working paper 2

Environmental Benefits of Transportation Investment

NCHRP Project 8–36, Task 22 Demonstrating Positive Benefits of Transportation Investment

prepared for

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prepared by

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Preface

The objective of NCHRP Project 8-36, Task 22 is to produce an easily understandable document that effectively communicates the positive impacts of investments in this nation's transportation system. The work will be used by AASHTO in its TEA-21 reauthorization efforts.

To achieve this goal, Cambridge Systematics has prepared four working papers, each covering an important aspect of the positive impacts of transportation investment, as follows:

1. Economic Benefits of Transportation Investment;

2. Environmental Benefits of Transportation Investment;

3. Community and Social Benefits of Transportation Investment; and

4. The Benefits of Reducing Congestion.

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Working Paper 2: Environmental Benefits of Transportation Investment

Introduction

Whether we are building new transportation infrastructure or expanding existing facilities and services, a common perception exists that such activities have negative impacts on the environment. In many instances this is not the case, and the activity has provided new opportunities for environmental protection, remediation, and even enhancement. Indeed, transportation investment can benefit not only the natural environment, but the built and cultural environment.

These benefits may be divided into a number of broad categories, each of which will be discussed in more detail in this paper.

1. **Transportation investment can improve air quality and energy efficiency –** Investments in clean vehicle technology, clean fuel technology, and congestion relief projects can reduce emissions and contribute to energy efficiency. Investments in ridesharing programs, transit, pedestrian, and bicycle facilities can reduce vehicle miles traveled.

2. **Transportation investment can reduce noise pollution –** New automobiles are far quieter than their predecessors thanks to advances in engine technology. Erecting "green" roadway sound barriers can muffle the sound of passing vehicles.

3. **Transportation investment can protect wetlands and safeguard clean water supplies –** Wetlands mitigation programs can ensure that the total acres of wetlands lost to new transportation projects is less than the number of new wetland areas created elsewhere. Controlling storm water runoff and soil erosion near roadways can reduce groundwater contamination.

4. **Transportation investment can reduce light pollution –** Installing fully shielded, full cutoff streetlights can not only save energy and reduces unwanted glare on roadways, it can help ensure our view of the night sky is not lost to sky glow.

5. **Transportation investment can help reclaim brownfields and provide a market for recycled materials –** Brownfields – polluted and abandoned industrial sites – are being cleaned up and rehabilitated for use as intermodal centers and other transportation-related facilities. The transportation industry uses a high percentage of recycled products, from asphalt cement to household plastics.

6. **Transportation investment can provide historic and ecological preservation benefits –** Transportation projects are subjected to rigorous state and federal environmental analyses, including archeological research that can broaden our understanding of North American history and prehistory. Moreover, responsible transportation investment need not adversely impact wildlife and ecosystems. Through mitigation measures such as ecoduct construction, the effect of new transportation projects on the natural environment can be minimized.

A sense of environmental stewardship is guiding the decisions of transportation departments across the U.S., with positive benefits for both the environment and the nation's transportation system.

1.0 Reduced Air Pollution and Improved Energy Efficiency

The nation's air quality has improved considerably in the past 30 years, due in part to a reduction in motor vehicle emissions. Cars and trucks today run cleaner than ever before and emit significantly lower levels of carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC, also called hydrocarbons, or HC). The introduction of unleaded gasoline has meant that emissions of lead have dropped to virtually zero. Tremendous strides in engine technology mean that the average car today produces 60 to 80 percent less pollution than the average car did in the 1960s. Overall, CO emissions from on-road vehicles fell 43 percent between 1970 and 1999. In contrast, CO emissions from non-transportation sources declined only 11 percent. VOC emissions fell 59 percent, twice as fast as non-transportation VOC sources. Only NOx emissions have increased, but by a modest 16 percent (see Figures 1 through 4).[1]

Tremendous strides in engine technology mean that the average car today produces 60 to 80 percent less pollution than the average car did in the 1960s.

These statistics are all the more impressive in light of three distinct trends. First, since 1970, vehicle miles traveled increased 140 percent – four times faster than the population. Second, congestion has worsened in areas of every size across the nation. Because vehicle emissions rise sharply when speeds fall below 20 mph, increased congestion often means increased pollution. Third, motor vehicle fuel efficiency has remained unchanged over the past decade. Since 1991, it has, in fact, declined.[2]

[1] Environmental Protection Agency, Office of Transportation and Air Quality, http://www.epa.gov/otaq.

[2] In 1999, the U.S. highway vehicle fleet (including all cars, light trucks, and heavy trucks) averaged 16.8 miles per gallon, less than five miles per gallon better than it averaged a half century earlier. Energy Information Administration, *Annual Energy Review 2000* (Washington, D.C.: U.S. Department of Energy, August 2001), 57.

