

## 2 IMPACTS

After more than 100 years of road and highway building, the United States is now criss-crossed by nearly four million miles of roadways.<sup>1</sup> That translates to nearly 19,000 square miles of asphalt, an area greater than the states of New Hampshire and Vermont combined, greater even than the country of Switzerland.<sup>2</sup> Add in all the parking lots, private roads, driveways and road shoulders, and the total amount of paved land comes to approximately one percent of the total area of the contiguous United States.<sup>3</sup>

The construction of roads and highways opens up vast areas of wilderness and farmland to residential and commercial development. The sprawl that occurred after World War II continues to spread, particularly in the South and West. Data from the U.S. Census shows that from 1990 to 2000, the population of central cities within metropolitan areas grew by eight percent. But during that same period, the population of the suburbs and exurbs (the most far-flung suburban developments) of those areas skyrocketed by nearly 18 percent.<sup>4</sup>

Roads and highways and the development they foster have severe impacts on habitat, wildlife and plants. These include roadkill; habitat loss, degradation and fragmentation; air, water, soil, and noise pollution; and invasive species. As noted in the recently published book by Richard Forman, Daniel Sperling and

other notable authors, *Road Ecology: Science and Solutions*, “The end result of a highly connected road system is a decrease in both the number and the abundance of the species that once inhabited the landscape.”<sup>5</sup>

### Roadkill

A four-million-mile network of roads and highways has led to unprecedented mobility for Americans. But that network also shatters natural habitat into many fragments, forcing animals to venture across the pavement in search of food, shelter or a mate. The result is an efficient death-trap for wildlife.<sup>6</sup>

Every day, one million vertebrates are killed on America’s roadways, according to the Humane Society of the United States and the



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Urban Wildlife Research Center.<sup>7</sup> This is an astonishing figure, but less so perhaps when one considers the sheer numbers of dead deer, squirrels, raccoons, and opossum passed by on the daily commute. Indeed, Americans kill more wildlife through collisions with vehicles than in any other way. In some locations, for particular species, the roadkill rate may exceed natural causes of death due to disease and predation.<sup>8</sup>

For some species, collisions with vehicles threaten their very existence. The state of Florida, which is largely characterized by low-

density, auto-oriented development, has become well-known for conflicts between wildlife and vehicles. In that state, the remaining populations of endangered or threatened species and subspecies such as the Florida black bear, the Key deer, and the Florida panther, are seriously jeopardized by collisions with vehicles. Roadkills of the Florida black bear have grown 29-fold, from just two or three during the 1970s to 90 in 1998. Roadkill is the leading known cause of death for the endangered Key deer. From 1970 to 1992, more than 1,000 Key

## WHAT'S NATURE LIKE NEAR A BUSY HIGHWAY?

Consider taking a leisurely stroll or nature walk in the edge of woods by a busy two-lane highway. The sense of leisure quickly evaporates in the face of traffic noise. Speeding vehicles evoke a sense of danger. You may be confronted underfoot with society's refuse. Busy roads and a bucolic outdoors seem incompatible.

So you move back into the wooded edge to look more closely. Many of the native forest birds seem to be missing – even for quite a distance into the forest; apparently it is too noisy. Indeed, few other forest vertebrates – mammals, frogs, turtles, snakes – are seen; it must be a road-avoidance zone for them, too. If you had ventured to walk along the roadside, you might have seen road-killed animals, though carcasses disappear quickly where road-kill scavengers hunt. The combination of road-avoidance zone and road-kill strip makes you realize what a barrier the busy highway is, dividing large natural populations into small ones that may be prone to local extinction. Also, wildlife movement corridors that connect distant patches across the landscape may be severed. You wonder whether this is an inadvertent collective assault on biodiversity.

Unlike the adjoining forest interior, the forest edge seems

to be full of generalist "weedy" plants, some of them non-native exotics, all persisting next to the open environment of a frequently mowed roadside. The roadside vegetation growing on earth that was homogenized and smoothed during road construction seems monotonous, largely devoid of its natural heterogeneity and richness. A few grasses, plus some non-native plants, tend to dominate at the expense of a diversity of native wildflowers. Open straight roadside ditches carry warmed water, alternating with pulses of rainwater, into a narrow, wooded stream that lost its valuable curves during road construction. A specific set of invisible chemicals has reached the roadside and perhaps the forest – nitrogen oxides, hydrocarbons, herbicides, roadsalt, and heavy metals such as zinc and cadmiums are typical. Entering the streams, wetlands, and groundwater around you, they inhabit all kinds of natural processes and are toxic to some of the species.

