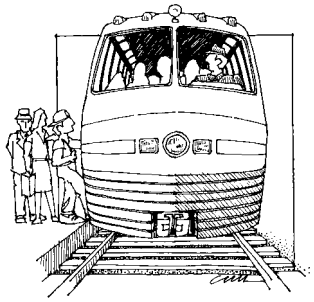
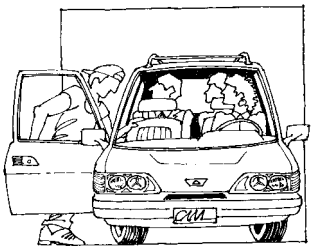
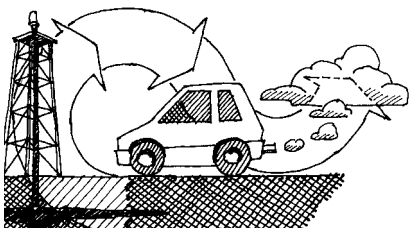
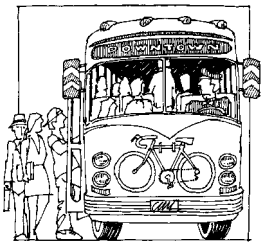
GETTING AROUND CLEAN AND GREEN

TRANSPORTATION AND THE ENVIRONMENT









NESEA

NORTHEAST SUSTAINABLE ENERGY ASSOCIATION
Leading the Way to Sustainable Transportation

GETTING AROUND CLEAN AND GREEN

TRANSPORTATION AND THE ENVIRONMENT

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Getting Around Clean and Green
Transportation and the Environment

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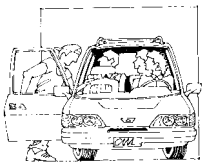
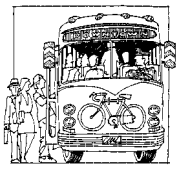
The Northeast Sustainable Energy Association is the nation's leading regional association involved in promoting awareness, understanding, and development of clean energy technologies that are good for the economy and the environment. Headquartered in Greenfield, Massachusetts, NESEA has worked successfully for 26 years in the fields of transportation, building construction, and renewable energy.

GETTING AROUND CLEAN AND GREEN

TRANSPORTATION AND THE ENVIRONMENT





INTRODUCTION

In this unit, students will explore their own transportation choices. They will also research the impacts various transportation options have on air quality, human health, and the environment, and will discover that they can make choices that will reduce many of the negative impacts of getting around in a car. Along the way, students will conduct research, work with graphs and charts, carry out surveys, and analyze the results. The final student project, a "Travel Guide of Clean & Green Ways to Get to Fun and Interesting Places," allows students to integrate all of what they've learned into a guide that will help friends and families get out and have fun while leaving the car (emissions) at home.

UNIT OVERVIEW

CHAPTER 1
INTRODUCTION TO TRANSPORTATION AND THE ENVIRONMENT

In this first lesson, students will identify their own transportation patterns and begin to consider the social and environmental costs and benefits associated with different modes of travel. This personal transportation information will serve as the basis for lessons.

Activities: Students will study transportation as a system that includes goals, inputs, processes, outputs, and feedback. Students will construct charts and graphs. They will make simple calculations to quantify how they, and the class as a whole, get around.

CHAPTER 2
TRANSPORTATION AND AIR QUALITY

This lesson addresses automobile pollutants and their effect on human health from an historic perspective. Students will realize that the challenge of reducing pollution from our transportation systems is an on-going struggle and that, although much is yet to be done, much has already been accomplished.

Activities: Students will research automobile pollutants, their effect on human health, and the historic efforts of those who are working for change. By constructing and interpreting timelines, students will evaluate the importance of social pressure in the acceptance of new technologies. By working with data, and constructing, reading, and interpreting graphs, students will analyze the effects of emission-reduction legislation and will come to their own conclusions about the effectiveness of pollution prevention efforts.

CHAPTER 3
CARPOOLING AND THE ENVIRONMENT

This and the next two lessons look at transportation choices students can make that will have a positive impact on reducing pollution and its negative impacts on human health and the environment. By helping students under-

stand that there are opportunities for action, we will empower them to become active, responsible citizens.

Activities: Students will conduct a data-gathering survey on the extent carpooling occurs in their community and compare this to census bureau data. Through simple calculations, students will quantify the pollution-saving value of carpooling. Students will design a carpool plan for their class.

CHAPTER 4
MASS TRANSIT

This lesson includes a brief introduction to the concept of mass transit but focuses primarily on the practical aspects of using local mass transit systems.

Activities: Students will interpret mass transit schedules and evaluate what it means for a mass transit system – a sample transportation system – to be successful. Students will read charts and graphs to plan a mass transit outing.

CHAPTER 5
GETTING AROUND CLEAN AND GREEN: A STUDENT CHALLENGE

This lesson draws on all that the students have learned by challenging them to produce a practical Travel Guide of Clean & Green Ways to Get to Fun and Interesting Places.

Activities: Production of a travel guide acts as the student's culminating project and provides the teacher with a valuable assessment tool. Student groups will plan environmentally sound outings to fun and interesting places of their choice and rate these trips in terms of fun, health, and environmental impact. The class will then assemble this collection of outings into a travel guide that they can share with friends, families, or the community at large.

RESOURCES

This unit supplies teachers with the necessary background information to bring the theme of clean and green transportation into the classroom. When information specific to a local setting is required, the unit directs the teacher on how to find that information. Although the unit provides background reading for students, it suggests web addresses and other resources that can further student research.

EDUCATION STANDARDS

This unit helps students develop skills and knowledge that address the following educational standards:

Standards for Technological Literacy. 2000
International Technology Education Association

Nature of Technology
Technology and Society
Design
Abilities for a Technological World
The Designed World

National Science Educational Standards. 1999
National Research Council

- Unifying Concepts and Processes
- Science as Inquiry
- Physical Science
- Science and Technology
- Science in Personal and Social Perspectives
- History and Nature of Science

National Geography Standards, Geography for Life. 1994
American Geographical Society, Association of American Geographers, National Council for Geographic Education

- The World In Spatial Terms
- Places And Regions
- Physical Systems
- Human Systems
- Environment And Society
- The Uses Of Geography

Curriculum Standards for Social Studies, Expectations of Excellence. 1994
National Council for the Social Studies

- Time, Continuity and Change
- People, Places and Environment
- Science, Technology, and Society
- Global Connections
- Civics

Principals and Standards for School Mathematics. 2000
National Council of Teachers of Mathematics

- Number and Operations
- Algebra
- Measurement
- Data Analysis and Probability
- Communication
- Connections
- Representation

CHAPTER 1

INTRODUCTION TO TRANSPORTATION AND THE ENVIRONMENT

CHAPTER 1

INTRODUCTION TO TRANSPORTATION AND THE ENVIRONMENT

ESSENTIAL QUESTIONS

▲ **What forms of transportation do people use most in this community?**

▲ **How do different forms of transportation effect us and the world around us?**

OBJECTIVES

The students will:

- Collect and record transportation data from daily experience.
- Analyze and compare personal transportation habits to those of the class.
- Classify components of a technological system in this case a transportation system.
- Compare environmental costs and benefits of various forms of transportation.

ACTIVITIES

PERSONAL TRANSPORTATION LOG

Time: Homework, minimum 1 hour over 3-4 days, ideally spanning 1 week. Personal transportation log analysis, 30 minutes in-class.

TRANSPORTATION SYSTEMS

Time: 45 minutes in-class.

STUDENT PREREQUISITES

- An understanding of percentages. Or this lesson can be used to reinforce a lesson on percentages.
- An understanding of energy and work.

STANDARDS

Technology: Understand a technological system.

Geography: Recognize consequences of technological advances on the environment.

Mathematics: Collect data; construct, read charts, practical application of percentages.

Language Arts: Group discussion, research.

History: Recognize the importance of individual choices and actions.

TEACHING NOTES

Few of us think about how we transport ourselves from one place to another, but the choices we make have definite impacts upon our society and the environment.

- In this lesson students will focus their attention on their own transportation choices and patterns by keeping a Personal Transportation Log.
- By doing simple calculations and by constructing a class chart, the students will be able to make comparisons between their own transportation habits and those of the class.
- Students will begin to consider the social and environmental costs and benefits associated with different modes of travel.
- This information will serve as the basis for later lessons, during which the exploration of transportation issues continues.
- Students will be evaluated on individual, small group, and whole class work by completing Personal Transportation Logs, worksheets, and by participation in class discussions.

BACKGROUND INFORMATION

Transportation is the process of moving people and products from one place to another. Where once human beings could get from point A to point B only by walking, we can now choose from many options. We even transport ourselves for recreation and exercise.

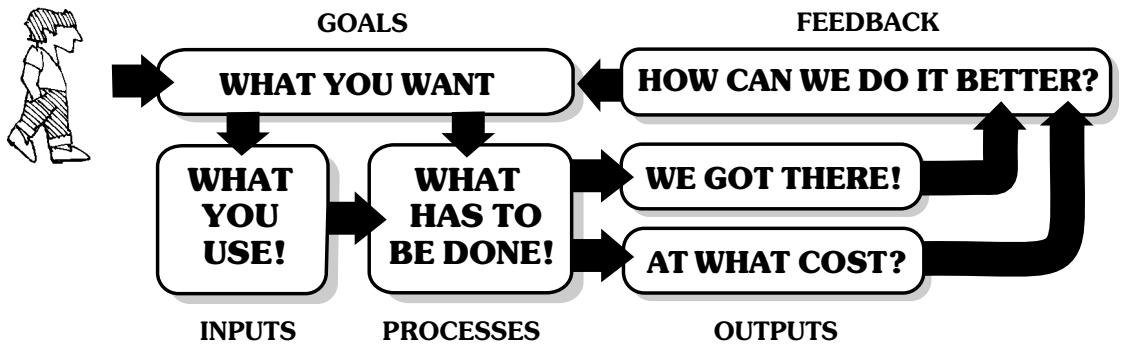
Moving things from here to there can be thought of as a transportation system. **A system includes: a goal, input, process, output and feedback.** The simplest transportation system is the act of walking to a destination – say to a river to get a drink of water. In this case the **goal** is to move oneself to the river. The **input** needed to do this includes a living body supplied with adequate food, water, and oxygen along with knowledge of how to get to the river. In this case the transportation **process** is to convert the food, water and oxygen into the energy needed to get to the river and then decide on what route to take and walk. The **output** is getting to the river, along with sweat, heat, and exhaled carbon dioxide and other gases. In this case let's imagine that our person chose to hike over a hill to get to the river. The **feedback** may be that the hill was too steep and that, in the future, this person will decide to take a path around the hill to get to the river. The transportation system is redesigned to meet a revised goal – to move oneself to the river using less effort.

Many aspects of today's transportation systems are actually outputs from other complex systems. Gasoline comes from oil that must be extracted, transported to refineries, and processed. This system itself relies on political, economic, and military systems that ensure companies maintain access to foreign oil. The refined gasoline must then be transported to local gas stations. Vehicles also need to be manufactured. To manufacture them, minerals need to be extracted from the earth and processed into useable forms. The finished vehicles need to be transported from one location to another. Consider too, the infrastructure necessary, (bridges, roads, railways etc.), creative processes of designing vehicles to carry people and goods, marketing schemes, road systems, and traffic rules for organization and safety.

As you can see, identifying all the components of a technology system can be challenging and confusing. The important point is for students to begin to see the larger picture of the pieces that need to be in place for a technology system to work, in this case a transportation system. **Use the following examples to help students understand parameters for defining a transportation technology system with regard to goals, input, process, output, and feedback.**

GOALS: A primary goal of any transportation system is to move products and people from point A to point B. Today, we can add recreation as another goal for some transportation systems. Less obvious, but just as important, goals of transportation systems are that they be low cost, get us to our destinations on-schedule and in a timely fashion, be safe, and be comfortable. Increasingly, many people would also like our transportation systems to be as close to pollution-free as possible and be independent of foreign-controlled resources, such as Middle East oil.

INPUTS: Gasoline, cars, minivans, roads, bridges, and drivers are all inputs into the United State's most popular transportation system – get-



ting around in family vehicles. Each of these inputs relies on additional complex systems such as: 1) mining metals and processing petroleum, 2) designing, manufacturing and transporting gasoline, cars, and trucks, 3) designing and building roads and bridges, and 4) staffing teachers, police, and the court system to train and monitor drivers for a safe transportation system. We can also add automotive repair, financial, insurance, and medical systems needed to maintain both cars and drivers.

PROCESSES: Converting fuel into motion is the most basic process of any transportation system. But other processes are important to maintain a safe, low cost, low pollution, timely transportation system. Safely driving the family car depends on systems that enforce traffic rules, educate drivers, and maintain roadways. Financial systems are needed to finance the purchase of new cars. Emissions regulations are needed to prevent too much pollution.

OUTPUTS: Moving products or people from one place to another are the central output of any transportation system. But many systems have unwanted outputs as well. Pollution, time spent stuck in traffic, spending money on insurance, fuel and car maintenance are a few examples.

FEEDBACK: How well is your transportation system working? Do you get to school on time or are you often stuck in traffic? Is your old car or bicycle still comfortable and safe? Do you spend too much money on insurance and car maintenance? Are there alternative transportation systems, or can you modify your current system in order to provide yourself with more of the desired outputs and less of the unwanted ones? Feedback enables you to evaluate the system and modify your goals.

Today, people travel much more than in the past. Whether by rockets or rollerblades, energy of one form or another is required, and these different forms of energy affect our environment in different ways. As this unit progresses, **students will become aware of the ways they move themselves around, what forms of energy they use, and the impact of their transportation choices on the environment.** Students will learn that the burning of fossil fuels plays a major role in polluting our air and changing the world's climate. **They should also realize that there are alternatives that are better for the environment.**

Forms of travel relying on human power have a relatively minimal impact on the environment. The energy required comes from the food the travellers eat. Because more food can be grown on the same land, food is a renewable energy source. In contrast, fossil fuels are not renewable in that it took millions of years to create them.

The invention of the automobile has had an enormous impact on the world. Although it offers amazing individual freedom, it has costs. ***Consider:***

- **Mining and manufacturing**
- **Changing our communities:** urban sprawl, suburbia, paving significant amounts of land, families spread far and wide; less contact with neighbors.
- **Pollution:** air (emissions); water (run-off, oil leaks, and spills); land (mining, landfills); noise; global climate change
- **Health and safety:** pollution; accidents (high death rate); road rage.

Any form of transportation that relies on fossil fuels contributes to many of these problems, but vanpools, buses, and trains are generally far more efficient and less polluting.

It is also possible to build vehicles that don't use fossil fuels, but instead use cleaner fuels, such as alcohol and methane, or even wind and sun. Electric vehicles are a growing reality and, even when plugged in to today's fossil fuel powered electric grid, they produce roughly half the pollution of a comparable internal combustion engine vehicle. Also, the pollution is shifted from cities, people, and roadsides to the power plant. If the power plant relies on renewable energy sources such as sun, wind, hydro, or geothermal, then emissions for the entire system are reduced much more dramatically.

ACTIVITY 1.A

PERSONAL TRANSPORTATION LOG

OUTCOMES

Students should be able to:

- Describe the different modes of transportation used in their community.
- Identify the types of transportation they personally use and compare this to the community at large.

TIME REQUIRED

- Homework, minimum 1 hour over 3-4 days, ideally spanning 1 week.
- Personal transportation log analysis, 30 minutes in-class.

MATERIALS

- Worksheets and Log for each student.
- Local map with mileage scale.
- String to measure mileage.

TEACHER PREPARATION

Assemble materials.

Establish small groups.

Prepare class chart 1.

ACTIVITY OVERVIEW

Students will come to understand their own transportation choices and patterns by keeping a Personal Transportation Log. By analyzing their own and their classmates' transportation habits, students will begin to realize how their behavior compares to that of others in their community. This information will serve as the basis for later lessons during which the exploration of transportation issues continues.

ACTIVITY

Discuss with the class,

"What are some ways you use to move yourselves from place to place?" (Cars, bikes, rollerblades, walking, school buses...etc.). These are all "modes" of transportation.

"Which mode do you use most often?" Have the students make predictions after considering all modes available to them. What percentages of their transportation needs do car, bicycle, and walking, etc. meet? For example: (30% car, 30% school bus, 15% walking, 25% bicycling).

For homework, ask students to collect data regarding their own transportation habits. Pass out and review the **Personal Transportation Log** so students are clear about what is expected. This assignment might extend over a weekend or cover an entire week. Try to include at least one school day.

To complete the log the students will need to include: the date, purpose of the trip, where they started and finished that particular trip, and the number of miles traveled. They may use a local map with a scale, and string, to help them make that estimate. This information will be used during the first lesson. Students will also refer back to this log in later lessons.

Transportation Log Review Questions:

Once students have completed their Personal Transportation Logs, discuss with them:

- What did you notice, realize, have trouble with?
- What modes of travel did you use? (Make a list of all modes).
- What were the modes you used most? The least?
- Do you think your data reflects a typical weekend/week of travel?
- How accurate were your predictions?

PERSONAL TRANSPORTATION LOG ANALYSIS

Hand out the Personal Transportation Log Analysis worksheet. Using this to guide them, have students calculate their number of miles traveled per mode, and the percentages of each.

Meanwhile, make a large class chart of all modes of travel mentioned above. *See sample chart below.* Have students work in small groups to pool their numbers before recording them on the class chart. After the chart is complete, have each group calculate class totals per mode of travel, and the percentages of each mode. Finally have each student group construct a bar graph indicating the relative use of the different modes. Have student groups share results. The students should be able to see identical results.

TEACHER LED DISCUSSION

Go over the review questions once more, but this time, ask students to focus on the class chart they just created. You may also want to ask:

Are there other modes used but not mentioned? Think of other times of the year.

Do you think the class percentages represent the percentages of an average American? Why or why not?

While discussing the results of the class's transportation logs, introduce the concept of transportation systems (technology systems). Introduce background information that will help them complete the **Technology Systems Worksheet**.

SAMPLE CLASS CHART

TRAVEL MODE	CAR WITH ONE PASSENGER AND ONE DRIVER	BICYCLE	WALK/RUN	CAR WITH MORE THAN ONE PASSENGER	BUS
NUMBER OF MILES TRAVELED BY EACH STUDENT GROUP					
TOTAL MILES TRAVELED					
PERCENTAGE OF ALL MILES TRAVELED					

STUDENT WORKSHEET 1.1

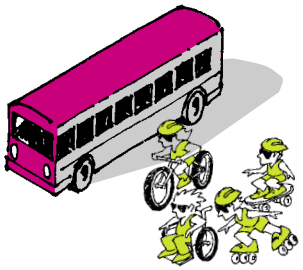
Personal Transportation Log

Sheet # _____ Name: _____

Use this chart to record all of the trips you take transporting yourself from one place to another. You will use this information in class.

DATE	PURPOSE OF TRIP	DESTINATION	DISTANCE	MODE OF TRAVEL (If by car, include number of passengers in car)
		TO: FROM:		
		TO: FROM:		
		TO: FROM:		
		TO: FROM:		
		TO: FROM:		
		TO: FROM:		

Personal Transportation Log Analysis



Name: _____

1. LIST ALL TRAVEL MODES YOU USED.
2. TOTAL THE NUMBER OF MILES TRAVELED FOR EACH MODE.
3. TOTAL ALL THE MILES TRAVELED.
4. DETERMINE THE PERCENTAGE OF TOTAL MILES FOR EACH MODE.

1. MODE OF TRAVEL	2. TOTAL # MILES PER MODE	4. PERCENTAGE OF TOTAL MILES TRAVELED

3. _____ TOTAL # MILES TRAVELED. 100%

CLASS STATISTICS

1. MODE OF TRAVEL	2. NUMBER OF CLASS MILES PER MODE	4. PERCENTAGE OF TOTAL MILES TRAVELED

3. _____ TOTAL # MILES TRAVELED. 100%

ACTIVITY 1.B

TRANSPORTATION SYSTEMS

OUTCOMES

Students should be able to:

- Describe how all transportation modes are part of transportation *systems*.
- Compare transportation modes in terms of the amount of energy, materials, pathways, and safety mechanisms they each require.
- Identify unwanted side effects of various transportation modes.
- Select transportation modes so as to reduce unwanted side effects.

TIME REQUIRED

- 60 minute discussion and worksheet. The "feedback" section makes a good homework assignment.

MATERIALS

- Completed Personal Transportation Logs (Activity #1 Homework)
- Technology Systems Worksheet (one per student)
- Calculators (optional)

TEACHER PREPARATION

Read the teacher background information.

Assemble materials.

ACTIVITY OVERVIEW

Students will come to understand how each mode of transportation they use relies on a broad array of pathways, fuels, materials, and safety measures. By comparing various modes of transportation, they will realize that each mode has desirable and undesirable side effects. By examining these side effects, they will be able to identify transportation modes that can get them where they want to go with fewer undesirable side effects.

ACTIVITY

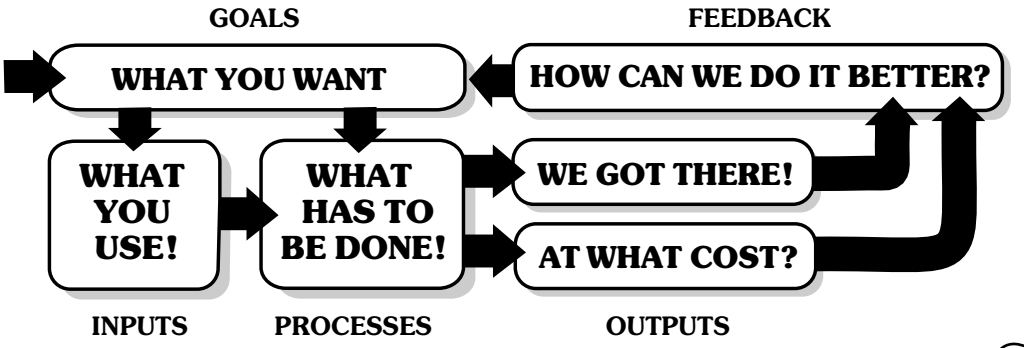
Hand out the student Transportation System Information Sheet. As a class discuss the meaning of "goal," "input," "process," "output," and "feedback" as they relate to transportation systems. Provide examples from the teacher background information, such as inputs needed for various transportation modes. Discuss energy sources, materials needed to build vehicles and pathways, and the systems we have in place to ensure human safety. Give examples of processes used to convert energy into motion. Discuss briefly what goals we may have for our transportation systems and some of the unwanted side effects that these systems produce. Have students complete the worksheets in small working groups.

Hand out the Technology Systems Worksheet. In small working groups, have students complete two worksheets, one for each of two modes of travel. The "feedback" section makes a good homework assignment.

Suggested Review Questions:

- What are the outputs (costs and benefits) of different travel modes? Different fuels?
- How have different transportation modes affected our lives, community, and environment?
- Since the car was invented what are some ways auto manufacturers have changed cars to (1) reduce things we don't like about them and (2) increase things we do like about them.
- How do you think people will transport themselves in 50, 100, and 1000 years?

Transportation System Information



WHAT YOU WANT

GOALS: What you want to get out of using a transportation system.

A primary goal of any transportation system is to move products and people from point A to point B. Today, another common goal is recreation. Less obvious goals are to be low cost, safe, comfortable, and to get us places promptly and on-schedule. Many people also want systems to be as pollution-free as possible and be independent of foreign-controlled resources, such as Middle East oil.

WHAT YOU USE!

Inputs: The materials and people needed to make a transportation system work.

Gasoline, cars, minivans, sport utility vehicles, roads, bridges, and drivers are all inputs to the most popular transportation system in the United States – getting around in family vehicles. Each of these inputs rely on additional complex systems such as: 1) mining metals and processing petroleum, 2) designing, manufacturing and transporting gasoline, cars, and trucks, 3) designing and building roads and bridges, and 4) staffing teachers, police, and the court system to train and monitor drivers for a safe transportation system. We can also add automotive repair, financial, insurance, and medical systems needed to maintain both cars and drivers.

WHAT HAS TO BE DONE!

Processes: Actions that are needed to make a transportation system work.

Converting fuel into motion is the most basic process of any transportation system. But other processes are important to maintain a safe, low cost, low pollution, timely transportation system. Safely driving the family car depends on enforced traffic rules, educated drivers, and maintained roadways. We need financial systems to help purchase new cars and emission regulations to prevent pollution.

