing sector than the United States (20.7 percent versus 14.3 percent). Manufacturing companies, both statewide and nationally, are becoming much more capital intensive and less labor-intensive because of increased global competition. Some of Alabama's most significant manufacturing industries are those that have environmental consequences—pulp and paper mills, chemical companies, rubber and plastics products industries, lumber and wood products firms, blast furnaces and steel mills, for instance. However, some of those industries contribute to greenhouse gas emissions much more than others.

Gross State Product

Manufacturing is an important part of the state's economy. The total real output of this sector, $21.5 billion in 1997, accounts for 23 percent of the total value of goods and services produced in the state. In 1997 the manufacturing sector employed 380,700

people in Alabama, accounting for about 21 percent of the state's nonagricultural employment. Following is a discussion of the most important components of Alabama's manufacturing industry. Many of these are industry groups which are of concern environmentally, but not necessarily because of greenhouse gas emissions.

Textile and apparel industries are the two largest employers in the state's non-durable manufacturing group. These industries include firms making woven and knitted fabric, carpets and rugs, and men's and women's clothing. In 1997 textile and apparel industries employed about 80,500 people, or approximately 4.4 percent of all nonagricultural workers in Alabama. Textile mill and apparel industries employment in Alabama declined in 1997. Most of the job losses in these two industries have occurred because Alabama-made products have lost their cost advantage and therefore their competitiveness against foreign producers. Most producers are now relocating their facilities to countries where labor costs are cheaper.

Paper and allied product industries include pulp and paper mills, paperboard mills, and firms manufacturing paperboard containers and boxes, and other miscellaneous paper products, such as paper bags, wallpaper, or stationery products. Collectively, firms in this industry employed 21,000 workers in Alabama in 1997 and produced $2.5 billion in goods and services. Despite employment declines, productivity in the paper industry has increased because of investments in new plants and equipment. The newly installed equipment, of course, meets environmental regulatory guidelines.

Manufacturers of chemicals and allied products, including industrial chemicals, plastics and synthetics, drugs, cleaners and toilet goods, paints, and agricultural chemicals, employed about 12,000 workers in the state in 1997. This is a capital-intensive industry. While chemical companies accounted for only 0.6 percent of employment, they contributed 2.2 percent of Alabama's output. Twenty-two percent of these firms' production is exported, particularly the United Kingdom, Mexico, Japan, and Canada.

In 1997 rubber and plastics product industries in Alabama employed 17,400 people and produced $950 million in output. Firms manufacturing tires and inner tubes, fabricated rubber products, and other miscellaneous plastic or foam products, such as disposable medical gloves or polyethylene bags, are included in this category. Over 50 percent of these industries' output is related to automobile demand, linking this sector to the automobile business cycle.

Fast-paced construction activity in recent years has meant that lumber and wood products firms have been one of the most rapidly growing industries in the state. These industries include logging; sawmills; millwork, plywood, and cabinets; wood containers; wood buildings and mobile homes; and wood preserving, such as treated wood poles and pilings. In 1997 the lumber and wood products industry group employed 37,800

workers, and generated about $1.75 billion in output. This sector of the economy depends on products from the forestry industry, but technically is not part of forestry. Rather, lumber and wood products companies are part of Alabama's manufacturing industry.

Primary and fabricated metals industries in the state include blast furnaces and steel mills; iron and steel foundries; aluminum rolling and drawing; hardware; fabricated structural metals; metal forgings and stampings; and other miscellaneous metal products, such as valves and wire. Firms in this industry group employed about 49,200 people in 1997 and produced real output of almost $3.3 billion. The value of goods and services from these industries increased more than 6 percent annually between 1992 and 1996, reflecting the strong economy.

