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# **JOBS-AT-RISK: SHORT-TERM AND TRANSITIONAL EMPLOYMENT IMPACTS OF GLOBAL CLIMATE POLICY OPTIONS**

**Final Report**

**Prepared by:**

**CONSAD Research Corporation  
121 North Highland Avenue  
Pittsburgh, Pennsylvania 15206**

**Principal Investigators: Wilbur A. Steger, Ph.D.  
Frederick H. Rueter, Ph.D.**

**12 May 1992**

**CONSAD Research Corporation**

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## EXECUTIVE SUMMARY

Despite the controversy over the existence, magnitude, and causes of the reputed global warming, a number of proposals have been advanced in both the world and national communities to stabilize, and subsequently reduce, the levels of carbon dioxide and other greenhouse gases. A study undertaken by CONSAD Research Corporation, and documented in this report, estimates the impacts on employment from policies designed to discourage carbon use -- policies such as a carbon tax (specifically analyzed in this study), or equivalent alternatives which would have similar impacts. More specifically, the study identifies a variety of short-term and longer-term effects of such policies on employment by state and identifies those industries where the jobs are likely to be. These impacts represent a range of consequences, including job losses, lower wages, underemployment, and diminished job security.

Based on the relative use of carbon-based fuels, and the interdependence and financial status of industries in this country, this report reaches the following conclusions regarding the economic impacts of a carbon tax, or an equivalent policy to reduce carbon use:

1. Job losses will be substantial:
  - a. In the short run, the first 3 to 5 years, resulting job losses will range from 240,000 to 360,000, and will be accompanied by adverse economic conditions, including high inflation, resembling the energy price shocks of the 1970s.
  - b. By the year 2000, the decrease in employment in that year could reach 600,000 or higher, depending on the magnitude of the carbon tax, or other similar costs associated with carbon use and CO<sub>2</sub> emissions.
  - c. In the longer run -- beyond the year 2000 -- job losses could rise beyond 1.6 million.
2. The jobs of nearly five million workers employed in vulnerable industries are at risk during the first several years. In addition to an increase in the jobless, substantial numbers of other workers will experience tangible adverse changes in their terms of employment: reductions in wages and hours worked, increased frequency and duration of layoffs, and diminished prospects for job growth. Almost 30 percent of these workers are in those industries most likely to

experience the most severe declines in employment in both the short-term and the intermediate-term.

3. Job consequences will vary among states and industries:

- a. Since about 90 percent of the nation's energy use is carbon-based (coal, natural gas, gasoline, etc.), the job losses and cost increases from a carbon tax or equivalent policy will be pervasive. States most likely to experience the largest declines in employment are: California, Illinois, Ohio, Pennsylvania, and Texas, and to a slightly lesser degree, Indiana, Kentucky, Louisiana, Michigan, New York, and West Virginia (see Figure 1).
- b. Industries with less than five percent of the nation's employment will incur more than 30 percent of the decline in employment; these include coal, metal mining, and oil and gas extraction. The probability that workers in these industries will lose their jobs is 8.5 times greater than in the remainder of the economy. Other vulnerable industries are utility and transportation services, as well as a number of manufacturing industries (see Figure 2).

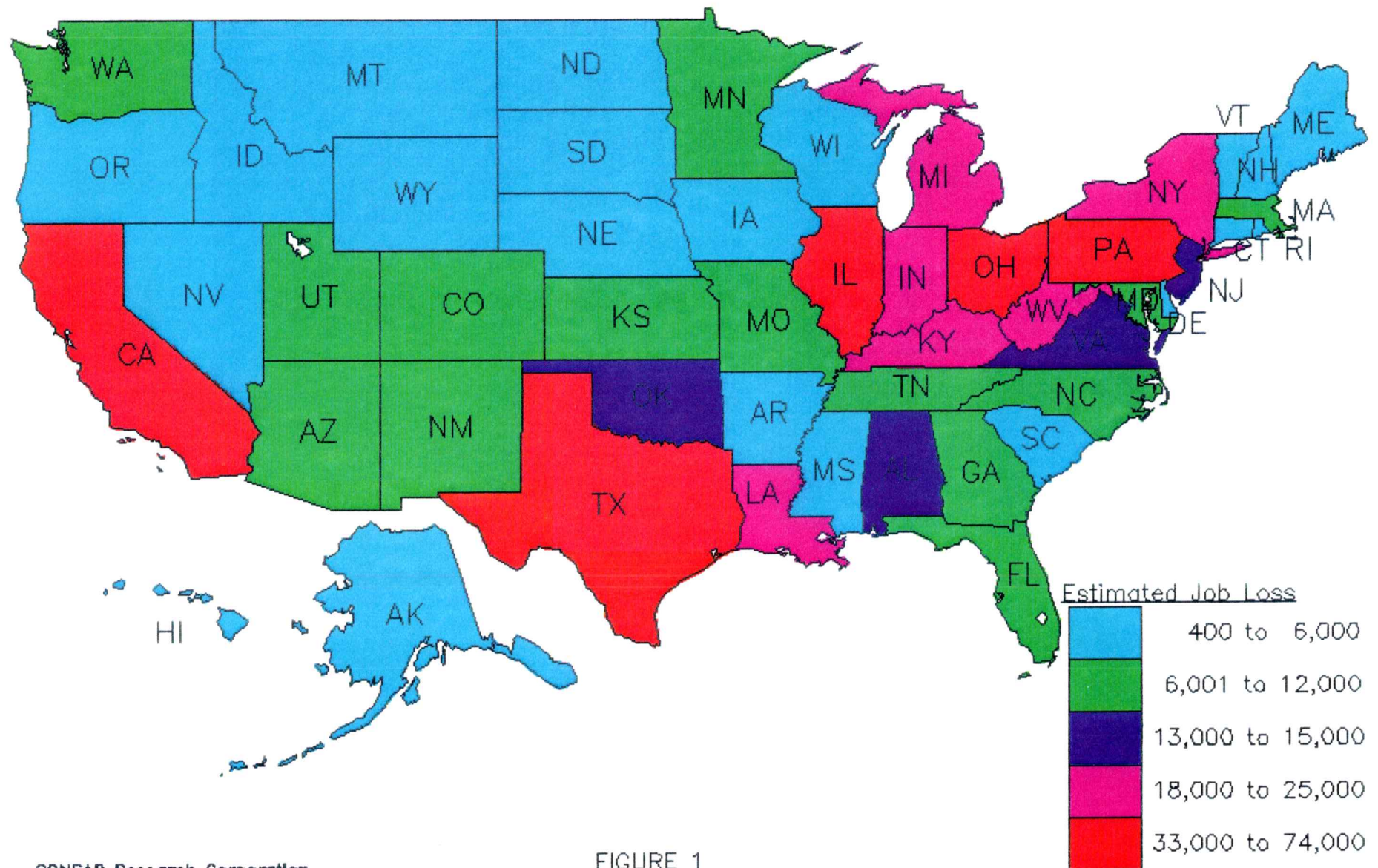
4. Alternatives to a carbon tax could have greater adverse effects on employment. Policies such as "command-and-control," "technological fixes," or enforced "voluntary" time tables, could well cause at least as much job loss and jobs-at-risk as would occur with an equivalent carbon tax.

5. Job losses will occur regardless of the way tax receipts are used. Policies to recycle revenue from carbon taxes have not been designed to reduce the negative employment impacts. Moreover, it is not likely that such policies could easily be developed and implemented. If tax receipts are used to finance reductions in corporate tax burdens in ways that encourage labor use and capital investment, job losses may be less severe. However, changes in corporate tax structures are unlikely to be sufficiently targeted and large enough to alleviate the projected job losses.

6. Some jobs will be created, but the number will be meager compared with the losses, and they will be in different professions. While substantial job losses will occur among "blue collar" manufacturing workers, the relatively small number of job gainers will principally be scientists, engineers, and skilled technicians involved in technology development. Retraining will not provide



# Estimated State Job Loss in the Intermediate Term



## Distribution of Manufacturing Sector Jobs Directly Affected - By Industry

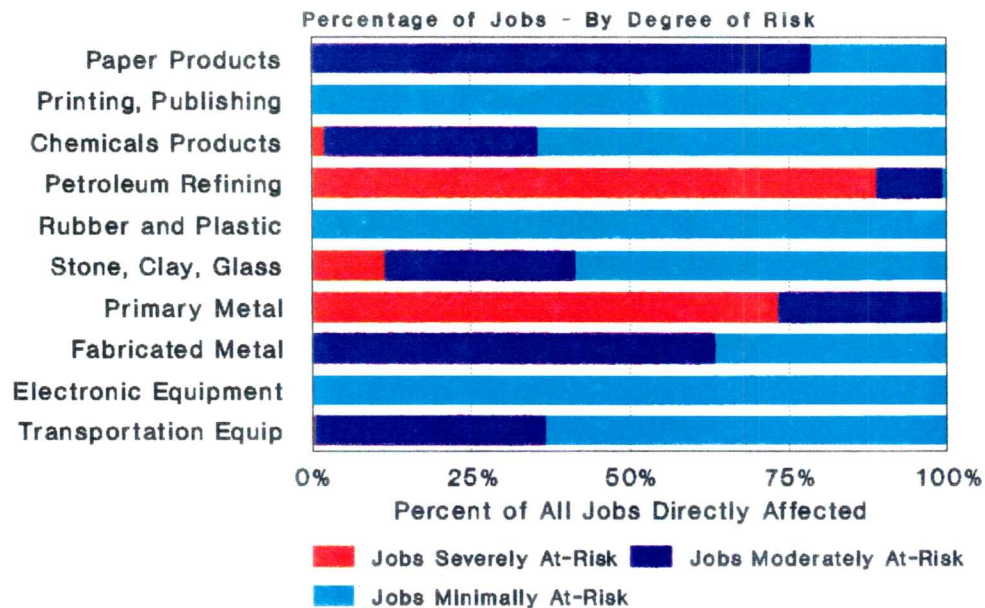
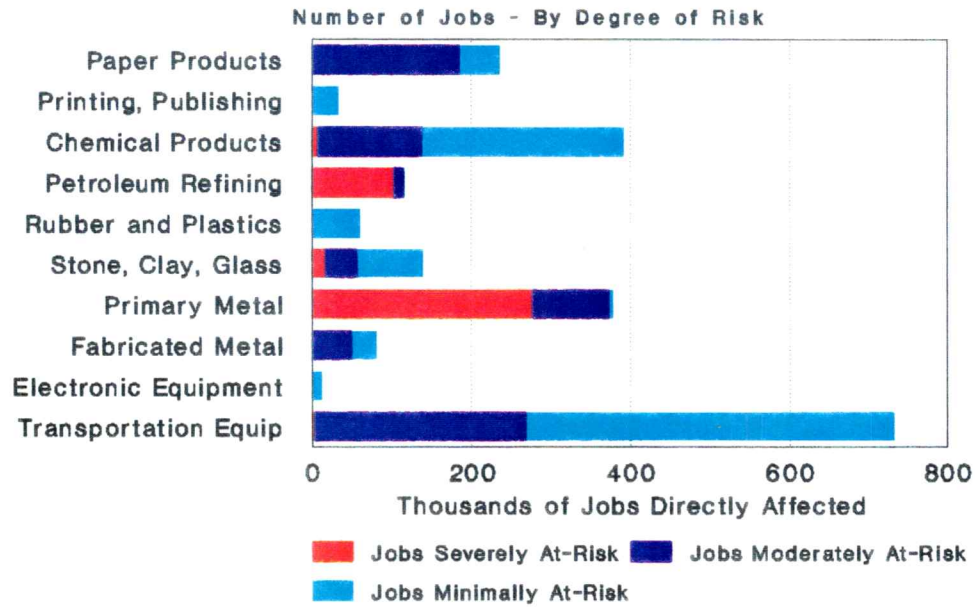


FIGURE 2



the job losers with the skills required for the emerging jobs, and adjustments in the labor market will be a complex long-term process.

7. Investment capability will be lower in industries hardest hit. Another sizable, real cost is the reduced capacity to invest which industries hit hard by the carbon tax will experience. Industries most in need of capital funds for restructuring and technological change will be most hard put to make such investments.

In conclusion, from an economic standpoint, a carbon tax -- or any other policy to reduce carbon use that compels industry to radically and prematurely restructure its way of doing business -- would impose enormously expensive and hidden costs on the economy. Much of this will be borne by an unsuspecting labor force. Even if the scientific evidence of the alleged benefits were more conclusive, the unavoidable social, physical, and emotional pain and suffering that would inevitably accompany such policies are unintended consequences that should eliminate the carbon tax, and similar policies, from serious policy consideration.

## 1.0 INTRODUCTION

This study estimates the effects on short-, intermediate-, and long-term employment from policies that have been proposed to discourage carbon use, whether those policies be a carbon tax or an equivalent command-and-control policy. The policy most prominently advocated to induce both public and private sector restraint is the carbon tax, a specific emissions fee, or "green charge," imposed on fossil fuels in proportion to their carbon content. Accordingly, the results presented in this report relate primarily to the carbon tax. Employment effects would be similar or possibly more severe under alternative policies, which impose equivalent or higher costs on businesses.

### 1.1 Objective

Most analyses of the impacts of policies designed to reduce carbon emissions have emphasized long-term consequences, describing these impacts with the broadest measures: changes in gross national product (GNP); changes in total employment nationwide; and changes in the national unemployment rate. While this analysis also considers the impacts on employment in the long term, as well as in the intermediate term (to the year 2000), it also provides a unique perspective to the issue of jobs impact. The report focuses on the short-term and transitional effects on employment, particularly in the industries and geographic areas where jobs are most likely to be affected. Which states or multi-state regions will experience the greatest adverse effects? And which industries

will be most impacted? Conversely, where will jobs be gained? Investigating and answering these questions is a primary objective; other economic issues relating to global climate change are considered as relevant.

## 1.2 Study Approach

A carbon tax, or other policies that are designed to reduce use of carbon and carbon dioxide emissions, will increase the cost of doing business to every firm or government organization in the United States. These cost increases will occur, directly or indirectly, due to the substantial increase in the cost of almost 90 percent of the energy that fuels the United States economy: coal, natural gas, gasoline and other petroleum products, and fossil fuel generated electricity.