WE GOT THERE!

AT WHAT COST?

Outputs: The results, whether intended or not, of using a transportation system.

Moving products or people from one place to another is the most basic output of any transportation system. But many systems have unwanted outputs as well. Pollution, time spent stuck in traffic, money spent on insurance, and car maintenance are a few examples.

HOW CAN WE DO IT BETTER?

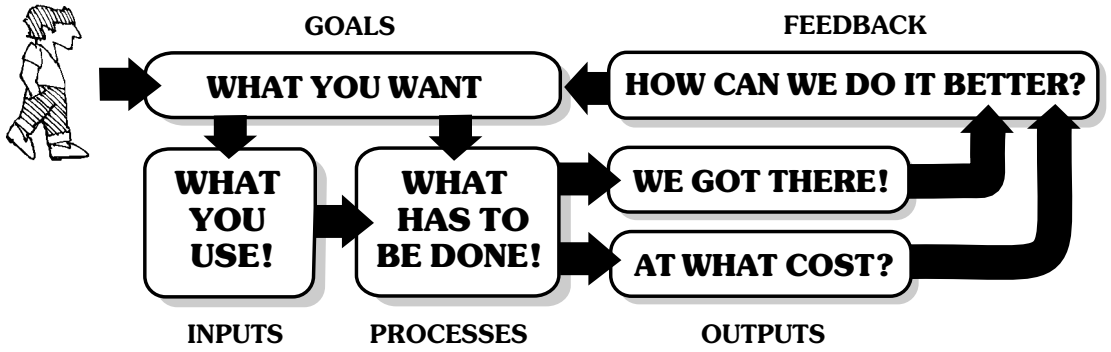
Feedback: Deciding how to adjust how you get around or choosing a new way so you are more pleased with the outputs.

How well is your transportation system working? Do you get to school on time? Are you often stuck in traffic? Do you dislike the pollution emitted by cars? Are there other transportation systems, or can you modify your current system in order to provide more desired outputs and less unwanted ones? Feedback enables you to evaluate and adjust your goals.

Technology Systems Worksheet

Name: _____

Look back at your Personal Transportation Log. Complete one worksheet for each of two trips. Use a different travel mode for each trip.



TRANSPORTATION MODE _____

1. GOALS: Circle all that apply.

Moving People Moving Objects Recreation Other _____

2. INPUTS: Briefly describe those that apply. What is needed for this transportation mode? Briefly describe where each input comes from.

Energy/Fuel: _____

_____

Goods/Materials: _____

_____

Pathways: _____

_____

Safety Measures: _____

_____

3.PROCESSES: What needs to happen for transportation to take place?

_____

_____

_____

Technology Systems Worksheet, page 2

4. OUTPUTS: List what happened, intended and unintended, as a result of the process?

Things you wanted to happen: _____

_____

_____

_____

Things you wish didn't happen: _____

_____

_____

_____

5. FEEDBACK: For this trip, consider other travel modes you could you have used to get where you wanted to go. Name one other mode that could have gotten you where you wanted to go without some of the unwanted side effects you listed under #4 above? Briefly describe this alternative technology system.

Revised goal: _____

Alternative travel mode: _____

Inputs needed: _____

_____

_____

_____

Processes to be used: _____

_____

_____

_____

Outputs (intended and unintended, as a result of the process): _____

_____

_____

_____

_____

CHAPTER 2

TRANSPORTATION AND AIR QUALITY

CHAPTER 2

TRANSPORTATION AND AIR QUALITY

ESSENTIAL QUESTIONS

▲ **How do automobile emissions affect our health and our planet?**

▲ **What are people doing to reduce harmful emissions?**

OBJECTIVES

The students will:

- Explain how automobiles contribute to air pollution.
- Research and understand the health effects of automobile pollutants.
- Recognize the importance of the individual, and that each person has the potential to make a difference.
- Understand a basic history of the environmental movement.
- Understand the role of the government, its affect on the individual and on the environment.

ACTIVITIES

WHO'S DRIVING CHANGE

Time: One or two 45-minute periods.

AIR POLLUTION AND HEALTH

Time: Option A – 45 minutes.
Option B – Two 45-minute periods.

EMISSIONS AND THE EPA

Time: 45 minutes, follow-up discussion as needed

STUDENT PREREQUISITES

- An understanding of percent change. Or this lesson can be used to reinforce a lesson on percent change.

STANDARDS

Technology: Understand unintended effects of technology.

Social Studies: Understand the effect of inventions that have transformed daily life.

Social Studies: Recognize the importance of individual choices, actions and character.

Health: Research impacts of environmental factors on health.

Civics: Role of the individual in the political process.

Civics: Role of government agencies.

Language Arts: Identify basic facts from scientific literature; oral presentations; use electronic media for research (optional).

Math: Read and analyze tables, graphs and charts.

TEACHING NOTES

After lesson #1 students should understand that automobiles play a major role in transporting Americans.

In this lesson students will learn about automobile pollutants, their effect on human health, and the efforts of those who are working for change. Students will realize that reducing pollution from our transportation system is an on-going challenge and, even though much has already been accomplished, much still remains to be done.

In the activity *Who Cares*, students will reconstruct the history of the automobile and identify many of the causes and effects between automotive technology and society over the last century.

In the activity *Air Pollution and Health*, students will research and report on the adverse effects of the six criteria air pollutants and the greenhouse gas, carbon dioxide.

In the activity *Emissions and the EPA*, students will explore the significance and relative success of the EPA's efforts to reduce automotive emissions. They should discover that, although pollution controls have greatly reduced individual auto emissions, much of these gains have been offset by increased miles driven.

Assessment: Research skills, worksheets, oral presentations, class participation.

BACKGROUND INFORMATION

The invention of the automobile transformed the world. It offered convenience, independence, and efficiency. Cars made it easier for people to live far away from their workplace and created new opportunities for leisure travel, adventure, and recreation. They even served as status symbols.

Today, travel by automobile also creates problems. We inadvertently damage air and water quality, and alter the global climate. Automobile pollutants significantly affect our health.

When a car's engine burns gasoline, several harmful compounds are emitted. These include carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC), and particulates. Before the transition to unleaded gasoline, car engines also emitted lead. In the presence of sunlight, NOx reacts with VOC to form Ozone (O3), also known as smog. The United States Federal Clean Air Act identifies these six pollutants as having significant health impacts on humans. These are often referred to as the six criteria pollutants. For more information see the student information sheet, "Adverse Effects of Automobile Emissions."

Automobile use also significantly increases atmospheric levels of carbon dioxide (CO2), a recognized heat-trapping or "greenhouse" gas. One-third of the United States' CO2 emissions come from the burning of fossil fuels for transportation. Increased CO2 in our atmosphere traps more of the sun's energy, which is likely causing changes to the climate around the world. For more information, see the student information sheet "Adverse Effects of Automobile Emissions."

When automobiles were invented, no one could have predicted all the effects they would have on the environment, nor all the related issues they would raise, including traffic accidents, deaths, noise, loss of land to asphalt, disposal of junked cars, road-building costs, urban sprawl, and road rage. The automobile has truly been an invention with many unforeseen consequences – both negative and positive.

By the 1940's, car exhaust and emissions from oil refineries had produced periods of severe air pollution in Los Angeles and other cities. In 1950, scientists linked automobile exhaust to the creation of smog. As the number of cars continued to increase, the American public became more aware of the environmental problems that stemmed from our use of oil and man-made chemical compounds.

In 1962 Rachel Carson published *Silent Spring*, a book that described many of the suspected side-affects of using man-made chemical compounds. *Silent Spring* reached millions of people and raised the environmental consciousness of the American people.

On Thanksgiving weekend 1966 pollution, trapped by weather conditions in New York City, was blamed for the deaths of 168 people. In 1969 Cleveland's oily Cuyahoga River burst into flames, again, catching the attention of the American public. Public outrage over these and other environmental problems helped lawmakers establish, in 1970, the U.S. Environmental Protection Agency (EPA) along with the Federal Clean Air and the Clean Water Acts.

As an independent agency of the US government, the EPA's mission was to assume responsibility for environmental regulation and protection. In time, emission standards were established which limited the amount of pollution generated by motor vehicles. In Activity 2A is a timeline of events related to transportation and the environment. Use it to discuss the impact of the automobile on society and the environment.

ACTIVITY 2.A

WHO'S DRIVING CHANGE?

OUTCOMES

At the end of this activity students should be able to:

- Identify groups of people who have influenced the design of the U.S.'s transportation systems over the last hundred years
- Propose how these groups influenced the U.S.'s transportation systems

TIME REQUIRED

- One or two 45 minute periods.

MATERIALS

- Student handout: Who's Driving Change?

For Option B

- A copy of the timeline cut into strips.

TEACHER PREPARATION

Become familiar with the timeline and background information.

Cut timeline into strips.

ACTIVITY OVERVIEW

While evaluating a timeline of events related to the development of the automobile students will begin to see how social pressures, economic influence, governmental action, and technology affected the development of our transportation systems. As a part of the discussion they will realize that the challenge of reducing pollution from our transportation systems is an on-going struggle and that, although much has been accomplished, much needs to be done.

During the activity they will place themselves in the shoes of their grandparents and parents. They will then step back into their own shoes and use what they have learned to form predictions on where the development of our transportation systems may go.

ACTIVITY

Explain to students that they will be investigating the history of the automobile and air pollution. Let them know that they will be asked to think about why people throughout history changed the way they got around and what groups of people drove these changes. For example: why did people stop using horse drawn carriages and start using trains to get from city to city? Why are automobile manufacturers trying to build cleaner cars?

Finally, they will be asked to think about the changes they might like to make in the way people get around today and predict what each change might do to the world of tomorrow.

Many students will find it helpful to have a large timeline of key events in the development of our nation's transportation systems available for their review during this activity. You may want to:

Option A: Hand out the background reading "Who's Driving Change?" and, as a reference source, the timeline "A History of Transportation and the Environment."

Option B: Have the class construct its own large-scale timeline that is posted somewhere in the room. Explain to the students that they will be participating in a class discussion concerning the history of the automobile and the environmental movement. To start, they will create, as a class, a timeline large enough to be displayed and used as a reference for this activity.

With a copy of the timeline cut into strips, separate the individual events. Randomly distribute one (or two) to each student.

Facilitate a discussion based on the timeline. Teacher background information is included.

Have the students share and post their event(s) on the timeline.

What other things happened during this time frame? Are they somehow related to this timeline? Can students place the birth years of their parents, grandparents, and great- grandparents?

Once students have a timeline available to them and have had a chance to review this timeline hand out to each student a copy of the background reading, "Who's Driving Change?"

Who's Driving Change:
A Class Discussion

Either through a class discussion or through small group discussions that then report to the class, have students respond to the discussion questions at the end of the handout "Who' Driving Change?"

During the discussion emphasize:

- **Major changes occur** when many people either support a change (e.g. they buy and use a new technology or product) or they demand a change (e.g. they ask their government to lead the way to a change.)

- **The Environmental Protection Agency was started** because U.S. citizens wanted their government to monitor and help control pollution.

- **Use this discussion to introduce** the following activities:

  Pollution and Health where students will learn more about automotive emissions, and

  Emissions and the EPA where students will analyze how successful the EPA has been in their efforts to reduce air pollution from cars.

A History of Transportation and the Environment

1825 First passenger railroad opens in England.

1860 First true bicycle, the "boneshaker," becomes popular in Europe and America.

1869 U.S. Transcontinental railroad opens.

1885 Safety bicycle invented in England. Its popularity created a demand for better roads. Automobiles would take advantage of the better roads.

1887 First electric street railway opens in Richmond, Virginia

1890s First electric and gasoline automobiles are developed and compete for popularity. Advantages of electrics: absence of noise and noxious odors; ease of control. Advantages of gasoline-powered vehicles: can travel longer distances without refueling, easier to refuel.

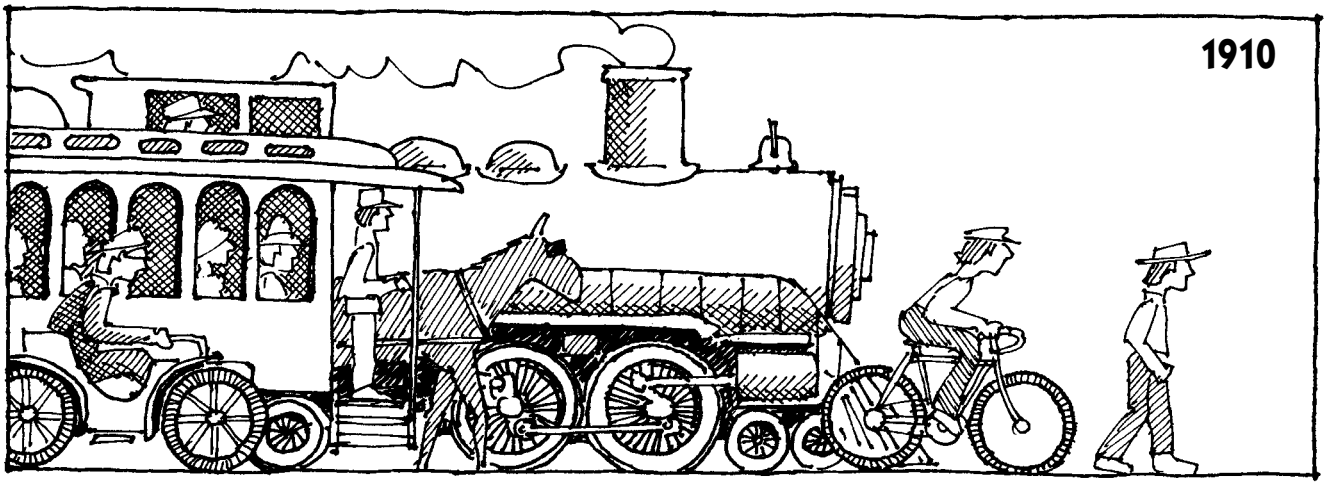
1890s Most larger communities have electric streetcar systems (trolleys).

1899 Americans could buy electric automobiles from more than a dozen manufacturers.

1900s Many early automobile owners fall in love with touring (driving out into the countryside). Gasoline automobiles, with their ease of refueling and range of travel without refueling, quickly become more popular than the electric automobiles.

1908 Henry Ford begins selling the Model T, designed for mass appeal.

1909 124,000 cars manufactured. In comparison, 2,000,000 horse-drawn carriages manufactured.



1914 Ford Motor Company introduces their new idea for increasing production, the moving assembly line. Model T, now costing $360, becomes affordable to more Americans.

1916 The Federal Aid Road Act offers federal funds to the states for road-building.

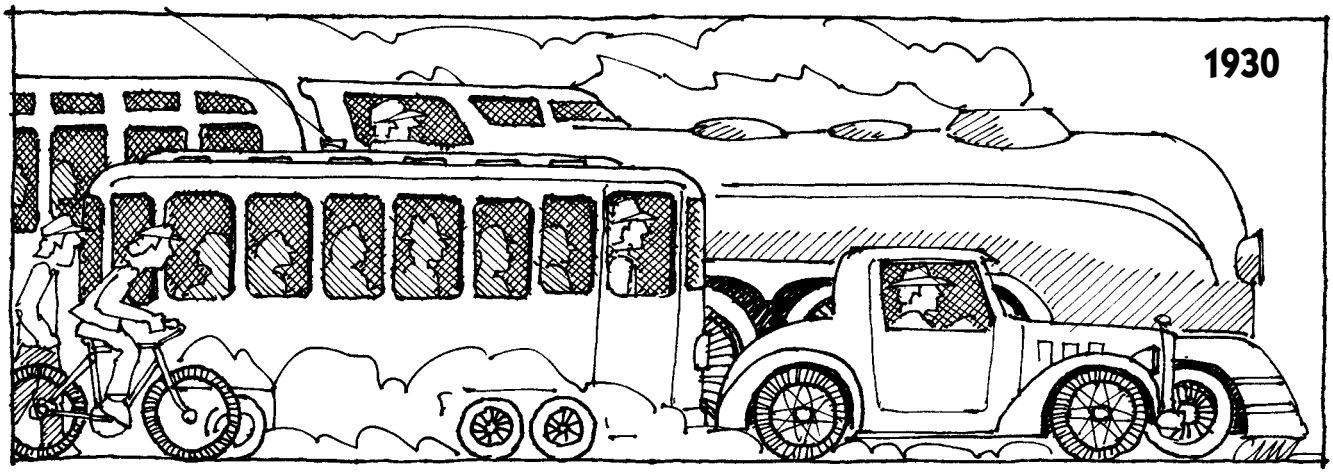
A History of Transportation and the Environment, page 2

1920 Studebaker Company stops making horse-drawn wagons.

1920s Outside cities, automobiles become the primary mode of travel.
Suburbs based on automobile transportation begin to develop.

1929 Nearly five million cars manufactured.
Americans own nearly one automobile for every five people.

1930s Trolley lines begin to close down because of competition from buses and cars.



1940 First super highway opened.

1940s Los Angeles and other cities begin to experience spells of severe air pollution, known as "gas attacks." Automobile exhaust and petroleum refinery emissions trapped in low-lying areas are the cause.

1950 Automobile exhaust is linked to the creation of smog.

1954 In Los Angeles, dense smog is blamed for causing 2000 automobile accidents in a single day.

1956 Interstate Highway Act passed. It leads to 44,000 miles of new highways.

1960 Numbers of cars escalate causing air and noise pollution in cities to become a major concern.

1963 Clean Air Act recommends national air quality standards.
Air quality remains primarily a local concern.

1964 California requires minimal emission control systems on 1966 model cars.

1965 Motor Vehicle Air Pollution Control Act provides money for researching impacts of automobile related pollutants. Recognized as a national issue, not a local one.

1966 On Thanksgiving weekend, weather conditions in New York City cause air pollution to build up for three days. Pollution levels are blamed for the deaths of 168 people.

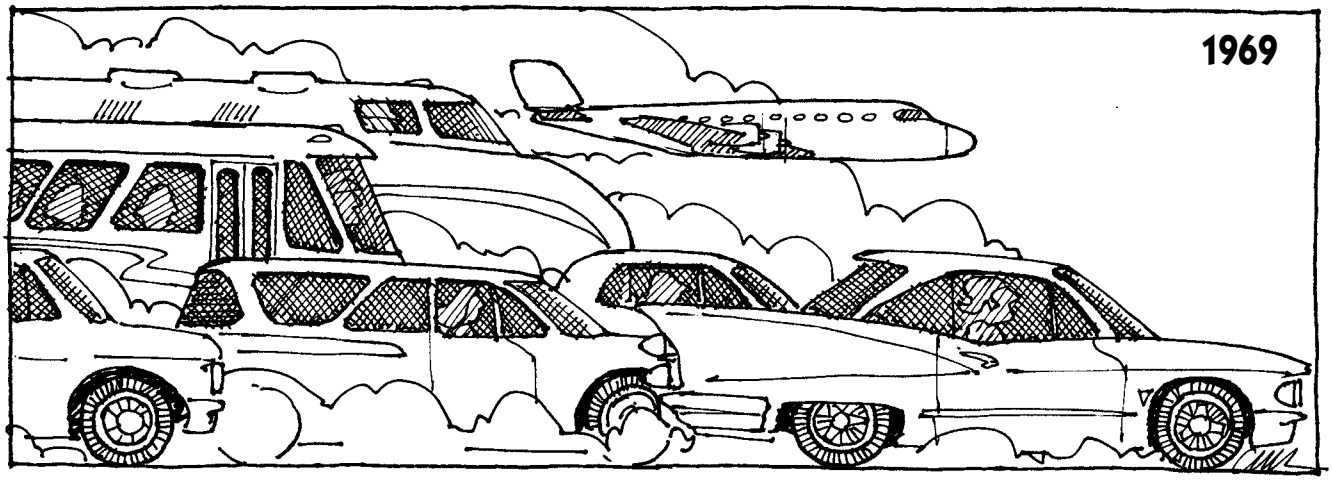
1967 Clean Air Act Amendment requires states to implement air quality standards set out in the 1963 Clean Air Act.

A History of Transportation and the Environment, page 3

1969 A photograph of the earth, taken from space, shows a tiny, fragile ball of limited resources, floating in a huge expanse of space. It dramatically alters human perceptions of our world.

1969 Nationwide public outcry over an oil spill from offshore drilling in southern California.

1969 Cleveland's oily Cuyahoga River bursts into flames catching the attention of the American public. Public outrage over this and other environmental problems helps lawmakers establish the EPA, the Clean Air Act, and the Clean Water Act.



1970 Congress establishes the Environmental Protection Agency (EPA) as an independent agency of the US government and gives the new Agency broad responsibility for regulating motor vehicle pollution.

1970 The Clean Air Act of 1970 calls for 90 percent reductions in automotive emissions from new cars by 1976. As part of the Clean Air Act the U.S. Government requires for the first time that air quality in the U.S. meet clean air standards for six specified pollutants. Automobile exhaust includes all six of these pollutants. (These are known as the six criteria pollutants.)

1970 The first Earth Day. 100,000 people marched down 5th Avenue in New York City.

1973 Oil Producing Exporting Countries (OPEC) limit the amount of oil exported to the USA resulting in a gas shortage, high prices, and very long lines at gas stations.

1974 At the request of the auto industry, Congress delays some reductions in automotive emission standards until 1978.

1974 Energy Policy Conservation Act establishes the first fuel economy goals and the Corporate Average Fuel Economy (CAFE) program establishes a phase-in of more stringent fuel economy standards beginning with 1975 models.

1975 Unleaded gasoline and catalytic converters appear in response to hydrocarbon and carbon monoxide pollution standards.

1977 At the request of automakers, amendments to the Clean Air Act relax some of the 1970 guidelines.

A History of Transportation and the Environment, page 4

1980s Minivans, which are held to lower fuel economy standards than cars, become highly popular.

1981 New cars meet the amended Clean Air Act standards for the first time.

1985 EPA adopts stringent emission standards for diesel-powered trucks and buses, to take effect in 1991 and 1994.

1989 The supertanker, "EXXON Valdez" spills 11 million gallons of crude oil into the pristine waters of Alaskaís Prince William Sound.

1990 Amendments to the Clean Air Act require stricter emissions designed to significantly improve air quality by 2005.

1990 California law requires automobile manufacturers to deliver zero-emission vehicles (electric vehicles) in the future.

1990s Sport Utility Vehicles, which are held to lower fuel economy standards than cars, become highly popular.

1992 Earth Summit in Brazil brings increase international attention to global warming and other major environmental problems.

1994 Phase-in begins for cleaner vehicles required by the 1990 Clean Air Act.

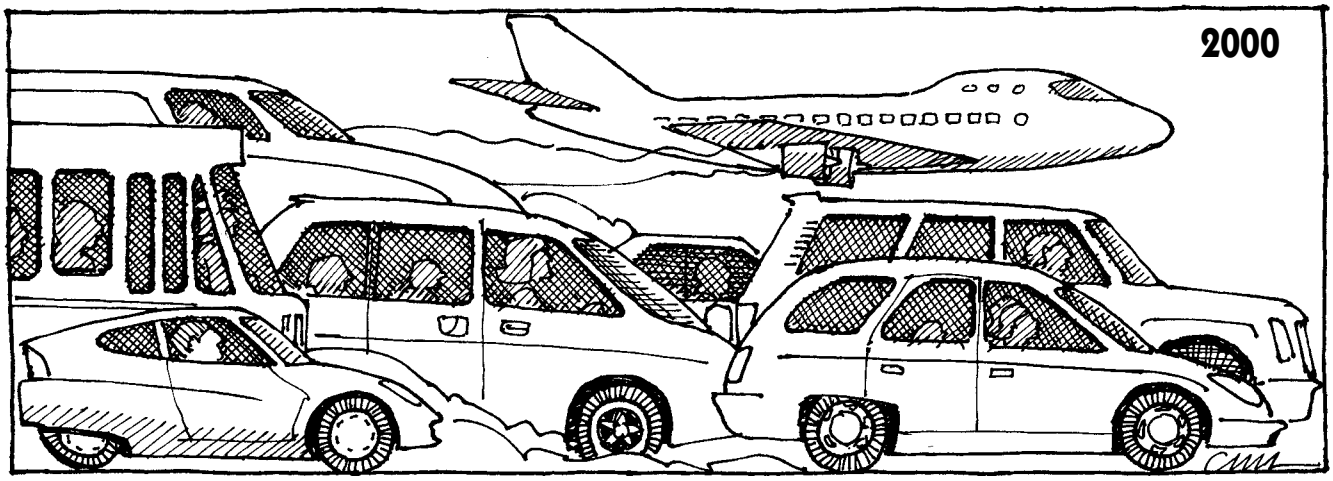
1996 The first commercially produced electric vehicle in nearly 100 years goes on sale in California.