Non-electrical and electrical machinery manufacturers in the state employed about 52,400 workers in 1997, with output totaling $2.9 billion. This group includes farm and construction-related and other metalworking machinery; industrial machinery; computer and office equipment; refrigeration machinery; electrical machinery; household appliances; lighting and wiring equipment; communications equipment; electronic components; and other electrical equipment and supplies, such as CD-ROMs. Firms producing electronic equipment and other machinery tend to be capital intensive and automated. These industries also tend to resist new environmental regulations.

In addition to motor vehicles, Alabama's transportation equipment sector includes companies manufacturing aircraft engines and parts; guided missiles; space and defense-related equipment; ships and boats; railroad equipment; and other miscellaneous transportation-related equipment, such as travel campers. This industry group employed 27,400 workers in 1997, accounting for 1.5 percent of nonagricultural employment in the state. Production totaled approximately $1.5 billion

The construction sector in the state employed almost 97,000 workers, about 5.2 percent of total 1997 nonagricultural employment. Firms in this sector engage in residential and nonresidential building and also heavy construction such as highways and roads, while others are special trade contractors (plumbing, insulation, roofing, electricians, etc. A thriving construction industry impacts Alabama's forestry industry. Through this channel construction projects impact the greenhouse gas emissions in the state.

**Trade**

About 425,500 Alabamians worked in retail and wholesale trade in 1997. With 23 percent of the state's nonagricultural workers, trade was the largest employment sector. In 1995 there were more than 7,300 wholesale establishments, almost all of them small. The story is much the same for retailers. Of the more than 25,300 Alabama retail establishments in 1997, 70 percent employed fewer than 10 people each. Whereas trade is

a significant part of the state's economy, it does not play a big part in greenhouse gas discussions.

**Services**

The services sector employed in 1997 approximately 22.5 percent of all nonagricultural workers. During the 1990s, services have been one of the fastest growing sectors in the state. The services sector is characterized by many small firms. In general, firms in the services sector have a lower value added per worker and lower average salaries than the manufacturing sector. Despite contributing over 22 percent of the state's total employment, services industries accounted for only 15 percent of the total value of goods and services produced by the state in 1997.

The fastest growing areas in the services sector are health services and business services, such as contract temporary services or electronic and computer equipment repair services, growing as a result of downsizing and outsourcing. Disposal of medical waste materials has been an environmental concern in the state, but not part of the greenhouse gas discussion.

**Transportation, Communications, and Public Utilities**

Alabama's transportation sector, which includes trucking, shipping, and railroad transportation, employed 48,000 in 1997. A slowing economy reduces the demand for commercial transportation. The transportation and public utilities portions of this industry grouped together represent approximately 72 percent of the state's greenhouse gas emissions. The communications industry encompasses telephone and telegraph, radio and TV broadcasting, and cable TV. These types of businesses employed approximately 21,000 people in 1997 and are typified by intense competition begun earlier in the decade. Public utilities in the state employed 19,700 people in 1997. In the face of deregulation,
competition, and a slowing economy, employment in public utilities is expected to remain flat. Whereas utilities are a major source of interest in greenhouse gas discussions, these firms are a tiny part of the state's economy.

**Mining**

Mining employment in the state has been declining, with 860 jobs lost in the last two years. About 10,000 workers were employed in mining in 1997. Coal mining has been hurt by slow export growth to both Western Europe and Japan. Coal mining is centered in west central Alabama and is actually only part of Alabama's total mining industry. Besides the other fossil fuels oil and gas, other minerals such as limestone, sand and gravel, marble, and clay are extracted in the state. In 1995 more tons of limestone were extracted than tons of coal. But coal mining and the burning of coal, oil and gas have significant greenhouse gas implications and coal industry representatives in Alabama have been vocal in their opinions about the reality of global warming.