Figure 1. On-Road Vehicle Carbon Monoxide Emissions

1970-1999

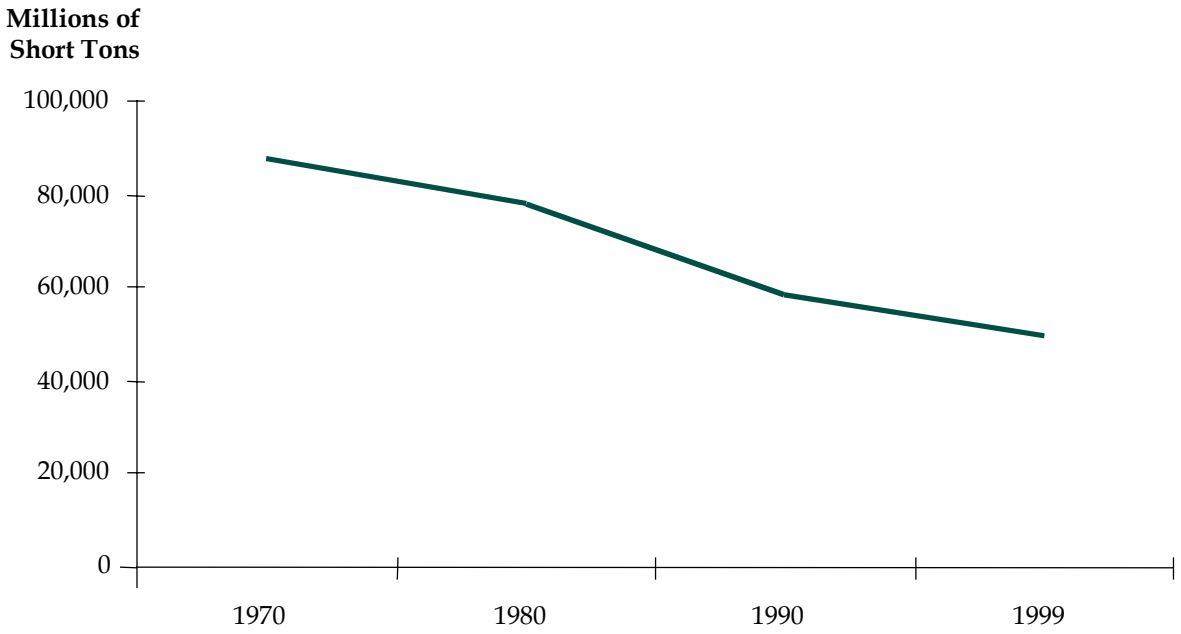


Figure 2. On-Road Vehicle Lead Emissions

1970-1999

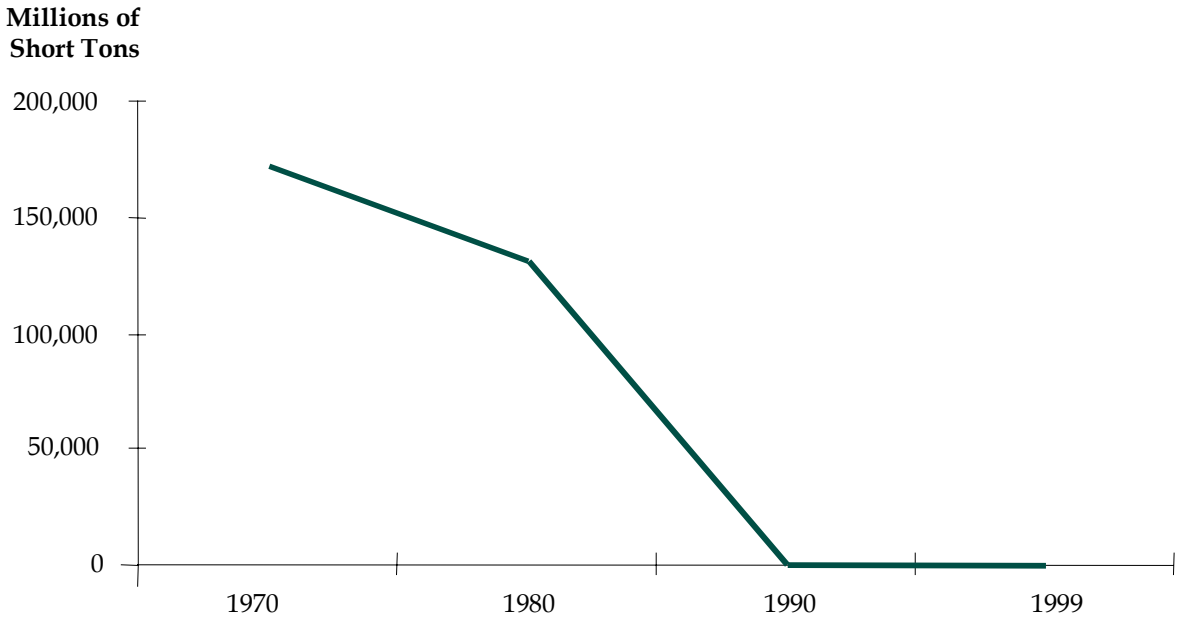


Figure 3. On-Road Vehicle Nitrogen Oxide and Volatile Organic Compounds Emissions

1970-1999

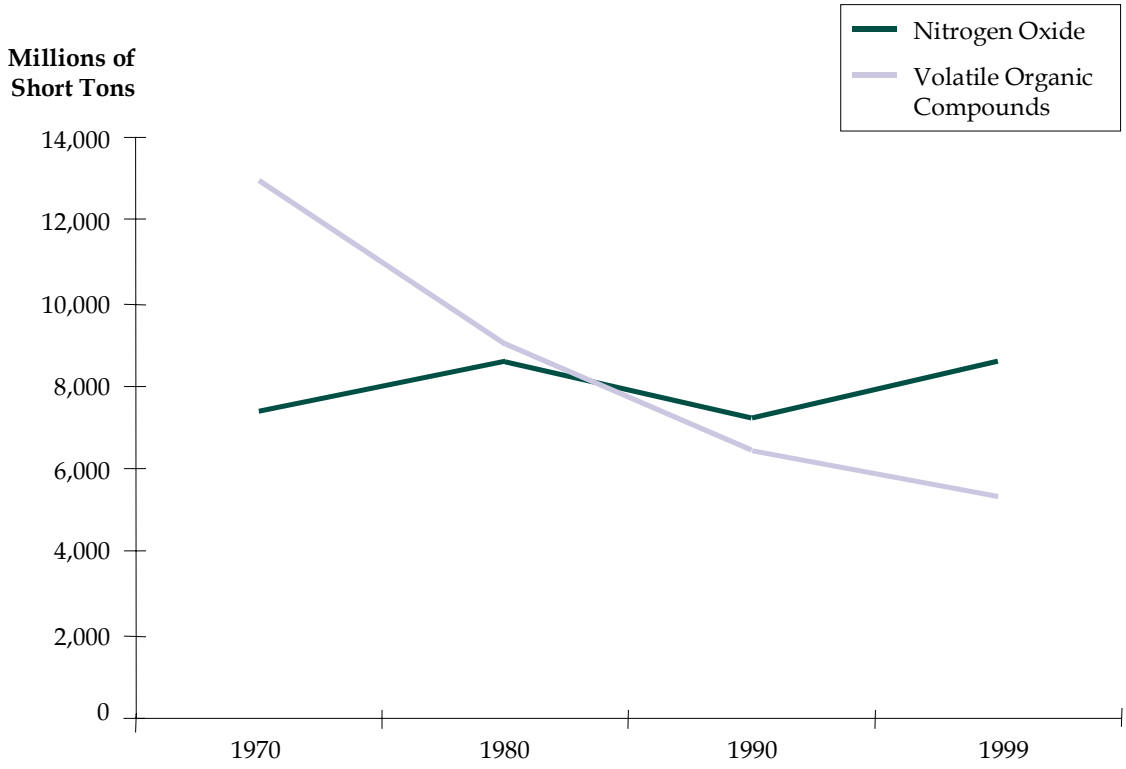
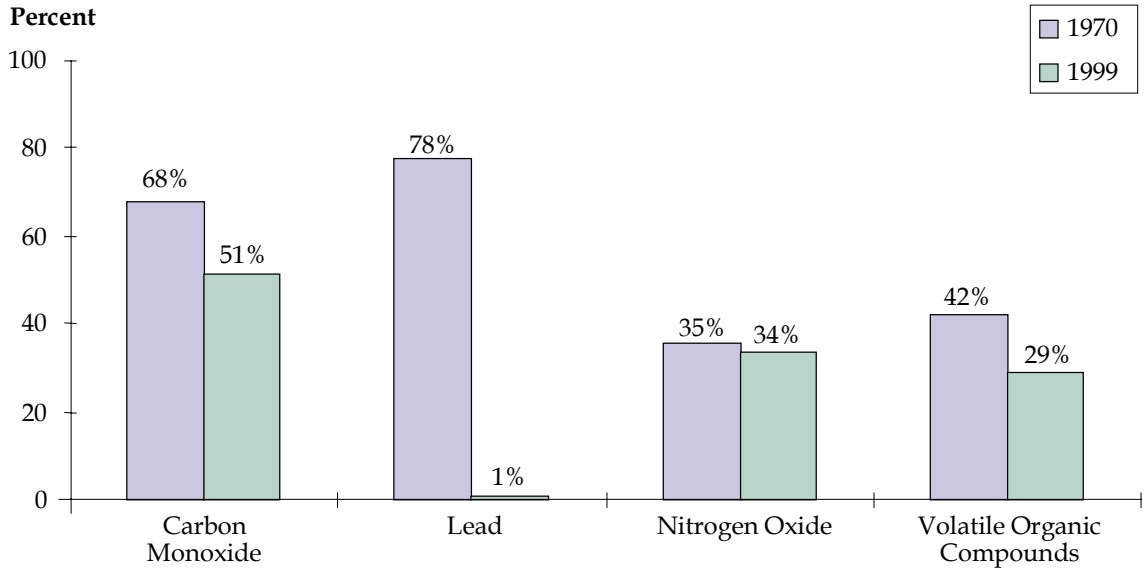