1997 An international treaty known as the Kyoto Protocol calls for mandatory reductions of the carbon dioxide emissions by industrial countries to slow global warming

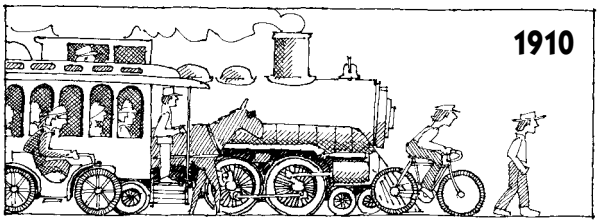
1998 U.S. EPA data shows that over 100 million people still live in counties with unhealthy air.

1999 The first electric-gasoline hybrid automobile goes on sale in America. It gets an average of 70 miles per gallon.

2000 Oil prices again rise sharply when OPEC nations limit the amount of oil they produce.



Who's Driving Change?



Although the automobile has been around since the late 1800s it wasn't until the 1920s that it became a primary form of transportation for most Americans. Up until 1914, when Henry Ford introduced the moving assembly line and brought the price of the Model T down to $360, cars had been too expensive for most Americans.

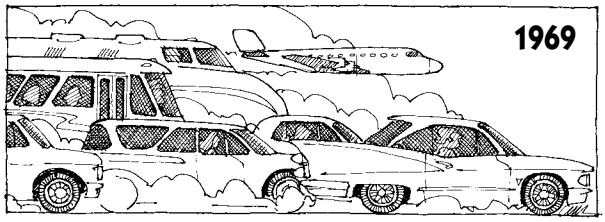
Until the late 1920s, you were more likely to ride an electric streetcar system (trolley), use a horse-drawn carriage, or ride a bicycle to get around town. That is, when you weren't walking. Roads outside of cities were poorly maintained and getting between the countryside and town was often difficult. Most people rode coal-powered passenger trains to get from town to town. During this time, bicyclists began to demand better town roads.

In 1916, the federal government made funds available for the first time for states to build and improve roads between towns. By 1929, with cars now affordable and roads improving, nearly one in five people had chosen to buy a car.

Throughout the 1930s increasing numbers of Americans choose the automobile as their preferred mode of transportation. The U.S. opened its first super highway in 1940.

In the 1940s, Los Angeles and other cities begin to experience spells of severe air pollution, known as "gas attacks." Automobile exhaust and petroleum refinery emissions trapped in low-lying areas were found to be the cause. In 1950, automobile exhaust was linked to the creation of smog and, in 1954 dense smog was blamed for causing 2000 automobile accidents in Los Angeles in a single day. By 1960, the number of cars has escalated to the point where air and noise pollution in cities had become a major concern.

Throughout the 1960s, America's growing use of the automobile continued to contribute to air and water pollution. During the 1966 Thanksgiving weekend, 168 people in New York City died from air pollution trapped by adverse weather conditions. In 1969, Americans were shocked when Cleveland"s oily Cuyahoga River burst into flames and an oil spill from offshore drilling in southern California threatened coastal wildlife.

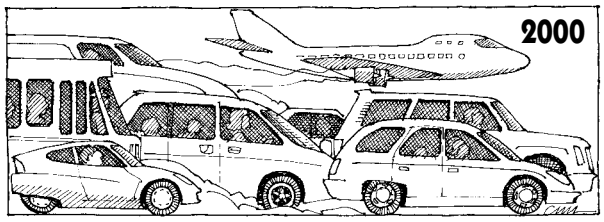


Public outrage over these and other environmental problems grew throughout the 1960s and, in 1970, 100,000 people marched down 5th Avenue in New York City for the first Earth Day. Public action finally spurred lawmakers into a period of action. In 1970 congress established the Environmental Protection Agency (EPA), the Clean Air Act, and the Clean Water Act.

Congress gave the EPA broad responsibility for regulating motor vehicle pollution and the Clean Air Act of 1970 called for 90 percent reductions in automotive emissions from new cars by 1976. Although some of these requirements were later delayed on request of the automobile manufactures, a period of actively cleaning up our air and water had begun.

Who's Driving Change, page 2

By 1975, unleaded gasoline and catalytic converters had appeared in response to hydrocarbon and carbon monoxide pollution standards. Cities with large populations took steps to improve air quality by improving their public transportation systems including better buses and subway systems. Throughout the 1980s, automobile manufacturers begin producing cleaner gasoline-powered cars as clean air standards and pollution regulations were gradually phased in. Many manufacturers also begin to design cars that run on cleaner, alternative fuels such as electricity, propane, natural gas, and ethyl alcohol/gasoline mix. Manufacturers began to sell some of these alternatively fueled cars in limited quantities. In 1999, the first electric-gasoline hybrid automobile went on sale across America. It got an average of 70 miles per gallon thereby reducing the amount of fuel it burned.



Although air and water quality have improved greatly over the last 30 years, Americans continue to hear of environmental pollution as a result of our Nation's use of oil. Beginning in the mid 1980s, consumers began to buy more minivans, pickup trucks, and sport utility vehicles (SUVs), vehicles that burned more gasoline per mile. In 1989, the supertanker, "EXXON Valdez" spilled 11 million gallons of crude oil into the pristine waters of Alaska's Prince William Sound and 1997 U.S. EPA data showed that over 100 million people still lived in counties with unhealthy air. A new threat, global warming, has also entered the news.

Discussion Questions:

During the following discussion, imagine living during each of the time-periods being talked about.

1. List the primary forms of transportation used in the U.S. from 1900 to 1930. What were some of the services or "wanted outputs" provided by these transportation systems? What do you think were some of the disadvantages or "unwanted outputs" of these transportation systems?

2. For the automobile to become widely used it had to be reasonably priced and sound roads had to exist on which to drive; neither of which was true in the early 1900s. In what ways do you think the general public helped bring about or support these changes?

3. As early as 1915, our country began to develop a system for moving cars. What were some of the advantages this system had over previous transportation systems? What disadvantages or "unwanted outputs" of this transportation system began to appear between 1940 and 1970?

4. In the early 1970s, automobile manufacturers began work on developing and marketing cleaner cars. In what ways did the general public help bring about or support this change? What role did the federal government play? What federal agency was given responsibility over regulating motor vehicle pollution?

ACTIVITY 2.B

AIR POLLUTION AND HEALTH

OUTCOMES

At the end of this activity students should be able to:

- Identify the major pollutants resulting from gasoline-powered motors.
- Describe how these emissions impact human health.
- Describe how these emissions impact the environment.

TIME REQUIRED

- Option A, using student handouts, 45 minutes.
- Option B, using suggested Internet sites, two 45-minute periods .

MATERIALS

- Student handouts
- Student access to the web (optional)
- Teacher access to the web (optional)
- Student worksheets

TEACHER PREPARATION

Assemble materials.

Read through background information.

Confirm Internet sites (optional).

Print out Internet sites (optional).

ACTIVITY OVERVIEW

Through research, students will become familiar with the environmental and health effects of the six criteria pollutants identified by the U.S. EPA along with the greenhouse gas, carbon dioxide. Although student information handouts are supplied, we recognize that many students are more motivated to conduct research if they have to do a little digging themselves. For this reason we have also supplied a list of Internet sites containing sound information on this topic. Alternatively, you may want to assign this as a library research project or use a computer- based encyclopedia.

ACTIVITY

Hand out the graphic showing the production of automobile pollution. Generate a discussion about air quality in your community. Ask the students:

- What is it that we are breathing? Do you think the composition or chemical makeup of our air has changed since the car was invented? How? (Examples: Carbon dioxide levels have increased by 30%. Automobiles, as well as industrial processes, have increased the levels of harmful chemical compounds in our air.)
- What affects the quality of the air we breathe in this community? Consider manufacturing, electricity generation, residential factors, as well as transportation.
- What are fossil fuels? (They are naturally occurring fuels formed from the remains of prehistoric organisms.)
- Does anyone know what the biggest polluter of our air is? (Passenger cars and small trucks) There is one vehicle for every 1.7 people in this country. Almost all of them run on gasoline, a fossil fuel.
- What comes out the tailpipe when a car burns gasoline? List on the board the major pollutants/compounds resulting from gasoline-powered motors.

Carbon monoxide (CO)
Results from incomplete combustion of fossil fuels

Carbon dioxide (CO2)
Results from combustion of fossil fuels

Nitrous oxides (NOx)
Results from burning fossil fuels at a high temperature

Volatile Organic Compounds (VOCs)
Results from evaporation of gasoline and are released during the incomplete burning of fossil fuels

Particulate Matter (PM)
Solid particles left over after combustion

Lead (Pb) Used to be contained in gasoline

Ozone (O3)
Results when NOx and VOC react in the presence of sunlight

- How do you think these emissions impact our health?

Assign this last question as a research project. Working alone or in small groups, assign specific pollutants to be researched. The Air Quality Worksheet is for them to use to document their findings. Have the individuals or groups report back to the class. During student presentations, all students should be responsible for recording information on pollutants researched by other groups and individuals.

SOURCES OF INFORMATION

Option A: Use the student background information sheet.

Option B: Internet or Library: These Internet sites have information on health effects of the major air pollutants.

- **www.scorecard.org** (Environmental Defense). For a descriptive listing of the criteria air pollutants go to www.scorecard.org, (1) Click on "Criteria Air Pollutants," (2) find and click on it again, (3) find the pollutant listed, click on that.

  This site also rates counties on emission levels of criteria air pollutants and health effects of air pollutants. Go to www.scorecard.org, (1) click on "Criteria Air Pollutants," (2) on the map, click on your state, (3) scroll down and click on the name of your state.

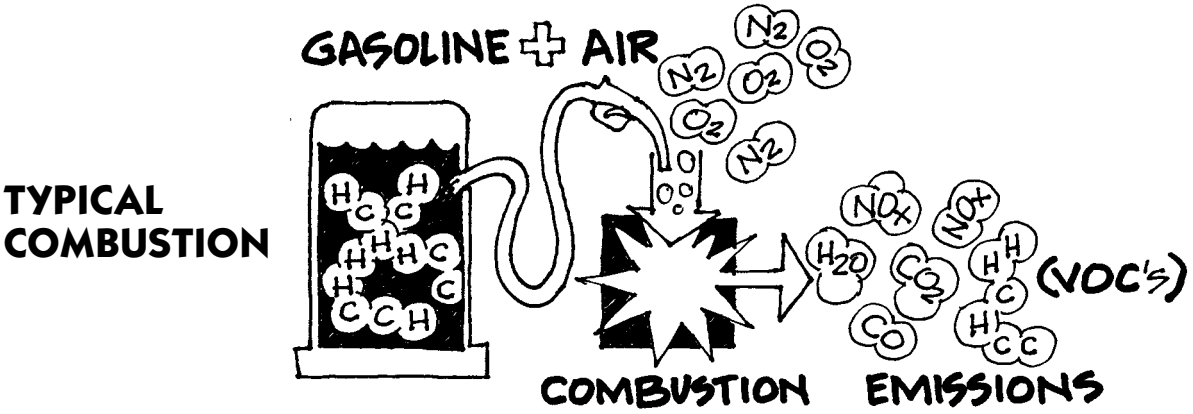
- **www.lungusa.org/air** (American Lung Association). Click on Outdoor Air Quality. Go to: Major Air Pollutants, Six major air pollutants

- **www.nsc.org/ehc/mobile/airpollu.htm** (National Safety Council). This site also has tips on what you can do to reduce air pollution.

- **http://www.epa.gov/oms/05-autos.htm** (US EPA Office of Mobile Sources). This site also has discussions on the combustion process, what has been done to control automobile emissions, and what emission control has meant for air quality.

- Information can also be found in online encyclopedias, although not as easily.

Adverse Effects of Automobile Emissions



Automobiles pollute the air. Although they are not the only source of air pollution, they are a major contributor. They discharge millions of tons of hazardous gases and particles every year. But even where it is not visible, the effects on our health are evident.

Air pollution can cause a wide range of problems from minor respiratory irritations and headaches to the more serious consequences of asthma, brain and nerve damage, cancers, birth defects, and even death. Unborn children, young children, and the elderly are especially at risk, along with those individuals with existing health problems.

The major air pollutants associated with cars and the burning of gasoline are: carbon monoxide, (CO), nitrogen oxides, (NOx), ozone (O3), volatile organic compounds, (VOC), particulate matter, (PM), and lead, (Pb). The burning of gasoline also produces carbon dioxide (CO2), a heat-trapping, or "greenhouse" gas.

AIR
is made up of 75.5% nitrogen (N2), 23.2% oxygen (O2) and 1.3% other trace coumpounds.

GASOLINE
is a mixture of many different hydrocarbons, molecules made up of hydrogen and carbon atoms. Trace amounts of other chemicals are added to adjust how it burns in car engines.

Carbon monoxide (CO): Carbon monoxide is a colorless, odorless, poisonous gas. It results from the incomplete combustion of gasoline. CO emissions are greatest when starting the engine, running an untuned car, and when outside temperatures are low. Carbon monoxide can accumulate in areas where there is not adequate ventilation such as garages, tunnels, and even along roadsides when traffic is heavy.

When inhaled, CO inhibits oxygen from reaching the brain, heart, and body tissue. It decreases alertness and slows reflexes. Low concentrations can cause dizziness, headaches, and fatigue. High concentrations can cause unconsciousness and death. People with heart and respiratory diseases are at greater risk.

PERFECT COMBUSTION

GASOLINE (hydrocarbons) **+** **AIR** (mostly oxygen and nitrogen) **=** **CARBON DIOXIDE (CO2)** **WATER (H2O)** **UNAFFECTED NITROGEN (N2)**

Adverse Effects of Automobile Emissions, page 2

Carbon dioxide (CO2): Carbon dioxide is a natural compound of air. We exhale it and plants need it for photosynthesis. But, by burning fossil fuels, humans are raising the level of carbon dioxide found in our air. When oil is pumped out of the ground, processed into gasoline, and burned, the carbon once trapped in the underground oil deposits is moved into our air. For every gallon of gasoline burned in a car's engine, about 20 pounds of carbon dioxide are released into the atmosphere. Since the industrial revolution began, humans have burned enough gasoline, oil, coal, and other fossil fuel to raise the concentration of CO2 in the atmosphere by 30%.

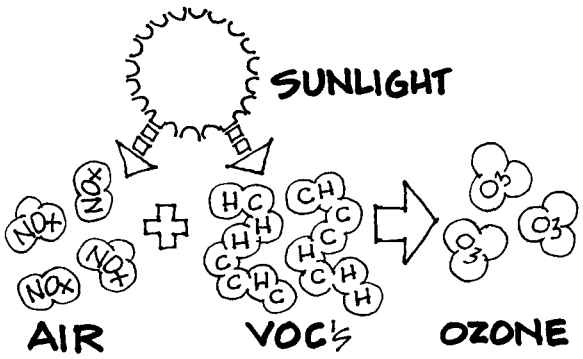
CO2 is a heat-trapping, or "greenhouse," gas. As its concentration in the atmosphere increases, it traps more of the sun's heat much as a car's window traps heat inside the vehicle on a sunny day. Scientific evidence continues to accumulate suggesting that this heat-trapping property of CO2 is causing the earth's average temperature to rise, resulting in changes to the climate. Although scientists cannot know the exact implications, they project flooding of coastal areas from rising sea levels and changes in precipitation and other local climate conditions that could alter forests, crop yields, and water supplies.

Nitrous oxides (NOx): Nitrous oxides include a variety of nitrogen compounds. These form when fuel is burned at high temperatures. They also play a major role in the formation of ozone, the primary component of smog.

Nitrogen dioxide, (NO2), It can irritate the lungs, particularly for those with asthma, and it may cause other respiratory diseases. As a gas, it is highly reactive with other compounds. As a solid, small particles can cause significant damage to air passages and lung tissues. It also reduces visibility.

Ozone (O3): Ozone is the most widespread air pollution problem. It is formed when NOx and VOC (Volatile Organic Compounds) react in the presence of sunlight.

The result is an intensely irritating gas that is the major component of smog. Warmer temperatures increase the amount of ozone formed. It is more problematic with higher temperatures during summer months.



Note: Harmful ground-level ozone should not be confused with beneficial ozone in the upper atmosphere. Automobile emissions contribute to ground-level ozone, but do not affect the ozone levels in the upper atmosphere. In the upper atmosphere, ozone is a naturally occurring compound that protects the earth from ultraviolet radiation Ozone at ground level can damage lung tissue, decreasing air capacity. It can cause coughing and choking, chest pain, labored breathing, and nausea. It affects healthy individuals and it aggravates existing conditions relating to the lungs, heart and allergies.

Volatile Organic Compounds (VOC): VOCs are organic chemicals that produce vapors easily. Organic chemicals are the basic chemicals found in all living things and in all products derived from living things. Many organic compounds we use do not occur in

Adverse Effects of Automobile Emissions, page 3

nature, but were synthesized by chemists in laboratories. At room temperature vapors readily escape from volatile liquid chemicals.

VOCs include gasoline, industrial chemicals such as benzene, solvents such as toluene and xylene, and perchloroethylene (principal dry cleaning solvent). VOCs are released from burning fuel, such as gasoline, wood, coal, and natural gas, and from solvents, paints, glues, and other products used at home or work. They are also released by evaporation of gasoline itself, such as while refueling at gas stations. Vehicle emissions are an important source of VOCs. Many VOCs are hazardous air pollutants; for example, benzene causes cancer.

VOCs react with nitrogen oxides in the presence of sunlight to form ozone, the major component of smog. (See ozone for more information).

Particulate Matter (PM): Particulate matter is made up of solid particles of various sizes, ranging from those visible to the human eye to those that are microscopic. Larger particles can be screened out by the nose and throat, but the smaller particles can find their way deep into the lungs and become trapped. There they can cause respiratory disease and lung damage, even cancer. Particles can also irritate the nose and throat and they can trigger breathing difficulties. For those people who already suffer from lung disease, heart disease or asthma, particulate matter are most harmful.

Lead (Pb): Lead is a toxic, heavy metal. It was once one of the most threatening air pollutants. Because of legislation requiring American automobiles to use unleaded gasoline, it is now less of a problem. However, it still continues to cause some concern as the soils along some roadsides remain contaminated. The unrelated issue of lead paint in older homes is a much more significant health concern.

Lead accumulates in the body so repeated exposure, as well as exposure to high concentrations, are both harmful. It affects the nervous, reproductive, digestive, kidney, and blood forming systems. High exposures can result in neurological disorders.

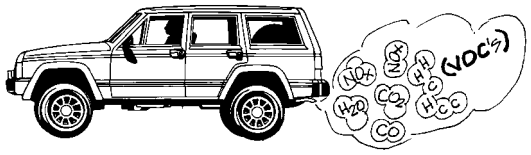
Note:

- Young children, the elderly, and those with compromised health are most at risk.
- Consideration must also be given to the effects of these pollutants in combination. It is generally assumed that the effects of these compounds acting together, add to the risk.

Air Quality and the Automobile

Name: _____

Use this worksheet to record information about the major automobile air pollutants.



POLLUTANT: _____

CHEMICAL NOTATION: _____

GENERAL INFORMATION: _____

_____

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EFFECTS ON HUMAN HEALTH: _____

_____

_____

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POLLUTANT: _____

CHEMICAL NOTATION: _____

GENERAL INFORMATION: _____

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EFFECTS ON HUMAN HEALTH: _____

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ACTIVITY 2.C

EMISSIONS AND THE EPA

OUTCOMES

By the end of this activity students should come to their own conclusions on what success the EPA has had in improving the quality of the air we breath by mandating reductions in car emissions. They will do this by:

- Constructing, reading and interpreting charts of emission data.
- Analyzing these charts to determine the effectiveness of emission control standards.
- Reporting on their findings to the class.

TIME REQUIRED

- 45 minutes, follow-up discussion as needed

MATERIALS

For each group:

- A data analysis pack. Each pack should pertain to a specific pollutant and contain:
  - Copied onto transparency film or tracing paper:
    1. blank chart of average emissions per car
    2. blank chart of total emissions for all cars
  - Copied onto white paper:
    1. chart of EPA emission standards
    2. blank chart of annual miles driven for all cars
  - For each student in the group:
    1 data set
    1 worksheet
- 2 different colored markers for drawing on the transparency film or tracing paper.

Note: Using tracing paper will allow students to use an overhead projector to share their findings with the class.

TEACHER PREPARATION

Copy the supplied blank charts onto transparency film.

Compile the data analysis packets.

ACTIVITY OVERVIEW

The Environmental Protection Agency was created in 1970 in response to wide spread public concern for the environment. As part of its mandate by congress, the EPA was assigned responsibility for regulating motor vehicle pollution. It has done this by setting emission standards for individual vehicles.

In this activity students will see that the standards set by the EPA have successfully decreased the emissions from individual vehicles. However, the students will also see that the number of vehicles has escalated, as has the average annual number of miles driven per vehicle. The net result is that the total emissions are being reduced at a slower rate than expected and, in some cases are actually increasing. The end result is that automobile emissions continue to be a major contributor to poor air quality in much of our country.

You may want to end this activity by asking students what they think they can do as individuals to improve the quality of the air we breath. Such a discussion will lead into the next two lessons where students explore the potentials of carpooling and/or using mass transit.

ACTIVITY

Divide the class into working groups. Give each group a data analysis pack relating to one specific automobile emission, CO2, CO, VOC, NOx, Particulates or Lead (Pb). These are among the emissions researched in activity 2A. Depending upon class and group size, groups may or may not be working with the same data.

Have each group divide the tasks of creating bar charts for (1) Average Emissions per Car on the grams/mile chart, (2) Total Emissions of All Cars on the million tons/year chart, and (3) Total Miles Driven by all Cars on the miles/year chart. Have them use different colors for each chart.

Ask each group to overlay the first two graphs on the EPA Emissions Standards chart. The x-axis of each chart should line up. Have the groups discuss the charts and have each student complete the first side of their worksheet.

Ask each group to present their charts and their interpretation of the data to the class. If charts are on transparency film have each group display their charts with an overhead projector. You may also wish to ask each group to summarize the adverse effects of the emission they are reporting on.

As each group presents their information have all students record summaries for each pollutant on the second page of their worksheets.

Suggested Review Questions:

- Would the EPA be pleased with these results?
- What are some other strategies the EPA could implement in their effort to preserve air quality?
- What can you do as an individual to help improve the quality of our air?