**Agricultural Services, Forestry, and Fisheries**

This sector encompasses agricultural services, like veterinary or farm labor and management services; landscaping; crop services, such as harvesting; and forestry and fishing. Poultry hatcheries and fish hatcheries are two of the fastest growing industries in this sector. Forestry is an extremely important component of greenhouse gas discussions, but its portion of Alabama's economic picture is much smaller. Even when forestry is grouped with related sectors, such as construction, and/or lumber and wood products manufacturing, the combined economic impact is dwarfed by some of Alabama's other significant industries.

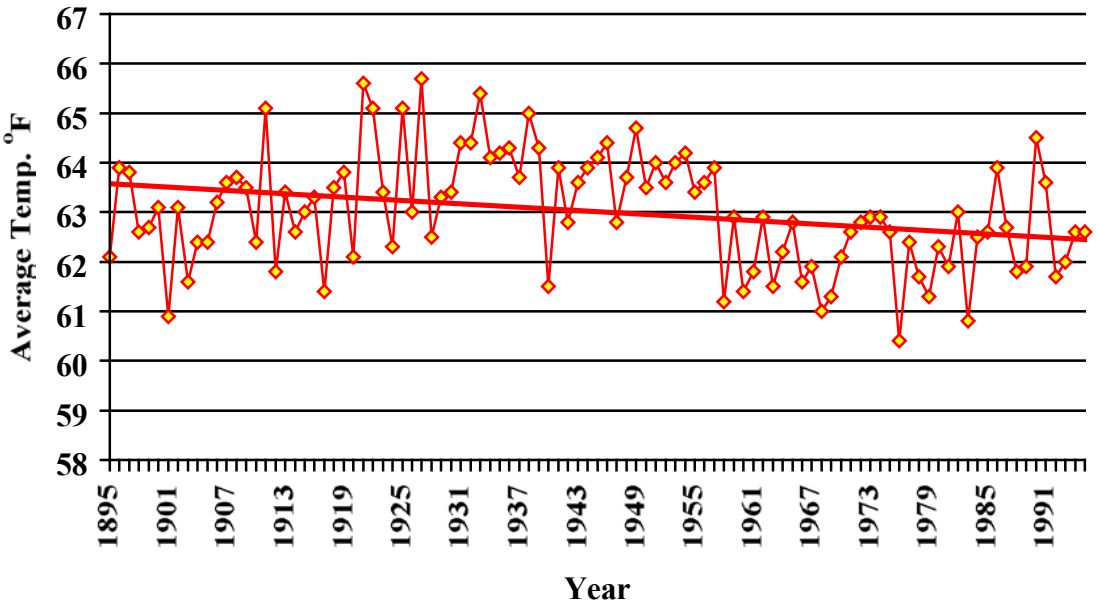
Table 5
Relative Importance of Industry Groups in Alabama's Economy
(Ranked by Employment Size)

| Rank | Industry Group | Percent of Total |
|---|---|---|
| 1 | Trade | 23.0 |
| 2 | Services | 22.0 |
| 3 | Manufacturing | 21.0 |
| 4 | Government | 18.7 |
| 5 | Construction | 5.1 |
| 6 | Transp., Comm., Pub. Utilities | 4.9 |
| 7 | Financial, Insurance, Real Estate | 4.5 |
| 8 | Mining | 0.6 |
| 8 | Agric. Services, Forestry, Fish | 0.6 |