What is it like next to a busy road? No place for a neighborhood walk. Or a path in a park. Or even a nature reserve. Here nature is both severed and impoverished. Road ecology is needed.

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deer were killed in collisions with vehicles, averaging 45 killed per year; since 1992 the number of individuals killed by cars each year has remained well above 30. The endangered Florida panther is also threatened by conflicts with vehicles. Only about 80 Florida panthers remain in the wild today, and as many as seven are killed each year by cars. In the spring of 2001, seven panthers were killed in just three months, breaking the previous record. Scientists fear that the population will be unable to sustain itself, given this mortality rate.<sup>9</sup>

Other threatened and endangered species throughout the rest of the country that are particularly at risk because of wildlife-vehicle collisions include the ocelot, the Canada lynx, the grizzly bear, desert tortoise, the San Joaquin kit fox, and the Houston toad.<sup>10</sup>

People are also victims. Collisions between larger wildlife species and vehicles often result in vehicle damage and injury or death to their human occupants. A study of accidents in Vermont between 1981 and 1991 found property damage in 94 percent of collisions between vehicles and deer. Nationwide, in 2001 vehicle-wildlife collisions were responsible for an estimated 29,000 human injuries and 177 human fatalities.<sup>11</sup>

## Habitat Loss

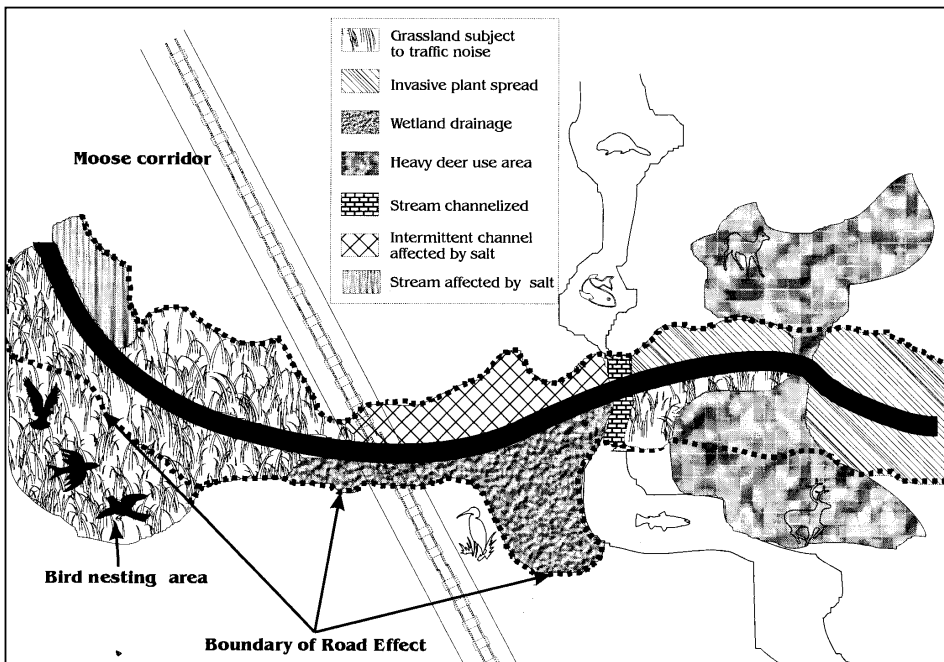
Habitat loss is the most significant threat to endangered species, 85 percent of which are imperiled in this way.<sup>12</sup> A 1976 study by the Council on Environmental Quality reported that

up to 48 acres of habitat is lost with the construction of one mile of Interstate highway.<sup>13</sup>

For many species, the very presence of a roadway can represent an impassable barrier, either psychologically or physically. For these species, roadways fragment existing habitat and isolate populations into smaller groups. This can be devastating to wide-ranging animals that need large areas of contiguous habi-

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tat to survive. Young animals may be so confined by habitat fragmentation that they are unable to establish their own territories. A host of related issues can arise, including genetic problems from inbreeding, which can result in weak or sterile offspring.<sup>14</sup> Research in Germany on how road barriers affected small local populations of the common frog found significant alterations in their genetic structure, including lower genetic variability among individuals.<sup>15</sup> Animal populations that are isolated are also more vulnerable to natural catastrophes such as flooding or drought because they are unable to move to other areas. Habitat fragmentation may also make it impossible for species to adapt to climate change, making