Figure 4. On-Road Vehicle Pollutant Emissions as a Percentage of U.S. Total

1970-1999



Continued investment in transportation is needed to ensure that the strong gains continue. Fuel combustion – mainly gasoline – is responsible for emissions of 70 percent of smog precursors and for 90 percent of carbon monoxide in urban areas.[3] In fact, 39 percent of the U.S. population lives in "non-attainment" areas, areas that fall below the standard set by the National Ambient Air Quality Standards for one or more of six criteria pollutants. Ground-level ozone (O_3) is chief among these, formed from a combination of NOx, VOCs, and sunlight.[4]

Transportation is also an important contributor to carbon dioxide (CO_2) emissions, since CO_2 is the product of gasoline and diesel fuel combustion. Carbon dioxide does not directly impair human health, but accounts for 83 percent of greenhouse gas emissions. Greenhouse gases trap the earth's heat and contribute to global climate change. While transportation-related CO and VOC emissions have fallen, CO_2 emissions have risen due to increased demand for gasoline and diesel fuel. Today, transportation-related activity accounts for one-third of total CO_2 emissions in the U.S. In 2000, transportation produced 515 million metric tons of CO_2, a roughly 50 percent increase over 1970 levels.[5] The Energy Information Administration predicts that in the coming years transportation sector CO_2 emissions will grow faster than residential, commercial, and industrial sector CO_2 emissions.[6]

Transportation investment can help reduce air pollution and improve energy efficiency in a number of ways. In many cities, transportation investment is hastening the change to vehicles that run on clean alternative fuels such as compressed natural gas (CNG). For example, the Los Angeles County Metropolitan Transit Authority is overhauling its entire bus fleet, systematically replacing old diesel buses with clean-burning natural gas buses. With over 1,000 CNG buses in operation, and another 1,000 to be delivered by 2004, the LACMTA boasts the nation's largest CNG bus fleet. Placing one CNG bus into service is the equivalent of removing the exhaust of 7.2 automobiles.[7] CNG buses produce less NOx, CO, and particulate matter than conventional diesel buses.

Placing one CNG bus into service is the equivalent of removing the exhaust of 7.2 automobiles.

In New York City, where taxis account for 10 percent of all vehicle miles traveled, a new Alternative Fuels Taxicab Program provides financial incentives for taxi owners to adapt

[3] Transportation Air Quality Center, *Transportation Control Measures: Telecommuting* (Washington, D.C.: U.S. Environmental Protection Agency, July 1998), 1.

[4] Bureau of Transportation Statistics, *The Changing Face of Transportation* (Washington, D.C.: U.S. Department of Transportation, 2000): I-22.

[5] Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2000* (Washington, D.C.: U.S. Department of Energy, November 2001), 21.

[6] Energy Information Administration, *Annual Energy Outlook 2001 with Projections to 2020* (Washington, D.C.: U.S. Department of Energy, December 2000), 97.

[7] Los Angeles County Metropolitan Transportation Authority, *MTA's State of the Bus System Report*, March 2001, available at http://www.mta.net as of September 2001.

their vehicles to run on CNG or to purchase new CNG vehicles. Taxi owners can bring their conventional vehicles to a certified conversion shop for conversion to a bi-fuel vehicle. In exchange for signing a statement promising to operate the vehicle exclusively on natural gas, the owner is reimbursed for the cost of the conversion. Alternatively, the owner can purchase a dedicated CNG vehicle and be reimbursed for the difference – about 6,000 dollars – compared to a conventional gasoline taxi. About 80 percent of the cost of reimbursement comes from the CMAQ Program, with the remaining 20 percent paid by private partners. As a result of the Alternative Fuels Taxicab Program, 300 CNG vehicles were operating in New York City by 1999, resulting in an annual reduction of over 18 tons of VOC and seven tons of NOx.[8] CNG-powered vehicles have another advantage over their gasoline-powered counterparts: On average, they emit almost 30 percent less CO_2 per mile traveled.[9]

Congestion relief measures on highways and at busy intersections and toll plazas can smooth the flow of traffic and reduced tailpipe emissions. Research has shown that hard acceleration and deceleration causes emissions to rise sharply. Moreover, studies by the Environmental Protection Agency suggest that increasing average arterial speeds from 10 to 20 mph, for example, reduces HC emissions by roughly 40 percent and NOx emissions by roughly 20 percent. Implementation of the EZ-pass electronic toll collection system on the New Jersey Turnpike in 2000 was estimated to reduce HC and NOx emissions on a typical weekday by 0.35 tons and 0.056 tons, respectively, as a result of reduced queuing and increased, steady speeds.[10] For more on the benefits of congestion reduction, see Working Paper 4, *The Benefits of Reducing Congestion*.

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"[San Diego's vanpool program] is an excellent program which benefits the county, city, and the employees. It relieves freeway congestion, thereby reducing pollution. Vanpools provide a fast, comfortable, and reliable way to get to work for many individuals."