A variety of approaches have been used to determine the jobs consequences likely to occur during three distinct time periods:

- The immediate, short-term phase which consists of the first three to five years. During this period there will be a helter-skelter of effects that are somewhat unpredictable using conventional econometric modelling methods. In addition to thousands of workers losing their jobs in plants and firms which cannot afford to pay the higher costs of doing business, a much larger number of workers will find the quality of their jobs severely and adversely impacted. Workers vulnerable to the tax will find their jobs to be at-risk, due to the potential for job loss, a decrease in compensation and/or benefits, and a reduction in job security.
- The transitional or intermediate phase, five to ten years, will last as long as firms continue to adapt to their new cost and demand structures. There will continue to be many jobs-at-risk, but the country should be in the beginning stages of a return to economic stability.



- The long-term phase where job losses will replace jobs-at-risk as the predominant employment issue and a new jobs issue will emerge: there will not be as many jobs in an economy that is operating at a lower overall level of economic activity than would be the case absent a carbon tax. Also, jobs that may be created will tend to be more technically oriented in contrast to the "blue collar" manufacturing jobs that will likely be eliminated. Many unemployed will not be qualified and will not be easily trained for this new employment.

Job losses in all time phases depend upon the vulnerability of the firm to adverse economic impacts from these externally imposed costs. These impacts will vary according to the way that direct demand for the firm's output (including services) is affected: in essence, the firm's ability to absorb these additional costs, pass them through in the marketplace, or change their way of doing business. If demand for the commodities or services produced by any industry sector exhibits some responsiveness to increases in costs of production, a carbon tax or similar policy will result in decreases in sales and production, and hence some level of job loss. The more vulnerable the firm, the less able it is to compete, and the more likely that there will be job loss.

Industries which provide services and products which are derived from the direct demand for primary energy, such as the industries in the bulk transport sector, will also experience a substantial decline in employment levels.

For purposes of this analysis, three categories of jobs-at-risk have been established (see summary in Table 1.1):

- Jobs severely at-risk are those in the most vulnerable industries with the highest probability that jobs will be eliminated due to plant closings or to a decline in business or bankruptcy. These workers stand the greatest chance of losing all wages and benefits.

**Table 1.1: Typical Economic Impacts on Jobs  
With Different Degrees of Risk**

| <b>Jobs Minimally<br/><u>at-Risk</u></b>                                                                                                                                                                                                                    | <b>Jobs Moderately<br/><u>at-Risk</u></b>                                                                                                                                         | <b>Jobs Severely<br/><u>at-Risk</u></b>                                                                                                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Periodic layoffs or reduced hours worked</li> <li>• Reduced wages and benefits</li> <li>• Increased uncertainty about future</li> <li>• Reduced business growth with curtailed research and development</li> </ul> | <ul style="list-style-type: none"> <li>• Prolonged layoffs</li> <li>• Reduced wages and benefits</li> <li>• Limited job growth</li> <li>• Little or no business growth</li> </ul> | <ul style="list-style-type: none"> <li>• Job loss</li> <li>• Lost benefits</li> <li>• Plant closings</li> <li>• Rapid business decline or bankruptcy</li> </ul> |

- Jobs moderately at-risk are those in vulnerable industries that have little or no growth potential. Employees in this category are subject to prolonged layoffs and will see their wages and benefits reduced substantially.
- Jobs minimally at-risk are those in vulnerable industries which could experience lower growth than would be the case in the absence of cost increases. These workers could see periodic layoffs or could be forced to reduce the number of hours worked. Wages and benefits could be lower.

An industrial sector and its employees are considered more vulnerable to adverse impacts from the imposition of a carbon tax: (a) the larger is the cost increase that it must bear, (b) the more limited its capacity to defray the cost increase through reducing its own profits, and (c) the more restricted its ability to pass the cost increase forward to its customers or backward to its suppliers, investors, or employees. The more vulnerable the industry, the larger will be the proportion of the jobs in the industry that will be lost. The relationship between industrial employment vulnerability and potential job loss is portrayed graphically in Figure 1.1.

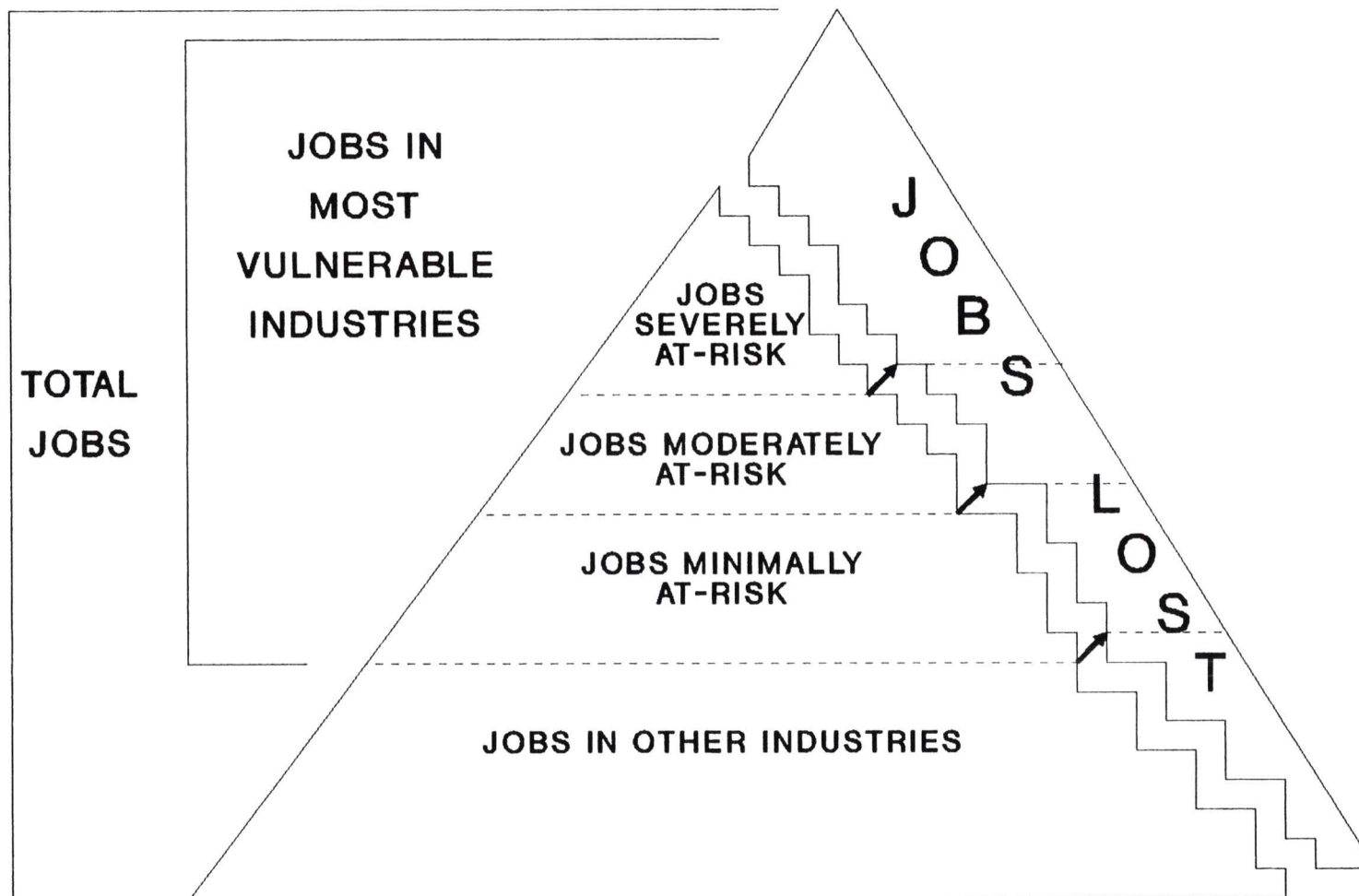
Procedures for estimating the numbers of jobs-at-risk and probable job losses that can reasonably be expected to result, in the short run, from the imposition of a carbon tax are described in Chapter 2 and in Appendices A and B.<sup>1</sup> Estimates developed by implementing the procedures for a hypothetical carbon tax of \$24 per ton are also presented in that chapter.

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<sup>1</sup>The appendices are bound separately and are available upon request.



## Employment Vulnerability and Job Loss



In the intermediate and long run, firms have considerably more flexibility in responding to, and attempting to reduce, the cost increases incurred as a result of a carbon tax. Existing physical equipment can be replaced with less carbon intensive, more energy efficient equipment as financial resources become available. More importantly, applied research and development can, where successful, provide technological improvements that will permit reductions in carbon utilization and gains in energy efficiency greater than those achievable with currently available technologies. Thus, in the long run, as firms and industries capitalize on these additional, emerging opportunities, patterns of economic activity throughout the nation will change. These changes in turn will require corresponding changes in patterns of employment. Some industries, jobs, occupations, and geographic areas will expand, while others should continue to decline.

The transition from the current pattern of economic activity to the pattern that will evolve in the long run if a carbon tax is imposed will entail major adjustments for workers. The adjustments will involve substantial retraining costs and relocation costs to different geographic areas. The projected transitions and adjustment costs, again focusing on jobs, that are likely to result from imposition of a carbon tax are investigated in Chapter 3 and in Appendix C.

## 2.0 SHORT-TERM JOB CONSEQUENCES: THE FIRST JOLT

Many workers and businesses will experience immediate, and adverse, economic effects following the imposition of a carbon tax. Approximately five million workers will be negatively affected and many thousand of these will lose their jobs as businesses and local governments attempt to adjust to the new post-carbon-tax world.

Individual actions taken by the firm in the short term (one to five years) following imposition of the carbon tax will collectively have an immediate impact on labor and wages, as well as on increases in consumer prices. This short-term phase, when firms attempt to reduce or deflect the impacts, will last until a reasonable accommodation is well underway to adjust to the economic forces affecting firms' production processes and the demands for their products.

During this short-term period:

- Employment effects will be immediate. Jobs will be lost from day one. The immediate effects of a carbon tax will not be unlike the disruptive and disturbing employment and inflation impacts resulting from the energy price shocks of the 1970s. No degree of advanced announcement of the tax will fully avoid these consequences.
- Millions of workers who are employed in vulnerable industries will be placed at-risk which could leave them economically disadvantaged. Substantial numbers of other workers will experience tangible adverse changes in their terms of employment: reductions in wages and hours worked, increased frequency and duration of layoffs, and diminished prospects for job growth. Moreover, many of these workers are in those industries most likely to experience the most severe decline in employment in both the short and the intermediate term.
- Job losses will occur widely throughout the nation but these losses will not be evenly distributed geographically. Almost 90 percent of the nation's energy



use is carbon based: coal, natural gas, gasoline and other petroleum products, and electricity generated with fossil fuels. As a result, the direct and indirect use of carbon in economic activity is pervasive, and cost increases will be experienced throughout the nation. Jobs will be lost in virtually all industries and in all states, but just a dozen states will most likely experience the greatest declines in employment.

- Job losses will not be evenly distributed among all industries. A disproportionate share of the decline in employment will occur in those industries where carbon use is greatest and in those industries and services dependent upon demand for carbon based fuels. The hardest hit industries will incur a very large share of the total decrease in employment; and workers in these industries will have much greater chances of losing their jobs.

Why do we care about such short-term job effects? Jobs are a critical concern, economically, socially and politically -- particularly when economic conditions are sluggish and troubled. Plants can close. Workers can lose their jobs, suffer prolonged layoffs, or experience reductions in their wages or hours worked. Furthermore, to the extent the above economic effects of a carbon tax resemble the impacts from the energy price shocks of the 1970s, prices will increase and jobs will be lost.

CONSAD's investigation of these immediate, short-term effects is not rooted in complex, econometric models. Data is simply inadequate to develop a comprehensive economic model of how firms adjust in the short run to increased costs caused by global climate change policies. Instead, CONSAD assesses the practical way that businesses will react once the tax is imposed and the impact this will have on employment. Responses to the tax will depend on: (a) the degree of cost increase, (b) the ability to absorb the tax, (c) the ability to pass on the tax, and (d) the flexibility in

restructuring business practices to mitigate the cost increase. The answers to these issues for each industrial sector and region of the country determine the vulnerability of firms to adverse economic consequences and their employees' risk of job loss or other, severe impacts on their terms of employment.

Job loss will be most common among workers in jobs that are severely at-risk. Yet, because a carbon tax will impel substantial cost increases, directly or indirectly, for most major forms of energy (coal, natural gas, gasoline and other petroleum products, and electricity from public utilities that operate generating stations fired with fossil fuels), the tax will ultimately cause cost increases and job losses for firms in all industry sectors.

Two measures of the short-term economic consequences of a \$24 per ton carbon tax are presented in this chapter. Section 2.1 presents estimates of the numbers of jobs-at-risk in the most directly affected industrial sectors. Section 2.2 presents estimates of the short-term job losses for all industrial sectors throughout the economy. Procedures for estimating the numbers of jobs-at-risk and probable job losses that can reasonably be expected to result, in the short term, are described in Appendices A and B, respectively.

## 2.1 Jobs-at-Risk in the Immediate Short Term

CONSAD's approach to estimating the number of jobs directly affected by a carbon tax in the short term utilizes the interindustry input/output model of the United States economy

developed by the U.S. Department of Commerce solely to estimate industry-specific cost increases that would result from the carbon tax rates. Each industry's estimated cost increase is, then, compared to its median return on sales, to estimate the share of each industry's profit margin that would be required to defray the cost increase. The resulting ratio value is used to classify industries, and the employment in those industries, by their degree of vulnerability or risk -- severe, moderate, or minimal -- to adverse employment consequences. A threshold of 2.5 percent anticipated increase in cost was adopted as the vulnerability standard. Then, data on total employment by industry and state, estimates of the sensitivity of regional electricity rates to coal prices, industry-specific data on financial conditions and international trade, and estimates as to the responsiveness of demand for the industry's products to general price increases, are used to make adjustments to the initial classification of jobs affected by degree of risk, thereby creating the final classification of jobs affected by region and degree of risk.

#### 2.1.1 Jobs-at-Risk: Industries

Within one to five years following imposition of a \$24 per ton carbon tax, about 4.87 million private sector, non-farm jobs (5.3 percent of total employment) are estimated to be directly affected and at-risk. Table 2.1 and Figures 2.1 through 2.3 summarize these estimates on the basis of both the degree of risk and the industries affected.



