

The U.S. transport sector is a significant source of greenhouse gases, accounting for 27 percent of U.S. emissions.²²¹ While it is widely recognized that emissions from transportation have a major impact on climate, climate change will also have a major impact on transportation.

Climate change impacts pose significant challenges to our nation's multi-modal transportation system and cause disruptions in other sectors across the economy. For example, major flooding in the Midwest in 1993 and 2008 restricted regional travel of all types, and disrupted freight and rail shipments across the country, such as those bringing coal to power plants and chlorine to water treatment systems. The U.S. transportation network is vital to the nation's economy, safety, and quality of life.

Extreme events present major challenges for transportation, and such events are becoming more frequent and intense. Historical weather patterns are no longer a reliable predictor of the future.²²² Transportation planners have not

Sea-level rise and storm surge will increase the risk of major coastal impacts, including both temporary and rail lines, and tunnels.

Coastal areas are also major centers of economic

Sea-level rise

Transportation infrastructure in U.S. coastal areas is increasingly vulnerable to sea-level rise. Given the high population density near the coasts, the potential exposure of transportation infrastructure to flooding is immense. Population swells in these areas during the summer months because beaches are very important tourist destinations.²²²

In the Gulf Coast area alone, an estimated 2,400 miles of major roadway and 246 miles of freight rail lines are at risk of permanent flooding within 50 to 100 years as global warming and land subsidence (sinking) combine to produce an anticipated relative sea-level rise in the range of 4 feet.²¹⁷ Since the Gulf Coast region's transportation network is interdependent and relies on minor roads and other low-lying infrastructure, the risks of service disruptions due to sea-level rise are likely to be even greater.²¹⁷

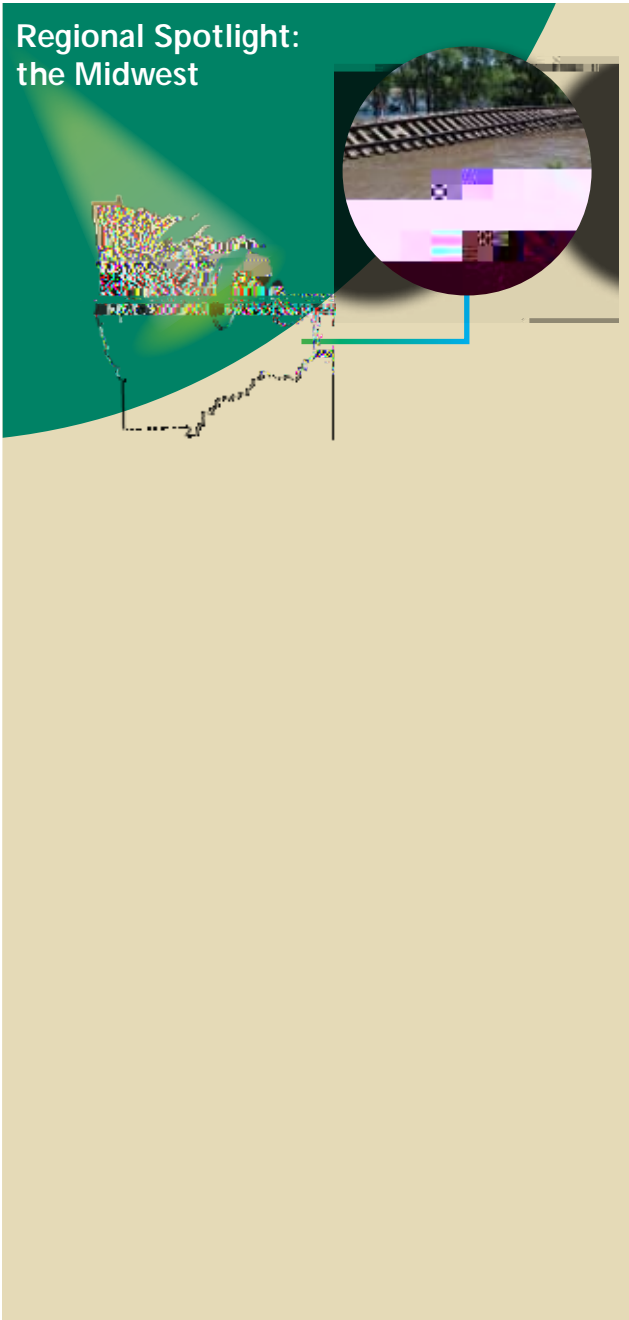


Air

Airports in coastal cities are often located adjacent to rivers, estuaries, or open ocean. Airport runways in coastal areas face inundation unless effective protective measures are taken. There is the potential for closure or restrictions for several of the nation's busiest airports that lie in coastal zones, affecting service to the highest density populations in the United States.