– Erlinda S. Soriano
San Diego vanpooler

Transportation investment can encourage environmentally-friendly modes of transport such as ridesharing, transit use, bicycling, and walking. Ridesharing reduces both congestion and vehicle miles traveled. A number of state, regional, and local incentives have been developed and funded in recent years to encourage ridesharing, and to encourage employers to promote

[8] Transportation Air Quality Center, *Creating Transportation Choices: Congestion Mitigation and Air Quality Improvement Program Success Stories* (Washington, D.C.: U.S. Environmental Protection Agency, August 1999): 19–20.

[9] Federal Highway Administration, *Transportation and Global Climate Change: A Review and Analysis of the Literature* (Washington, D.C.: U.S. Department of Transportation, 1997), 79.

[10] Wilbur Smith Associates, *Operational and Traffic Benefits of EZ-Pass to the New Jersey Turnpike, Executive Summary* (20 August 2001), available at the New Jersey Turnpike Authority web site, http://www.state.nj.us/turnpike, as of September 2001.

ridesharing among their employees. These incentives include area-wide commute organizations (or "third-party" agencies) that provide carpool and vanpool matching services, and state and local tax credit and subsidy programs. Federal funding, channeled through the states, has often come from the Congestion Mitigation and Air Quality (CMAQ) Program, a federal program created under the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. California has one of the most comprehensive set of tax incentives in the nation to encourage ridesharing. Employees receive a personal exemption of rideshare costs from gross income for carpooling, buspooling, and mass transit use, and a tax credit for non-employer-sponsored vanpool expenses. Employers receive a deduction or tax credit for a number of allowable expenses, including vanpool subsidies and the purchase of company buses or vans.[11]

Transit investments can also reduce air pollution. In St. Louis, the construction of a new light rail line in 1993 has reduced vehicle miles traveled by as much as 139,100 miles per day, translating into a daily savings of 7,130 gallons of fuel. During its first year of operation, the new line was estimated to have reduced carbon emissions by 4,500 to 9,600 metric tons. Because it is powered by electricity, the St. Louis light rail system is quiet, efficient, and exhaust-free.[12] In the Northeast Corridor, electrification of the main rail line between Boston and New Haven in 2000 allowed for faster intercity rail service. Amtrak ridership between Boston and Washington, D.C. is increasing steadily as new, high-speed Acela train sets are introduced. The Federal Railroad Administration estimates that as a result of this project, emissions of CO and VOC in the Northeast Corridor will fall by five percent, while NOx emissions will fall by 15 percent. These reductions come not only as a result of the switch from diesel to electric traction, but as a result of diversion from other, more polluting modes of travel.[13]

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Transportation investment designed to encourage cycling for the purposes of commuting and running short errands can help reduce pollution and greenhouse gas emissions, since a bicycle is a zero-emissions vehicle. In 1995, just 0.9 percent of all trips were taken by bicycle. Yet according to a Harris survey, 17 percent of adults would sometimes bicycle to work if secure storage and changing facilities were available, 18 percent would bicycle commute if they

According to a Harris survey, 20 percent of adults would sometimes bicycle to work if they could ride on safe bike lanes.

[11] Transportation Air Quality Center, *Transportation Control Measures: Commute Alternative Incentives* (Washington, D.C.: U.S. Environmental Protection Agency, July 1998): 1–8; Transportation Demand Management Institute, *TDM Case Studies and Commuter Testimonials* (Washington, D.C.: Association for Commuter Transportation, August 1997).

[12] Transportation Air Quality Center, *Transportation Control Measures: Improved Public Transit* (Washington, D.C.: U.S. Environmental Protection Agency, July 1998), 5.

[13] Federal Railroad Administration, *Intercity Freight and Passenger Rail: State and Local Project Reference Guide* (Washington, D.C.: U.S. Department of Transportation, April 2001).

were offered a financial incentive to do so, and 20 percent would bicycle commute if they could ride on safe bike lanes. Even with the relatively limited investment that has taken place over the past 30 years, cycling – not just as a recreational activity but as a viable commuting mode – has grown steadily in popularity. Between 1977 and 1995 the number of person trips made by bicycle increased 30 percent.[14]

"I ride my bike 12 miles to meet the bus I take to my office. Why do I do it? For fitness, to reduce wear and tear on my car, and to lessen pollution. I'm doing it, too, for the kids who will be inheriting the planet. I want to do my part."

– Owen Barry
New Jersey bicycle commuter

One of the most ambitious programs in the nation designed to increase bicycle mode share is New York City's Bicycle Network Development project. Using CMAQ funds, the New York City Department of City Planning and the Department of Transportation are building a 900-mile city-wide bike network. The network includes on-street bike lanes as well as off-street dedicated bike paths, and focuses especially on river bridge crossings, transit access, and bike parking. Since the project's creation in 1994, cycling in Manhattan has increased 15 to 20 percent, translating into an annual emissions reduction of 45 tons of VOC and nearly 50 tons of NOx. In 1999, the Bicycle Network Development project won the Federal Highway Administration's Environmental Excellence Award for Non-Motorized Transportation.[15]

Investment in pedestrian facilities to make walking a safer and more attractive mode of transport has similar benefits. We all make at least part of every trip on foot, after all, even if it is only from our parked car to a shop on the other side of the street. The quality of the pedestrian environment therefore effects everyone. Pedestrian investment takes a number of forms: wide sidewalks, traffic lights that give pedestrians a "WALK" signal without requiring excessive waits, clearly painted "zebra stripe" crosswalks at intersections, benches, shade trees, good lighting and other streetscape amenities make walking enjoyable. Traffic calming devices such as speed tables, raised or textured crosswalks, chicanes, miniature traffic circles, and tight intersection curb radii that encourage cars to slow down as they round the corner also constitute investments with important pedestrian benefits.

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[14]Don Pickrell and Paul Schimek, *Trends in Personal Motor Vehicle Ownership and Use: Evidence from the* Nationwide *Personal Transportation Survey* (Cambridge: U.S. DOT Volpe Center, 23 April 1998): 10; Tod Litman, *Quantifying the Benefits of Non-Motorized Transport for Achieving TDM Objectives* (Victoria, BC: Victoria Transport Institute, 1999): 9; U.S. Environmental Protection Agency and U.S. Department of Transportation, The Commuter Choice Initiative National Standard of Excellence.

[15]Transportation Air Quality Center, *Creating Transportation Choices: Congestion Mitigation and Air Quality Improvement Program Success Stories* (Washington, D.C.: U.S. Environmental Protection Agency, August 1999): 21–22; Transportation Demand Management Institute, *TDM Case Studies*.