Table 2.1: Distribution of Jobs Directly Affected in the Short-Term by Industry and Degree of Risk (1)

| SIC Description                                       | Total<br>Employment<br>(1989) | Jobs<br>Severely<br>at Risk | Jobs<br>Moderately<br>at Risk | Jobs<br>Minimally<br>at Risk | Total<br>Jobs<br>Directly<br>Affected | Total Jobs<br>Directly<br>Affected<br>as a Pct<br>of Total<br>Employment |
|-------------------------------------------------------|-------------------------------|-----------------------------|-------------------------------|------------------------------|---------------------------------------|--------------------------------------------------------------------------|
| <b>MINING INDUSTRIES</b>                              |                               |                             |                               |                              |                                       |                                                                          |
| 10 METAL MINING                                       | 53,200                        | 24,600                      | 0                             | 0                            | 24,600                                | 46.2%                                                                    |
| 12 COAL MINING                                        | 139,400                       | 138,500                     | 900                           | 0                            | 139,400                               | 100.0%                                                                   |
| 13 OIL AND GAS EXTRACTION                             | 278,000                       | 266,800                     | 11,100                        | 0                            | 278,000                               | 100.0%                                                                   |
| 14 NONMETALLIC MINERALS, EXCEPT FUELS                 | 107,600                       | 0                           | 5,400                         | 20,800                       | 26,200                                | 24.3%                                                                    |
| MINING INDUSTRIES SUBTOTAL                            | 578,200                       | 429,900                     | 17,400                        | 20,800                       | 468,100                               | 81.0%                                                                    |
| <b>MANUFACTURING INDUSTRIES</b>                       |                               |                             |                               |                              |                                       |                                                                          |
| 26 PAPER AND ALLIED PRODUCTS                          | 644,700                       | 0                           | 184,100                       | 50,900                       | 235,000                               | 36.5%                                                                    |
| 27 PRINTING AND PUBLISHING                            | 1,547,200                     | 0                           | 0                             | 33,000                       | 33,000                                | 2.1%                                                                     |
| 28 CHEMICALS AND ALLIED PRODUCTS                      | 896,100                       | 7,800                       | 130,400                       | 252,100                      | 390,400                               | 43.6%                                                                    |
| 29 PETROLEUM AND COAL PRODUCTS                        | 115,400                       | 102,600                     | 12,100                        | 800                          | 115,400                               | 100.0%                                                                   |
| 30 RUBBER AND MISC. PLASTICS PRODUCTS                 | 907,700                       | 0                           | 0                             | 60,100                       | 60,100                                | 6.6%                                                                     |
| 32 STONE, CLAY, AND GLASS PRODUCTS                    | 542,200                       | 15,900                      | 40,900                        | 81,200                       | 138,100                               | 25.5%                                                                    |
| 33 PRIMARY METAL INDUSTRIES                           | 773,900                       | 276,800                     | 96,900                        | 3,400                        | 377,100                               | 48.7%                                                                    |
| 34 FABRICATED METAL PRODUCTS                          | 1,537,200                     | 0                           | 50,500                        | 29,300                       | 79,800                                | 5.2%                                                                     |
| 36 ELECTRONIC & OTHER ELECTRIC EQUIPMENT              | 1,646,100                     | 0                           | 0                             | 11,700                       | 11,700                                | 0.7%                                                                     |
| 37 TRANSPORTATION EQUIPMENT                           | 1,956,900                     | 3,100                       | 264,500                       | 463,300                      | 731,000                               | 37.4%                                                                    |
| MANUFACTURING INDUSTRIES SUBTOTAL                     | 10,567,400                    | 406,300                     | 779,300                       | 985,900                      | 2,171,500                             | 0                                                                        |
| <b>TRANSPORTATION AND UTILITY SERVICES INDUSTRIES</b> |                               |                             |                               |                              |                                       |                                                                          |
| 40 RAILROAD TRANSPORTATION                            | 292,000                       | 132,700                     | 159,300                       | 0                            | 292,000                               | 100.0%                                                                   |
| 41 LOCAL AND INTERURBAN PASSENGER TRANSIT             | 301,900                       | 76,300                      | 135,500                       | 90,100                       | 301,900                               | 100.0%                                                                   |
| 44 WATER TRANSPORTATION                               | 157,000                       | 36,500                      | 6,700                         | 113,700                      | 157,000                               | 100.0%                                                                   |
| 45 TRANSPORTATION BY AIR                              | 625,200                       | 71,500                      | 553,700                       | 0                            | 625,200                               | 100.0%                                                                   |
| 49 ELECTRIC, GAS, AND SANITARY SERVICES               | 882,100                       | 248,700                     | 500,600                       | 102,800                      | 852,100                               | 96.6%                                                                    |
| TRANS & UTIL SERVICES INDUST SUBTOTAL                 | 2,258,200                     | 565,800                     | 1,355,800                     | 306,700                      | 2,228,200                             | 98.7%                                                                    |
| ALL INDUSTRIES                                        | 91,923,200 (2)                | 1,401,900                   | 2,152,500                     | 1,313,300                    | 4,867,800                             | 5.3%                                                                     |

Note: All employment figures are rounded to the nearest 100.

- (1) Represents jobs directly affected within one to five years following the imposition of a \$24 per ton carbon tax.
- (2) This figure represents 1989 total private-sector, non-farm employment in all industries (including 1991 railroad employment).

## Distribution of Mining Sector Jobs Directly Affected - By Industry

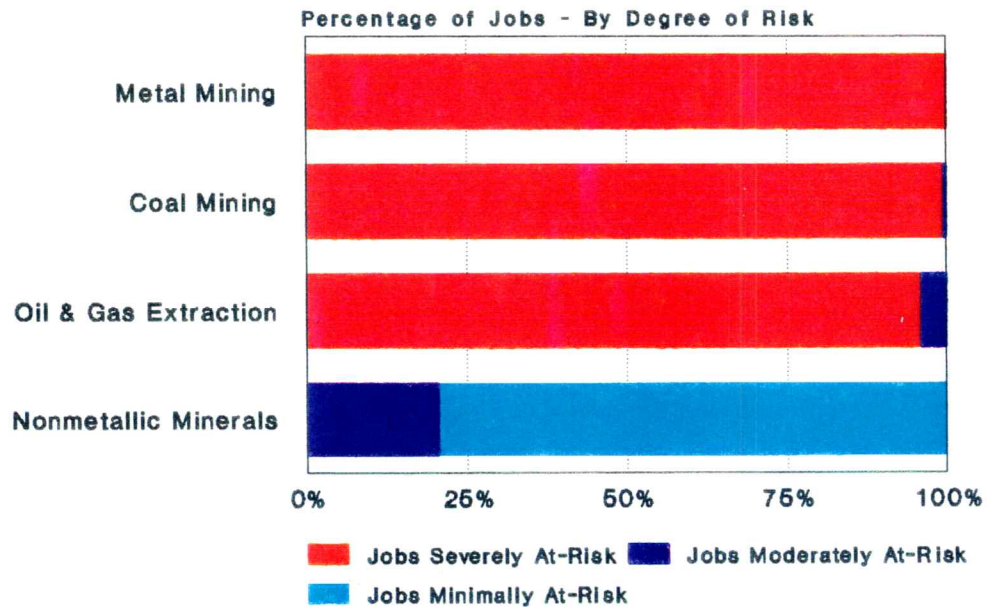
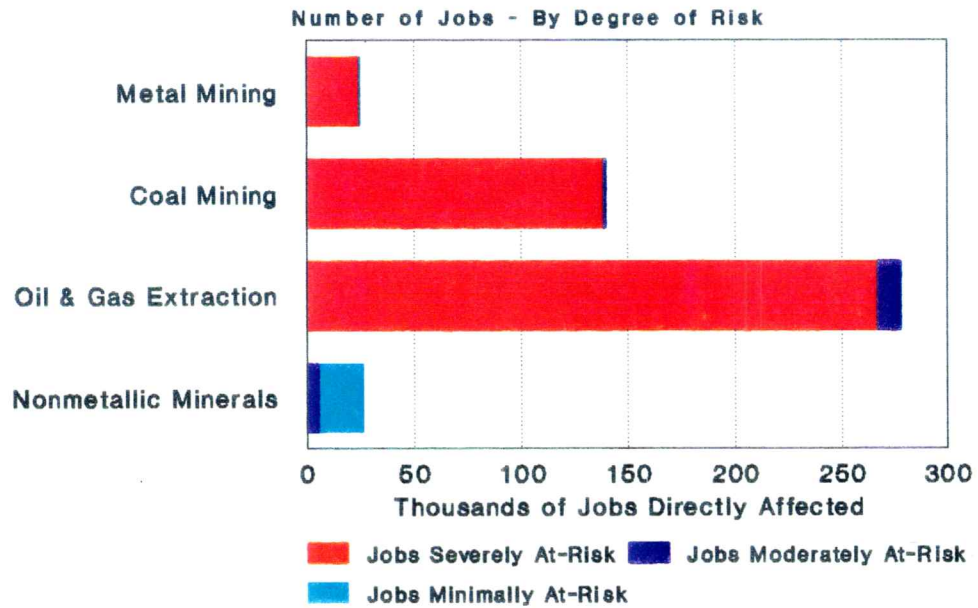


FIGURE 2.1

## Distribution of Manufacturing Sector Jobs Directly Affected - By Industry

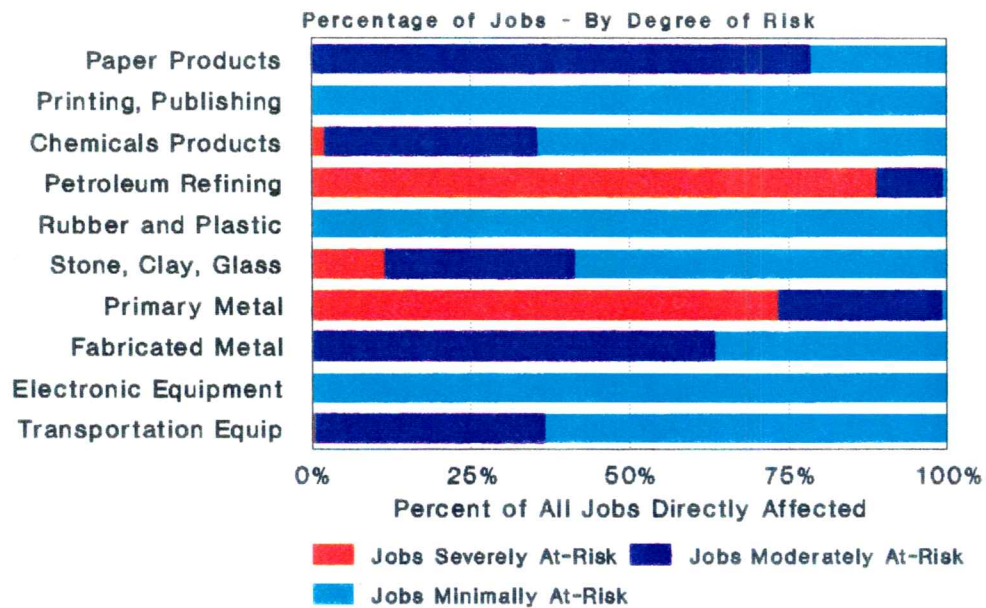
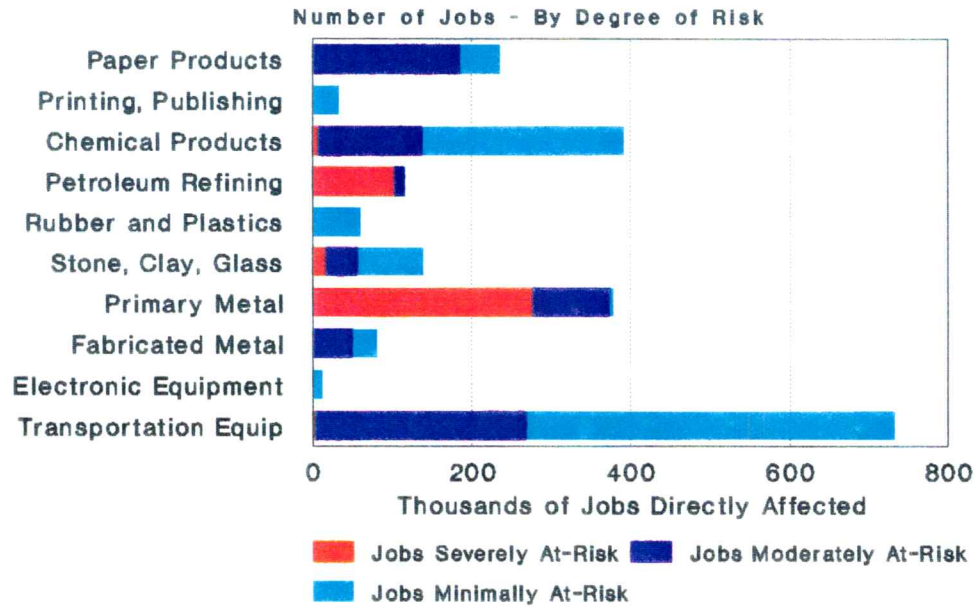


FIGURE 2.2



## Distribution of Transportation Services and Utility Sector Jobs Directly Affected - By Industry

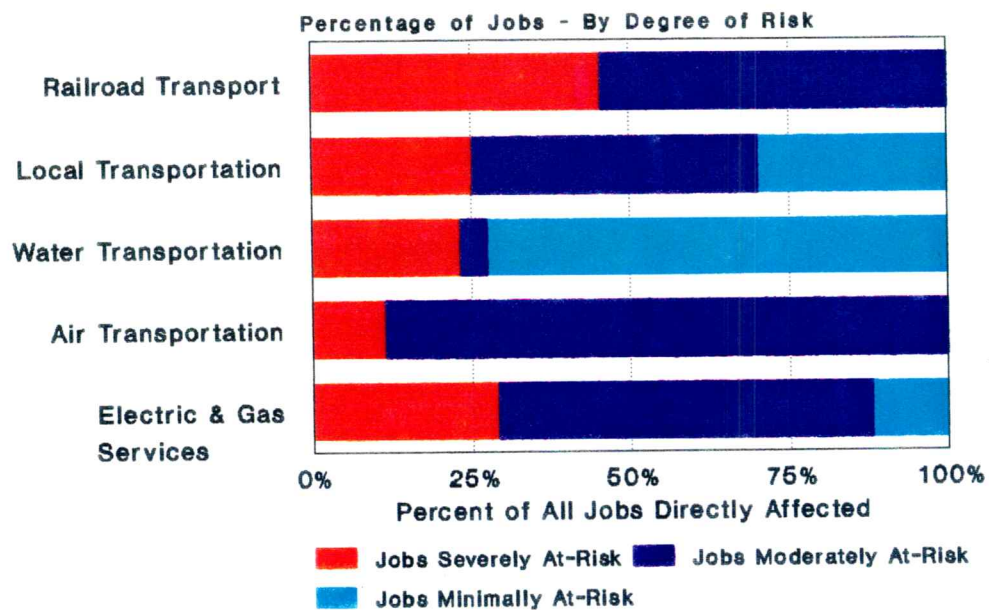
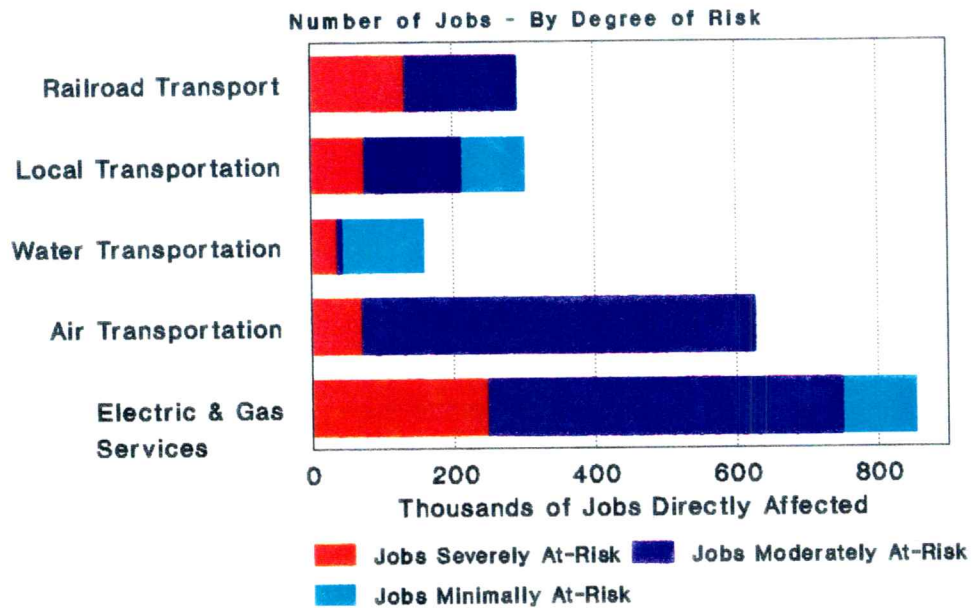