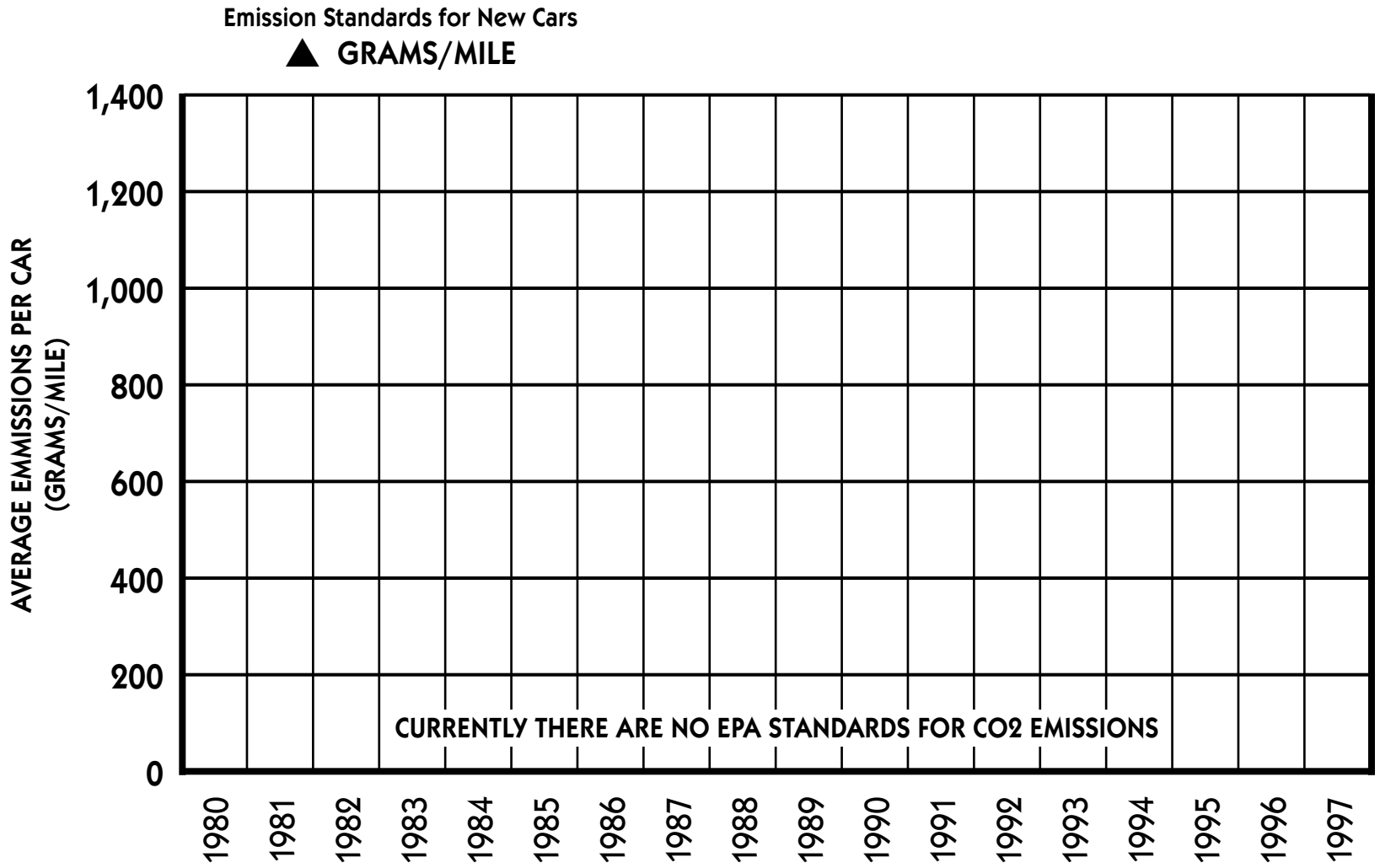
Carbon Dioxide (CO2) Data Set

YEAR	EMISSION STANDARDS FOR NEW CARS (grams/mile)	AVERAGE EMISSIONS OF ALL CARS IN USE (grams/mile)	TOTAL MILES DRIVEN IN ONE YEAR BY ALL CARS IN USE (billion miles)	TOTAL EMISSIONS IN ONE YEAR FROM ALL CARS IN USE (million tons)
1980	N/A	572	1,527	962
1985	N/A	506	1,774	991
1990	N/A	446	2,144	1,055
1993	N/A	425	2,296	1,077
1994	N/A	426	2,357	1,108
1995	N/A	424	2,422	1,131
1996	N/A	424	2,485	1,159
1997	N/A	413	2,560	1,165

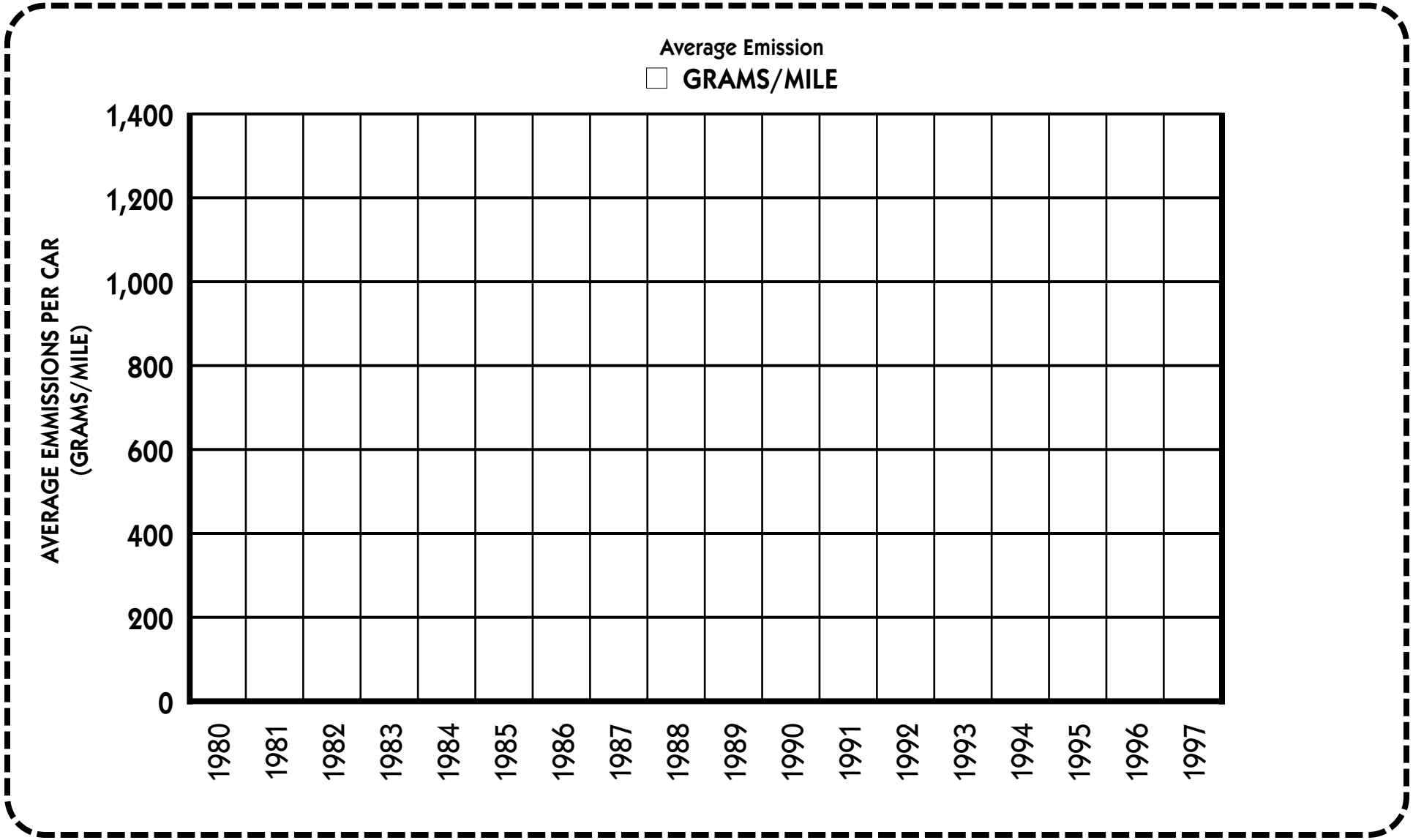
Currently there are no emission standards for CO2.

Source: Transportation Energy Data Book: Edition 19. 1999.
Stacy C. Davis. Oak Ridge National Laboratory

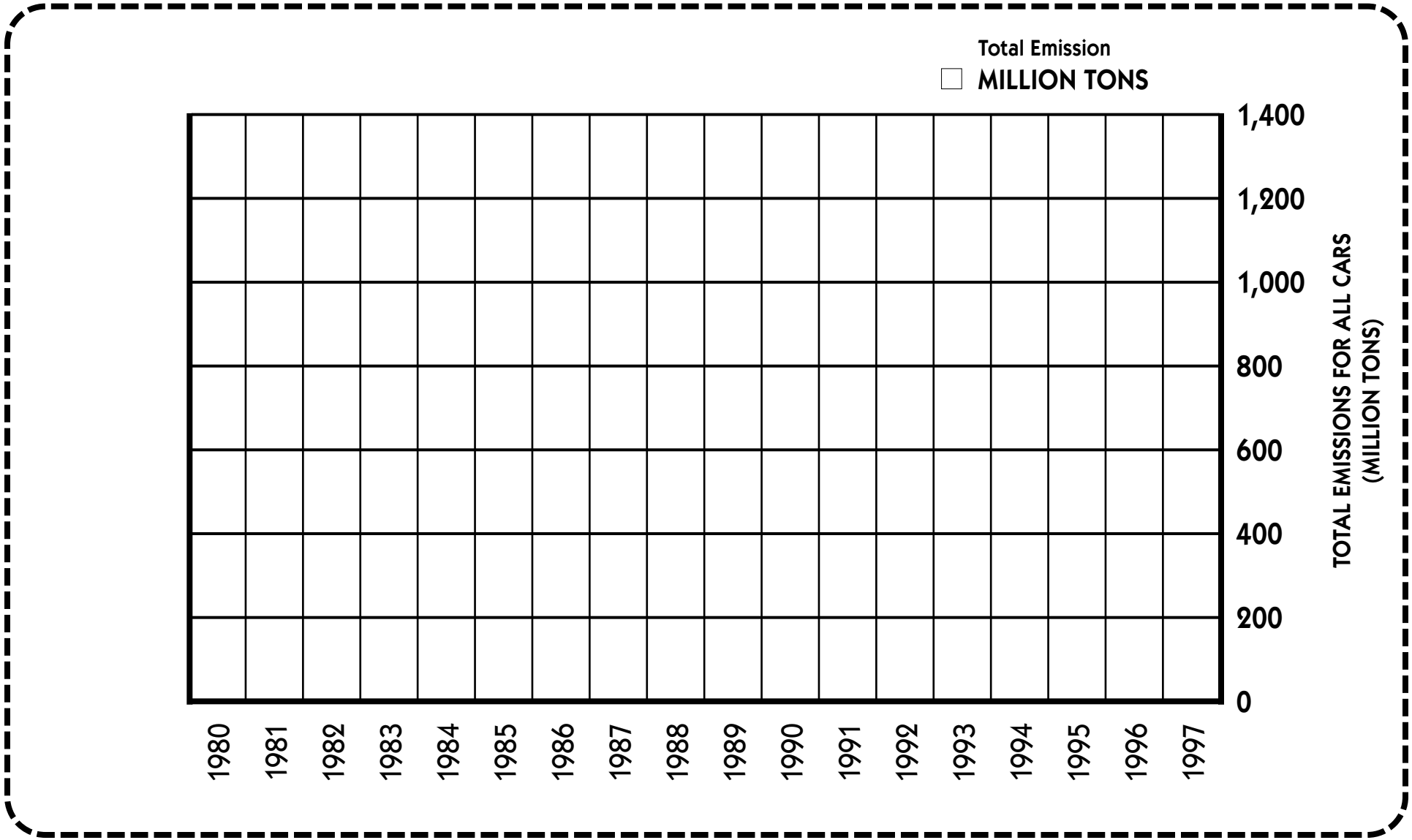
CO2 Emission Standards for New Cars



CO2 Average Emission for Cars on the Road



CO2 Total Emissions for All Cars

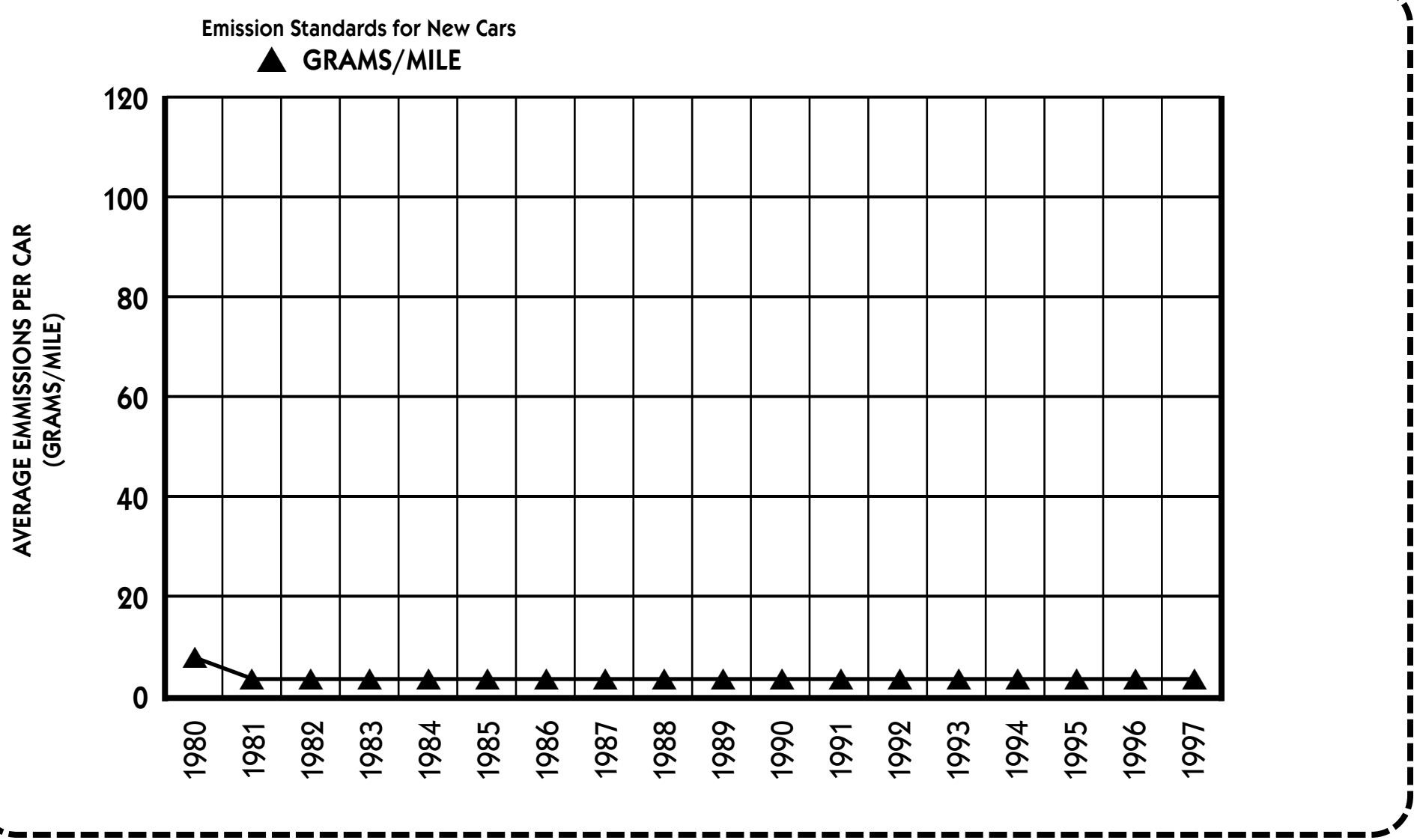


Carbon Monoxide (CO) Data Set

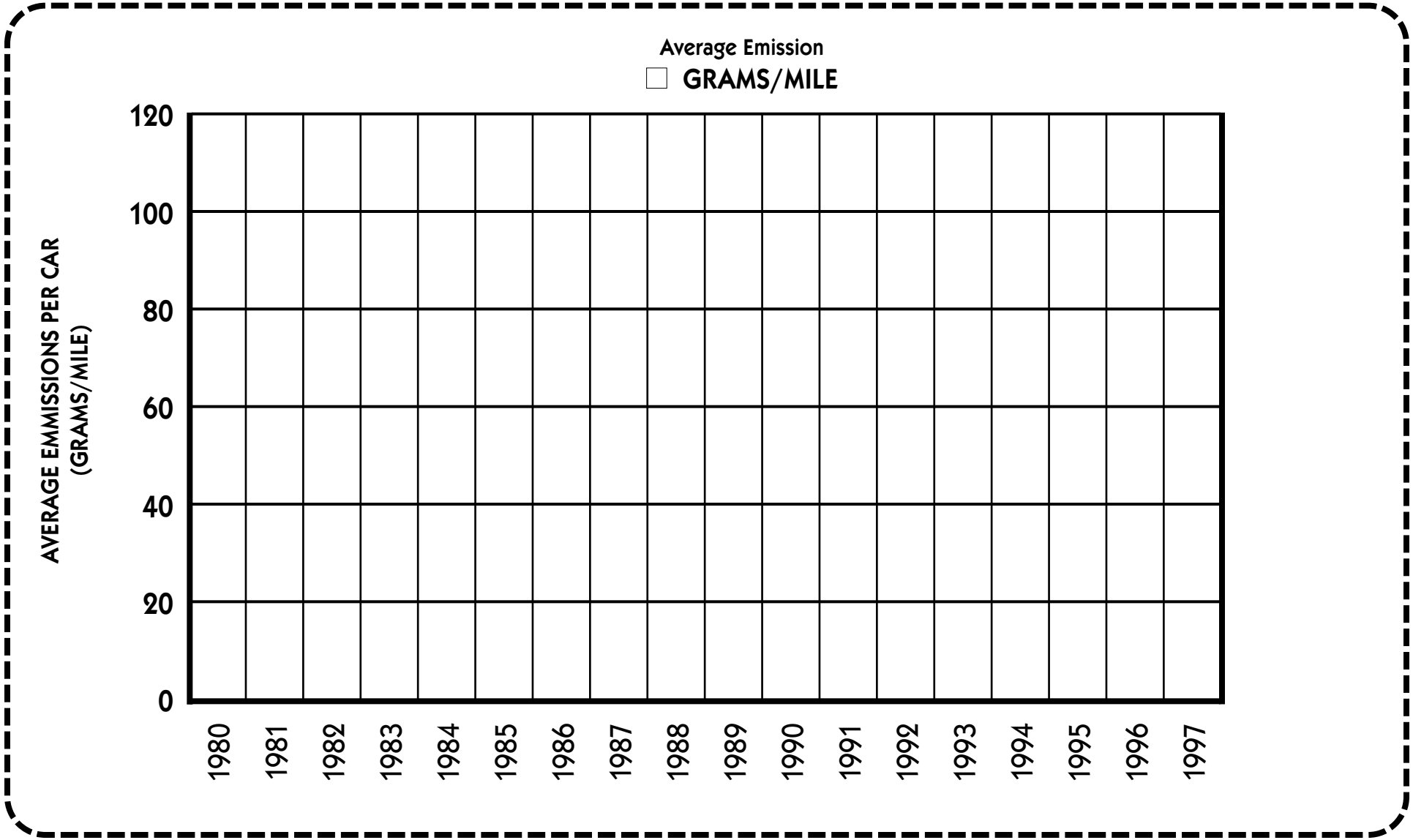
YEAR	EMISSION STANDARDS FOR NEW CARS (grams/mile)	AVERAGE EMISSIONS OF ALL CARS IN USE (grams/mile)	TOTAL MILES DRIVEN IN ONE YEAR BY ALL CARS IN USE (billion miles)	TOTAL EMISSIONS IN ONE YEAR FROM ALL CARS IN USE (million tons)
1980	7	46.4	1,527	873
1985	3.4	39.6	1,774	899
1990	3.4	24.5	2,144	957
1993	3.4	23.8	2,296	977
1994	3.4	23.6	2,357	1,005
1995	3.4	20.3	2,422	1,026
1996	3.4	19.4	2,485	1,052
1997	3.4	17.8	2,560	1,057

Source: Transportation Energy Data Book: Edition 19. 1999.
Stacy C. Davis. Oak Ridge National Laboratory