## Possible effects of global warming in Alabama

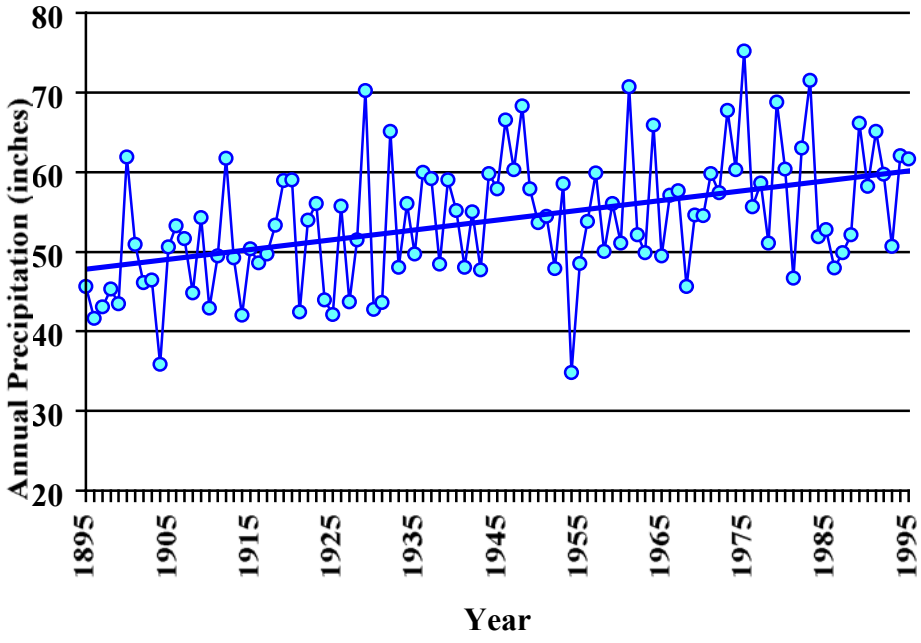
Although global data indicate that a warming trend of approximately one degree F is now evident, temperature data for Alabama over the past 100 years show a slight cooling trend (about one degree F for the 100 years), in line with several climate model scenarios for the Southeast.

**Alabama Temperature data, 1895-1995**




Precipitation data for the state shows an increase of about 12 inches for the 100 years, leading to some speculation about the interaction of these two parameters in affecting Alabama's climate.

**Alabama Precipitation Data, 1985 - 1995**



Increased rainfall and the possibility of more severe storm events could lead to increased risks of flooding in the future. Global warming could lead to polar ice melts and sea level rise, which would affect Alabama's coastline and associated wetland areas. Any long-term temperature change can lead to migration of forests, changes in agricultural practices, changing patterns of diseases, and possible population shifts. It is premature do attempt to detail such possible changes in this study, but future research should help develop additional information about these important potential impacts of climate change.

## Recommended greenhouse gas reduction strategy options

In order to develop and screen greenhouse gas reduction strategy options, an Advisory Panel of stakeholders was selected. Members included representation from State agencies, utilities, the legislature, industry, regulators, industrial development, and environmentalists. Four meetings were required to reaching a consensus on option recommendations.

Panel members were provided with background notes on climate change and greenhouse gases, and were exposed to the Alabama Greenhouse Gas Inventory which was just being completed. A facilitator lead a brainstorming session for mitigation of greenhouse gas options, which resulted in the identification 45 options. The options were then screened according to four equally weighted criteria using a Likert scale. The criteria were:

Benefit Area:
1) Mitigation of GHG Emissions

Areas of Policy Acceptability:
2) Political Feasibility
3) Institutional Acceptability
4) Administrative Ease in Implementation

Rankings were generated by averaging the scores of the four acceptability criteria and ranking the resulting mean scores and their associated options from highest to lowest. The top 20 options were modified and put into the five general categories of energy conservation, waste reduction and recycling, methane, transportation, and sequestration options and represent the final recommendations made by the Advisory Panel and the technical staff, with additional input from four public meetings held around the state in which attendees were exposed to the project activity and asked for comments. Additional details on the process of developing these options can be found in the companion publication to this report.