FIGURE 2.3

Of the total jobs directly affected, 29 percent are expected to be severely at-risk, 44 percent moderately at-risk, and 27 percent minimally at-risk.<sup>1</sup> Due in part to the large numbers of employees in particular industries, the utility sector is projected to experience the most jobs directly affected in the short term, followed by the transportation equipment sector, and the air transportation sector.

In relative terms, however, the results indicate that metal mining, coal mining, oil and gas extraction, petroleum and coal products manufacturing, and primary metals manufacturing are the industries that are hardest hit by a carbon tax. Between 73 and 100 percent of the jobs directly affected in each of these industries are severely at-risk. Employees in the transport services sectors that serve these basic industries are equally at-risk. Conversely, non-metallic minerals, printing and publishing, rubber, and electronics are likely to be the least affected of the most vulnerable industries. Between 72 and 100 percent of the jobs directly affected in each of those industries are minimally at-risk. Most of the estimated jobs that are severely at-risk are concentrated in the following industries: primary metals, oil and gas extraction, utilities, coal mining, and railroad transportation.

#### 2.1.2 Jobs-at-Risk: Location

The greatest number of jobs directly affected is in the Midwest region, followed by the South Atlantic region, the

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<sup>1</sup>See pages 1.3 through 1.5 for definitions of jobs-at-risk.

Southwest region, and the Mid-Atlantic region. Together, these four regions account for 68 percent of all jobs directly affected. In terms of their distribution by degree of risk, the North Central region has the greatest percentage of jobs directly affected that are severely at-risk, followed by the Southwest region, and the Mid-Atlantic region (see Figure 2.4).

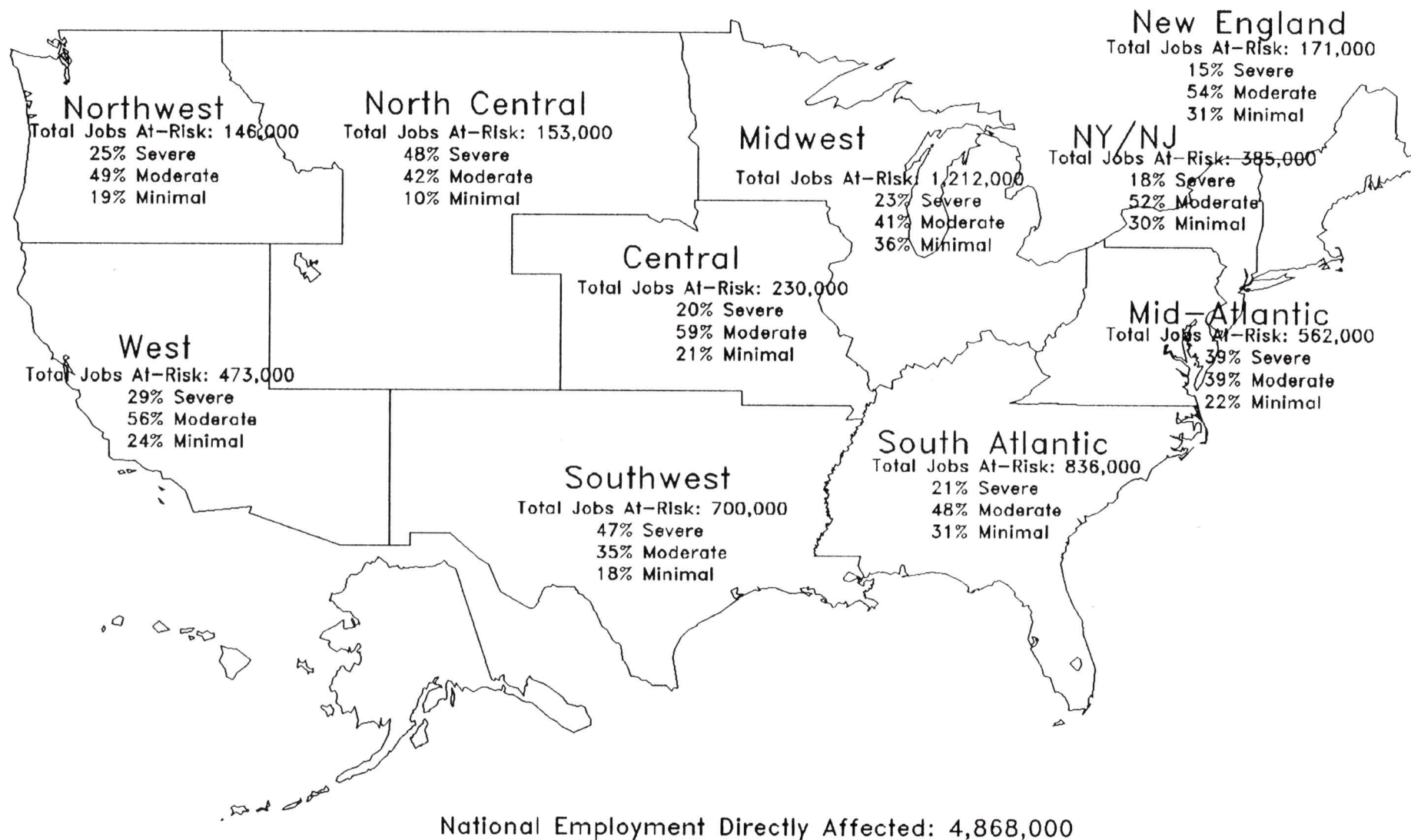
Figures 2.5 and 2.6 display state-level results on employment directly affected and severely at-risk. In terms of the number of jobs directly affected, New York, Pennsylvania, Ohio, Michigan, Illinois, Texas, and California have the greatest numbers. In the severely at-risk category, Pennsylvania, Ohio, Indiana, Illinois, Kentucky, Louisiana, Texas, and California fare the worst in absolute terms.

In relative terms (i.e., jobs directly affected as a percentage of total state employment), West Virginia, Kentucky, Michigan, Louisiana, Wyoming, and Alaska have the highest percentages of their state's employment at-risk (Figure 2.7). In terms of jobs severely at-risk (Figure 2.8), West Virginia, Kentucky, Indiana, Alabama, Louisiana, Texas, Oklahoma, New Mexico, Utah, Wyoming, Montana, North Dakota, and Alaska have the highest percentages of their state's employment in this category. Among this group, more than five percent of total state employment in Alaska, Kentucky, Louisiana, West Virginia, and Wyoming is severely at-risk.

Figure 2.9 highlights those industries in selected states that have the greatest numbers of jobs severely and moderately at-risk.