The road-effect zone \*

extinction much more likely.<sup>16</sup>

Even large, adult animals such as bobcats, wolves, and grizzly bears, have been found to avoid roads, so that while the roads may not present a physical barrier to movement, they still restrict movement and therefore fragment habitat.<sup>17</sup> Elk in western Montana have been found to avoid areas within one-quarter to one-half mile of roads, depending on the type of road and the amount of traffic it supports. A study of grizzly bears in British Columbia found that the bears would avoid areas within one-half mile of roads. Experts in the ecological impacts of roads have stated that the “impact of road avoidance must well exceed the impact of either roadkills or [direct] habitat loss in road corridors.”<sup>18</sup>

The effect of habitat fragmentation is devas-

tating to populations of wide-ranging animals. In addition to direct loss and fragmentation, much additional habitat is degraded by such factors as noise, air and water pollution, and by the creation of new microclimates that border roadways. Such microclimates often have more sunshine and wind, lower humidity and different patterns of rainfall, snowfall and snowmelt than adjacent areas.<sup>19</sup> These edge habitats are often unsuitable for native species, but attractive

to invasive, non-native species.<sup>20</sup>

Though the extent of habitat degradation varies depending on the type of roadway and its subsequent use, the effect can be felt as much as 3,000 feet beyond the edge of the pavement. Scientists estimate that this road-effect zone currently impacts as much as 15 to 20 percent of the land surface of the U.S.<sup>21</sup> These individual factors are discussed below.

## Pollution

Roads, highways, and the development they facilitate cause air, soil, water and noise pollution. One study of 23 important pollutants found along roads determined that 83 percent came from vehicles.<sup>22</sup> Driving is one of the

largest contributors to air pollution — motor vehicles are responsible for more than two-thirds of the carbon monoxide in the atmosphere, a third of the nitrogen oxides (which react to form ozone or smog and also form acid rain), and a quarter of the hydrocarbons (which also contribute to ozone).

Almost every plant type — conifers, broad-leaved trees, shrubs, herbs, and grasses — includes one or more species that are especially susceptible to ozone. For all types of vegetation, ozone interferes to some extent with the production and storage of starches, reducing growth rates and weakening plants. This makes plants more vulnerable to disease, insect attacks, and other environmental stresses.<sup>23</sup>

Cars and trucks also emit pollutants that form acid rain. Acid rain is a serious problem for aquatic ecosystems and has wide-ranging effects on the many species that depend on them, including insects, amphibians, fish, birds, and mammals. Spikes in acidity caused by spring snowmelt in New England have killed brook and rainbow trout, as well as Atlantic salmon. Amphibians are particularly susceptible to acid rain, which reduces their reproductive success. While acidification does not typically harm mammals and birds directly, it may harm them indirectly by reducing their food supply. In fact, acid rain has been linked to declines in songbirds such as the wood thrush because it reduces the supply of the calcium-rich foods the birds depend on.<sup>24</sup>

Motor vehicles also emit a variety of heavy metals: motor oil and tires contain zinc and cad-

mium; gasoline contains nickel; and diesel fuel contains lead. These heavy metals have been found in greater concentrations closer to roads and in areas with higher traffic volumes.

Research on earthworms has found concentrations of heavy metal high enough to kill earthworm-eating animals.<sup>25</sup> A study of little brown bats, short-tailed shrews, and meadow voles along the Baltimore-Washington Parkway found lead at or above levels known to cause death or reproductive impairment in domestic animals.<sup>26</sup>

Chemicals used in the maintenance of road-

*A one-acre parking lot produces about 16 times as much runoff as a one-acre meadow.*

ways also contaminate roadside ecosystems. While many state departments of transportation have begun to reduce the use of herbicides and other chemicals, the use of herbicides continues to damage roadside ecosystems.<sup>27</sup> Those chemicals may promote the invasion of weedy and exotic species, which are resistant to herbicides. Even more worrisome, herbicides can be transported from treated roadsides into aquatic environments. If large amounts of these herbicides find their way into lakes or streams, biological communities could be seriously jeopardized.<sup>28</sup>

According to the U.S. Environmental Protection Agency, approximately 10 million tons of rock salt were used on the nation's roads between the mid-1980s and the mid-1990s. That usage was found to have caused at

least 11 percent of the impaired stream miles reported nationally.<sup>29</sup> The most commonly used road salt is known to contaminate drinking water supplies, and to be toxic to many species of plants, fish, and other aquatic organisms.<sup>30</sup> Road salt used in the Rochester, New York area caused a ten-fold increase in the chloride concentration in Irondequoit Bay of Lake Ontario.<sup>31</sup> Finally, wildlife may be attracted to road salt as an easily accessible salt lick and may then end up as roadkill.<sup>32</sup>