Many of the options recommended are "no regrets" options, which should probably be pursued even without a global warming threat, in order to maintain a sustainable growth economy. Where appropriate, the Advisory Panel indicated a preference for voluntary rather than mandated programs. This should not be surprising, since the debate about the reality of global warming continues at the local, state, national, and world arena. Without clearer proof of global warming, policy makers from conservative states such as Alabama will not be anxious to implement local and state mandates to reduce emissions. The potential future reduction of emissions, real or traded, by national policy, as implied by global treaty discussions, will impact coal mining, energy companies, and the manufacturing sector, all of which are well represented in this state. The economic effect of such policies will result in changes in aggregate prices, income distribution, employment, and output and trade of a region, and could result in more economic harm than the harm from global warming itself. Federal mandated policies directed to industry should carefully consider the issues of effectiveness, efficiency, administration, tax alternatives, and dynamic effects. The options recommended are:

**Energy Efficiency**

This category is meant to cover a broad area of "no-regrets" conservation options in the area of energy efficiency for all sectors. Alabama appears to be a high-energy consumption state, based on the 1990 Greenhouse Gas Inventory, and energy efficiency is a major options area. Existing federal and state programs to promote energy efficiency should be stressed and enhanced. Specifically recommended are:

**Energy efficiency audits in all sectors** - Existing programs in this area estimate a 14% reduction in energy use, and a 25% rate of those actually following through with changes. These programs should be expanded in all sectors.

**Increased building efficiency standards, commercial sector -** The Alabama Building Energy Conservation Code (ABECC) is estimated to have reduced energy use annually by 6,000 BTU per square foot, with 3,600,000 square feet of new or renovated space added in 1995, or a 605 ton $CO_2$ reduction.

**Modification of Existing Production Methods for the industrial sector-** A program to review industrial production methods with a view toward energy reduction is felt necessary by the Panel. This program may interact with other recommended options.

**Cogeneration Facilities for the Industrial Sector -** The energy efficiency of cogeneration is created by using the heat produced during

electric generation to make steam for the industrial process or hot and chilled water for heating and cooling. Some cogeneration system efficiencies surpass 80 percent through the use of recovered heat, compared to utility plant efficiencies of 35 percent. In a 1986 survey by the Alabama Department of Economic and Community Affairs, 252 megawatts of capacity was identified as high potential for cogenerating development. Conversion from gas-fired combined cycle electricity supply and gas boiler for steam to self-fired gas turbine and use of waste steam for heat would save about 200,000 tons of $CO_2$ emissions.

The Alabama Department of Economic and Community Affairs' Science, Energy, and Technology Division is the logical focus of efforts to plan, implement and/or integrate these options with existing programs, including those contained in the U.S. Climate Change Action Plan, such as Climate Challenge, Climate Wise, Integrated Resource Planning, Renewable Energy Commercialization, and others. The agency should work with utilities to promote energy efficiency to their customers, and to stress improved efficiency as a standard requirement for future new deregulated energy facilities. In addition, incentives should be considered for alternative energy sources such as solar and wind.

**Waste Reduction and Recycling**

This is a category of options to reduce waste and therefore reduce energy consumption and methane generation from landfills. Alabama appears to be above average in per capita methane emissions from landfills. Several specific options for utilization of methane generated from agriculture were discussed, but did not rank high enough for inclusion in the final recommendation listing. However, such options could also qualify as energy efficiency and "no-regrets" options and should be pursued where feasible.

**Modification of Existing Production Methods for the industrial sector-** A program to review industrial production methods with a view toward waste reduction is felt necessary by the Panel. This program may interact with the recommended energy efficiency option with the same title.

**Buy/Use More Recycled Materials for all sectors -** Alabama has a strong recycling program and needs to promote the purchase and use of recycled materials by all sectors, especially government. There is no market for recycled paper until we buy it. Government has to lead the way. The initiative can operate as a part of the existing recycling program.

**Development and Implementation of a State Recycling and Waste Reduction Plan -** Alabama Public Law 89-824 mandates each county to develop a long range solid waste management plan and established a goal of 25% reduction of solid waste to landfills, but the law is not enforceable. P.L. 90-564 established recycling at schools and institutions in the state, especially cardboard and office paper if local markets exist, and the composting of yard waste. The state also supports community recycling efforts with $5-10,000 grants. However, no statewide plan is in effect to cover the above recommendations. Recycling in Alabama has made some big strides with the support of the existing legislation. Alabama ranks Number One in the Southeast in value added, and has created 18,600 jobs in the recycling industry, representing approximately 5.0% of the total manufacturing employment in the state. Energy savings from used oil and solids recycling are estimated at 2.145 TBTU's.