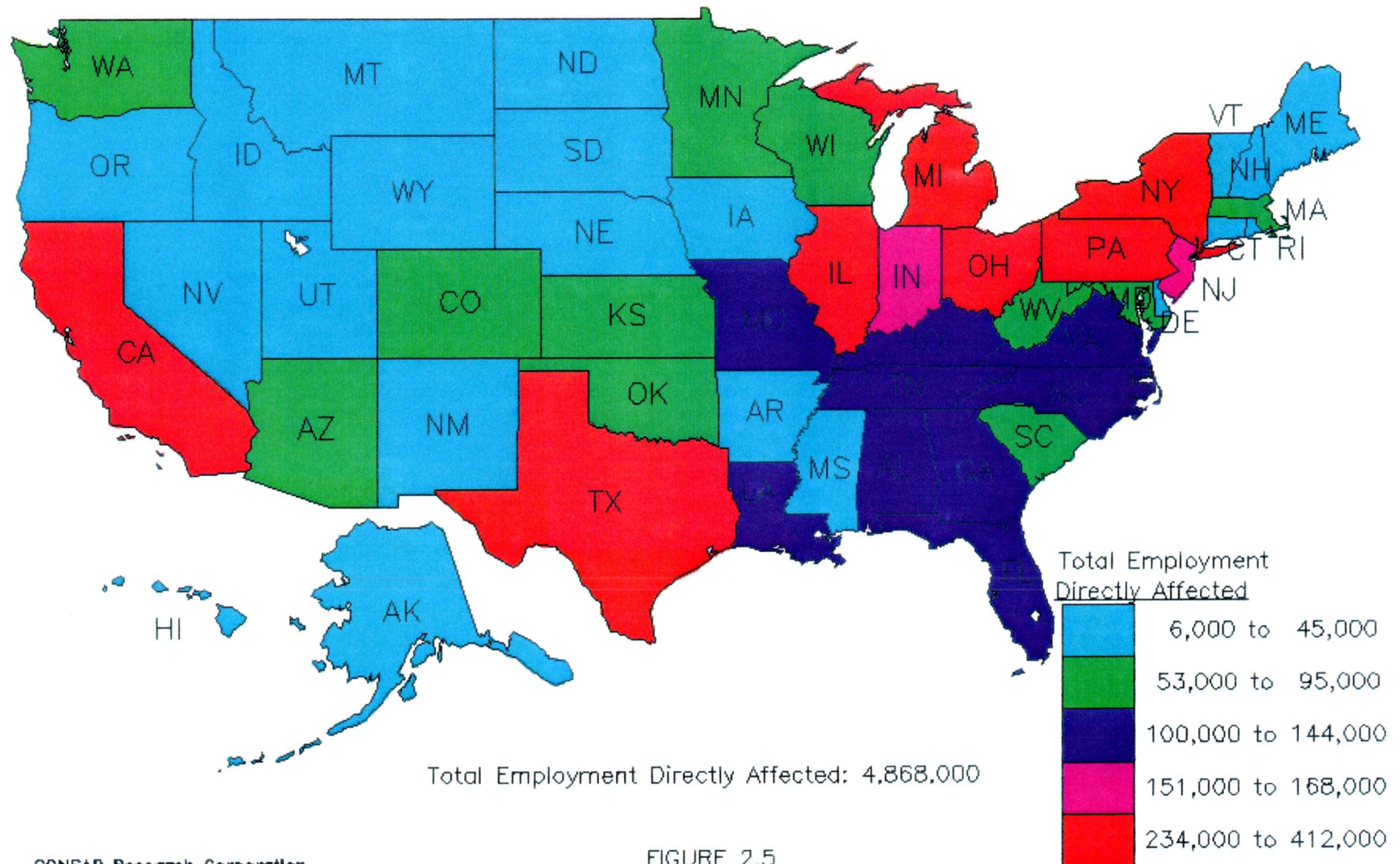


# Total Employment Directly Affected with Degree of Risk: By Region



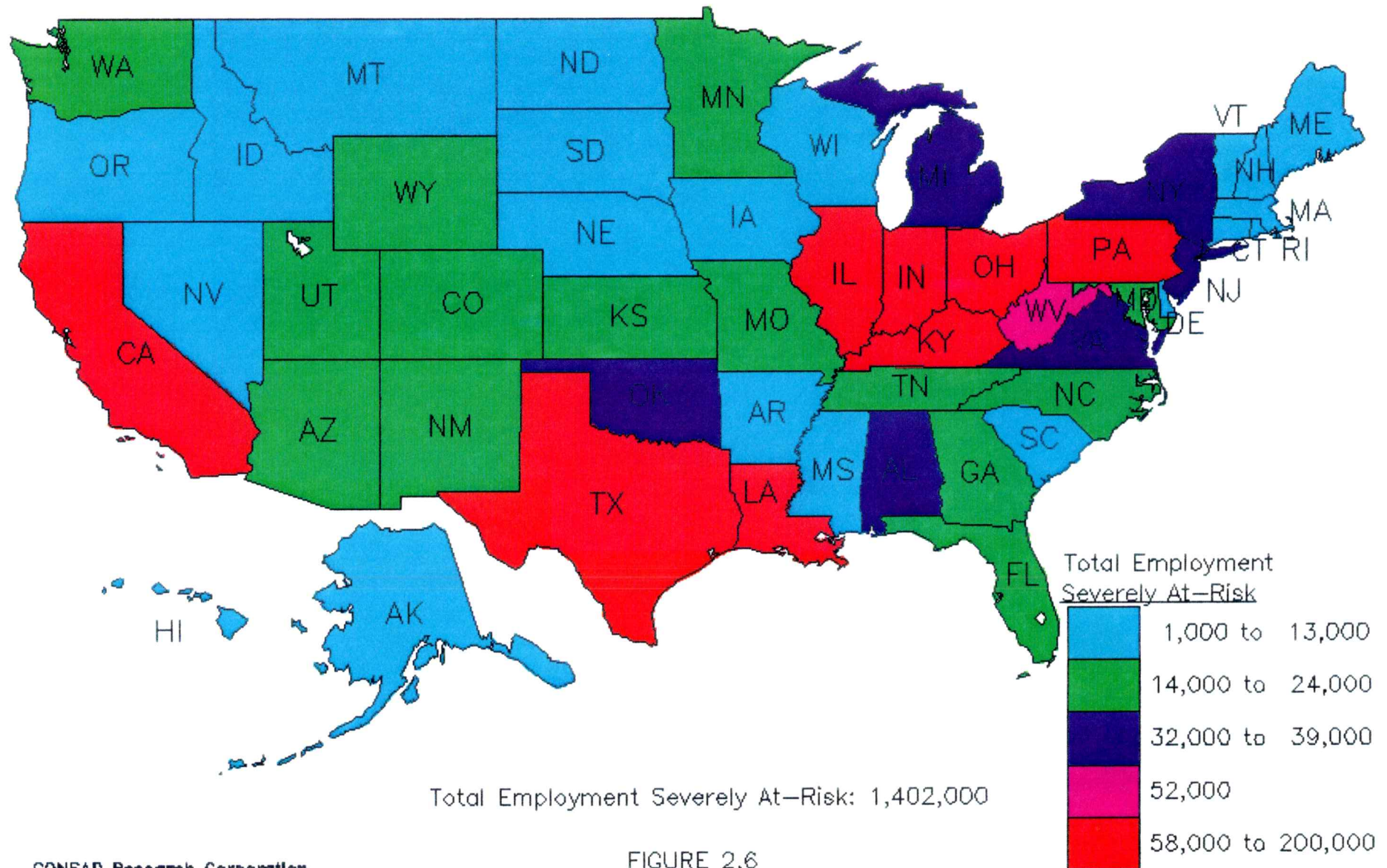
2.11

# Total State Employment Directly Affected



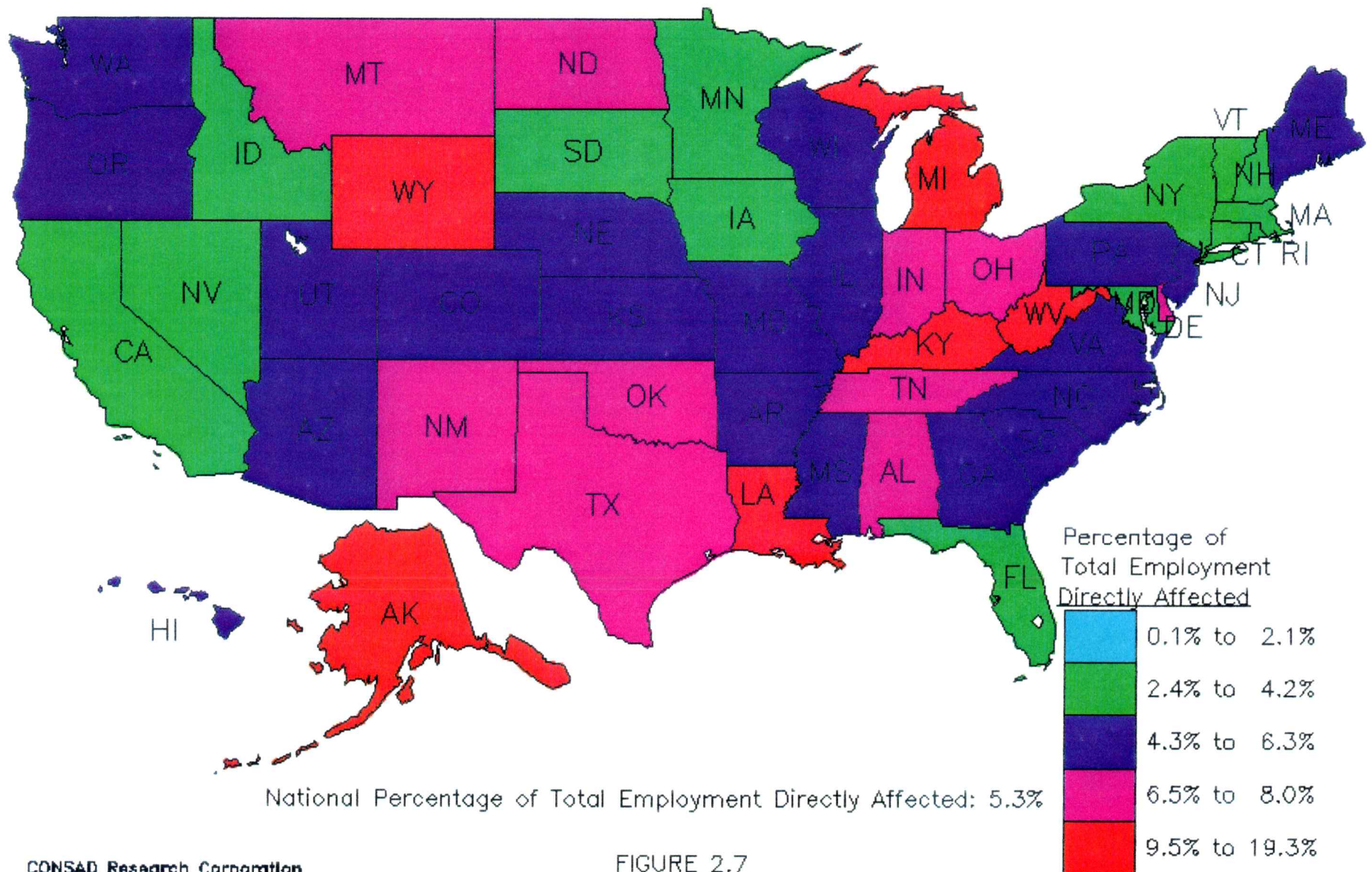


# State Employment Directly Affected: Severely At-Risk



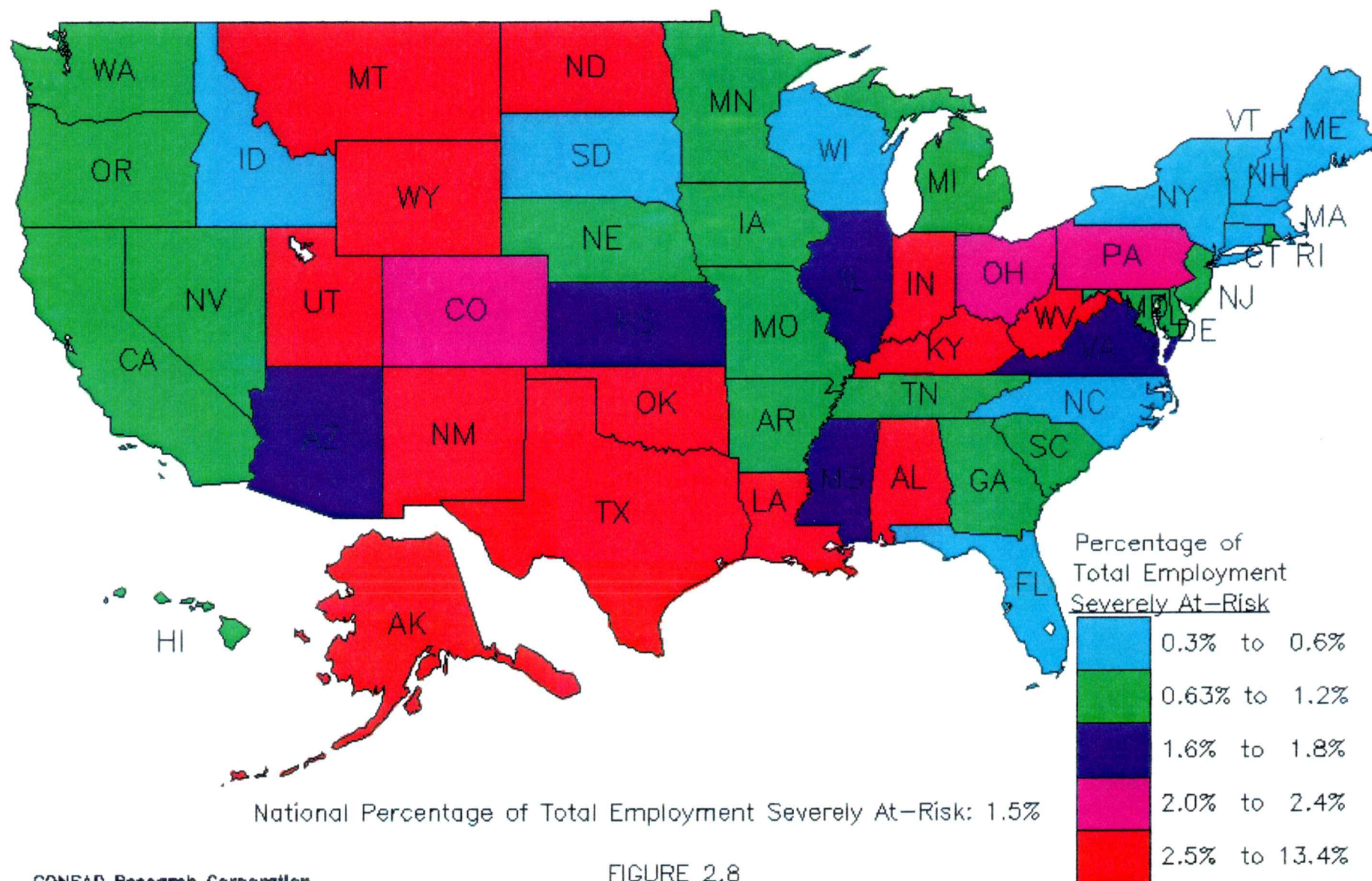


# Percentage of Total State Employment Directly Affected

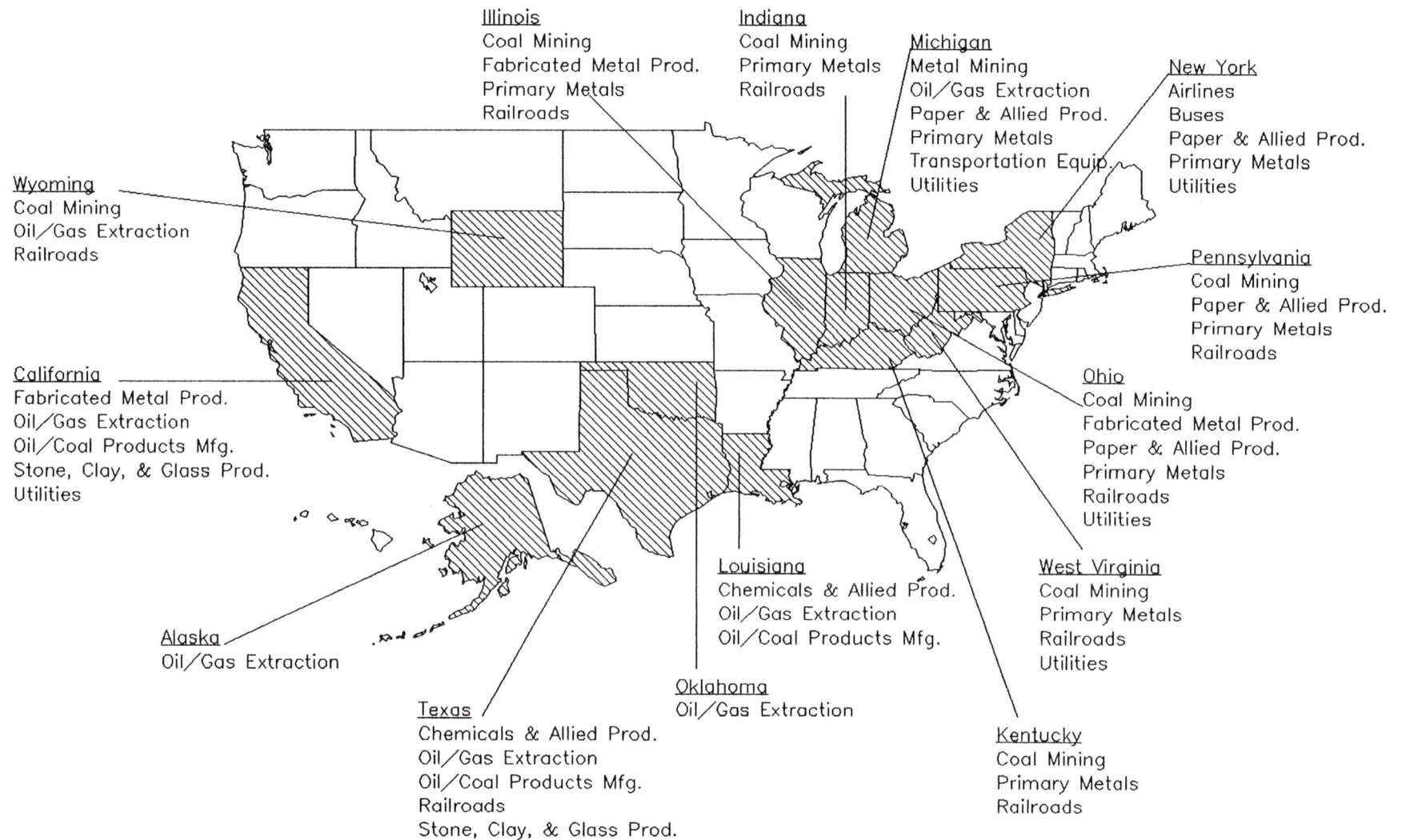




# Percentage of Total State Employment Severely At-Risk



# Most Vulnerable Industries in Selected States





As indicated, the most vulnerable industries most often include: coal mining, oil and natural gas extraction, oil/coal products manufacturing, primary metals manufacturing, utility services, and railroad transportation.

## 2.2 Jobs Lost in the Immediate Short Term

### 2.2.1 Results

As with jobs-at-risk, the estimates of jobs lost in the short term is not based on econometric modelling or theory. If firms attempt to pass their production cost increases on to their customers, they can expect -- depending upon the responsiveness of the demand for their products to general price increases -- decreases in the quantities of their products demanded. Furthermore, assuming firms, again, in the short run, cannot easily change their production processes, fewer workers will be needed to produce their products as the amount demanded decreases in response to increased prices. Consequently, firms directly affected will have to reduce employment to cope with the decline in demand caused by higher prices.

In addition to these direct job losses, the imposition of a carbon tax will also produce potential short-term indirect and induced job losses in other industries. That is, job losses will result for employees of firms that furnish goods and services both to directly impacted industry sectors and to employees from the directly affected industry sectors. These indirect and induced impacts are expected to be at least as large as the direct impacts.

Within the short term following the imposition of a \$24 per ton carbon tax, approximately 240,300 to 360,400 jobs are expected to be lost directly and indirectly as a result of the carbon tax. It is expected that the indirect job losses will disproportionately fall on those industries that furnish goods and services both to the most heavily directly affected industries as well as to the employees who will lose their jobs in those industries. These estimates are, generally, consistent with the short-term job loss estimates produced by other researchers (see Section 2.2.2).