Flooding from increasingly intense

Regional Spotlight: the Midwest



ance from the U.S. Occupational Safety and Health Administration states that concern for heat stress for moderate to heavy work begins at about 80°F as measured by an index that combines temperature, wind, humidity, and direct sunlight. For dry climates, such as Phoenix and Denver, National Weather Service heat indices above 90°F might allow work to proceed, while higher humidity areas such as New Orleans or Miami should consider 80 to 85°F as an initial level for work restrictions.²²⁷ These trends and associated impacts will be exacerbated in many places by urban heat island effects (see *Human Health* and *Society* sectors).

Wildfires are projected to increase, especially in the Southwest (see *Southwest* region), threatening communities and infrastructure directly and bringing about road and rail closures in affected areas.

In many northern states, warmer winters will bring about reductions in snow and ice removal costs, lessen adverse environmental impacts from the use of salt and chemicals on roads and bridges, extend the construction season, and improve the mobility and safety of passenger and freight travel through reduced winter hazards. On the other hand, more freeze-thaw conditions are projected to occur in northern states, creating frost heaves and potholes on road and bridge surfaces and resulting in load restrictions on certain roads to minimize the damage. With the expected earlier onset of seasonal warming, the period of springtime load restrictions might be reduced in some areas, but it is likely to expand in others with shorter winters but longer thaw seasons. Longer construction seasons will be a benefit in colder locations.²²²

Water

Warming is projected to mean a longer shipping season but lower water levels for the Great Lakes and St. Lawrence Seaway. Higher temperatures, reduced lake ice, and increased evaporation are expected to combine to produce lower water levels as climate warming proceeds (see *Midwest* region). With lower lake levels, ships will be unable to carry as much cargo and hence shipping costs will increase. A recent study, for example, found that the projected reduction in Great Lakes water levels would result in an estimated 13 to 29 percent increase in shipping costs for Canadian commercial navigation by 2050, all else remaining equal.²²²

If low water levels become more common because of drier conditions due to climate change, this could create problems for river traffic, reminiscent of the stranding of more than 4,000 barges on the Mississippi River during the drought in 1988. Freight movements in the region could be seriously impaired, and extensive dredging could be required to keep shipping channels open. On the other hand, a longer shipping season afforded by a warmer climate could offset some of the resulting adverse economic effects.

at affected airports, and could require some airports to lengthen runways. Recent hot summers have seen flights cancelled due to heat, especially in high altitude locations. Economic losses are expected at affected airports. A recent illustrative analysis projects a 17 percent reduction in freight carrying capacity for a single Boeing 747 at the Denver airport by 2030 and a 9 percent reduction at the Phoenix airport due to increased temperature and water vapor.²²²

Drought

Rising air temperatures increase evaporation, contributing to dry conditions, especially when accompanied by decreasing precipitation. Even where total annual precipitation does not decrease, precipitation is projected to become less frequent in many parts

of the country.⁶⁸ Drought is expected to be an increasing problem in some regions; this, in turn, has impacts on tra(y)70(.).TJ0.01 Tcc6.413 0 0 6.41em icry

In cold areas, the projected decrease in very cold days will mean less ice accumulation on vessels, decks, riggings, and docks; less ice fog; and fewer ice jams in ports.²²²

Air

Rising temperatures will affect airport ground facilities, runways in particular, in much the same way they affect roads. Airports in some areas are likely to benefit from reduction in the cost of snow and ice removal and the impacts of salt and chemical use, though some locations have seen increases in snowfall. Airlines could benefit from reduced need to de-ice planes.

More heat extremes will create added operational difficulties, for example, causing greater energy consumption by planes on the ground. Extreme heat also affects aircraft lift; because hotter air is less dense, it reduces the lift produced by the wing and the thrust produced by the engine – problems exacerbated at high altitudes and high temperatures. As a result, planes need to take off faster, and if runways are not sufficiently long for aircraft to build up enough speed to generate lift, aircraft weight must be reduced. Thus, increases in extreme heat will result in payload restrictions, could cause flight cancellations and service disruptions