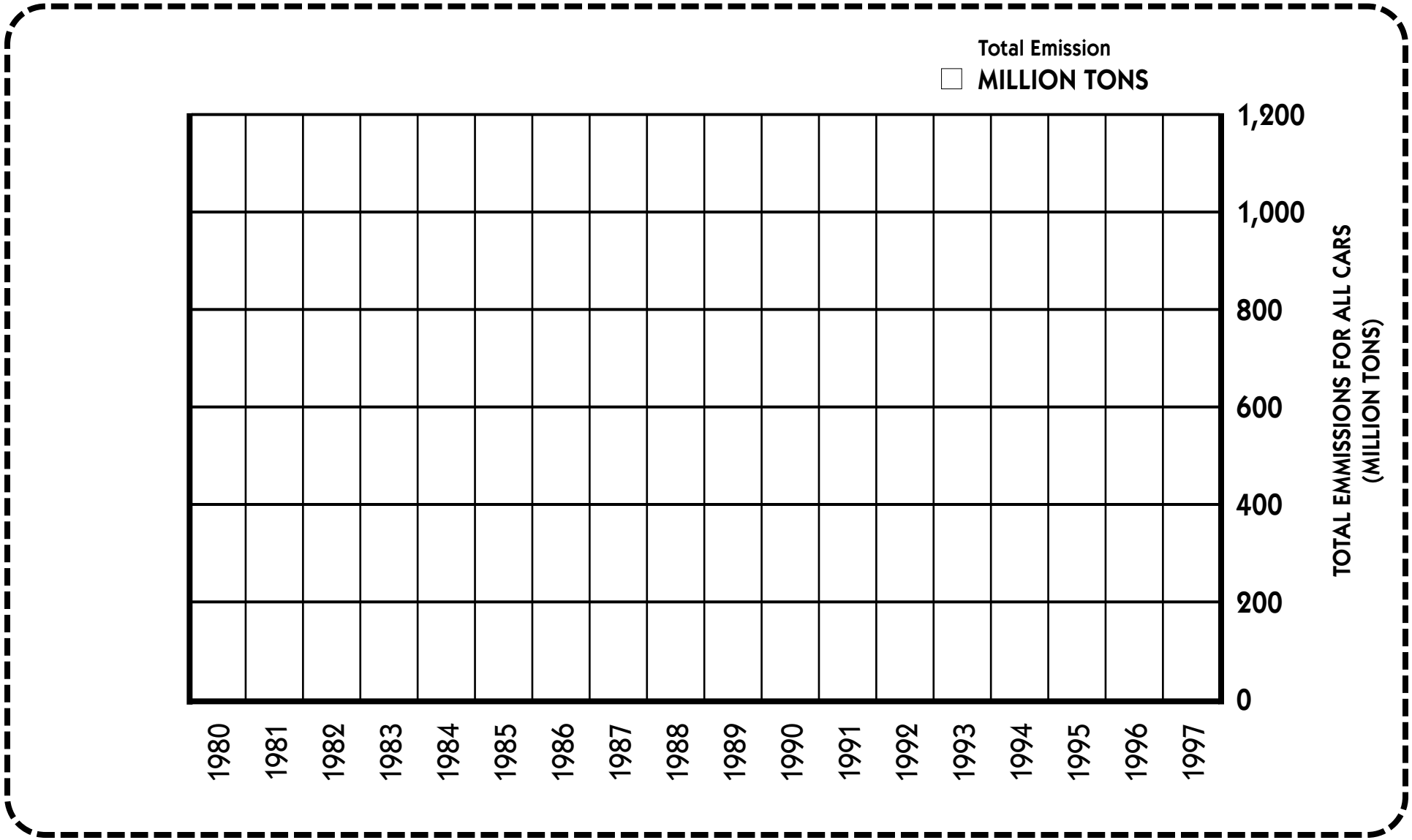
CO Emission Standards for New Cars



CO Average Emission for Cars on the Road



CO Total Emissions for All Cars

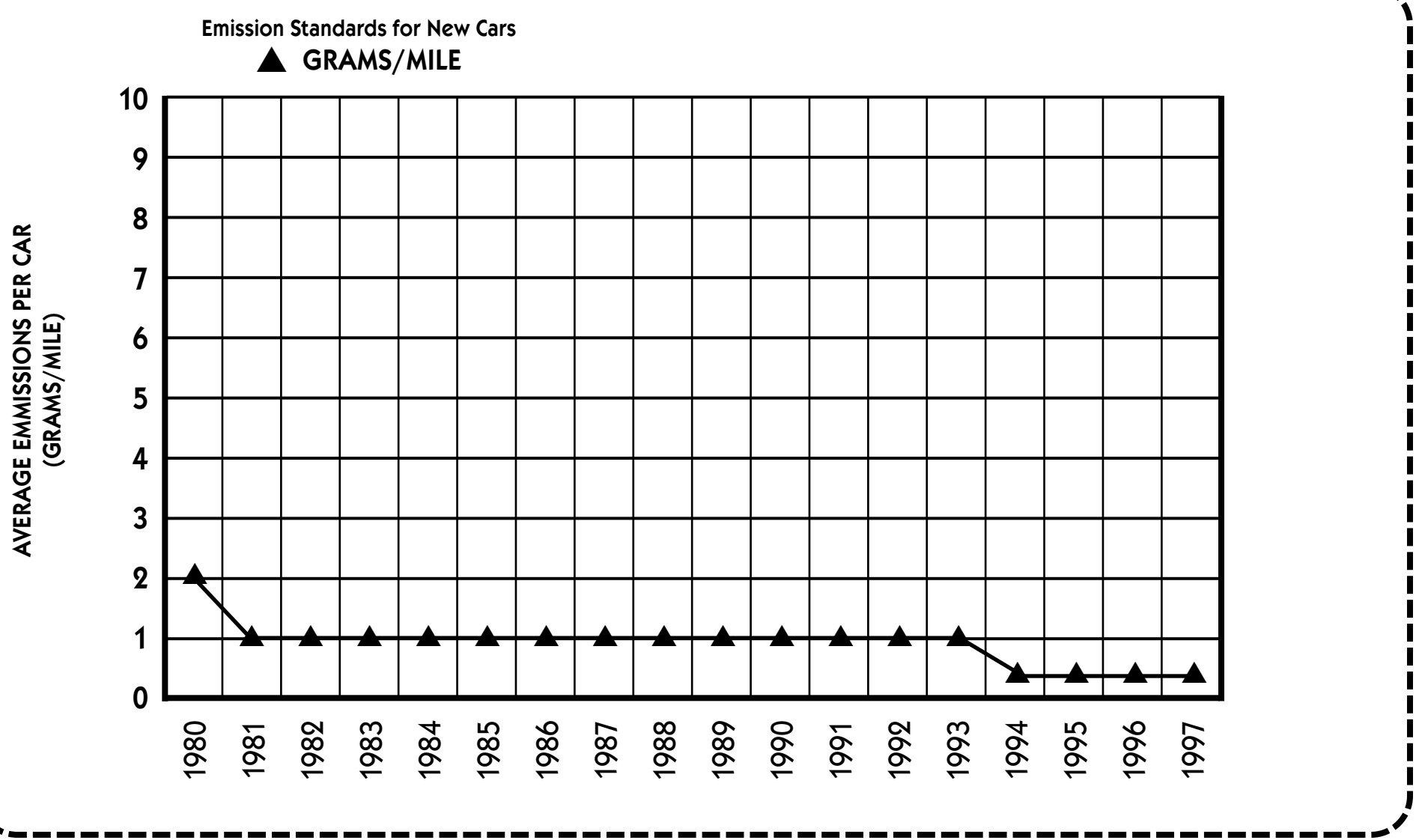


Nitrogen Oxides (NOx) Data Set

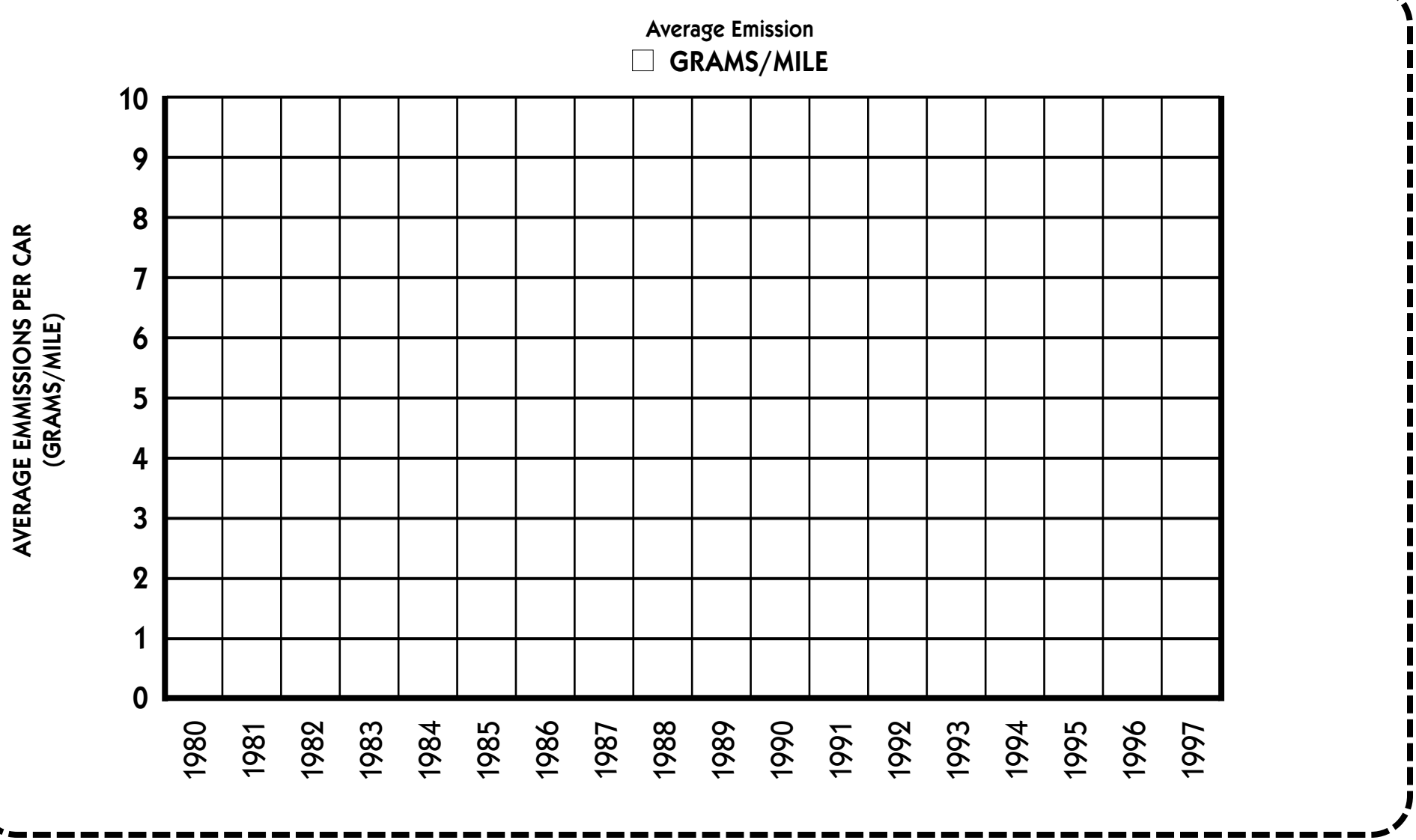
YEAR	EMISSION STANDARDS FOR NEW CARS (grams/mile)	AVERAGE EMISSIONS OF ALL CARS IN USE (grams/mile)	TOTAL MILES DRIVEN IN ONE YEAR BY ALL CARS IN USE (billion miles)	TOTAL EMISSIONS IN ONE YEAR FROM ALL CARS IN USE (million tons)
1980	2	5.1	1,527	8.6
1985	1	4.1	1,774	8.1
1990	1	3.0	2,144	7.0
1993	1	3.0	2,296	7.5
1994	0.4	3.0	2,357	7.7
1995	0.4	2.7	2,422	7.3
1996	0.4	2.6	2,485	7.3
1997	0.4	2.5	2,560	7.0

Source: Transportation Energy Data Book: Edition 19. 1999.
Stacy C. Davis. Oak Ridge National Laboratory

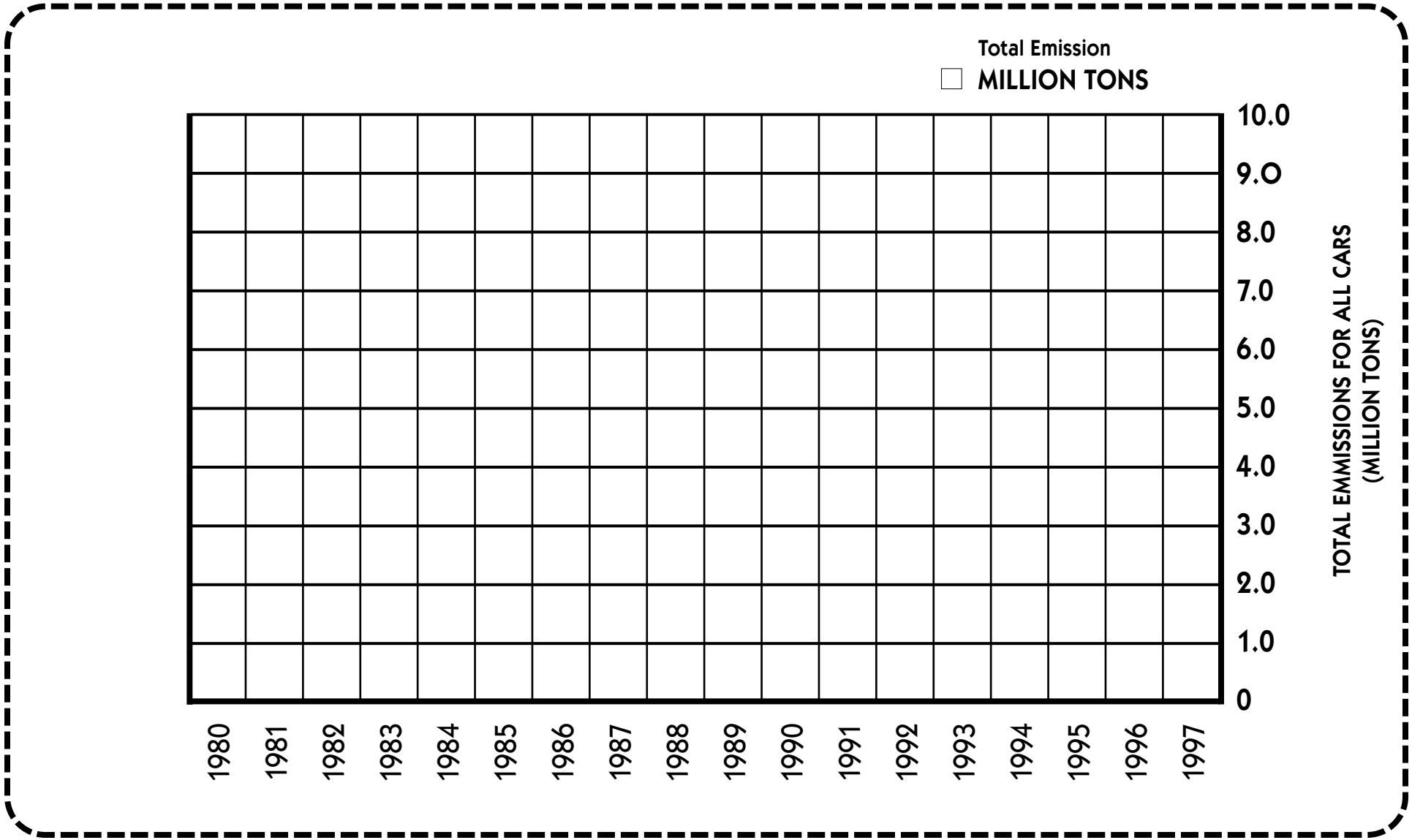
NOx Emission Standards for New Cars



NOx Average Emission for Cars on the Road



NOx Total Emissions for All Cars

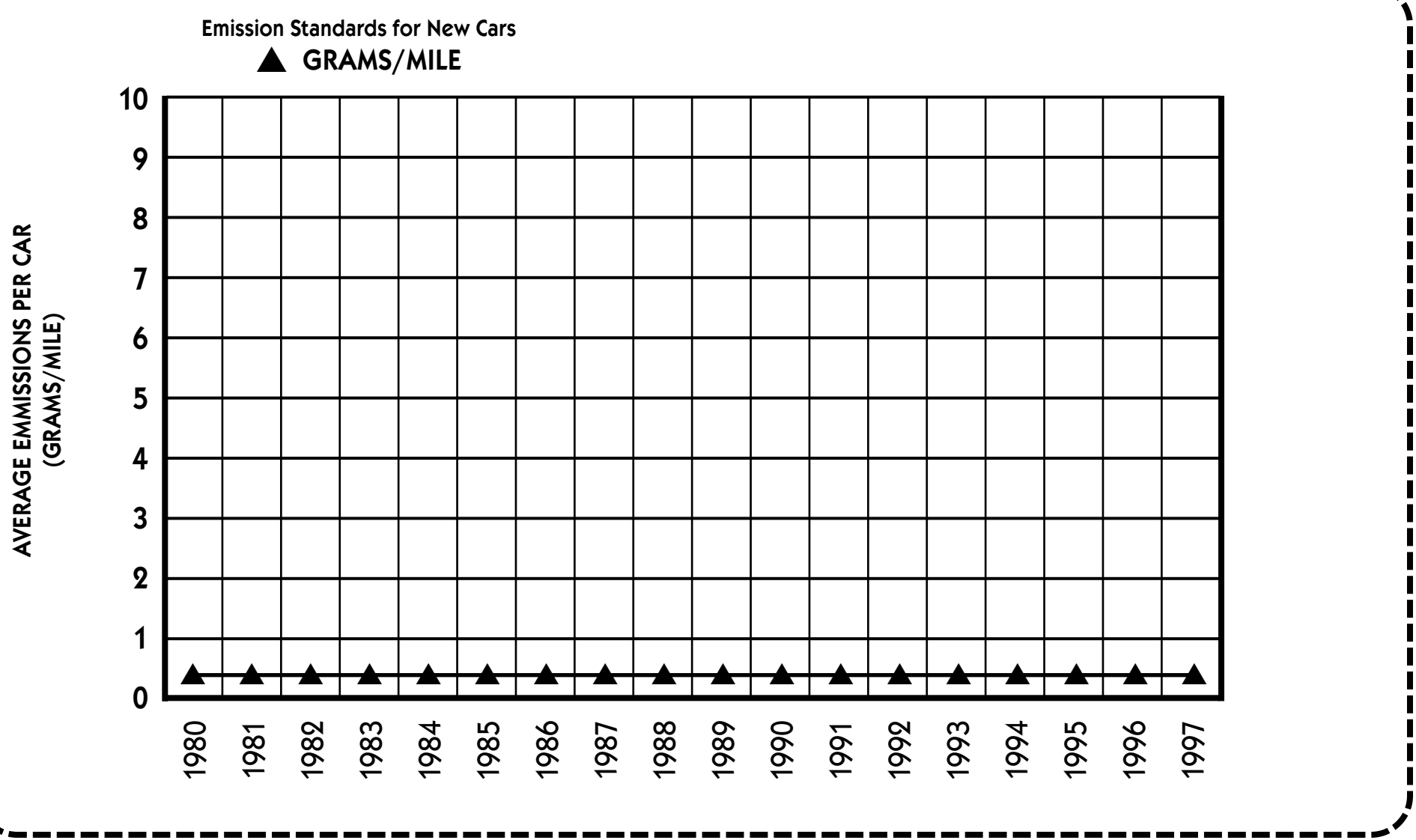


Volatile Organic Compounds (VOC) Data Set

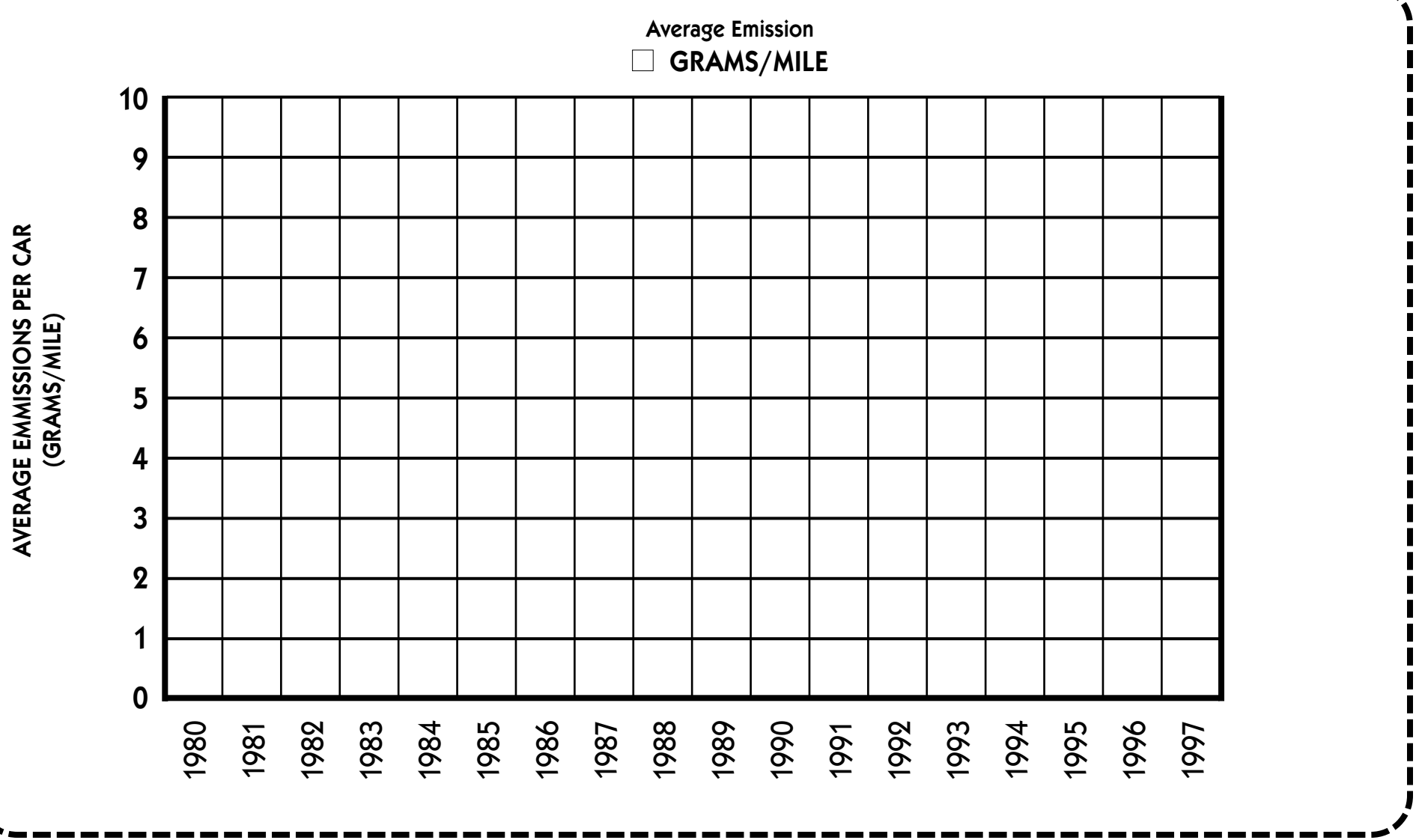
YEAR	EMISSION STANDARDS FOR NEW CARS (grams/mile)	AVERAGE EMISSIONS OF ALL CARS IN USE (grams/mile)	TOTAL MILES DRIVEN IN ONE YEAR BY ALL CARS IN USE (billion miles)	TOTAL EMISSIONS IN ONE YEAR FROM ALL CARS IN USE (million tons)
1980	0.41	5.3	1,527	9.0
1985	0.41	4.8	1,774	9.4
1990	0.41	2.7	2,144	6.3
1993	0.41	2.4	2,296	6.1
1994	0.41	2.5	2,357	6.4
1995	0.41	2.1	2,422	5.7
1996	0.41	2.0	2,485	5.5
1997	0.41	1.9	2,560	5.2

Source: Transportation Energy Data Book: Edition 19. 1999.
Stacy C. Davis. Oak Ridge National Laboratory