While the majority (approximately 68 percent) of the jobs that are directly lost are expected to be in sectors that are not in the group of most vulnerable industries, the likelihood of job loss is far greater among workers in the most vulnerable industries. Specifically, a worker in the group of most vulnerable industries is 8.5 times more likely to lose his or her job in the short term as is a worker in a non-vulnerable industry. More than 32 percent of direct job losses are projected to occur in industries that employ only 5.3 percent of the nation's job holders.

Further examination of the estimates of the jobs directly lost in the short term at the two-digit standard industrial classification (SIC) industry level reveals that the industries with the largest estimated numbers of jobs directly lost include the following:

| <u>SIC</u> | <u>Description</u>                  | <u>Estimated Number<br/>of Jobs Directly<br/>Lost in the<br/>Short Term</u> |
|------------|-------------------------------------|-----------------------------------------------------------------------------|
| 58         | Eating and drinking places          | 10,500-15,700                                                               |
| 49         | Electric, gas and sanitary services | 8,400-12,500                                                                |
| 12         | Coal mining                         | 6,500-9,800                                                                 |
| 13         | Oil and gas extraction              | 5,800-8,800                                                                 |
| 45         | Transportation by air               | 5,300-8,000                                                                 |

Moreover, in relative terms (determined on the basis of the number of jobs lost in an industry as a percentage of total employment in the industry), those industries (at the two-digit SIC level) most impacted include most of the same industries:

| <u>SIC</u> | <u>Description</u>                  | <u>Jobs Directly<br/>Lost As a<br/>Percentage of<br/>Employment in<br/>the Short Term</u> |
|------------|-------------------------------------|-------------------------------------------------------------------------------------------|
| 12         | Coal mining                         | 4.7-7.0                                                                                   |
| 13         | Oil and gas extraction              | 2.1-3.1                                                                                   |
| 29         | Petroleum and coal products         | 1.4-2.2                                                                                   |
| 49         | Electric, gas and sanitary services | 0.9-1.4                                                                                   |
| 45         | Transportation by air               | 0.9-1.3                                                                                   |

Not surprisingly, those industries expected to incur the greatest number of jobs directly lost in the short term -- both in absolute and relative terms -- are generally those industries that have been designated most vulnerable to the carbon tax. One notable exception is the restaurant industry. With its more than six million workers, this industry, in absolute terms, is expected to have the greatest number of jobs directly lost.

#### 2.2.2 Evidence from Macroeconomics Models

In this section, CONSAD's estimates of total jobs lost in the short term are compared to the short-term job losses estimated by other researchers. In particular, the results from the following



studies were reviewed: Data Resources, Inc. (DRI)/McGraw-Hill for the U.S. Congressional Budget Office (CBO), the U.S. Department of Commerce, the U.S. Environmental Protection Agency (EPA), and The Urban Institute (through EPA); and the Goulder Computable General Equilibrium (CGE) Model. These results were found to be generally compatible with the short-term job loss estimates produced by CONSAD. Detailed descriptions of both the DRI/McGraw-Hill Econometric Model and the Goulder CGE Model are provided in Appendix C.

The few analysts who have estimated short-term impacts have concentrated on aggregate outcomes. Nevertheless, the few estimates made have indicated sizable, short-term, adverse employment consequences, substantial declines in national income and substantial costs for reducing CO<sub>2</sub> emissions. In particular, the CBO, based on simulations conducted with the quarterly econometric model of the U.S. economy developed by DRI/McGraw Hill, has projected that a moderate \$10 per ton carbon tax which gradually increases to \$100 per ton of carbon would, during its first five years, provoke a two percent decline in GNP (a decrease of more than \$100 billion annually). Moreover, the CBO states that:

The transition could be much more difficult if carbon charges were imposed suddenly...by 1992 the economy could enter a period of stagnation for several years, with little GNP growth and sharp rises in unemployment. These calculations suggest that it would be difficult to mitigate these effects through other measures (CBO, 1990, p.37).

The results derived from the DRI/McGraw-Hill Econometric Model, in a study performed for the U.S. Department of Commerce, indicate that employment is projected to decline by 326,000 jobs within three years following the imposition of a \$24 per ton carbon tax (see Table 2.2). In a DRI/McGraw-Hill study performed for the EPA with a \$15 per ton carbon tax, short-term declines in employment, regardless of how the revenues from the carbon tax are assumed to be used, are expected sometime within the first five years after the carbon tax is imposed (see Table 2.2). The largest declines in employment range from 177,000 jobs within one year after the carbon tax is imposed (assuming the tax receipts are used to finance a reduction of employer-paid payroll taxes), to 310,000 jobs three years after the carbon tax is imposed (assuming the tax revenues are used to increase federal revenues). In comparison, the CBO (1990) analysis using the DRI model shows increased unemployment ranging from more than 200,000 to more than 500,000 jobs during these early years.

Data on short-term changes in total employment, by industry, associated with a \$15 per ton carbon tax are provided in Table 2.3 for the first two uses of the carbon tax revenues considered in Table 2.2. Regardless of whether it is assumed that the carbon tax receipts are used to increase federal government revenues or to reduce personal income taxes, the largest declines in employment occur three to four years after the tax is imposed. Those industries experiencing the largest numbers of lost jobs include

Table 2.2: Short-Term Changes in Total Employment Associated  
with a Carbon Tax and Different Uses of Tax Receipts

| Initial Carbon<br>Tax Rate | Use of Carbon Tax Receipts           | Years After Imposition of Carbon Tax |          |          |          |          |
|----------------------------|--------------------------------------|--------------------------------------|----------|----------|----------|----------|
|                            |                                      | 1                                    | 2        | 3        | 4        | 5        |
| \$24 per ton (1)           | Personal income tax reduction        | + 90,000                             | - 52,000 | -326,000 | - 1,000  | +203,000 |
| \$15 per ton (2)           | Federal revenue increase             | - 33,000                             | -222,000 | -362,000 | -358,000 | -317,000 |
|                            | Personal income tax reduction        | + 43,000                             | - 66,000 | -283,000 | -323,000 | -258,000 |
|                            | Corporate income tax reduction       | 0                                    | - 40,000 | - 90,000 | - 90,000 | -200,000 |
|                            | Employee-paid personal tax reduction | + 60,000                             | 0        | -170,000 | -240,000 | -220,000 |
|                            | Employer-paid payroll tax reduction  | -177,000                             | -161,000 | +260,000 | +395,000 | +614,000 |
|                            | Investment tax credit increase       | + 30,000                             | +190,000 | +220,000 | + 80,000 | -230,000 |

(1) Carbon taxes designed to stabilize CO<sub>2</sub> emissions at prior levels six years after imposition, to reduce CO<sub>2</sub> emissions 10 percent below prior levels 16 years after imposition, and to reduce CO<sub>2</sub> emissions 20 percent below prior levels 26 years after imposition in United States and OECD countries. Study sponsored by U.S. Department of Commerce (DRI/McGraw-Hill, 1992a).

(2) Carbon tax increased five percent annually for 20 consecutive years and held constant thereafter. Study sponsored by U.S. Environmental Protection Agency (DRI/McGraw-Hill, 1992b).



Table 2.3: Short-Term Changes in Industry Employment Associated with a Carbon Tax (1)

A. Tax Receipts Used to Increase Federal Government Revenues

| Industry                            | Years After Imposition of Carbon Tax |          |          |          |          |
|-------------------------------------|--------------------------------------|----------|----------|----------|----------|
|                                     | 1                                    | 2        | 3        | 4        | 5        |
| All nonagricultural establishments  | - 32,900                             | -221,600 | -361,800 | -358,000 | -317,300 |
| Mining                              | 1,000                                | - 3,000  | - 5,000  | - 7,000  | - 8,000  |
| Transportation and public utilities | - 2,000                              | - 14,000 | - 27,000 | - 29,000 | - 27,000 |
| Contract construction               | - 6,900                              | - 24,100 | - 39,800 | - 41,800 | - 35,800 |
| Primary metal industries            | 0                                    | - 5,000  | - 7,000  | - 5,000  | - 4,000  |
| Fabricated metal products           | - 1,000                              | - 7,000  | - 9,900  | - 7,100  | - 5,100  |
| Machinery, except electrical        | - 1,000                              | - 6,900  | - 12,000 | - 8,000  | - 4,100  |
| Electrical machinery                | - 1,000                              | - 5,900  | - 8,900  | - 7,000  | - 4,000  |
| Transportation equipment            | - 4,000                              | - 13,000 | - 17,000 | - 12,000 | - 8,000  |
| Miscellaneous manufacturing         | - 5,000                              | - 35,000 | - 43,000 | - 33,800 | - 27,700 |
| Services                            | - 3,600                              | - 32,700 | - 62,700 | - 69,100 | - 65,400 |
| Government                          | - 1,500                              | - 9,300  | - 28,400 | - 43,300 | - 53,800 |

B. Tax Receipts Used to Reduce Personal Income Taxes

| Industry                            | Years After Imposition of Carbon Tax |          |          |          |          |
|-------------------------------------|--------------------------------------|----------|----------|----------|----------|
|                                     | 1                                    | 2        | 3        | 4        | 5        |
| All nonagricultural establishments  | 43,900                               | - 66,500 | -282,700 | -323,300 | -258,500 |
| Mining                              | 1,000                                | - 2,000  | - 11,100 | - 14,100 | - 10,800 |
| Transportation and public utilities | 2,900                                | - 1,800  | - 17,800 | - 25,200 | - 22,900 |
| Contract construction               | - 10,800                             | - 40,800 | - 70,900 | - 82,000 | - 80,200 |
| Primary metal industries            | 1,000                                | - 3,000  | - 9,000  | - 7,000  | - 6,000  |
| Fabricated metal products           | 1,000                                | - 5,000  | - 10,900 | - 11,000 | - 8,000  |
| Machinery, except electrical        | 1,000                                | - 4,000  | - 15,000 | - 15,100 | - 12,000 |
| Electrical machinery                | 1,900                                | - 3,000  | - 10,000 | - 10,000 | - 8,100  |
| Transportation equipment            | 900                                  | - 5,000  | - 14,900 | - 12,900 | - 8,000  |
| Miscellaneous manufacturing         | 10,900                               | - 13,900 | - 42,900 | - 38,000 | - 32,900 |
| Services                            | 16,400                               | 9,800    | - 23,200 | - 29,700 | - 10,800 |
| Government                          | 0                                    | - 4,700  | - 17,300 | - 27,300 | - 37,500 |

(1) Carbon tax set initially at \$15 per ton and increased five percent annually for 20 consecutive years and held constant thereafter (The Urban Institute, 1992).

services, miscellaneous manufacturing, contract construction, government, and transportation and public utilities.

In the scenario where the carbon tax receipts are used to reduce personal income taxes (bottom half of Table 2.3), the largest declines in total employment in the short term -- 283,000 to 323,000 jobs -- also occur three to four years after the carbon tax is imposed. Moreover, those industries with the largest numbers of lost jobs are the same as described above.

A comparison of the results of the DRI/McGraw-Hill Econometric Model with those of the Goulder CGE Model is provided in Table 2.4. While the industrial sector definitions (i.e., aggregations) vary somewhat between the two models, the results are qualitatively consistent with each other. Both models project declines in economic activity and, in turn, declines in employment in each industry sector, in the short term, following the imposition of a carbon tax. In the DRI/McGraw-Hill model, the largest declines in total employment are projected in the contract construction sector and in the mining sector. The metals and machinery and transportation equipment sectors are also expected to have declines in employment substantially greater, in percentage terms, than most other industries. The Goulder model results indicate that coal output is expected to decline 37.1 percent in the short term followed by an 8.9 percent decline in petroleum refining output, a 3.3 percent decline in electric utility output, and a 2.8 percent decline in gas utility output. Again, CONSAD's estimates of short-term job losses are consistent with these results. The same

Table 2.4: Short-Term Percentage Changes in Industry Economic Activity Associated with a Carbon Tax

| DRI/ McGraw-Hill Econometric Model (1) |                                                             |        |                                                              |        | Goulder Computable General Equilibrium (CGE) Model (2)               |                                                                                         |
|----------------------------------------|-------------------------------------------------------------|--------|--------------------------------------------------------------|--------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Industry                               | Carbon Tax Receipts<br>Used to Increase<br>Federal Revenues |        | Carbon Tax Receipts<br>Used to Reduce<br>Personal Income Tax |        | Carbon Tax<br>Receipts<br>Used for Lump<br>Sum Income<br>Replacement | Industry                                                                                |
|                                        | Year 3                                                      | Year 4 | Year 3                                                       | Year 4 |                                                                      |                                                                                         |
| Mining                                 | - 0.71                                                      | - 1.00 | - 0.71                                                       | - 1.00 | - 0.08<br>-37.14<br>- 1.39                                           | Agriculture and<br>non-coal mining<br>Coal mining<br>Crude petroleum<br>and natural gas |
| Transportation and<br>public utilities | - 0.46                                                      | - 0.48 | - 0.30                                                       | - 0.42 | - 3.30<br>- 2.81                                                     | Electric utilities<br>Gas utilities                                                     |
| Petroleum and<br>products (3)          | 0                                                           | 0      | 0                                                            | 0      | - 8.91                                                               | Petroleum refining                                                                      |
| Contract construction                  | - 0.77                                                      | - 0.76 | - 1.37                                                       | - 1.49 | - 0.29                                                               | Construction                                                                            |
| Metals and<br>machinery (4)            | - 0.66                                                      | - 0.47 | - 0.78                                                       | - 0.75 | - 0.51                                                               | Metals and machinery                                                                    |
| Transportation<br>equipment            | - 0.87                                                      | - 0.61 | - 0.76                                                       | - 0.66 | + 0.02                                                               | Motor vehicles<br>(transportation<br>equipment)                                         |
| Miscellaneous<br>manufacturing (5)     | - 0.40                                                      | - 0.31 | - 0.40                                                       | - 0.35 | - 0.37                                                               | Miscellaneous<br>manufacturing                                                          |
| Services (6)                           | - 0.17                                                      | - 0.18 | - 0.06                                                       | - 0.08 | - 0.43<br>- 0.01                                                     | Services, except<br>housing<br>Housing services                                         |

(1) Carbon tax initially set at \$15 per ton and increased five percent annually for 20 consecutive years. Estimated changes in economic activity represent changes in employment (DRI/McGraw-Hill, 1992b).

(2) Carbon tax set at \$25 per ton on a partial-destination basis (i.e., on carbon-based products with substantial carbon content). Estimated changes in economic activity represent changes in production (Goulder, 1991b).