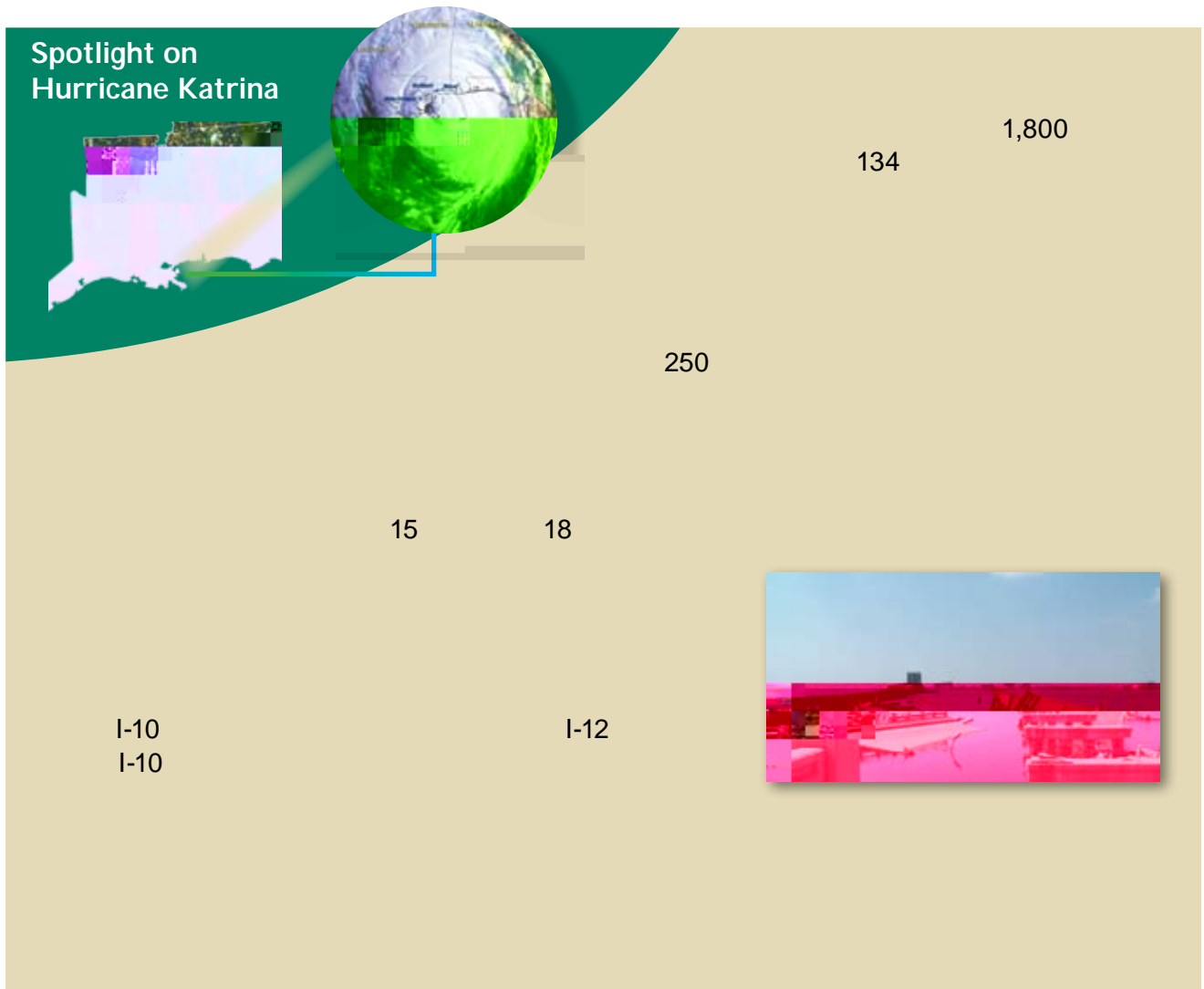
and higher storm surge and waves. Transportation planners, designers, and operators may need to adopt probabilistic approaches to developing transportation projects rather than relying on standards and the deterministic approaches of the past. The uncertainty associated with projecting impacts over a 50- to 100-year time period makes risk management a reasonable approach for realistically incorporating climate change into decision making and investment.²¹⁵

Land

There will be a greater probability of infrastructure failures such as highway and rail bridge decks being displaced and railroad tracks being washed away. Storms leave debris on roads and rail lines, which can damage the infrastructure and interrupt travel and shipments of goods. In Louisiana, the Department of Transportation and

Development spent \$74 million for debris removal alone in the wake of hurricanes Katrina and Rita. The Mississippi Department of Transportation expected to spend in excess of \$1 billion to replace the Biloxi and Bay St. Louis bridges, repair other portions of roadway, and remove debris. As of June 2007, more than \$672 million had been spent.

There will be more frequent and potentially more extensive emergency evacuations. Damage to signs, lighting fixtures, and supports will increase. The lifetime of highways that have been exposed to flooding is expected to decrease. Road and rail infrastructure for passenger and freight services are likely to face increased flooding by strong hurricanes. In the Gulf Coast, more than one-third of the rail miles are likely to flood when subjected to a storm surge of 18 feet.²¹⁷



sediment in rivers and scouring of bridge sup-