The options indicated would be best administered and focused at the state environmental agency, the Alabama Department of Environmental Management (ADEM) or alternately, at the Alabama Department of Economic and Community Affairs (ADECA). ADEM has been supporting a State Recycling and Waste Reduction Plan for several legislative sessions without success. Again, the U.S. Climate Change Action Plan has existing programs to support waste reduction such as WasteWi$e and Industrial Assessment Centers which should be tapped for potential resources. Waste reduction could also encompass other resources such as water, and planning for future quantities, quality, demands, and uses for water are recommended.

**Methane/Natural Gas**

These options are aimed at reduction of methane and natural gas emissions from transmission leaks, and from coal mining operations. Alabama is above the national per capita average of methane emissions due to the coal mining activity in the state. Coalbed methane recovery from deep coal seams in Alabama prior to mining is a significant industry and has reduced methane emissions from mining operations by 25%.

**Recapture Leaking Methane/Natural Gas from distribution pipelines and refineries -** Although leaking gas from pipelines and refineries represents only about 1% of the total greenhouse gas emissions, it is recommended that a program be developed to minimize this methane source in the future.

**Increase Methane Recovery Prior to Mining -** As mentioned above, coalbed methane recovery from deep coal seams has reduced mining operation methane releases by some 25%. Enhancement of coalbed methane operations for the future is encouraged.

**Research to Capture More Methane During Mining -** Capture of methane during mining is in conflict with the safety requirements of MSHA, and the Panel felt better coordination between agencies in matters such as safety versus gas emissions would be helpful. This reinforces our general recommendation that all agencies communicate their policies and interests among themselves and develop more empathy for other agency actions.

The U.S. Climate Change Action Plan has several programs for methane reduction and recovery including Research, Development, and Demonstration (RD&D) projects for methane from coal mining and landfills, coalbed methane outreach, AgStar, and Ruminant Livestock Methane. While not specifically outlined in the options above and under waste reduction and recycling, the recapture of methane from landfills should be considered at several of the large landfills in the state.

**Transportation**

This sector had the most options. As mentioned above, the panel was clear that it was basically against enforced options, preferring voluntary programs, but some such as improved auto and truck maintenance may require some mandatory aspects.

**Improve Auto Maintenance for old and newer cars -** Programs are recommended to improve vehicle maintenance of old and new cars in the State. No inspection programs are currrently operating in the State.

**Traffic Lights Coordination -** Use of coordinated traffic lights is recommended for urban areas. In a project in a populated Birmingham suburb, the equivalent of 2,040 tons of $CO_2$ were reduced by improved traffic flow signalization.

**More Public Transportation -** Support of transit systems in urban areas in Alabama is recommended. Riderships in five transit systems reduced individual vehicle $CO_2$ emissions by an estimated 6,000 tons in 1996.

**Encourage Natural Gas/Alternative Fuel Fleets -** Support of programs to develop alternative fuel fleets including electric and solar car

technologies is recommended, especially in urban areas and by government entities.

**Enhance Car/Van Pooling -** Programs to encourage car-pooling and other options such as the use of restricted traffic lanes in urban areas are recommended. Park and Ride lots should be expanded.

**Encourage Barge and Rail Transport -** Alabama has well-developed rail and water transportation and methods should be pursued to better utilize this resource.

These options are best pursued by agencies at both the local municipal and state levels. Existing programs in the U.S. Climate Change Action Plan in this area include Transportation Efficiency Strategy, Promoting Telecommuting, and Clean Cities. Bicycle and pedestrian ways encourage changes in transportation habits and should be developed whenever feasible.