(3) Production of petroleum and products is declining in baseline scenario; decline is not affected by carbon tax.

(4) Includes DRI/McGraw-Hill model sectors for primary metal industries, fabricated metal products, non-electrical machinery and electrical machinery.

(5) Includes 14 individual industrial sectors from DRI/McGraw-Hill model.

(6) Includes DRI/McGraw-Hill model sectors for services and for finance, insurance, and real estate.



generally carbon-intensive industry sectors are expected to be most heavily impacted by the imposition of a carbon tax.

### 3.0 INTERMEDIATE AND LONG-TERM JOB LOSSES AND TRANSITION EFFECTS

In the intermediate and long run (more than five years) following the imposition of a carbon tax, businesses will have greater flexibility to respond to the cost increases from a carbon tax or an equivalent policy to reduce carbon use. In the intermediate run, as existing physical equipment wears out or becomes obsolete, current equipment can be replaced with less carbon intensive, more energy efficient equipment. However, the replacement process may be somewhat delayed because a carbon tax will divert funds from a business which would otherwise be available for investment. As a result, on balance, a carbon tax may well impede and retard the replacement of existing carbon-intensive equipment instead of stimulating and advancing replacement.

In the long run, applied research and development could produce technological improvements that will provide reductions in carbon use and increases in energy efficiency. To the degree, however, that these technological improvements are embedded in new physical equipment and cannot be achieved by modifying existing equipment, the improvements will be introduced into firms' production processes principally as the existing equipment is replaced, and only as financial resources permit. Nevertheless, in the long run, as improved technologies are implemented, patterns of economic activity throughout the nation will change, and associated patterns of employment will gradually adapt.

To evaluate the likely employment consequences of intermediate and long-term business adjustments, the results from several appropriate studies have been reviewed and synthesized. The studies have been sponsored primarily by the U.S. Department of Commerce (DOC) or the U.S. Environmental Protection Agency (EPA), and have employed either DRI/McGraw-Hill econometric models, the Goulder computable general equilibrium (CGE) model, or the Jorgenson-Wilcoxon CGE model. Descriptions of the structure and implementation of each of these models are presented in Appendix C. Results from these models in regard to employment effects in the intermediate run, are summarized in Section 3.1, and results relating to long-term effects are presented in Section 3.2.

### 3.1 Intermediate Term Results

Table 3.1 contains projections of changes in national employment levels in 2000, the year when specific carbon reducing targets are being advocated under several CO<sub>2</sub> mitigation proposals. These projections have been derived using DRI/McGraw-Hill econometric models. Separate estimates are presented for two levels of carbon taxes in 2000: \$24.43 and \$120 per ton. In addition, for the \$24.43 per ton scenario, separate estimates are reported for six different ways in which the revenues from the carbon tax might be used (so-called revenue recycling).

As shown in Table 3.1, in all instances but one, large decreases in employment are projected in 2000 if a carbon tax is imposed. Depending upon the tax schedule and the way in which the



Table 3.1: Intermediate-Term Changes in Total  
Employment Associated with a Carbon Tax  
and Different Uses of Tax Receipts in 2000

| Carbon Tax<br>Rate in 2000 | Use of Carbon Tax Receipts             | Change in<br>Employment |
|----------------------------|----------------------------------------|-------------------------|
| \$120 per<br>ton (1)       | Personal income tax reduction          | -658,000                |
| \$24.43 per<br>ton (2)     | Federal revenue increase               | -410,000                |
|                            | Personal income tax reduction          | -335,000                |
|                            | Corporate income tax reduction         | -330,000                |
|                            | Employee-paid payroll tax<br>reduction | -310,000                |
|                            | Employer-paid payroll tax<br>reduction | +339,000                |
|                            | Investment tax credit increase         | -270,000                |

(1) Carbon tax designed to stabilize CO<sub>2</sub> emissions at prior levels six years after imposition, to reduce CO<sub>2</sub> emissions 10 percent below prior levels 16 years after imposition, and to reduce CO<sub>2</sub> emissions 20 percent below prior levels 26 years after imposition in United States and OECD countries. Study sponsored by U.S. Department of Commerce (DRI/McGraw-Hill, 1992a).

(2) Carbon tax initially set at \$15 per ton in 1990 and increased five percent annually for 20 consecutive years and held constant thereafter. Study sponsored by U.S. Environmental Protection Agency (DRI/McGraw-Hill, 1992b).

tax receipts are used, job losses range from somewhat less than 300,000 to more than 600,000.

The only scenario where total employment has been projected to increase in the year 2000 assumes that all revenues generated by the carbon tax will be transferred from the government to businesses in the form of reductions in the payroll taxes paid by employers. With two other business tax reduction scenarios, however, decreases in total employment have been projected for 2000: in these two scenarios, carbon tax revenues will be transferred to businesses in the form of either decreases in corporate income taxes or increases in the investment tax credit.

These results suggest that for the adverse effects of a carbon tax on employment to be mitigated, a highly unlikely transfer of tax revenues to businesses must be tightly focused on firms' required payments on their employees' accounts. In effect, the carbon tax revenues must be used to finance business subsidies that, at the margin, reduce firms' costs of employing workers, and thereby encourage the firms to maintain or increase the sizes of their workforces -- a policy that has unpredictable consequences for the carbon reduction sought by the scenario.

In addition, readers should recall that during the first two years after imposition of a carbon tax, as reported in Section 2.2.2, using all of the tax revenues to reduce the payroll taxes paid by employers has been shown to be insufficient to avoid decreases in total employment. Rather, in those years, total

employment has been projected to fall by 177,000 and 161,000 under the employer-paid payroll tax reduction.

Furthermore, as explained below, it is most unlikely that job losses could be avoided in the industries projected to experience the most adverse economic impacts as a result of a carbon tax, even if the payroll taxes paid by firms in those industries were reduced to zero. In those industries, large explicit wage subsidies -- a very unlikely public policy -- would doubtless be required to avert decreases in employment in response to a carbon tax. Besides, with fixed income recipients facing the price increases brought on by the carbon tax, a full use of the carbon tax receipts to reduce corporate taxes is highly unlikely.

Looking somewhat beyond the year 2000, Figure 3.1 displays the yearly differences from the base case projected for both employment and unemployment in the simulation performed by DRI/McGraw-Hill for the U.S. Department of Commerce; the annual levels of the carbon tax are also presented. These estimates, compiled by DRI/McGraw-Hill in a special data retrieval and validation assignment conducted expressly for CONSAD, forecast the number of jobs lost in 2000 to be 658,000. The year in which the maximum number of jobs is projected to be lost, relative to the base case, is 2007. The difference in employment forecast for that year is 1,685,000 jobs. The projected difference in unemployment also achieves its peak level of 1,323,000 in that year. (Almost identical results occur in the year 2003.) The anticipated yearly loss of more than



## Employment and Unemployment Difference from Base, DOC/OECD Model

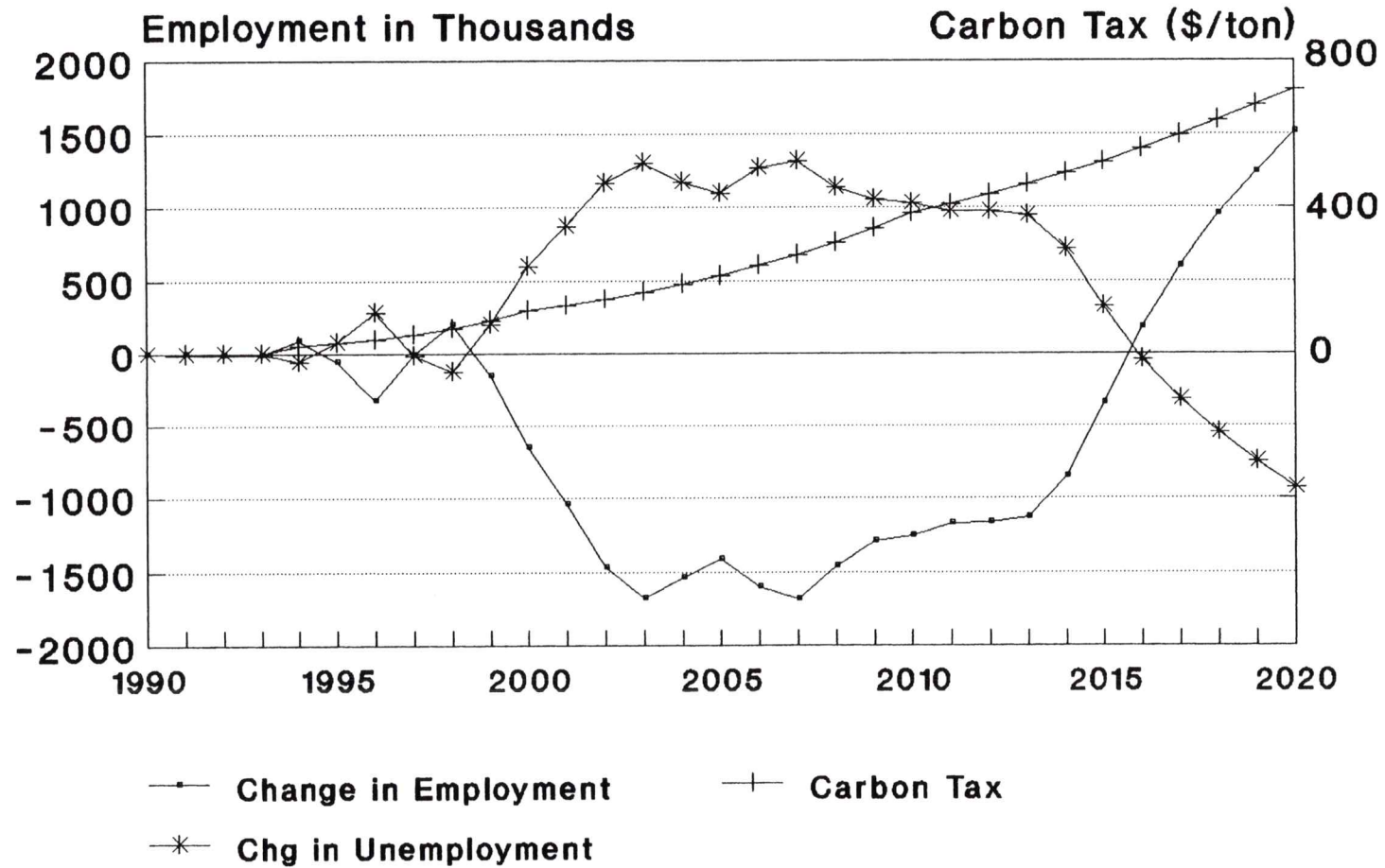


FIGURE 3.1

1,000,000 jobs continues throughout the first decade of the 21st century.

The results presented above all relate to aggregate employment. Forecasts of changes in economic activity are seldom reported for individual industries. Where such forecasts have been developed, however, they uniformly indicate that a specific group of industries will experience severe, adverse economic impacts in 2000 as a result of the imposition of a carbon tax beginning in 1990.

Table 3.2 presents projections derived with the DRI/McGraw-Hill Econometric Model for a carbon tax set initially at \$15 per ton. These data reveal that, regardless of whether the carbon tax revenues are used to increase federal government revenues or to reduce personal income taxes, the industries incurring sizable projected job losses include: contract construction, transportation and public utilities, mining, miscellaneous manufacturing industries, government and, somewhat less consistently, services. These are the same industries for which substantial short-term job losses have been forecast, as reported previously in Table 2.3.

Moreover, results from the Goulder CGE model are once again broadly consonant with the comparable projections from the DRI/McGraw-Hill model. In particular, for 2000, both models forecast declines in economic activity, and hence in employment, for all industries reported in Table 3.3. Both models estimate the largest percentage decreases in the mining industries. In

Table 3.2: Intermediate-Term Changes in  
Industry Employment Associated  
With a Carbon Tax in 2000 (1)

| Industry                            | Carbon Tax Receipts Used to     |                                  |
|-------------------------------------|---------------------------------|----------------------------------|
|                                     | Increase<br>Federal<br>Revenues | Reduce<br>Personal<br>Income Tax |
| All nonagricultural establishments  | -409,600                        | -335,200                         |
| Mining                              | - 17,000                        | - 17,000                         |
| Transportation and public utilities | - 32,700                        | - 29,700                         |
| Contract construction               | - 32,100                        | -110,100                         |
| Primary metal industries            | - 4,000                         | - 8,000                          |
| Fabricated metal products           | - 7,000                         | - 13,000                         |
| Machinery, except electrical        | - 3,900                         | - 14,000                         |
| Electrical machinery                | - 6,000                         | - 11,000                         |
| Transportation equipment            | - 9,000                         | - 12,100                         |
| Miscellaneous manufacturing         | - 29,000                        | - 41,000                         |
| Services                            | - 99,300                        | - 5,600                          |
| Government                          | - 81,800                        | - 52,800                         |

(1) Carbon tax set initially at \$15 per ton and increased five percent annually for 20 consecutive years and held constant thereafter (The Urban Institute, 1992).



Table 3.3: Intermediate-Term Percentage Changes in Industry Economic Activity Associated with a Carbon Tax in 2000

| DRI/ McGraw-Hill Econometric Model (1) |                                                             |                                                              | Goulder Computable General Equilibrium (CGE) Model (2)               |                                                   |
|----------------------------------------|-------------------------------------------------------------|--------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------|
| Industry                               | Carbon Tax Receipts<br>Used to Increase<br>Federal Revenues | Carbon Tax Receipts<br>Used to Reduce<br>Personal Income Tax | Carbon Tax<br>Receipts<br>Used for Lump<br>Sum Income<br>Replacement | Industry                                          |
| Mining                                 | -2.56                                                       | -2.56                                                        | -39.0<br>- 0.9                                                       | Coal mining<br>Crude petroleum<br>and natural gas |
| Transportation and<br>public utilities | -0.54                                                       | -0.49                                                        | - 3.6<br>- 2.3                                                       | Electric utilities<br>Gas utilities               |
| Petroleum and<br>products (3)          | 0                                                           | 0                                                            | - 7.2                                                                | Petroleum refining                                |
| Metals and<br>machinery (4)            | -0.37                                                       | -0.80                                                        | - 0.4                                                                | Non-energy<br>manufacturing                       |
| Transportation<br>equipment            | -0.46                                                       | -0.62                                                        |                                                                      |                                                   |
| Miscellaneous<br>manufacturing (5)     | -0.27                                                       | -0.39                                                        |                                                                      |                                                   |
| Contract construction                  | -0.53                                                       | -1.82                                                        |                                                                      |                                                   |
| Services (6)                           | -0.23                                                       | -0.01                                                        | - 0.5                                                                | Non-energy services                               |

(1) Carbon tax initially set at \$15 per ton and increased five percent annually for 20 consecutive years. Estimated changes in economic activity represent changes in employment (DRI/McGraw-Hill, 1992b).