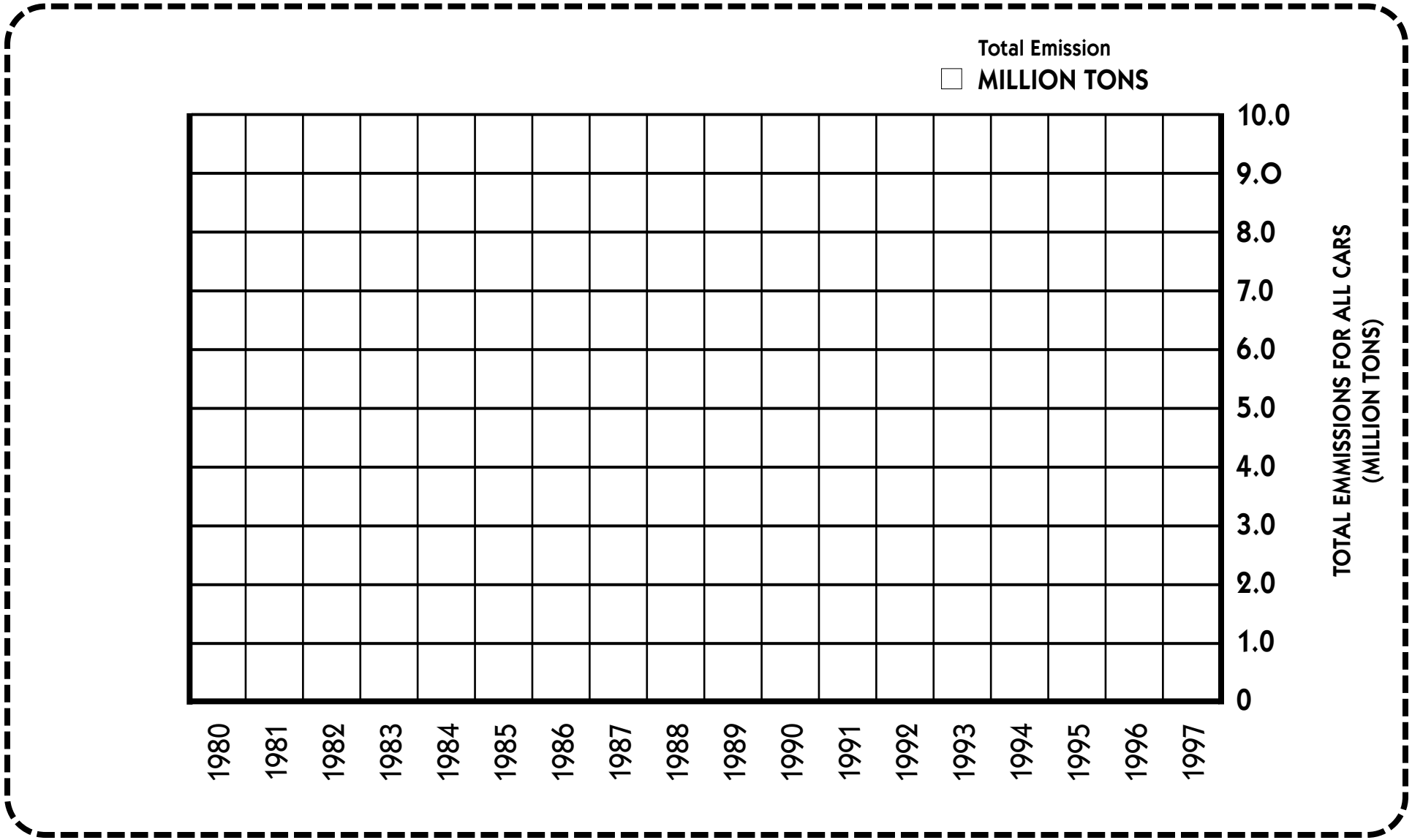
VOC Emission Standards for New Cars



VOC Average Emission for Cars on the Road



VOC Total Emission for All Cars

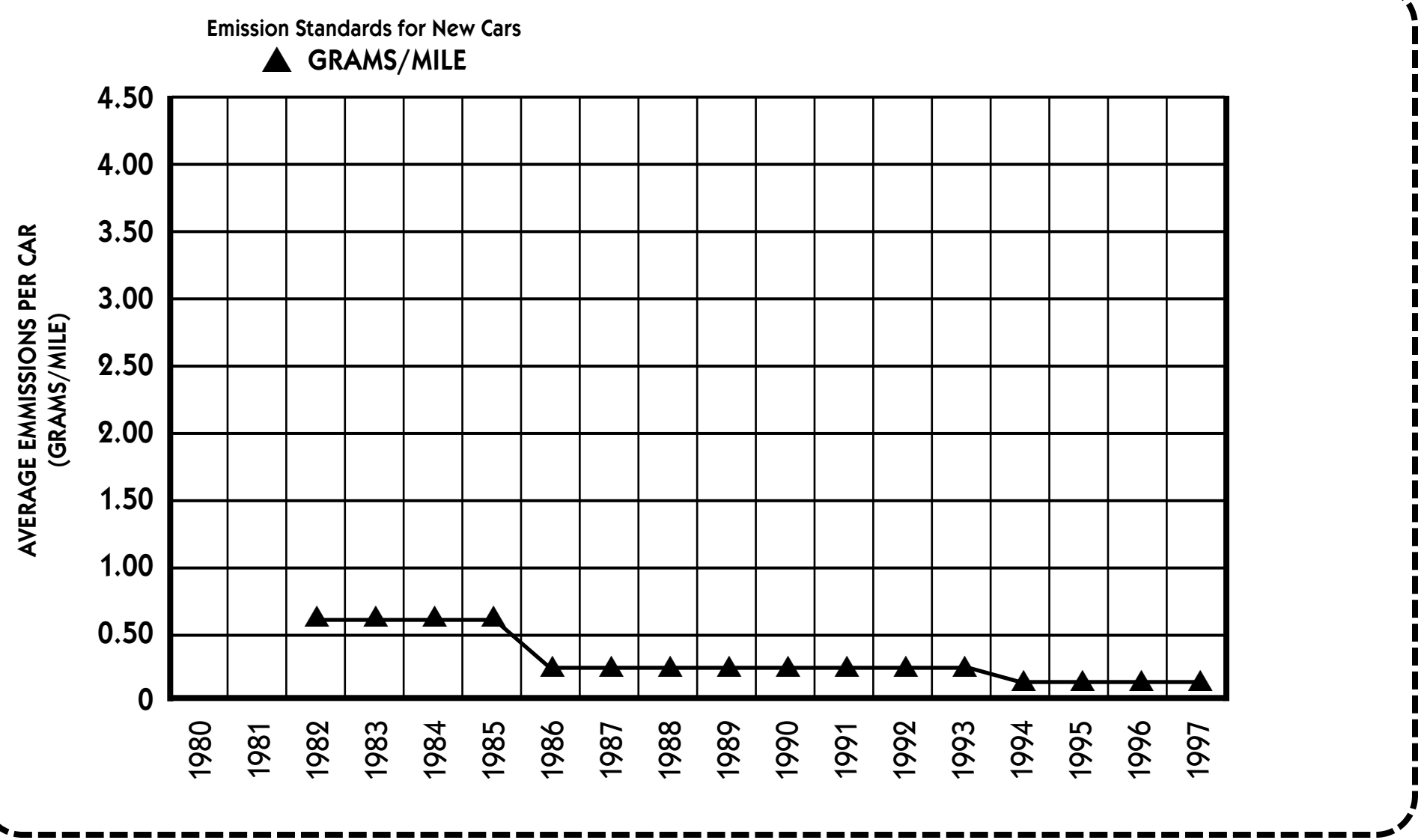


Particulates Data Set

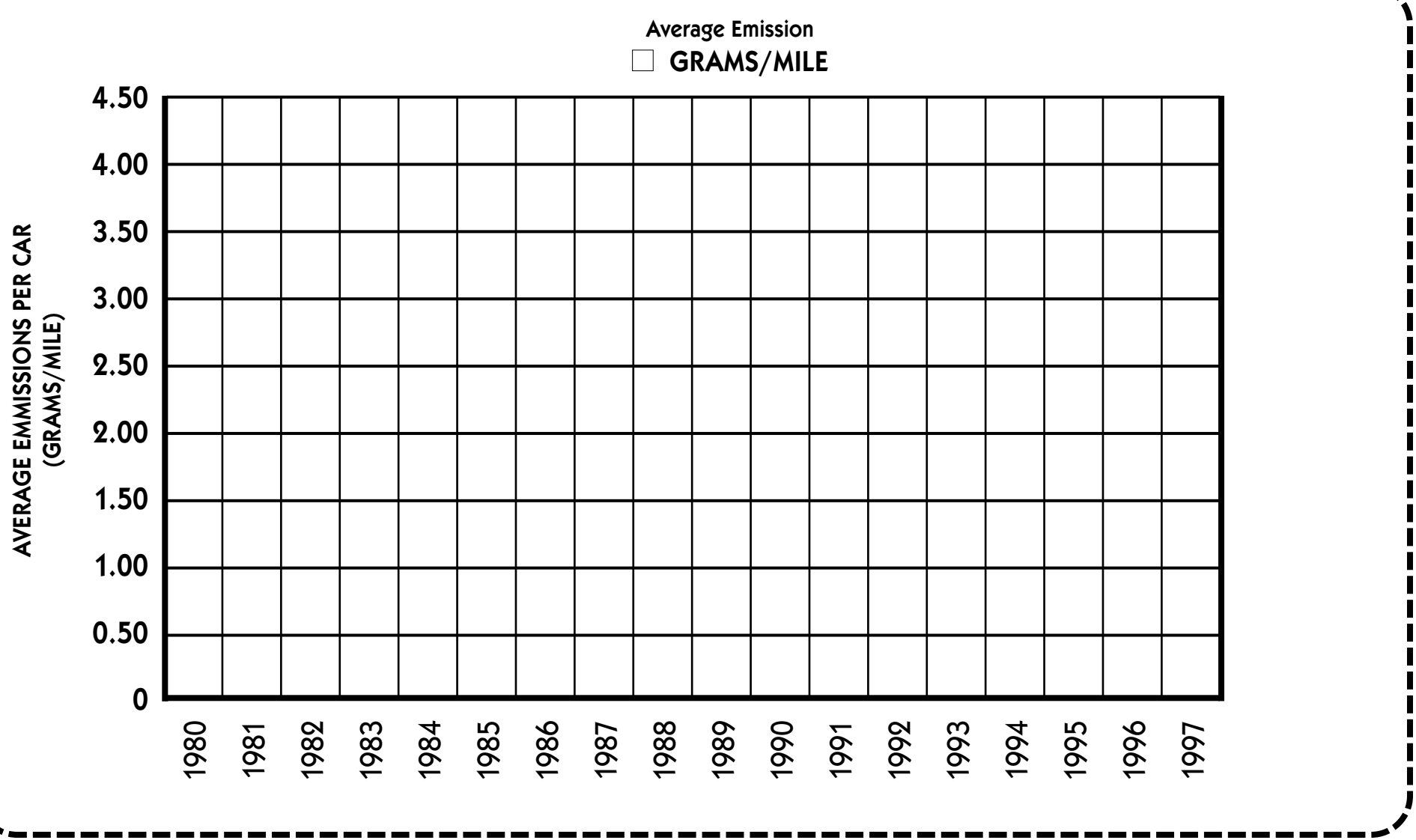
YEAR	EMISSION STANDARDS FOR NEW CARS (grams/mile)	AVERAGE EMISSIONS OF CARS IN USE (grams/mile)	TOTAL MILES DRIVEN IN ONE YEAR BY ALL CARS IN USE (billion miles)	TOTAL EMISSIONS IN ONE YEAR FROM ALL CARS IN USE (million tons)
1980	N/A	0.24	1,527	397
1985	0.6	0.19	1,774	363
1990	0.2	0.14	2,144	336
1993	0.2	0.13	2,296	321
1994	0.08	0.12	2,357	320
1995	0.08	0.11	2,422	293
1996	0.08	0.10	2,485	282
1997	0.08	0.10	2,560	268

Source: Transportation Energy Data Book: Edition 19. 1999.
Stacy C. Davis. Oak Ridge National Laboratory

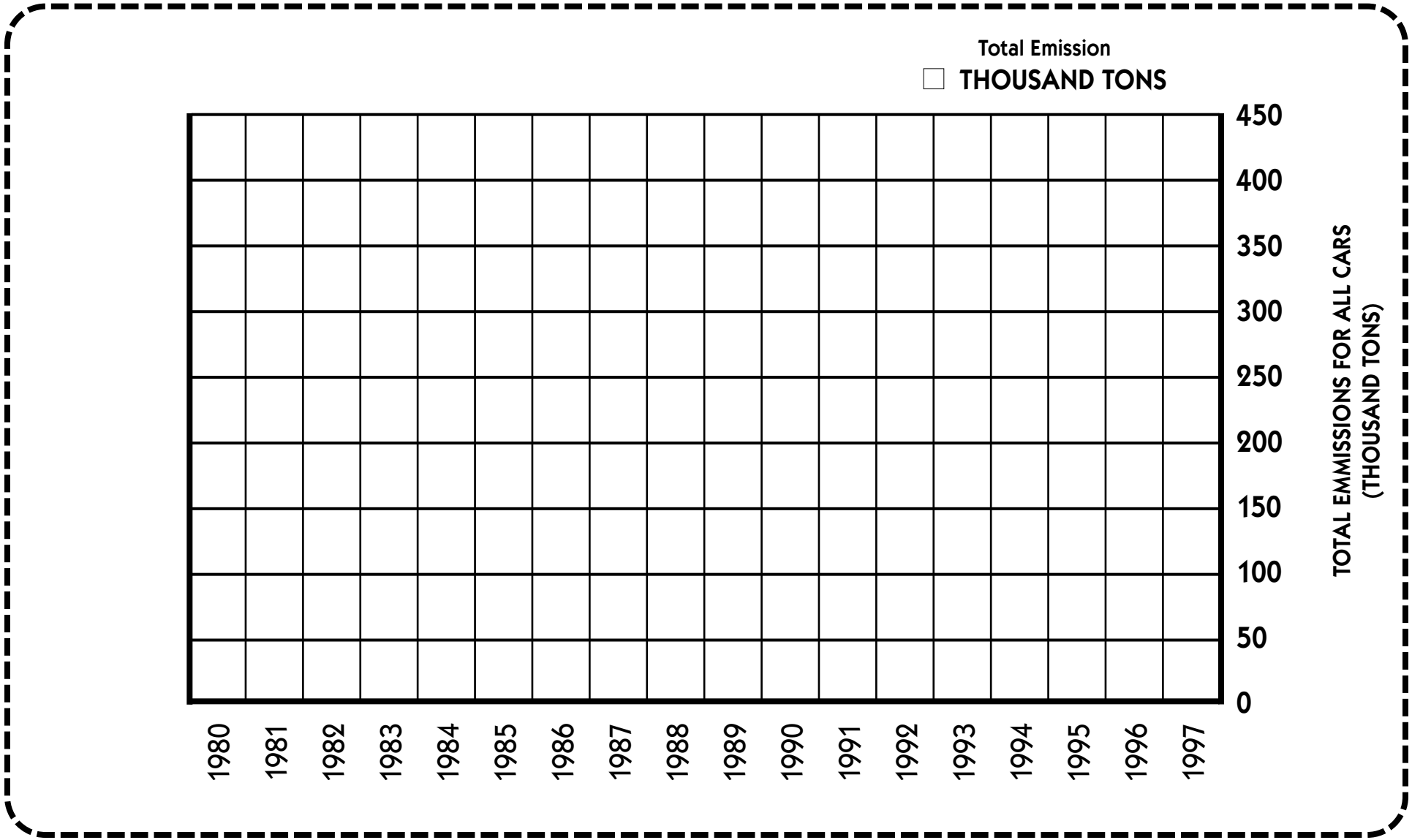
Particulates Emission Standards for New Cars



Particulates Average Emission for Cars on the Road



Particulates Total Emissions for All Cars



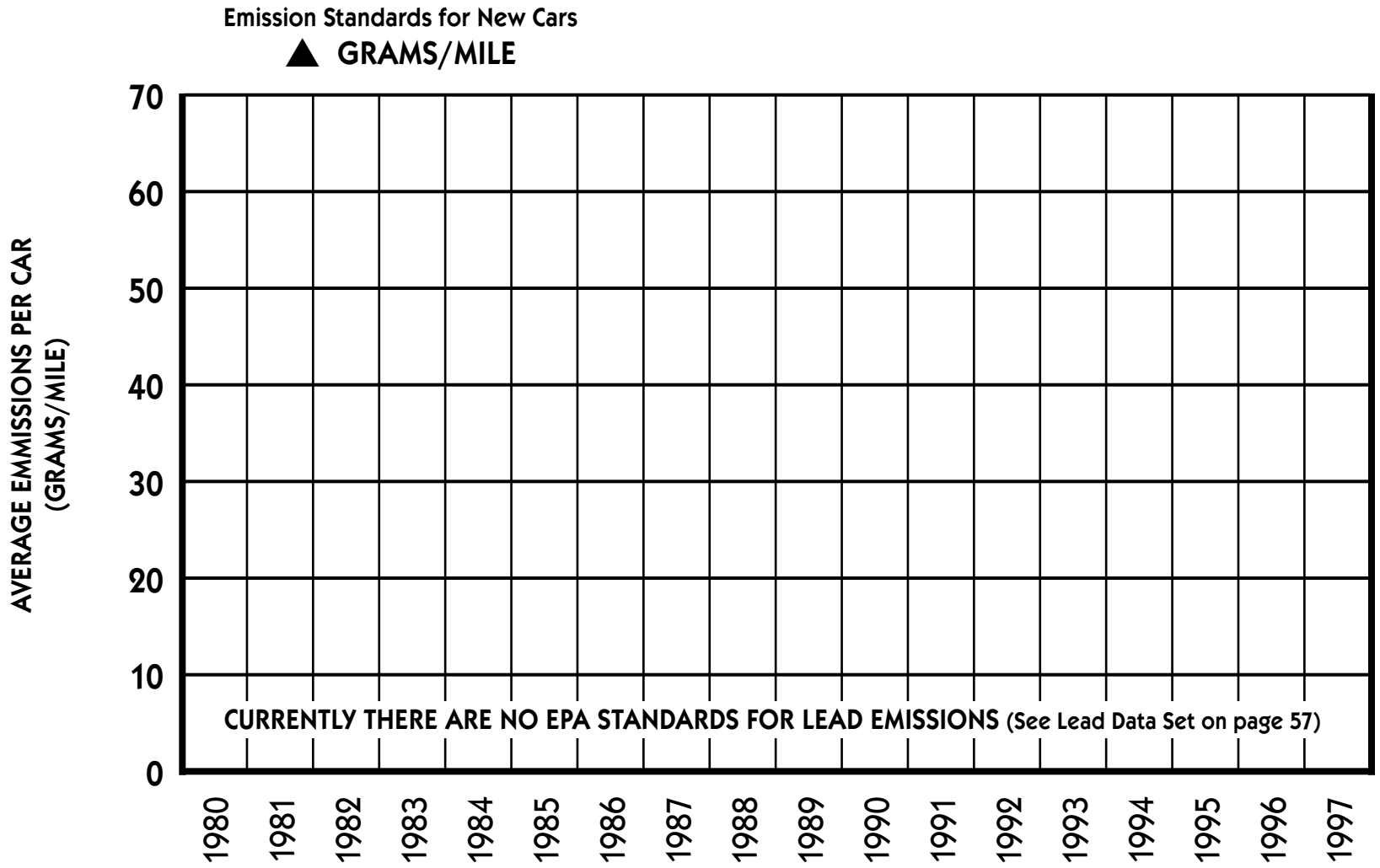
Lead (Pb) Data Set

YEAR	EMISSION STANDARDS FOR NEW CARS (grams/mile)	AVERAGE EMISSIONS OF ALL CARS IN USE (grams/mile)	TOTAL MILES DRIVEN IN ONE YEAR BY ALL CARS IN USE (billion miles)	TOTAL EMISSIONS IN ONE YEAR FROM ALL CARS IN USE (million tons)
1980	N/A	35.9	1,527	60.5
1985	N/A	9.2	1,774	18.1
1990	N/A	0.2	2,144	0.4
1993	N/A	0.0	2,296	0.0
1994	N/A	0.0	2,357	0.0
1995	N/A	0.0	2,422	0.0
1996	N/A	0.0	2,485	0.0
1997	N/A	0.0	2,560	0.0

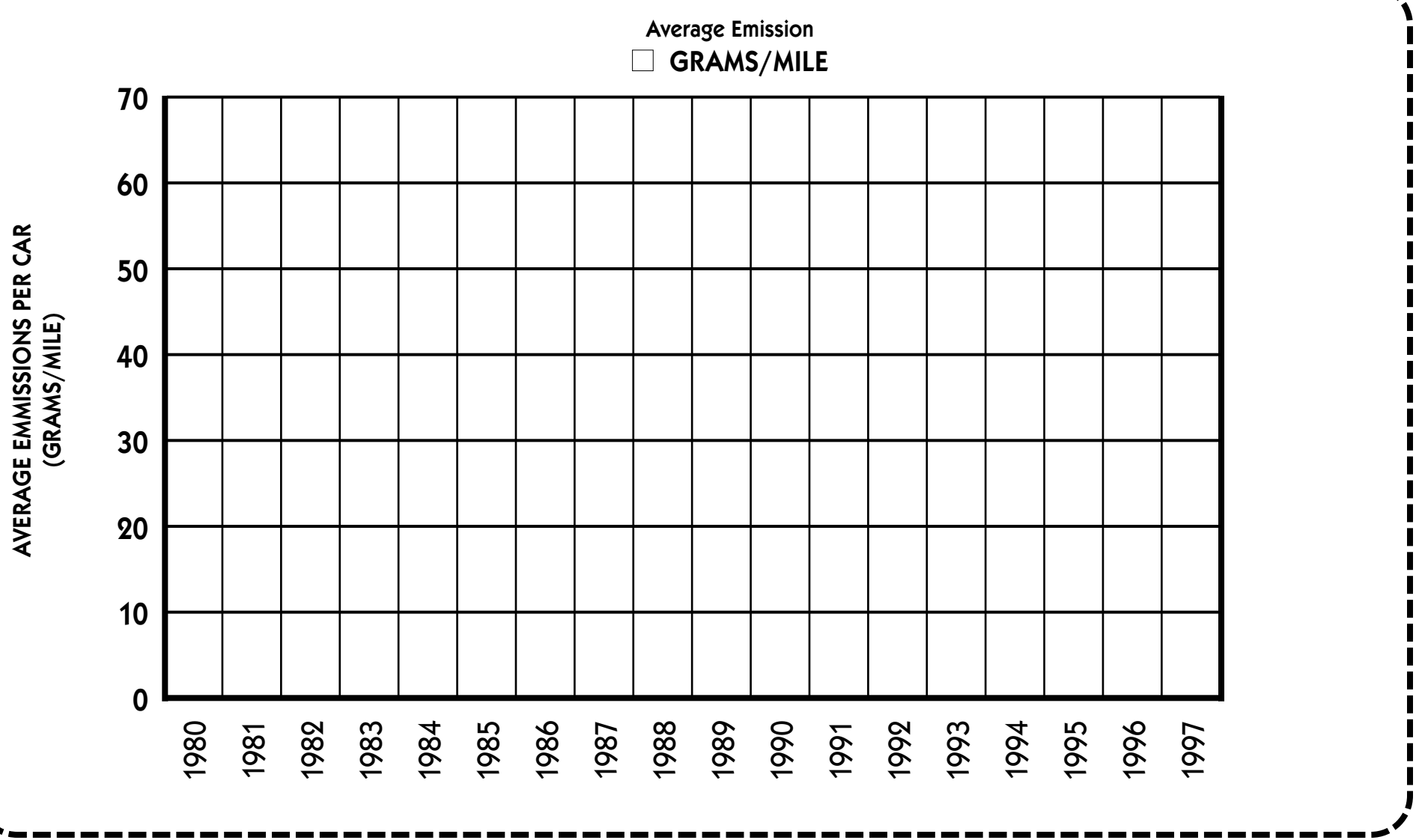
The EPA never established emission standards for lead. Instead, oil refineries were required to supply unleaded gasoline so that catalytic converters could be used to reduce carbon monoxide and VOC emissions.

Source: Transportation Energy Data Book: Edition 19. 1999.
Stacy C. Davis. Oak Ridge National Laboratory

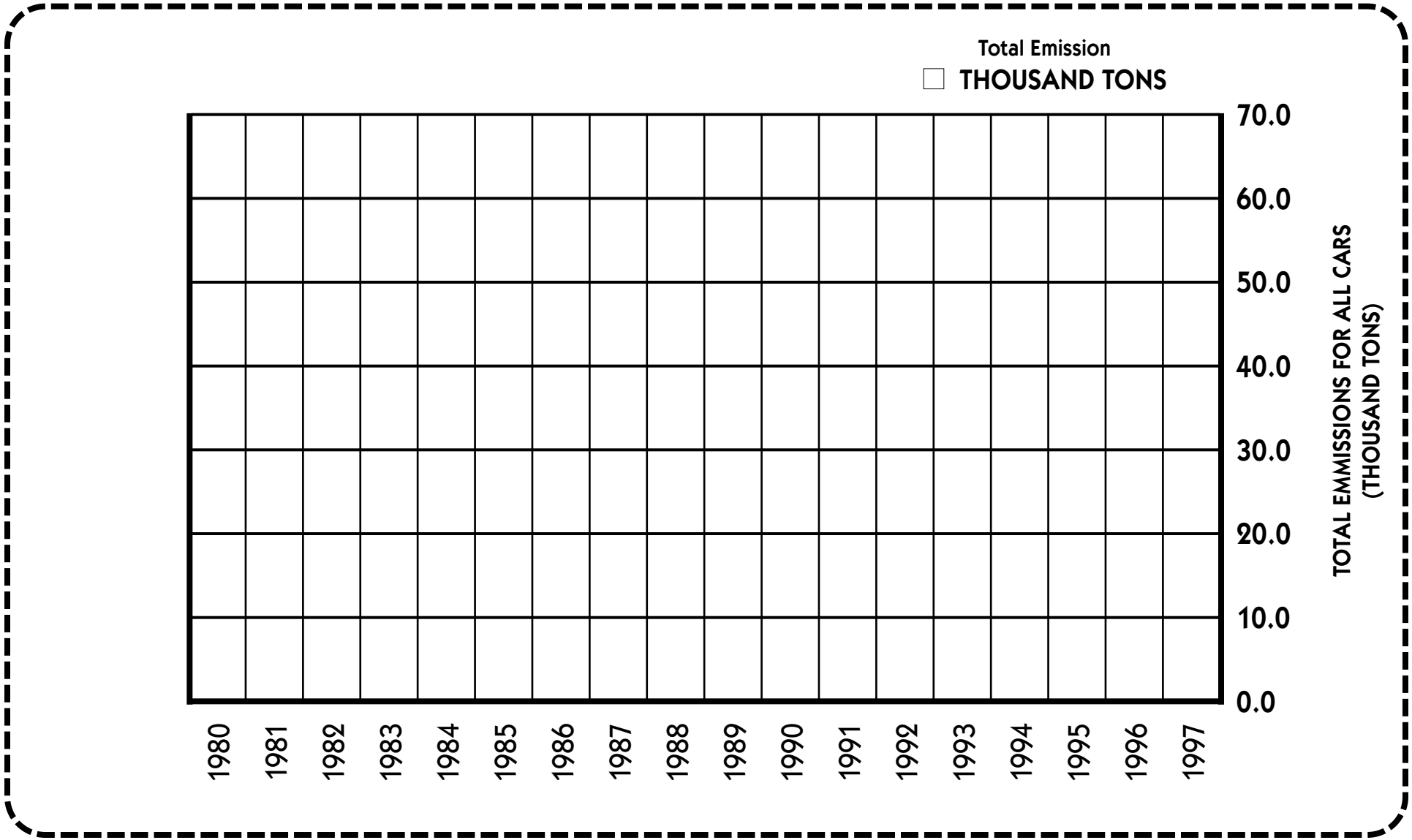
Lead (Pb) Emission Standards for New Cars