2.0 Reduced Noise Pollution

Transportation investment can reduce noise pollution. Since the 1970s, highway noise has been mitigated as a result of quieter engines, better vehicle mufflers, and the construction of roadside noise barriers. Noise barriers reduce noise levels by five to 10 decibels, cutting the loudness of traffic noise by as much as 50 percent. A 10-decibel reduction makes the sound of a passing tractor trailer no louder than that of a passing automobile. Sound barriers are most effective within 200 feet of a highway – typically the first row of homes. Studies have shown that, contrary to popular opinion, a sound barrier constructed on one side of a highway only does not increase noise levels perceptibly on the other side of the highway.[16]

Since 1970, 44 states and the Commonwealth of Puerto Rico have constructed over 1,600 miles of noise barriers at a cost of over 1.9 billion 1998 dollars.

Since 1970, 44 states and the Commonwealth of Puerto Rico have constructed over 1,600 miles of noise barriers at a cost of over 1.9 billion 1998 dollars. The pace of noise barrier construction is increasing; nearly a third of total expenditures have occurred since the mid-1990s. Noise barriers usually take the form of walls up to 25-feet high, made from a variety of materials including concrete, masonry block, wood, metal, and brick. For aesthetic purposes, a combination of materials may be used or the wall may be textured or decorated with murals.[17] This was the case with a 1.5-mile noise barrier along Highway 47 near Pueblo, Colorado. Local artists worked closely with transportation officials to design a wall that was both functional and visually pleasing.[18] Similarly, a noise barrier constructed parallel to the new Pima Expressway through Scottsdale, Arizona boasts Southwestern themes such as 40-foot purple lizards and giant cactus.[19] Plantings may be added in front of a wall to make it more attractive and to further reduce noise levels. Sound barriers may also be built of earth mounds or "berms." These are somewhat more effective than walls at blocking sound, but require a larger right-of-way.

"I was trying to tie it [the Highway 47 noise barrier] in with the environment, rather than have it be something that would conflict with the environment."

– Judith Williams
Pueblo, Colorado artist

Investment in electric vehicle technology can also reduce noise pollution. Electric trolleybuses, for example, such as the ones operated in Dayton, Ohio, produce 22 to 25

[16] Federal Highway Administration, *Keeping the Noise Down: Highway Traffic Noise Barriers* (Washington, D.C.: U.S. Department of Transportation, February 2001).

[17] Federal Highway Administration, *Highway Traffic Noise Barrier Construction Trends* (Washington, D.C.: U.S. Department of Transportation, April 2001), 1–2.

[18] Malcolm Howard, "The Great Wall Debate," *Colorado Springs Independent*, 16 December 1999.

[19] Kim Sorvig, "A Sound Solution?" *Planning* (April 2001): 12.

fewer decibels than conventional diesel buses. This means that a passing trolleybus is roughly two to three times quieter than a passing diesel bus.[20] Similarly, Amtrak's new electric Acela trains are far quieter than the diesel-powered trains they replaced Between Boston and New Haven.

Other railway noises have been mitigated as a result of EPA noise standards. These apply to the operation of locomotives and rail cars in motion as well as to four major rail yard noises: locomotive load cell test stands, switcher locomotives, car coupling operations, and retarders. Rubber mats placed between the tracks at grade crossings also help reduce noise. But for many Americans, the most serious form of railway-related noise pollution is the sudden blast of a locomotive whistle and the clang of warning bells as a train approaches a grade crossing. Because studies have shown that the likelihood of a road-rail accident increases 62 percent when whistles are not sounded, the practice is a sensible one. However, investment in a variety of supplemental grade crossing safety measures, such as median barriers, four-quadrant gates, and vehicle proximity alert systems can allow communities the option of establishing "quiet zones."[21]

3.0 Wetlands Protection and Reduced Water Pollution

Transportation investment can help protect wetlands. In the 1970s, some 450,000 acres of wetlands were being lost each year, primarily to agricultural activity. Today, wetlands loss has been reduced to 50,000 acres per year, less than 10 percent of which is estimated to be from highway construction activities. However, the Federal-Aid Highway Program is actually creating 2.5 acres of wetlands for every acre it takes for road construction. This has resulted in a net gain of 11,628 acres of wetlands nationwide since 1996.[22]

One recent wetlands mitigation project carried out in Wayne County, Michigan, has been awarded a Design For Transportation National Merit Award by the U.S. DOT. In the mid-1990s, to replace wetlands lost to the expansion of the Detroit Metropolitan Wayne County Airport, a much larger wetland totaling nearly 1,000 acres was created. Pre-existing natural features were used in order to increase the likelihood that a viable, sustainable natural habitat would emerge. Dams were built, drains were redirected, basins were dug, thousands of tons of dirt were moved, and wetlands plants were introduced in

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[20] Kevin Brown, *The Benefits of Clean, Quiet, Emission-Free Transit Service: Promoting the Trolleybus in Vancouver* (Vancouver, BC: The Tbus Group, February 2001).

[21] Federal Railroad Administration, *Intercity Freight and Passenger Rail: State and Local Project Reference Guide* (Washington, D.C.: U.S. Department of Transportation, April 2001); "Crossing Equipment Options: High-tech, Low-tech, No-Tech,: *Railway Age* (November 1996): 41.; Kristi Matoba, "Grade Crossings: A Look at the Future," *Railway Track and Structures* 96 (June 2000): 63.

[22] Bureau of Transportation Statistics, *The Changing Face of Transportation* (Washington, D.C.: U.S. Department of Transportation, 2000): I-25.

a process that took over a year. The result was Crosswinds Marsh, which today blends several types of habitats and is home to 172 species of plants, 25 species of birds, 11 species of fish, and 28 species of mammals. A variety of low-impact recreational activities are now permitted in Crosswinds Marsh, including hiking, horseback riding, canoeing, and fishing, and the area is used as an outdoor classroom by elementary schools, high schools, and universities.[23]

The Beach Lake Mitigation Bank, located in the Stone Lake National Wildlife Refuge in Rancho Cordova, California, includes 90 acres of wetland and riparian woodland that have been restored to provide mitigation credits for future transport projects. This facilitates new projects and eliminates the need for a piecemeal approach to mitigation construction and monitoring. In Duluth, Minnesota, 2.5-acre park located on top of Interstate 35 is home to one of the few formal English Rose Gardens in the United States. The Leif Ericson Park Rose Garden contains 99 varieties of rose bushes and 2,000 plants, as well as trees, shrubs, and other flowers. It provides open space with a dramatic view of Lake Superior.