(2) Carbon tax set at \$25 per ton on a partial-destination basis (i.e., on carbon-based products with substantial carbon content). Estimated changes in economic activity represent changes in production (Goulder, 1991b).

(3) Production of petroleum and products is declining in baseline scenario; decline is not affected by carbon tax.

(4) Includes DRI/McGraw-Hill model sectors for primary metal industries, fabricated metal products, non-electrical machinery and electrical machinery.

(5) Includes 14 individual industrial sectors from DRI/McGraw-Hill model.

(6) Includes DRI/McGraw-Hill model sectors for services and for finance, insurance, and real estate.

addition, the DRI/McGraw-Hill model predicts relatively large percentage reductions in employment for the transportation and public utilities, transportation equipment, and contract construction industries, while the Goulder model projects relatively large percentage decreases in output in the electric utilities, gas utilities, and petroleum refining industries. These results are generally consistent with the estimates of short-term job losses presented in Chapter 2. Most notably, the same carbon-intensive industries are projected to be heavily impacted by the imposition of a carbon tax in both the short-run and the intermediate-run.

### 3.2 Long-Term Consequences

The models that are best-suited for estimating the long-term economic effects of prospective public policies are computable general equilibrium (CGE) models. Projections of the long-term economic consequences of imposing a carbon tax have been developed with two CGE models: the Goulder model and the Jorgenson-Wilcoxon model. Descriptions of these models are contained in Appendix C.

The most pertinent results tabulated for these models in available reports are the estimated long-term percentage differences in the output levels of specific industries when a carbon tax is imposed, relative to their estimated output levels without a carbon tax. Those results are summarized for the two models in Table 3.4. The results reported for the Jorgenson-Wilcoxon model relate to output levels projected in 2020 for two

Table 3.4: Long-Term Percentage Changes in Output Associated with a Carbon Tax

| Industry                                  | Jorgenson-Wilcoxon Computable General<br>Equilibrium (CGE) Model (1) |                                 | Goulder Computable General<br>Equilibrium (CGE) Model (2) |                                              |
|-------------------------------------------|----------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------|----------------------------------------------|
|                                           | Stabilization of CO <sub>2</sub><br>Emissions in 2020 at             |                                 | Long-Term<br>Steady<br>State                              | Industry                                     |
|                                           | 1990<br>Levels                                                       | 80 Percent<br>of 1990<br>Levels |                                                           |                                              |
| Agriculture, forestry,<br>and fisheries   | + 0.4                                                                | + 1.2                           | - 0.7                                                     | Agriculture and<br>non-coal mining           |
| Metal mining                              | - 0.9                                                                | - 2.3                           |                                                           |                                              |
| Non-metallic mineral mining               | - 0.9                                                                | - 2.7                           |                                                           |                                              |
| Coal mining                               | -26.3                                                                | -53.1                           | -42.6                                                     | Coal mining                                  |
| Crude petroleum and<br>natural gas        | - 3.2                                                                | -11.2                           | -10.5                                                     | Synthetic fuels                              |
| Electric utilities                        | - 5.3                                                                | -15.1                           | - 4.6                                                     | Electric utilities                           |
| Gas utilities                             | - 1.7                                                                | - 5.6                           | - 3.3                                                     | Gas utilities                                |
| Petroleum refining                        | - 2.5                                                                | - 8.3                           | - 7.2                                                     | Petroleum refining                           |
| Construction                              | - 0.5                                                                | - 1.4                           | - 0.9                                                     | Construction                                 |
| Primary metals                            | - 1.4                                                                | - 3.1                           | - 0.6                                                     | Metals and machinery                         |
| Fabricated metal products                 | - 0.5                                                                | - 1.0                           |                                                           |                                              |
| Machinery, except electrical              | - 0.8                                                                | - 2.2                           |                                                           |                                              |
| Electrical machinery                      | - 0.6                                                                | - 1.5                           |                                                           |                                              |
| Motor vehicles                            | - 0.8                                                                | - 2.1                           | - 0.5                                                     | Motor vehicles<br>(transportation equipment) |
| Stone, clay and glass<br>products         | - 1.0                                                                | - 2.7                           | - 0.7                                                     | Miscellaneous manufacturing                  |
| Chemicals, rubber and<br>plastic products | - 0.9                                                                | - 2.5                           |                                                           |                                              |
| Food and kindred products                 | + 0.9                                                                | + 2.7                           |                                                           |                                              |
| Tobacco manufactures                      | + 0.5                                                                | + 1.7                           |                                                           |                                              |
| Other manufacturing and trade             | - 0.1 to -0.8                                                        | 0.0 to -2.2                     |                                                           |                                              |
| Finance, insurance and<br>real estate     | - 0.1                                                                | - 0.1                           | - 0.9                                                     | Services, except housing                     |
| Other services                            | + 0.1                                                                | + 0.3                           | - 0.8                                                     | Housing services                             |
| Government enterprises                    | - 0.3                                                                | - 0.7                           |                                                           |                                              |

(1) Required carbon tax projected for 2020 is \$16.96 per ton for stabilization of CO<sub>2</sub> emissions at 1990 levels and \$60.09 per ton for stabilization at 80 percent of 1990 levels (Jorgenson, Slesnick and Wilcoxon, 1991).

(2) Carbon tax set at \$25 per ton on a partial-destination basis (i.e., on carbon-based products with substantial carbon content) (Goulder, 1991b).



alternative carbon tax schedules: one designed to stabilize CO<sub>2</sub> emissions at their 1990 levels, and the other designed to stabilize emissions at 80 percent of those levels. The results reported for the Goulder model relate to output levels projected for a \$25 carbon tax when the model achieves a steady-state pattern of economic activity.

The data in Table 3.4 indicate that long-term decreases in output are projected for virtually all industries in response to a carbon tax. Moreover, both models forecast that massive percentage reductions in output will occur in the coal mining industry, and that large percentage decreases will be experienced in the production of other fossil fuels (crude petroleum and natural gas, synthetic fuels), in petroleum refining, and in electric and gas utilities. The Jorgenson-Wilcoxon model, which includes a more detailed specification of industries, also projects sizable percentage decreases for certain manufacturing industries (e.g., primary metals; non-electrical machinery; motor vehicles; stone, clay, and glass products; and chemicals, rubber, and plastic products), and for metal and non-metallic mineral mining. Most other industries are predicted to experience relatively small long-term declines.

Long-term output effects of the magnitudes projected by those models for the coal mining industry imply that substantial changes in the composition of employment will occur over a period of 20 years. The changes in industry output are strongly indicative of the long-term structure of the economy toward which transitional

adjustments would be directed. Comparing the industries that are projected to be hard-hit in the intermediate term and the long term with those forecast to be heavily impacted in the short term provides strong confirmatory evidence that the estimates of jobs-at-risk and jobs directly lost that have been developed in Chapter 2 typically relate to the same industries that the CGE models indicate to be severely affected in the long-term. Although there is insufficient industry detail in the CGE models to permit explicit comparison with the results from Chapter 2, the same industries are consistently determined to be most severely affected -- coal mining; crude oil and gas extraction; chemicals; petroleum refining; primary metals; stone, clay, and glass products; non-electrical machinery; rubber and plastics; motor vehicles; electric and gas utilities; and components of the transportation industry.

It is also important to note, in Table 3.4, the paucity of industries that are projected to experience increases in output and, perhaps, employment after the imposition of a carbon tax or equivalent policy. Those industries include only: agriculture, forestry, and fisheries, food and kindred products, and tobacco manufacture. Clearly, the growth and development projected for these industries is inadequate to offset, to any substantial degree, the structural job losses projected for all of the other industries examined.

In summary, our review of pertinent analyses performed with current econometric and CGE models has yielded substantial corroborating evidence that policies intended to reduce CO<sub>2</sub>

emissions will have sizable and enduring adverse effects on jobs and unemployment in both the intermediate and long terms.



#### 4.0 CONCLUSIONS AND RECOMMENDATIONS

This study of the economics of the carbon tax reveals that a carbon tax or any other equivalent policy would impose enormously expensive and hidden costs on the economy -- which will be borne by an unsuspecting labor force. Even if the scientific proof of the benefits were more conclusive, the negative jobs consequences of the carbon tax would eliminate those benefits. If one were to design the most immediately damaging method to mitigate the effects of global climate change, a carbon tax would be high on the list.

##### 4.1 The Extravagance of Short-Term Sacrifice

It is well known that CO<sub>2</sub> emitted into the earth's atmosphere will reside there for an extended period -- one or two centuries -- before it is fully assimilated. Consequently, for any cumulative reduction in CO<sub>2</sub> emissions that might be sought throughout a multiyear period, the precise timing of the constituent reductions in emissions is relatively unimportant. Most importantly, no appreciable advantage is gained by achieving the reductions early in the period rather than deferring them until later in the period.

Conversely, the cost of achieving reductions in CO<sub>2</sub> emissions in the short run is extremely high. Because fuel requirements are, to a substantial degree, embodied in the existing stock of physical equipment, opportunities for switching from carbon-intensive fuels to fuels with markedly lower levels of CO<sub>2</sub> emissions are, in the short run, severely limited. Short-term reductions in carbon utilization and CO<sub>2</sub> emissions can therefore be accomplished

principally through decreases in production and consumption, necessarily requiring, for an unfortunate small percentage of the workforce, substantial sacrifices in income and employment.

Alternatively, if reductions in CO<sub>2</sub> emissions are coordinated with the replacement of physical equipment as it becomes obsolete or inoperative, the costs incurred in achieving the emissions reductions will be much lower than those that would be required to accomplish the reductions immediately. The incremental cost of acquiring less carbon-intensive, more energy-efficient physical equipment at, or near, the normal time for equipment replacement will generally be substantially less than the cost of achieving equivalent emissions reductions earlier. Perhaps most importantly, coordinating emissions reduction with normal equipment replacement can avert the extreme deadweight costs associated with foregone consumption and corresponding job losses. In addition, deferring premature action provides an opportunity for technological improvements to emanate from successful research and development activities during the intervening time period. Accelerated implementation of improved technology can further reduce the costs of achieving any specific reductions in CO<sub>2</sub> emissions.

#### 4.2 Economic Incentives and Research and Development Expenditures

The purpose of the carbon tax is to induce businesses to take actions to reduce their carbon use which they would not otherwise have taken. Such incentives are asserted to be economically efficient mechanisms for achieving environmental objectives because

they encourage businesses that are most knowledgeable about their particular business activities to identify and implement the most cost-effective methods for achieving compliance with the stated environmental objectives. More specifically, it is claimed that businesses are most knowledgeable about the feasible compliance options and the costs of implementing those options for the particular business activities that they routinely operate and maintain.

In the case of the carbon tax, however, it is generally acknowledged that the most cost-effective methods that are ultimately achieved to reduce carbon use will depend upon the success of research and development efforts to develop improved, less carbon-intensive, technologies for performing specific business activities. Moreover, those same businesses can reasonably be expected to be most knowledgeable about the research and development programs that would be most successful in achieving even greater reductions, than are currently feasible, in the carbon-intensiveness associated with performing their business activities.

However, conducting research and development programs is expensive, and the carbon tax will extract revenues from businesses that will reduce their net cash flows, decrease their profits, and hence restrict their ability to obtain funding from lenders and investors. Thus, the carbon tax will likely systematically deny to firms the financial resources necessary to fund the research and development projects that are essential to identifying and



demonstrating more cost-effective options for reducing CO<sub>2</sub> emissions. Paradoxically, while the carbon tax has been strongly advocated as a cost-effective means for reducing carbon-intensiveness, it may, on balance, greatly impede the technological advancement that is so important to achieving even greater, more cost-effective, reductions in carbon use.

#### 4.3 Revenue Recycling: Not Appropriate or Sufficient

Revenue recycling, as a positive offset to the economically depressive carbon tax, is proving to be a distraction. Clearly, whatever is better fiscal policy today should be substituted for the current revenue system, regardless of the carbon tax! Granted, were there a carbon tax, its receipts would have to be recycled back to the economy (though some of it would almost certainly be used to increase government expenditures); to date, no recycling option that appears to be (politically and economically) feasible in any way invalidates the conclusions about the nation's jobs and the industries and states most affected. Basically, job losses will occur regardless of the way tax receipts are reused. No regime for expending the carbon tax receipts that has been devised to date alleviates the extensive job impacts described above, nor is it likely that one could be so designed. If tax receipts are used to finance reductions in corporate tax burdens in ways that encourage capital investment, job losses may be less severe. However, readily implementable changes in corporate tax structures

are unlikely to be sufficiently targeted and generous to alleviate the projected job losses.

#### 4.4 Relocation, Retraining, and Other Dislocation Costs

There is substantial physical and mental pain and anguish -- admittedly, difficult to quantify -- from prolonged layoffs or loss of benefits and income. There also are very serious health conditions, including mortality, tied to job, income, and wealth loss. Indeed, public health experts, occupational medicine specialists, and epidemiologists are increasingly seeking linkages between occupational, job status, and health records to study the relationship between psychosocial job characteristics and health outcomes.

Easier to monetize are the job retraining activities, public and private, sought by workers displaced by employment transition problems. We might draw on the experience of the Clean Air Act of 1990 where, under the Job Training Partnership Act, clean air employment transition funds up to \$250 million (\$50 million during an individual fiscal year), are available for the delivery of dislocated worker services to workers whose dislocation occurs as a consequence of an employer's compliance with the Clean Air Act. Approximately 15,000 prospective "job losers" resulting from the Clean Air Act are to be covered under the Act (if fully funded). To monetize the prospective costs of retraining workers whose jobs will be affected adversely by a carbon tax, it would not take many of the estimated job losers (e.g., 25 percent of all job losers by

the year 2000) to be an order of magnitude greater than those covered under the Clean Air Act of 1990.

Many of these dislocation-related costs will be borne, partially or totally, by the workers themselves, and by the private sector generally. Workers will (by and large) pay for relocation costs -- certainly if the move is undertaken for the purpose of searching for a new job. Much retraining cost will be borne by an employer, either the original employers retooling their firms and keeping their workers, or the employers whom the displaced employees have newly joined.

Given the magnitude of significant structural changes involved in the economy described above, and the likely differences in technical skills and skill levels between declining and growing industries, we can expect long, personally costly periods of unemployment and underemployment.



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