**Sequestration**

This category was meant to address methods of capturing or sequestering carbon dioxide from the air. About two-thirds of Alabama's 32 million acres is classified as commercial forestland.

**Improved Promotion of New Tree Planting Programs -** New tree planting programs can be utilized by industry to offset future $CO_2$ emissions and should encouraged by state forestry programs. Local governments should be encouraged to have tree commissions and urban foresters. Urban tree planting is becoming increasingly important across the nation.

**Improved Management of Existing Forest Stands -** Much of Alabama's 21 million acres of forestlands is privately owned, and programs should be enhanced for increasing biomass productivity on this land to sequester $CO_2$ and to protect the future of Alabama's forests.

These options are best pursued by the State Forestry Commission, in conjunction with other agencies, and U.S. Climate Change Action Plan activities, such as Reduce Depletion and Accelerate Tree Planting in Non-Industrial Private Forests, and Promote Recycling and Pollution Prevention in Pulp and Paper Industry.

## Other General Recommendations

Several recommendations are of a general nature. The Panel feels that there is a lack of understanding about the theory of global warming and its relation to other air pollution problems such as acid rain, ozone depletion, and the like. **Education of the public and the legislative, political, and business and religious leaders on environmental issues, specifically air pollution items and greenhouse gases is recommended.** Likewise**, communication and coordination between environmental/health and safety/and other agencies** is highly recommended to remove barriers to potential mitigation of emissions and emission effects.

All of the above options are summarized in Table 6.

**Table 6**
**Summary of Mitigation Option Recommendations**

| Category | Option | Description |
|---|---|---|
| **Energy Efficiency** | Energy Efficiency Audits | Audits for all sectors |
| | Increased Building Efficiency Standards | Improve commercial sector standards |
| | Modify Existing Production Methods | Energy reduction in the industrial sector |
| | Cogeneration Facilities | Improve energy efficiency through cogeneration in the Industrial sector |
| **Waste Reduction and Recycling** | Modify Existing Production Methods | Waste reduction in the industrial sector |
| | Buy/Use More Recycled Materials | All sectors of the Alabama economy utilize more recycled products |
| | State Recycling and Waste Reduction Plan | Develop and implement a comprehensive waste plan |
| **Methane/Natural Gas** | Recapture leaking natural gas/methane | Distribution pipeline and refinery leaks should be minimized |
| | Increase coalbed methane recovery | Enhance coadbed methane pre-mining activities |
| | Research to capture methane during mining | Coordinate with agencies to develop new technology to capture methane |
| **Transportation** | Improve auto maintenance | Old and new car voluntary inspection programs |
| | Traffic lights coordination | Expand coordinated signalization in urban areas |
| | More public transportation | Support of transit systems in urban areas |
| | Encourage alternate fuel fleets | support programs to develop CNG, electric, and solar cars |
| | Enhance car/van pooling | Encourage/expand park and ride lots, restricted traffic lanes, and car/van pooling |
| | Encourage barge/rail transport | Develop methods to better utilize water and rail transport |
| **Sequestration** | New tree planting programs | Enhancement of tree planting programs, tree commissions, and urban foresters |
| | Improved management of existing forest stands | Programs directed to private owners to increase biomass productivity |
| **General** | Education | Improve public, legislative, political, business, and religious leaders understanding of environmental issues, especially the role of greenhouse gases in global warming |
| | Communication | Coordination between environmental/health and safety/and other agencies to remove potential barriers to mitigation of emissions and emission effects |

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## Companion Publication

A companion publication, ***EPA Alabama Climate Change Program: Policy Planning to Reduce Greenhouse Gas Emissions (Phase 2), Final Report***, available from the Environmental Institute, The University of Alabama, contains all of the background supporting material for this project, including the complete 1990 greenhouse gas inventory, advisory panel participants, panel and public meeting minutes, and details of the development and ranking of policy options.

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