The Federal-Aid Highway Program is creating 2.5 acres of wetlands for every acre it takes for road construction.

In Newport News and Norfolk, Virginia, the construction of nesting boxes for endangered peregrine falcons permitted the Virginia DOT to perform much-needed construction and maintenance work on the James River and Berkeley Bridges, while providing an environment for the birds that is both safer and more conducive to breeding. In 1998, the Beach Lake Mitigation Bank, the Leif Ericson Park Rose Garden, and the falcon nest boxes each received an FHWA Excellence in Highway Design Award under the category of Environmental Protection and Enhancements.[24]

Transportation investment can also safeguard water quality by reducing pollution from storm water runoff from roadways and parking lots. Because these surfaces are impermeable, pollutants that collect on their surface can be washed into nearby lakes, ponds, and drinking water reservoirs. Parking lot runoff is especially harmful to the environment: A one-acre parking lot produces 16 times more runoff than a one-acre meadow, and usually contains more pollutants than runoff from other forms of impermeable cover because parked cars often drip fluids. Recent studies show that by channeling and filtering the water as it runs off the pavement, the most harmful pollutants can be removed before they enter the water supply. Open, natural drainage systems constructed or planted along the sides of roadways – detention and sediment basins, vegetated buffer strips, marshes, and ponds – have proven to be the most effective.

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[23] *Design for Transportation National Awards 2000* (Washington, D.C.: U.S. Department of Transportation, 2000): 42; "Wayne County's Crosswinds Marsh Wins National *Design For Transportation* Award," press release dated 12 June 2000, available at http://www.waynecounty.com/airport as of September 2001.

[24] *Excellence in Highway Design 1998 Biennial Awards* (Washington, D.C.: Federal Highway Administration, 1998).

For example, field tests of a natural drainage system along a roadway near Orlando, Florida showed significantly reduced pollution runoff during a single season of large storms. Runoffs of suspended solids, lead, zinc, phosphorous, and nitrogen were found to have decreased between 59 percent and 91 percent on average.[25] In northern Virginia, similar benefits have been documented along State Route 7 at Goose Creek thanks to the construction of swales – vegetated depressions adjacent to roadways that provide storm water drainage and filtration. Field testing of a 275-meter long swale during the summer of 1997 revealed that 94 percent of suspended solids and 99 percent of total phosphorous flowing from the roadways during heavy rain were prevented from entering the groundwater.[26] In Austin, Texas, two vegetated strips treating highway runoff were also monitored to test their pollution removal effectiveness. In this instance, 85 percent of total suspended solids were removed, as well as significant percentages of other contaminants including zinc, iron, phosphorous, and lead.[27]

Field tests of a natural drainage system along an Orlando roadway showed decreases in runoffs of suspended solids – lead, zinc, phosphorous, and nitrogen – on the order of 59 to 91 percent.

Use of porous surfaces in transportation construction can also improve water quality by allowing contaminated rainwater to pass through the pavement and be absorbed by the soil below. Sidewalks, walkways, driveways, small parking areas, and low-volume roads can be constructed of lattice blocks or bricks set in sand, permitting water to pass through. For larger parking lots and somewhat higher traffic volume roadways, a porous layer of asphalt can be applied atop a stone reservoir. The rainwater passes through the asphalt, collects in the reservoir, and slowly percolates into the soil beneath. Porous surfaces filter sediment, trace metals, and other pollutants from the roadways before they contaminate nearby water supplies. They also provide roadside vegetation, urban street trees in particular, with a source of water. Because porous surfaces lack the strength and durability of conventional pavement, however, they are not suitable for use on major roadways.[28]

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[25] Environmental Protection Agency, *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality* (Washington, D.C: U.S. Environmental Protection Agency, January 2001): 52–53.

[26] Jan-Tai Kuo, Shaw L. Yu, Elizabeth A. Fassman, and Henry Pan, "Field Test of Grassed Swale Performance in Removing Runoff Pollution," *Journal of Water Resources Planning and Management* 127 (May 2001): 161–71.

[27] M. E. Barrett, M. V. Keblin, P. M. Walsh, J. F. Malina Jr., and R. J. Charbeneau, *Evaluation of the Performance of Permanent Runoff Controls: Summary and Conclusions*, Center for Research in Water Resources Online Report 97-3 (Austin: University of Texas at Austin, 1997), 33.

[28] Environmental Protection Agency, *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality* (Washington, D.C: U.S. Environmental Protection Agency, January 2001): 51–52.

4.0 Reduced Light Pollution

Excessive or misdirected lighting from streetlights and other man-made sources produces unwanted glare, light trespass, and uplight while using money, energy, and natural resources. Most seriously, it is threatening to obliterate forever our view of the heavens. Americans living in large cities have already been deprived of a view of a star-filled sky that humans enjoyed for thousands of years. For professional astronomers, the problem is particularly serious because many of the discoveries that advance the frontiers of their science require dark skies free of urban sky glow. Mount Wilson Observatory in Southern California is already in jeopardy. Fully 99 percent of people living in the continental U.S. never see a truly dark sky from where they live.

To reduce light pollution and lighting-associated energy costs, many transportation agencies can invest in better designed lighting fixtures that achieve a higher degree of lighting control. Poor quality existing fixtures are being replaced or retrofit, often with energy efficient low-pressure sodium fixtures. All new streetlights must be full cutoff with no direct uplight and little sideways light that can cause glare. The city of Tucson, 55 miles northeast of Kitt Peak National Observatory, converted from mercury vapor to sodium lights and installed downward-facing fixtures on 40,000 streetlights. Fifty other communities surrounding Kitt Peak have taken similar measures. As a result, urban sky glow visible from the observatory is abating and municipal power costs have been reduced. Despite the absence of a prominent observatory, the state of Maine passed legislation requiring that streetlights financed by the state be fully shielded and projected downward to prevent light trespass. Because lower wattage bulbs can be used to achieve the same roadway illumination, the Maine law is saving energy and taxpayer dollars. In all, six states have legislation limiting the use of outdoor lighting: Arizona, Colorado, Connecticut, Maine, New Mexico, and Texas.[29]

"We often light as if we were trying to water a flower pot with a lawn sprinkler."