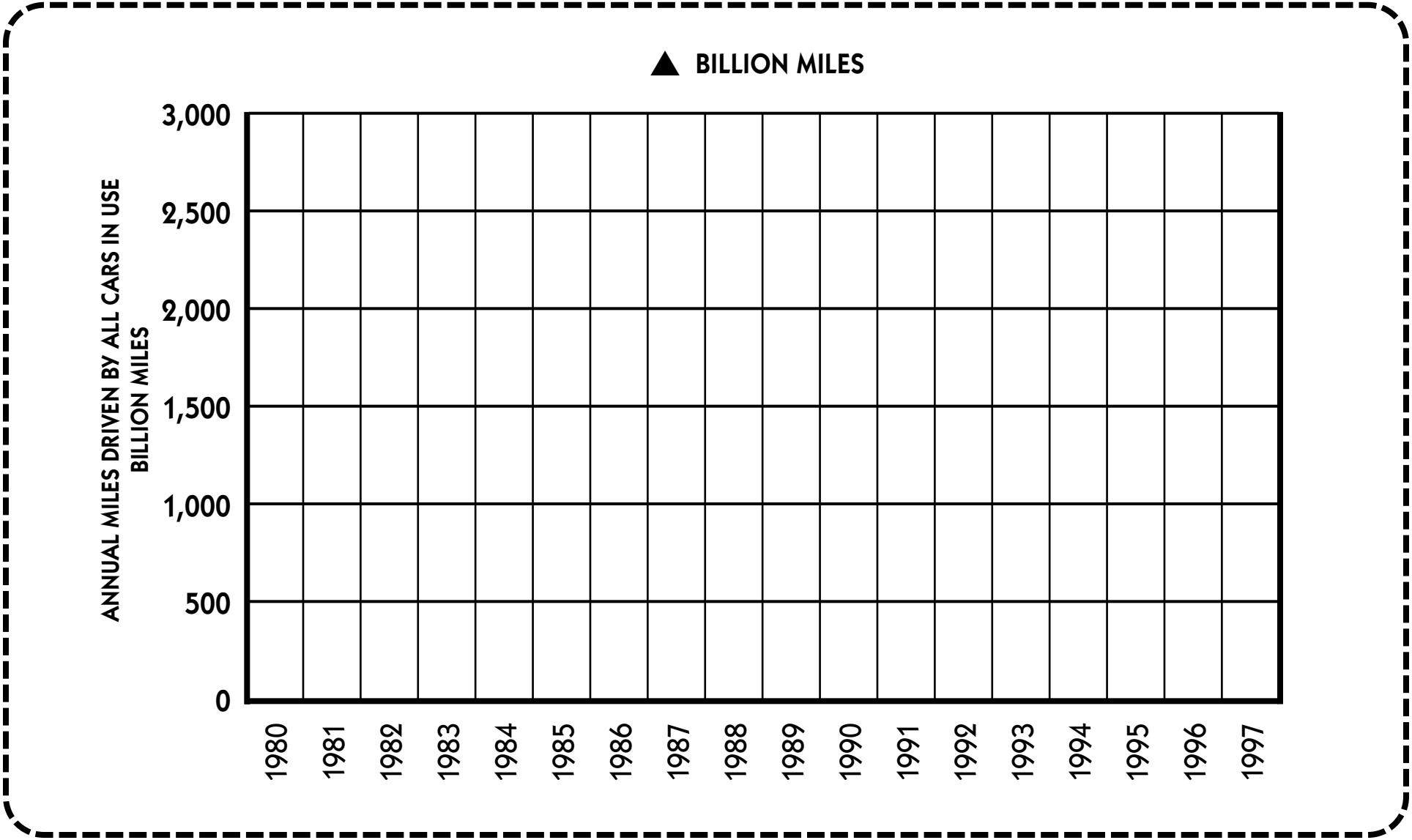
Lead (Pb) Average Emission for Cars on the Road



Lead (Pb) Total Emissions for All Cars

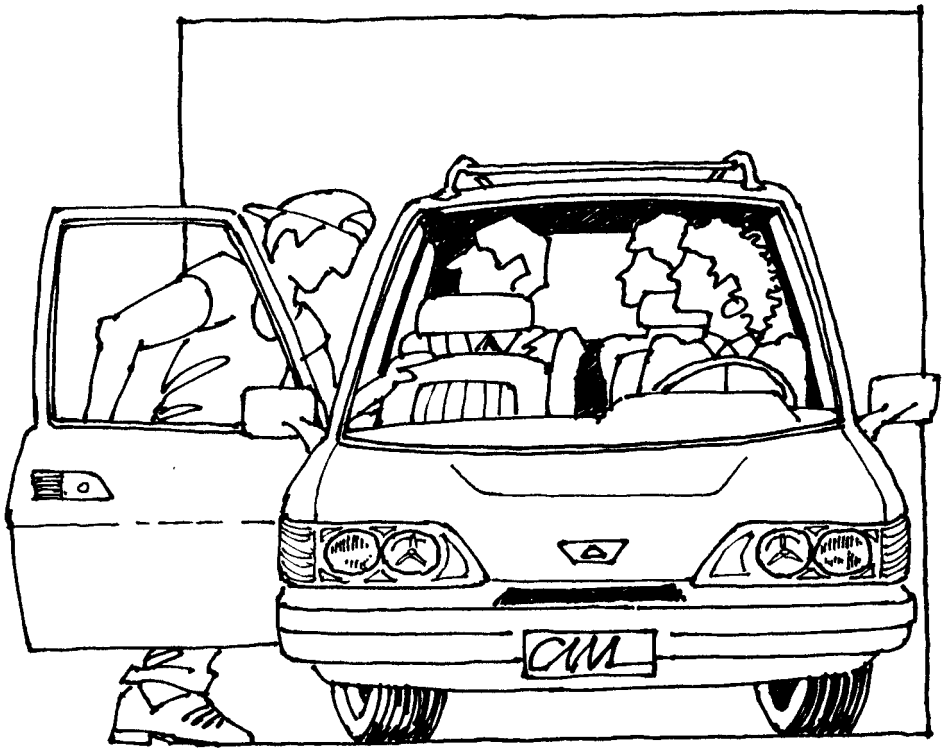


Annual Miles Driven by All Cars in Use



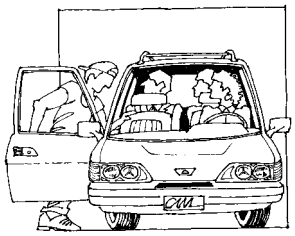
CHAPTER 3

CARPOOLING AND THE ENVIRONMENT



CHAPTER 3

CARPOOLING AND THE ENVIRONMENT



ESSENTIAL QUESTIONS

▲ **What is carpooling and to what extent does it occur in this community?**

▲ **How do you set up a carpooling network?**

OBJECTIVES

The students will:

- Collect and record data to determine the extent carpooling occurs in their community.
- Appraise how their data compares with national census data.
- Select appropriate data for analysis.
- Analyze data to estimate amount of pollution avoided by local people who carpool.
- Examine the environmental, economic and social implications of carpooling.
- Design a carpool system.

ACTIVITIES

NEIGHBORHOOD CARPOOL SURVEY

Time: Homework plus 40 minutes in-class.

CARPOOL CHALLENGE

Time: 45 minutes.

STUDENT PREREQUISITES

- Familiarity with the emission data in lesson 2.

STANDARDS

Technology: Understand transportation systems.

Mathematics: Collect data; number sense; problem solving.

Economics: Natural limits require people to choose between conflicting goals.

Health: Analyze impacts of environmental factors on health.

Language Arts: Discussion, presentations; Optional: write editorial.

History: Recognize the importance of individual choice and actions; Understand rights of individuals in conjunction with ideals of community participation.

Geography: Students locate their community within the context of the world; Understand the consequences of human actions on the earth.

TEACHING NOTES

As we have seen, the automobile offers personal convenience and independence. But we have also seen some of the negative consequences that continue to threaten our health and our environment. Although carpooling won't eliminate these impacts, it provides a way for citizens to begin to address some of them as individuals.

In this lesson students will explore the concept of carpooling, and they will conduct a data-gathering study to learn how much carpooling occurs in their community. By doing simple calculations, the students will be able to quantify the pollution-avoiding value of carpooling. Students will then design a carpool plan for their class.

Students will work in small groups both when

conducting the study after school hour, and when designing the carpool plan.

Assessment: Small group work, worksheets, editorial, carpool plan, and class presentation. The students will write an editorial (for the local paper) in which they argue the case for or against carpooling in their community. Using their data as well as the knowledge gained thus far in this unit, students should be able to write an informative piece.

BACKGROUND INFORMATION

When people get together and share rides, they are carpooling. It can be a social event, minimize automobile emissions and save space on the roads and in parking lots. Carpooling can also reduce personal expenses from gasoline use, tolls, parking, and wear and tear on individual vehicles. If many people were to carpool, time spent in travel could be reduced since there would be fewer vehicles on the road.

Carpooling isn't necessarily easy to organize. People have busy lives and varied schedules. Unless people live near each other and travel to the same general location at the same time, carpooling can be logistically challenging. There can be social concerns as well. How much do you enjoy the other individual(s), and can you depend on them to be on time?

Points For Class Discussion: Carpooling can take effort to coordinate, but there are situations where it can be worth the effort.

For example, consider these scenarios:

- Gasoline prices were significantly higher, as in Europe or Canada. The incentive to reduce gasoline use would be greater.
- Governments established carpool lanes for vehicles with three or more people. Using the carpool lanes could save considerable time and reduce frustration in locations where congestion was significant.
- Where air pollution was a highly noticeable problem. Local school children might pressure their families and neighbors to share rides, (much as they pressured their families to recycle).
- The carpool provided an enjoyable social experience.
- A family could function with one fewer car, thereby saving money for other luxuries.

ACTIVITY 3.A

NEIGHBORHOOD CARPOOL SURVEY

OUTCOMES

As a result of this activity students will:

- Use multiple techniques to gather, analyze, and interpret data;
- Draw a conclusion, based on their data analysis, on whether cumulative individual actions can play a significant role in reducing transportation-related pollution in your community.

TIME REQUIRED

- Homework plus 45 minutes in class.

MATERIALS

- Student Worksheets
- Clipboard per group
- Calculator per group
- Local map

TEACHER PREPARATION

Communicate with parents about student survey.

Review survey analysis worksheet and be prepared to give concrete examples that can help students understand the mathematical concepts they are working with in this activity.

Option A: Gather journey to work and population data from the web.

Option B: If you wish students to find their own information on the web, become familiar with the required web sites.

ACTIVITY OVERVIEW

Students conduct a survey of rush-hour vehicle occupancy in their neighborhoods to estimate the percent of people whom carpool. They compare this estimate with U. S. census data and calculate how much carpoolers reduce pollution in their town. This activity shows students how personal choices can have far-reaching effects on the entire community.

ACTIVITY

SURVEY: For homework, students will work in small groups to collect data on carpooling in their community. They will gather this information by observing passing cars, preferably during evening rush hour between 5- 6:30, and counting the numbers of passengers in each.

Working with a map of your community, have students identify data collection locations and times. Make sure to take into account:

- personal safety;
- visibility (ability to count passengers),
- minimizing counting the same cars twice.

Assign small groups of neighborhood kids to each location. Give students time in class to discuss their different roles: who will be counting passengers, who will be responsible for record keeping, etc. The students will use the worksheet to record their final tallies.

Students should also survey the adults at home on whether they carpool and how far they travel to work.

Caution students about safety.
Be sure to communicate with parents about this activity. Student safety is of prime importance. In some communities at certain times of the year, it may be dark during rush

hour. In this case it may be preferable to conduct the study earlier in the day. Students need to be visible to motorists and students need to be able to count numbers of passengers

IN-CLASS DATA ANALYSIS: Although students should start off working as a class, you may want students to complete most of the work in groups or as individuals. They will need two pieces of information from the Internet, percent of carpoolers in your community and total community population. You may want to supply them with this information or ask students or groups of students to get the information. At the end of the lesson, students should work on the final editorial as individuals.

As a class, ask the students to compile their results on the board. Ask them to share information collected from their families. Have them report 1) the total distance adults in their families travel to work and 2) the total number of family adults surveyed. Ask the students to calculate the average distance to work for all adults surveyed.

Each group should also share 1) the total number of people counted, 2) the total number of people sharing rides, and 3) the percent of people counted who shared rides. From this data have the class calculate the percent of people counted who shared rides for all groups.

Have the class compare this number with U. S. census data for your area. This information can be found on the web at **http://www.census.gov/population/www/socdemo/journey.html.** Here you can find 1990 data by state, by the 50 largest metropolitan areas, and by the 50 largest cities. Choose what data you wish to work with.

Ask the students why the two values may be different? This can include discussions on such topics as: sample size both in number and in time span, locations of data collection, year data was collected, and size and make-up of community sampled.

Ask the students as a class or as teams to choose which value they believe represents their town best, theirs or the U. S. census. Have them use that value when completing the remainder of the worksheet. Note: you will need to supply students with your community's population or have them go onto the Internet to find the information. You can find this information at **www.census.gov/population/www/estimates/mcdplace.html.**

Completing this worksheet requires a fair amount of mathematical thinking. You may want to pre-review the worksheet and be prepared to give concrete examples to help students understand the mathematical concepts they are working with.

ASSESSMENT: Accuracy and mathematical thinking recorded on worksheet. Also, have students write an editorial opinion, based on their discoveries, about whether or not they believe that carpooling could play a significant role in reducing transportation-related air pollution in their neighborhood.

Neighborhood Carpool Survey

Names: _____

_____

_____

_____

Working in small groups, you will collect information about carpooling in your community. Find a safe spot next to a reasonably busy road in your community. On a weekday evening, between 5:00 PM and 6:30 PM, record the number of occupants in each car that passes by. Try for a sample of at least 50 cars. Use hash marks to track the number of cars in each category below. For Example: 𝍸 /// represents 8.

Date: _____ Starting time: _____ Ending time: _____

Location: _____

ONE PERSON	TWO	THREE	FOUR	FIVE (or more)

TOTALS:	NO. OF CARS	NO. OF PEOPLE
One-person occupancy cars:	_____	_____
Two-person occupancy cars:	_____	_____
Three-person occupancy cars:	_____	_____
Four-person occupancy cars:	_____	_____
Five-person occupancy cars:	_____	_____

Total number of people counted: _____

Total number of people sharing rides: _____

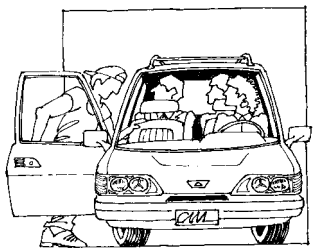
Percent of people counted who shared rides: _____

FAMILY DATA

Distances that adults in your families travel to work _____ _____ _____ _____

Numbers of adults in your families who carpool to work: _____ _____ _____ _____

Neighborhood Carpool Survey Analysis



Name: _____

With this analysis you will estimate the amount of pollution that carpoolers in your community avoid producing. By reducing pollution, we can make the air healthier for everyone.

GATHER INFORMATION

1. Percent of people counted by entire class who shared a ride. _____ %

2. Average distance to work for all adults surveyed. _____ miles

3. From US Census Data for the geographic area: _____

Percent of workers who carpooled in 1990: _____ %
Note: This data can be found at www.census.gov/population/www/socdemo/journey.html

4. Circle the percent that you and your team feel best represents your community.

Explain why you choose this number? _____

_____

_____

5. a) From US Census Data: The population of your community: _____ people
Note: This data can be found at www.census.gov/population/www/estimates/mcdplace.html

b) On a national average half the population works.
Use this to estimate the working population of your community _____ people

6. Estimate the number of people who carpool to work in your community.

Workers x %/100 = No. of people who carpool _____ people

7. How many car trips per day do these carpoolers avoid if they all ride 2 to a car?
(With 2 people to a car they won't use half of their cars. This will happen twice a day.)

Number of trips avoided each day with 2 to a car: _____
trips avoided/day by carpoolers

8. The national average trip length to work is 12 miles. Compare this with the average trip length to work of all adults surveyed by your class. Choose the number that you and your team feel best represents your community.

Estimated average distance to work in your community _____ miles

Explain your reasoning for this choice. _____

_____

_____

Neighborhood Carpool Survey Analysis, page 2

CALCULATE OUTPUTS

9. Calculate how many miles per day on average carpoolers **avoid driving** if they all ride 2 to a car?

Miles avoided **per day** with 2 to a car: _____ miles

10. Calculate how many miles per year on average carpoolers **avoid driving** if they all ride 2 to a car? Let's say there are 240 workdays in each year.

Miles avoided **per year** with 2 to a car: _____ miles

11. Use the following numbers to calculate the amount of pollution **avoided per year** by carpoolers in your community.

Average grams per mile of car emissions:

CO2 413 grams/mile
CO 18 grams/mile
NOx 3 grams/mile
VOC 2 grams/mile

CO2 emissions *avoided per year* by carpoolers in your community

Emissions avoided with 2 to a car: _____ grams

CO emissions *avoided per year* by carpoolers in your community

Emissions avoided with 2 to a car: _____ grams

NOx emissions *avoided per year* by carpoolers in your community

Emissions avoided with 2 to a car: _____ grams

VOC emissions *avoided per year* by carpoolers in your community

Emissions avoided with 2 to a car: _____ grams

12. Convert each of these into pounds. 1 lb = 454 grams.

CO2 _____ lbs. CO _____ lbs. NOx _____ lbs. VOC _____ lbs.

13. These estimated numbers assume two-person carpools. Many people carpool with more than one other person, thus the avoided pollution may even be greater. On the other hand not all people who carpool carpool every workday. Still, given the results from your carpool survey and subsequent estimates, consider the possible impact carpooling could have on your community.

Write an editorial opinion, based on your discoveries, about whether or not you believe that carpooling could play a significant role in reducing transportation-related pollution in your community.

_____

_____

_____

_____

_____

ACTIVITY 3.B

CARPOOL CHALLENGE

OUTCOMES

As a result of this activity students will:

- Demonstrate an understanding of scale and map reading skills.
- Exhibit critical and creative thinking in solving a real-world logistical puzzle.
- Determine direct environmental benefits of a class carpool plan.

TIME REQUIRED

- 45 minutes in class.

MATERIALS

- Large local map with scale
- Copies of local map for students
- Tracing paper or overhead transparencies
- Colored markers
- String to measure mileage
- Calculator (optional)
- Overhead projector
- Transparencies

TEACHER PREPARATION

Find appropriate local map and reproduce as needed.

ACTIVITY OVERVIEW

Using a local map, students will design a carpool plan that most efficiently transports each classmate from their home to the school for a hypothetical event. In the case of some urban schools, carpooling may not be feasible. In this case proceed to lesson #5, Mass Transit.

ACTIVITY

Have each student locate where they live on a master class map and indicate the location with their initials. If there are issues of privacy, have the student(s) randomly mark a location within the school district.

As individuals, each using a copy of the local map, have students find the shortest route from their house to school and measure this distance in miles. Have them record this route on their map along with the number of miles. In the meantime, establish groups of students by the proximity of classmates' homes.

Divide the class into groups.

Teacher note: By doing this challenge, students may see the benefits or problems with carpooling more clearly. Issues may arise concerning friendships and cliques. It would be an opportunity to discuss these issues, before, during, or after the challenge. These are real concerns for students and they are real for adults as well.

Depending upon how much time you have available, there are two options:

1. Challenge Express:
Tell the students that they are to design a carpool plan that transports each classmate in the group from their home to the school using the least number of miles driven. Have them record this route on their map along with the number of miles it covers. Have each group calculate the number of miles they avoid driving by carpooling.

Have each group share their results with the class. As a class, add up the total number of miles they could avoid by everyone carpooling.

2. Challenge in-depth:
(A logistical challenge). Tell the students that they are to design a carpool plan that transports all classmates from their homes to the school using the least number of miles driven by all cars involved. Have them record each route on their map along with the number of miles each route covers and the total number of miles of all carpool routes.

CHALLENGE GUIDELINES:

- There can be no more that five students to a car.
- Students must be picked up right outside their homes.
- Each design should be clearly drawn on a map. Each carpool vehicle's route should be indicated by a different color.
- Students should be prepared to present and defend their completed designs to the class. If time is short, share the designs with the least number of vehicle miles.
- Classmates should be prepared to verify or challenge each other's designs and calculations

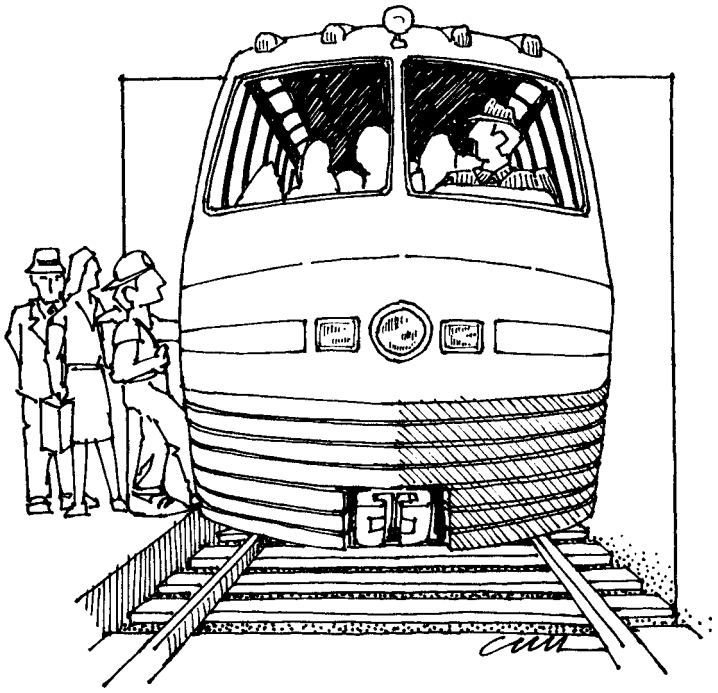
Carpool design routes can be traced using overhead transparencies or tracing paper placed over a map. Transparencies allow students to easily present their results to the class. An option would be to have the students transfer their plans to a final copy and have displayable maps.

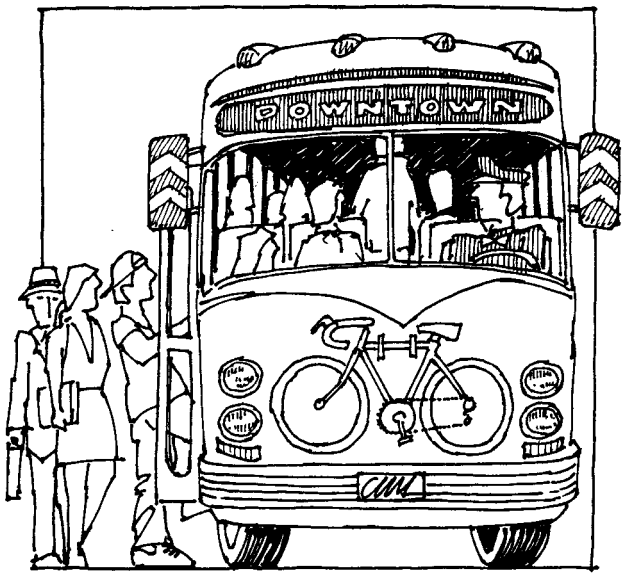
Have the whole class determine the amount of pollutants saved with the winning design. By calculating the number of vehicle miles necessary to drive each student to school individually, the worst-case scenario could be quantified. (To do this, have each student determine the distance they live from the school. Add these together for a class total.) Compare the class's total number of vehicle miles to the best-case scenario, (the winning design).

Note: The average car emits almost one pound of CO2 per mile. A pound of CO2 at 1 atmosphere and 80° F. occupies approximately the volume of one 55 gallon oil-barrel. The benefits of carpooling should be evident.

CHAPTER 4

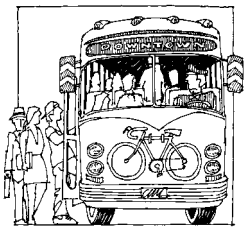
MASS TRANSIT





CHAPTER 4

MASS TRANSIT



ESSENTIAL QUESTIONS

- **What is mass transit?**
- **What mass transit is available in my community and how do I use it?**
- **Does using mass transit reduce pollution?**

OBJECTIVES

The students will:

- Understand the concept of mass transit.
- Evaluate environmental and social factors relating to mass transit.
- Read and analyze a local mass transit schedule and map.

ACTIVITIES

PLAN A MASS TRANSIT OUTING
Time: 45 minute-class.

STUDENT PREREQUISITES

- Some familiarity with reading maps.

STANDARDS

Technology: Understand a transportation system: Document a design process.

Mathematics: Read charts and graphs.

Social Studies: Recognize the importance of individual choices and actions. Read maps.

Economics: Natural limits require people to choose between conflicting goals.

Civics: Role of the government at the national, state, and local levels.

Health: Recognize environmental factors on health.

Language Arts: Oral presentations.

TEACHING NOTES

Mass transit, or public transportation, drastically reduces the amount of pollution that is emitted into the air.

This lesson includes a brief introduction to the concept of mass transit but focuses primarily on the practical aspects of using local mass transit systems (reading a schedule and planning an outing). Some school districts will have to look beyond their immediate communities to nearby cities. Urban districts may choose to focus on a variety of mass transit systems available to them.

By introducing this topic, rural and urban children alike will have a new appreciation for the role mass transit plays in contemporary society.

Assessment: During the first activity, there will be an opportunity to informally assess individuals as they learn to read a transit schedule. Worksheets will allow for more formal assessment. Students will document a travel plan, the results of which will be verified by classmates. The challenge in lesson #5 will allow students to apply conceptual information gained in this lesson.