– The International Dark Sky Association

5.0 Brownfields Reclamation and Recycling

A number of brownfields have been cleaned up and reused for transportation-related purposes, breathing new life into abandoned industrial sites spurned by private developers. The Environmental Protection Agency defines brownfields as "abandoned, idled, or underused industrial and commercial facilities where expansion or redevelopment is

[29] International Dark Sky Association Information Sheet 1 (May 1996) and 60 (June 1999), available at http://www.darksky.org/ida/index.html as of September 2001.

complicated by real or perceived environmental consequences."[30] Because of the costs and liabilities associated with brownfield reclamation, site owners, developers, and lenders often avoid investing in them. As a result, the General Accounting Office estimates that in 1995 there were between 13,000 and 450,000 brownfields in the U.S.[31] Yet some transportation agencies have not shied away from returning brownfields to productive use. In the late 1990s, for example, three Massachusetts transportation agencies invested more than 35 million dollars to help transform a 245-acre site from a contaminated industrial wasteland to a thriving transportation, retail and office center. The site, located in Woburn, 10 miles north of Boston, had for more than a century been home to chemical concerns, leather tanneries, and manufacturing sites that left behind highly toxic soil contaminants including arsenic, chromium and lead. By the early 1980s, the site was given Superfund status and ranked among the most contaminated sites in the nation. Today, the site features a new Interstate 93 interchange and a regional transportation center. The new interchange is providing much-needed relief to the extremely congested I-93/I-95 (Route 128) interchange, one mile to the south. The 2,400 space transportation center provides a convenient, secure location for commuters to switch to carpools, vanpools, buses and trains and is helping the Massachusetts into compliance with the Clean Air Act. The public investment in the site spurred private development, resulting in more than 750,000 square-feet of hotel, retail, and office development in what was only a decade ago a highly undesirable location.[32]

In 1993, a Metrolink station was opened in the St. Louis suburb of Wellston, Missouri on a contaminated parcel of land once occupied by an electric utility company. The station quickly became a magnet for a variety of commercial and residential development projects, giving a much-needed boost to a faded city that had lost 60 percent of its population since the end of World War II. A 120,000-square-foot educational and training center, the Cornerstone Project, was first on the scene, occupying one of the former electric company buildings. A much larger technology park, including 825,000 square-feet of industrial space, 20,000 square-feet of retail space, and about 50 homes is now under construction on an adjacent 100-acre parcel. The park is anchored by four companies: Moog Automotive, General Electric, Interglobal (a specialty lighting manufacturer), and ViJon (a health and beauty care products manufacturer). This latter company has constructed a new gate to provide easier access to the Metrolink station.[33]

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[30] Environmental Protection Agency, Office of Solid Waste and Emergency Response, Brownfields Initiative quick-reference fact sheet, April 1996.

[31] U.S. General Accounting Office, *Community Development: Reuse of Urban Industrial Sites* (Washington, D.C.: U.S. Government Printing Office, June 1995).

[32] Massachusetts Highway Department, Massachusetts Port Authority, Massachusetts Bay Transportation Authority, "Transportation Investments Support Re-Development of Superfund Site in Woburn, MA." unpublished paper.

[33] Ann Eberhart Goode, Elizabeth Collaton, and David Smallen, *Brownfield Redevelopment and Transportation Policy* (Washington, D.C.: Northeast-Midwest Institute, undated), 10.

The transportation industry has long used recycled materials for highway construction. Waste products from oil refining are used in asphalt cement, while fly ash, fine particles of ash resulting from the combustion of coal, helps improve the quality and durability of Portland cement concrete. Additionally, 80 percent of asphalt removed during road widening and resurfacing projects is recycled each year.[34] The transportation industry also purchases a number products made from recycled materials, thereby saving money and providing new uses for a variety of cast-off household goods from empty plastic milk jugs to old tires. Recycled transportation products include channelizers (barrels or drums that direct traffic around areas of road repair or construction), delineators (temporary road markers that come in many shapes and sizes), parking stops (used in parking lots to keep vehicles from rolling beyond a designated parking area), traffic barricades, and traffic cones. For example, between 1993 and 1997, the states of Indiana, Maine, Massachusetts, Michigan, New Jersey, New York, Vermont, and Wisconsin collectively purchased 50,000 recycled-content traffic cones for highway and tunnel construction and airport use. The Kentucky Department of Highways purchased 3,000 flexible delineators in 1994, while the Texas Department of Transportation uses recycled-content channelizers on highways across the state.[35]

Eighty percent of asphalt removed during road widening and resurfacing projects is recycled each year.

6.0 Historic and Ecological Preservation Benefits

Transportation investment that acknowledges the unique history, architecture, and ecology of a site can ensure that historic structures, archeological remains, and wildlife habitats are preserved. Section 106 of the National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on any "district, site, building, structure, or object that is included in or is eligible for inclusion in the National Register."[36] This means planners and developers must be careful to avoid damaging or destroying objects of archaeological or historic significance in the path of new transportation facilities. As a result, departments of transportation across the country employ a growing army of cultural resource specialists to survey proposed sites, determine their

[34] American Road and Transportation Builders Association, *The Untold Story: Transportation and the Environment*, Washington, D.C., undated.

[35] Environmental Protection Agency, *1997 Buy-Recycles Series Transportation Products* (Washington, D.C.: U.S. Environmental Protection Agency, November 1997).

[36] National Historic Preservation Act of 1966, Section 6."

historical significance, and remove artifacts from the ground for safe keeping in museums.[37]

For example, on behalf of the Wyoming Department of Transportation, the Office of the Wyoming State Archeologist is excavating a site north of Laramie on the banks of Plumbago Creek and adjacent to State Highway 34. The site shows evidence of human habitation from Paleoindian through Late Prehistoric times, including chipped stone tools, flaking debris, and faunal remains.[38] Another Paleoindian site has been uncovered in the Brook Run area of Culpepper County, Virginia, by Virginia Department of Transportation archeologists. Tools made from jasper dating to 9500 BCE have been unearthed at the site, which was discovered in 1998 during the course of a cultural resources survey along Route 3. The highway will be widened to four lanes in 2006.[39] In Tucson, excavations conducted on a 12-acre archaeological site within an Arizona DOT right-of-way have uncovered over 60 houses from a large Hohokam village (600–1150 CE), as well as artifacts that date to the Early Ceramic period (100–600 CE) and the Early Agricultural period (1200 BCE–100 CE).[40] In Fort Meyers, Florida, a dig undertaken as part of a Florida DOT project to upgrade the approaches to the new Edison Bridge has yielded the remains of a U.S. military cemetery. On the site of Forts Harvie and Myers, which stood between 1841 and 1865, some 20 burial features were identified, and the partial remains of 17 individuals exhumed.[41]

TE-Funded Historic Preservation Projects (in millions)

Facility Type	Federal Funding	Number of Projects
Rehabilitation of active rail depots/intermodal centers	$117.1	177
Historic bridges	78.5	246
Historic streetscapes	67.0	236
Historic byways and tourism	118.7	360
Other historic transport facilities	231.7	581
Community revitalization	89.5	311
Archaeological planning	18.6	100

[37] Deborah Selinsky, "They Dig it When the Past Gets in the Future's Way," *Business North Carolina* 19 (September 1999): 18.

[38] Julie Frances, "Wyoming Archeology Awareness Month," available at http://www.cr.nps.gov/aad/statearc/wyoming/wyom99d.htm as of September 2001.

[39] Virginia Department of Transportation, "Brook Run Archeological Site One of the Earliest in North America," available at http://www.vdot.state.va.us/info/brookrun.htm as of September 2001;

[40] "Arizona DOT Projects Preserve History, Save Money," AASHTO web site document, available at http://transportation.org/aashto/success.nsf/allpages/AZPreservingHistory as of November 2001.

[41] Florida Department of Transportation, "Environmental Management Office Publication Abstracts," available at http://www.dot.state.fl.emo/pubs/abstract.htm as of September 2001.

Transportation investments can help ensure the more recent historical record remains intact as well. The Transportation Enhancements (TE) program in particular has helped fund the preservation and rehabilitation of numerous historic rail depots, historic bridges, historic streetscapes, historic byways, and other historic transport facilities such as canals, urban trolley systems, unused railroad corridors, waterfronts, rail infrastructure, and lighthouses.[42]

"The alarm went off when they came through here [Brook Run]…. Instead of finding one or two artifacts, they were getting 300 artifacts."

– Eric Voigt
Senior archaeologist,
Louis Berger

For example, a turn-of-the-20th-century railroad depot in Holly Springs, Georgia that has recently been renovated using TE funds now serves as a community center. Care was taken to ensure that the renovations did not alter the building's original design, in order that it qualify for listing on the National Register of Historic Places. The project has acted as a catalyst for the preservation of other historic properties in Holly Springs and the creation of a downtown historic district.[43]

In the river town of Wheeling, West Virginia, TE funds helped restore the historic customs house. Built in 1859 and now known as Independence Hall, the building was once an important intermodal transportation hub for traffic transferring between the Ohio River, the National Road, and the Baltimore and Ohio Railroad in Wheeling. Thanks in part to TE funds used for repairs and improvements to the roof, structure, and interior of Independence Hall has been given a new life as a museum and a gathering place for special events. The building is now a National Historic Landmark and is listed on the National Register.[44]

In the Adams-Figuroa Historic District in downtown Los Angeles, a commitment to historic preservation has ensured that a street widening project has not altered the historic look and feel of the neighborhood. Twenty-nine beautifully ornate streetlights dating to 1906 were removed so that construction could proceed, and were then replaced with 33 nearly exact reproductions following the project's completion. The same company that manufactured the original streetlights manufactured the new ones, using the original wooden molds that had been kept in a factory storage room for nearly a century. Large Sycamore trees were planted between the lights to replace the original trees. New sidewalks were also installed. The project, funded by the Federal Highway Administration, won California's

[42] "Historic Preservation Enhancements: Recycling America's Transportation Past," *Connections: The Newsletter of the National Transportation Enhancements Clearinghouse* 1 (October 1997), 1–3.

[43] National Transportation Enhancements Clearinghouse, *Communities Benefit! The Social and Economic Benefits of Transportation Enhancements* (Washington, D.C.: NTEC, 2000), 12.

[44] Ibid., 22.

1999 Excellence in Transportation Award for historic preservation/cultural enhancement.[45]

Ecological preservation is no less a concern than historic preservation. Millions of mammals, birds, reptiles, and amphibians are struck and killed by motor vehicles every year. Wide-ranging large carnivores such as wolves, grizzly bears, and mountain lions are particularly vulnerable as they cross roadways in search of food. Slow-moving animals such as turtles and salamanders are also at risk, especially when they attempt to cross roadways to reach mating or nesting sites on the other side. The population of one federally endangered cat, the ocelot, has been reduced to about 80 animals, in part as a result of roadkill. The federally-threatened grizzly bear occupies less than two percent of its former home-range in the U.S. The population of a unique coastal prairie grouse known as the Attwater's prairie chicken has declined from one million at the turn of the 20th century to just a few dozen today. Road building has fragmented their habitat into three isolated and unstable units that are hastening this bird's extinction. Fortunately, wildlife overpasses and underpasses – commonly known as ecoducts or "critter crossings" – can reduce roadkill while guarding against habitat loss and fragmentation.

"Underpasses like this one [in Lake County, Florida], together with land acquisition and habitat protection, are tools we can use to minimize the impacts of highways on wide-ranging mammals."

– Terry Gilbert
Florida Fish and Wildlife Conservation Commission

For example, the Florida Department of Transportation, together with the Florida Fish and Wildlife Conservation Commission, designed and built an underpass for black bears on a stretch of State Route 46 in Lake County. A dirt floor box culvert, 47-feet long, 24-feet wide, and eight-feet high, was built under the two-lane road. To give nervous animals a greater sense of security when using the culvert, the road was elevated to provide a clear sight line, a 40-acre tract of land was purchased in the bears' travel corridor, and rows of pine trees were planted on either side of the opening to provide protective cover. Not only do bears use the underpass, but 11 other species of animals, including bobcats, grey foxes, and whitetail deer. In Glacier National Park, Montana, a goat passage under a highway bridge serves a similar function. In Marion County, Florida, a "land bridge" planted with native vegetation allows animals to cross a busy highway by night and people to cross by day.[46]

[45]Patricia Reid, "FHWA Helps Restore Historic Neighborhood in Los Angeles," *Public Roads* 63 (July–August 1999): 29.

[46]Federal Highway Administration, "Critter Crossings: Linking Habitats and Reducing Road Kill," available at http://www.fhwa.dot.gov/environment/wildlifecrossings as of September 2001.

Conclusion

Over the past three decades, transportation investment has resulted in a number of important environmental benefits. Most impressive are the improvements in air quality that have come even as the number of vehicle miles traveled has increased, thanks to cleaner vehicles, cleaner fuels, and a variety of transportation control measures including improved transit, bicycle and pedestrian programs, traffic flow improvements (often relying on ITS), rideshare programs, and HOV lanes. Strides have been made to reduce transportation-related noise, water, and light pollution as well. At the same time, rigorous preservation measures ensure that new transport projects tread lightly on the land; indeed, were it not for some new projects, many important archeological and historical sites would go undiscovered and undocumented, and many contaminated industrial sites would remain vacant. In the future, the air we breathe will become even cleaner as vehicle emissions decline still further. The environment as a whole will benefit from an increasingly multimodal approach to transportation investment, which focuses not just on increasing vehicle movement, but on improving access for people and goods.