BACKGROUND INFORMATION

Americans are traveling more miles each year. Because the automobile is the travel mode of choice for most Americans (there is one car for every 1.7 individuals), and because it is also the largest polluter of our air, we have reasons to explore and encourage alternatives. Because pollution threatens our quality of life, we should reexamine our lifestyles, including our transportation choices. One way to significantly decrease air pollution, traffic congestion, and land loss to roads is to establish and use mass transit systems.

Buses, trains, ferries, subways, airplanes, trolleys, and other vehicles designed to transport large numbers of people are all forms of mass transit.

What makes a mass transit system successful?

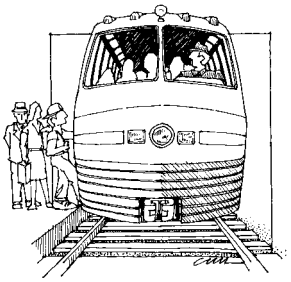
SYSTEM GOALS

Convenient: "stops" need to be accessible to homes, places of employment, schools, commercial establishments, and entertainment centers. A successful mass transit system must get you to where you want to go when you want to go there.

Safe: People need to feel that they will not be threatened either by the vehicle itself, or by other people.

Comfortable: The vehicles need to be designed to fit the human body well. They need to be large enough to transport the numbers of people using the system.

Economically feasible: The cost of transporting an individual must be reasonable. It must compare favorably to other modes of transportation.



Well used: A critical number of passengers need to use the system for it to be feasible and for it to continue.

Reliable: Passengers need to know that the vehicle will be where it is scheduled to be and that they can depend on it to get them where they need to be.

Efficient: Time is important. Passengers want to know that they are getting where they want to go in a reasonable amount of time.

Other Considerations:

People concerned for public health and a healthy environment would consider a mass transit system successful if it helped to make a cleaner world.

At one time mass transit systems played a much larger role in transporting people, and not only in large cities. But cars offered people unrivaled freedom, enjoyment, and personal efficiency. As a result the landscape of cities, towns, and even the countryside, changed to accommodate the car.

Today automobile transportation is central to our way of life. As communities attempt to balance the transportation needs of their citizens with economic, social, and environmental pressures, mass transit offers many benefits. When successful, it can, and does rival the appeal of the automobile.

ACTIVITY 4.A

PLAN A MASS TRANSIT OUTING

OUTCOMES

As a result of this activity students will:

- Interpret maps and schedules.
- Plan an outing using information from maps and schedules.
- Evaluate environmental benefits of using mass transit over single passenger cars.

TIME REQUIRED

- 45-minute class.

MATERIALS

- Overhead or copies of "Pollution By Mode Of Travel" and "Feet, Pedals, or Tracks."
- Overhead projector if using transparency.
- Local mass transit schedules (enough for each student or photocopies of pertinent information).
- Local map.

TEACHER PREPARATION

Locate source for mass transit schedules.

Be familiar with schedules, information.

ACTIVITY OVERVIEW

By planning a group outing using mass transit, students will become familiar with local mass transit opportunities, terminology, schedules, and routes. Individual students will follow this up by planning another outing for homework. Inviting someone from a local mass transit authority to speak to the class would make an excellent introduction to this activity.

Depending upon the community, students may or may not be familiar with local mass transit opportunities and terminology. Adapt your approach to their understanding and experience.

ACTIVITY

Write the vocabulary words on the board and introduce mass transit with the overheads "Pollution by Mode of Travel" and "Feet, Pedals, or Tracks".

VOCABULARY:

Mode of transportation	**Departure time**
Mass transit route	**Connection**
Mass transit stop	**Passenger mile**
Arrival time	

Begin a discussion on mass transit and define the vocabulary words as they come up in conversation.

Here are some suggested questions to begin with.

- What is mass transit?
- What mass transit travel modes are available in this community? (Rural areas may need to consider the closest city).
- Does mass transit play an important role in transporting local people? Why or why not? Display the overhead "Public Transportation." Ask for volunteers to decipher "Tires, Pedals, or Tracks."
- What are the environmental implications of the graphic, "Pollution By Mode Of Transportation." Ask for volunteers to decipher this graphic. (Passenger miles are determined by dividing the total emissions of each by the average number of passengers.)
- How does mass transit get started?
- What are the roles of government and the private sector?
- What factors (system goals) would be important for a mass transit system to be successful?

Pass out local mass transit schedules. If this is a problem, photocopy relevant charts and information. As a class, read through a schedule. Use a local map to help orient the students. Locate different landmarks, routes, stops, days, times, cost, etc. Discuss safety issues. Guide the class through a simple trip to a local destination.

For practice, students can present riddles to the class or small group.
"I am leaving the town hall on the 10:30 bus. Traveling on the green line, I'll arrive at the cinema at 10:55. If the movie starts at 11:10 and lasts two hours, which bus will I leave on to get back home?"

Individually or in small groups have students use a mass transit schedule to plan an afternoon outing in the local or neighboring community. Hand out the Mass Transit Travel Plan Worksheet to guide them through the process. You will need to establish the parameters at the top of the worksheet: beginning and ending times, beginning and ending location, and the destination. Modify the challenge as needed.

Parameters:

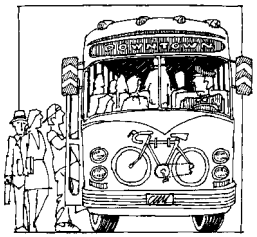
- All students begin and end at the school. (Make sure there is an official stop there or somewhere nearby).
- Their outing can begin when school ends for the day.
- They need to decide on a destination and have a plan as to how they will get there and back by 6:00 PM.
- Using the worksheet provided, each student will record the information as requested.

Brainstorm some possible destinations with the students. Is there somewhere to go watch a sporting event, movie, ice cream, shopping, or exercise?

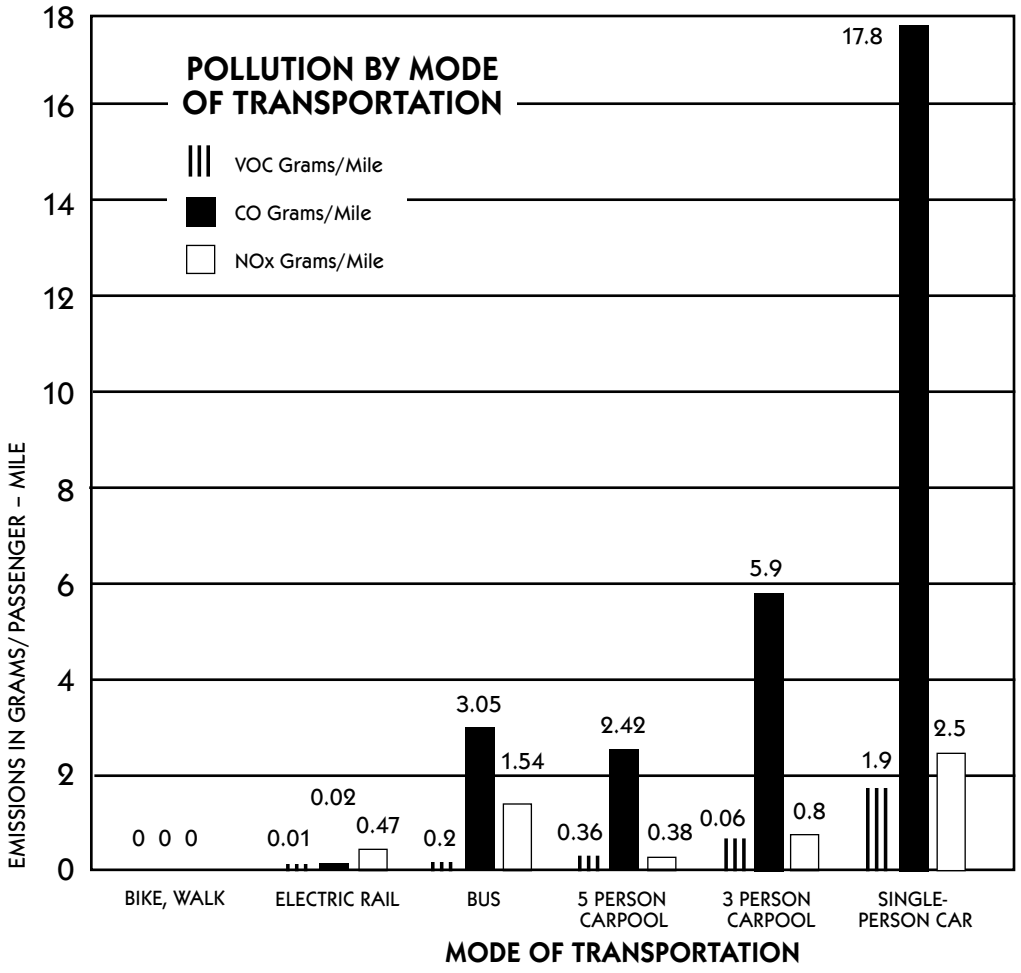
Upon completion, travel plans should be shared with the class. Meanwhile classmates can verify the results.

STUDENT INFORMATION

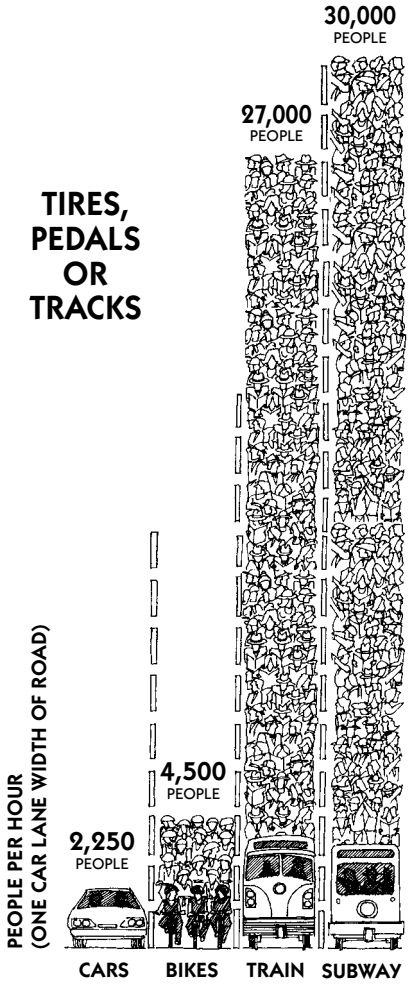
Public Transportation



Using public transportation can drastically reduce the amount of pollution that is emitted to the air. Look at the following charts to compare the pollution created by using different forms of transportation.



Source: American Public Transit Association (based on national average vehicle occupancy rates)



STUDENT WORKSHEET 4.1

Mass Transit Challenge

Name: _____

The Challenge: Using mass transit schedules and a local map, plan an afternoon outing in your own or a neighboring community.

1. Your outing must:

- ☞ Begin no earlier than _____
- ☞ End no later than _____
- ☞ Begin and end at (location) _____

2. Decide on a destination. Where would you like to spend some time after school? Follow a route noting times and locations. Be sure you will be able to get from your starting point to your destination and back, in the time allowed.

Destination: _____

3. Which mass transit system will you use? _____

4. Which route? _____

5. Where is the nearest "stop" where you can board? _____

6. When does it depart? _____

7. How much will it cost? _____

8. What time will you arrive at your next location? _____

9. Where is that location? _____

10. Is this the nearest stop to your destination? _____

11. Is this in walking distance to your destination? _____ If yes, go to Question # 14

12. Will you need to make a connection? _____

Mass Transit Challenge, page 2

13. If so, list all routes you will need to take to get yourself to your destination:

ROUTE	LOCATION	ARRIVAL	DEPARTURE TIME

14. When do you need to be back at the "stop" for your return trip? _____
(Be sure you will make all connections on your return trip.)

15. How long will you have at your destination? (Leave time for walking.) _____

16. If you need to make one or more connections, list them here:

ROUTE	LOCATION	ARRIVAL	DEPARTURE TIME

17. What time will you arrive back at your final destination? _____

18. Is it before your designated finish time? _____

19. Check a local map to determine how many miles this trip covers. _____

20. Use the table Pollution by Mode of Travel to determine the amount of pollution a single passenger car and a bus would produce traveling this distance. How much pollution would this trip avoid producing if you choose the bus over the car?

_____

CHAPTER 5

GETTING AROUND CLEAN AND GREEN: A CHALLENGE

CHAPTER 5

GETTING AROUND CLEAN AND GREEN: A CHALLENGE

ESSENTIAL QUESTIONS

▲ **What day-long outings are possible in this and/or a neighboring community?**

▲ **How can we transport ourselves in the most environmentally friendly way?**

OBJECTIVES

The students will:

- Explore the range of transportation and leisure options available in their community.
- Use information gained thus far to plan an environmentally friendly intermodal outing.
- Create an intermodal travel guide for their community.

ACTIVITIES

INTERMODAL CHALLENGE

Time: 45-minute class period.

INTERMODAL TRAVEL GUIDE

Time: Ongoing over several days.

STANDARDS

Technology: Understand transportation systems.

Language Arts: Knowledge of different genres; group discussions; presentations; write compositions with clear focus, logical statements, and adequate detail.

Geography: Map local community.

Mathematics: Collect data; construct, read charts, practical application of percentages.

Language Arts: Group discussion, research

Economics: Compare ways to accomplish a goal, select those with greatest benefits

History: Recognize the importance of individual choices and actions.

TEACHING NOTES

In this lesson students will plan an environmentally sound outing that requires the use of several modes of travel. It will be an opportunity for them to utilize, in a practical way, the information and knowledge they have acquired thus far in this unit. By assembling this collection of outings into a travel guide, the students will be sharing their knowledge and their efforts with the community.

Once the parameters are established, the students will largely be self directed. The teacher will play an advisory role. Keep in mind the goal is to create a user-friendly intermodal fun travel guide that informs community members of environmentally appropriate transportation choices. It will be used for assessment, but it will also be an opportunity for students to perform a community service project and to explore career opportunities.

Guidelines are provided for planning the outings and creating the guide. Use these as suggestions, adapting them to your needs. Allowing students some independence and control will likely increase their sense of ownership and personal

investment in this project. Ideally, it will be an enjoyable, creative, and challenging process resulting in a valuable product.

Although creating the travel guide can be considered a culminating project and a valuable assessment tool, it is also an opportunity for students to explore a variety of career possibilities. A finished guide would require writers, editors, publishers, graphic designers, cartographers, and marketers in charge of advertisement and distribution. Individuals could contact local transportation facilities and relevant organizations and businesses to enlist their support, organizing a community-wide collaboration. The end result will be a useable and informative document. Through this publication, the students will inform others, influence transportation behaviors, and contribute to making their community a healthier, cleaner place.

BACKGROUND INFORMATION

Intermodalism refers to the transporting of people, goods, or services using a variety of travel modes. Travel modes include anything from walking, skating, and rowing to riding bicycles, horses, subways, buses, cars, and airplanes.

ACTIVITY 5.A

INTERMODAL CHALLENGE

OUTCOMES

As a result of this activity students will:

- Research, plan, and write a travel guide entry.
- Evaluate intermodal trips for environmental impact, comfort, cost, and fun.
- Compose a written description of an intermodal trip.

TIME REQUIRED

- 45-minute class period.

MATERIALS

- Worksheets
- Local maps (with scale)
- Mass transit schedules
- Brochures of local establishments
- Examples of travel guides
- Local telephone book
- Environmental Impact Rating Chart

TEACHER PREPARATION

Gather materials.

Review and/or revise rubric.

ACTIVITY OVERVIEW

Students will plan, research, and write guides for specific outings. The class will need to establish environmental standards for various travel modes. This work will provide content for the class's travel guide that students will complete in the next activity.

ACTIVITY

Present the challenge and explain that the activity will culminate with the creation of a travel guide that the class will assemble for use in their community. Hand out and go over the first introductory worksheet and the supplied rubric. Alternatively, have students develop their own rubric. Students need to be clear about all expectations before they begin. Review requirements as well as the rubric that will be used to assess their work.

Decide if you want the students to work individually, in pairs, or small groups. Provide them with the opportunity to periodically share their works in progress.

Before they begin to plan their outings, the class should decide on the audience for this guide. Do they want it to be for middle school students, teenagers in general, families, the general population, or a combination?

Each group will need to establish environmental standards for various transportation modes. They can use Chart 5.1 to determine relative emissions for the different modes of travel. Or have them calculate this from data in Table 5.1.

Start off by brainstorming possible adventures to get students thinking and inspired. Then hand out the student worksheet "Design a Travel Guide Entry" to help guide and organize their work.

Options:

- Give awards for the most usable, fun, environmentally friendly, original, etc.
- Take a vote and make a class trip to an appropriate destination.

Clean and Green Ways to Get to Fun and Interesting Places: A Travel Guide for your Community

STUDENT CHALLENGE:

Design and write an entry for a Travel Guide of Clean and Green Ways to Get to Fun and Interesting Places in your community.

THE ENTRY MUST:

- ✔ Describe how to get to a fun or interesting place in your community or in a neighboring community.
- ✔ Rate the mode(s) of travel used in this outing for their environmental-friendliness.
- ✔ Describe the time and expense needed for travel.
- ✔ Include a map showing the route of travel.

THE OUTING MUST:

- ✔ Begin after 7 am and end no later than 10 PM.
- ✔ Use the most environmentally-friendly means of transportation possible without taking too much time.
- ✔ Be affordable, not exceeding $5 for travel per person.
- ✔ Have appeal for your target audience.

YOU WILL BE GRADED ON THE FOLLOWING

- Summary information should be clear and accurate.
- Map should be neat, clear, accurate, and to scale. It should include landmarks, route(s), and key locations.
- Environmental statement should be clear and concise.
- Narrative description should be well written, accurate, clear, and appealing to your chosen audience.
- Clear oral presentation.

Pollution by Mode of Travel

TABLE 5.1

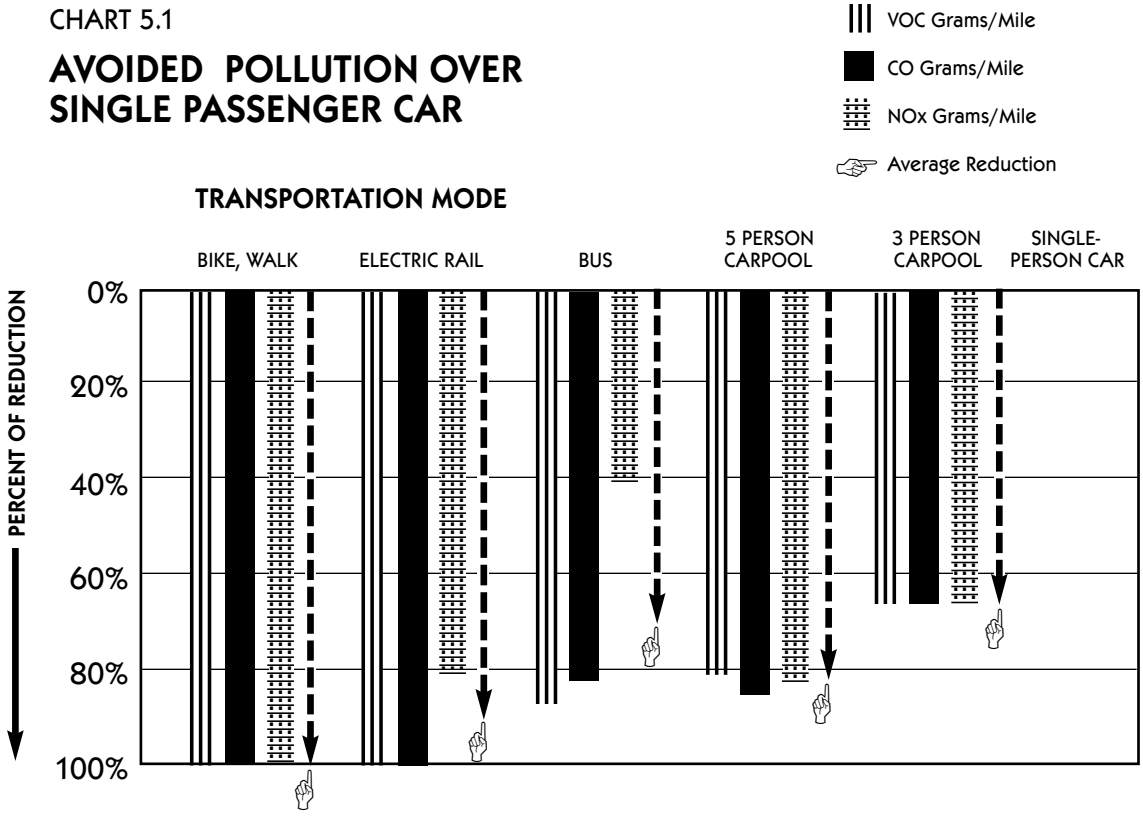
POLLUTION BY MODE OF TRAVEL

For typical work trips based on national average vehicle occupancy rates, pollutant emissions in grams per passenger mile are:

	Grams/Passenger Mile of		
	VOC	C0	NOx
Bike, Walk	0	0	0
Electric Rail	0.01	0.02	0.47
Bus	0.2	3.05	1.54
5-Person Vanpool	0.36	2.42	0.38
3 Person Carpool	.06	5.9	0.8
Single-Person Car	1.9	17.8	2.5

CHART 5.1

AVOIDED POLLUTION OVER SINGLE PASSENGER CAR



Design a Travel Guide Entry

Name: _____

Choose a destination: _____

List all travel modes that you can use to get there.
You can combine different modes in one trip.

_____

_____

_____

_____

Which travel mode(s) would be best for the environment and why?

_____

_____

_____

_____

Which travel modes best balance environmental, time, and cost considerations and why?

_____

_____

_____

_____

What are the vital times and locations: **To get there?**

_____ _____

_____ _____

_____ _____

_____ _____

What are the vital times and locations: **To get home?**

_____ _____

_____ _____

_____ _____

_____ _____

What is the total cost per person? _____

_____

Design a Travel Guide Entry, page 2

Environmental Statement:
Rate how environmentally friendly this trip is on a scale of 1 through 10 with 1 being the most polluting and 10 the cleanest. Explain why you chose the rating you did.

Environmental Rating: _____

Narrative Description:
Write a clear set of directions for someone to follow who wants to take this trip. You should ideally take the trip yourself and then describe it. An alternative is to imagine the trip, look at a map, and read what you can about what you would see. In either case, you will need to write a description for the guidebook. It needs to be well written and make the trip sound appealing, but be honest.

Summary Statement: Summarize this trip in one or two short sentences.

STUDENT INFORMATION

Rubric

Name: _____

Check appropriate boxes.
Add number of checks in each column to complete the grading equation in last row.

(Maximum is 100) _____

Required Components	Exceptional Job	Well Done	Adequate. Complete	Inadequate. Lacking quality or quantity	Not Done. Missing major pieces
SUMMARY					
TRIP APPEAL					
MAP					
ENVIRONMENTAL STATEMENT					
NARRATIVE					
PRESENTATION					
GRADE: _____ = 4	+ _____ X 16	+_____ X 12	+_____ X 8	+_____ X 4	+ 0

ACTIVITY 5.B

INTERMODAL TRAVEL GUIDE

OUTCOMES

As a result of this activity students will:

- Work as integrated teams to plan, implement, and complete a publishable travel guide.
- As a team, make a class presentation.

TIME REQUIRED

- Ongoing over several days.

MATERIALS

- A set of completed Travel Guide. Worksheets for each working group.

TEACHER PREPARATION

Assign roles or devise method for determining roles.

Contact community agencies for support. (optional)

ACTIVITY OVERVIEW

The students will work as a publishing house to assemble an intermodal travel guide of *Clean and Green Ways to Get to Fun and Interesting Places* in their community.

ACTIVITY

Divide the class into teams, each with its own function. You will need:

- **Environmental Raters** to decide on environmental standards to use for consistency throughout the guide. They will rate each trip by the same standard (perhaps a five-star system based on average emissions per mile).
- **Editors** to check and correct the written pieces. You may want several groups for this task. One for each written section.
- **Content Designers** to complete the page layout, including where maps go and how the written entries are formatted.
- **Cover Designers** to design the cover, write the guide's introduction, and develop a table of contents.
- **Marketers** in charge of advertisement and distribution.

Have each group give a presentation to the class explaining the steps they took to complete their task and why they made the decisions they did.

How each team completes its task and interacts with the other teams will depend largely on the resources available to the class. Access to computers, scanners, or other graphic tools versus needing to cut, paste, and photocopy will influence how this activity is set up.

Celebrate completion of the *Guide* by taking a trip to one of the fun or interesting locations listed.