## Water Pollution

Roads, highways and parking lots are what hydrologists call impervious surfaces. Those impervious surfaces cause runoff to flow more quickly into open bodies of water, rather than allowing it to seep naturally into the ground to recharge aquifers. A one-acre parking lot produces about 16 times as much runoff as a one-acre meadow. Numerous studies have found that when impervious surfaces cover more than ten percent of a watershed, the rivers, creeks, and estuaries they surround become biologically degraded.<sup>33</sup>

Runoff flowing into streams, rivers, or creeks leads to erosion and sedimentation, thereby degrading aquatic habitat. As runoff flows over pavement, its temperature rises. Because warmer water has less dissolved oxygen, it can make the affected body of water unsuitable for certain plants, invertebrates, and fish.<sup>34</sup>

Runoff also carries with it numerous pollu-

tants, including sediment, nutrients, trace metals, pesticides and petroleum hydrocarbons. The addition of nutrients can lead to algal blooms, which can diminish clarity and, when the algae decays, reduce dissolved oxygen levels below the threshold requirement of some fish and invertebrates. In many aquatic environments, excess nitrogen leads to algal growth. Nitrogen comes from many sources. But as much as 25 percent of the additional nitrogen that finds its way into coastal estuaries comes from atmospheric deposition, much of which originates from motor vehicles. (Cars and trucks are responsible for one-third of atmospheric nitrogen oxides.)<sup>35</sup>

Trace, or heavy metals from cars and trucks may also poison aquatic environments.<sup>36</sup> One study of heavy metals found that even though parking lots and major streets covered just six percent of the watershed, they contributed a quarter of the metals, and 64 percent of the petroleum hydrocarbons in the watershed.<sup>37</sup>

## Noise Pollution

Noise pollution from roads and highways, initially during construction and later from heavy traffic, can degrade wildlife habitat and impair biodiversity. Most frequently, noise pollution leads wildlife to avoid roads, but it has also been shown to change reproductive behavior and other patterns of activity. Often, noise pollution causes an increase in the heart rate and in the production of stress hormones in animals. Birds and other wildlife that commu-

nicate by auditory signals are especially vulnerable to noise pollution. Territory establishment and defense may also be disrupted by noise from roadways.<sup>38</sup> Research on toads and tree frogs found that highway noise resulted in abnormal reproductive behavior in the vicinity of major roads.<sup>39</sup> The presence of songbirds has been shown to decline even at low noise levels, and sharply drops near roads.<sup>40</sup>

## Invasive Species

Non-native or invasive species pose a significant threat to our nation's biological diversity, and are causing substantial economic burdens. Each year, approximately \$137 billion nationwide is lost to the effects of invasive plants on agriculture, industry, recreation, and the environment. An estimated 4,600 acres of land are invaded daily by invasive plants.<sup>41</sup> Invasive species impact nearly half the species currently listed as threatened or endangered under the federal Endangered Species Act.<sup>42</sup>

Roads and highways can encourage the entry of invasive species in four ways: 1) road medians and corridors have often been planted with exotic plant species; 2) techniques used to maintain roadways may encourage the growth of invasive or exotic plant species; 3) roads may facilitate the spread of invasive plant and animal species; and 4) degradation of habitat caused by roadways may usher in exotic and invasive plants and animals.

Many state and local departments of transportation have landscaped roadsides with non-

native plant species. Invasive woody plant species, in particular, have been planted along some roadsides to reduce erosion, control snow accumulation, reduce headlight glare, or enhance aesthetics.<sup>43</sup> Unfortunately, the planting of invasives may have unexpected negative consequences for wildlife habitat. Research of Massachusetts roadsides found that in half of the locations where non-native woody species were planted, the species had spread into the adjacent woods.<sup>44</sup> It was not until the 1987 Surface Transportation and Uniform Relocation Assistance Act (SUTRAA) that the federal government require states to plant native wildflower seeds or seedlings as part of landscaping projects undertaken on highway projects that receive federal assistance.<sup>45</sup>

Road or highway maintenance may also encourage the spread of invasive species. Roadside mowing tends to reduce the richness of plant species and favor exotic plants.<sup>46</sup> Mowers and other maintenance equipment that is not thoroughly washed may also inadvertently spread invasive species by carrying seeds from one site to another.<sup>47</sup> Fertilization or soil transfer in roadside management is also known to alter roadside vegetation significantly, typically in favor of invasive species.<sup>48</sup>

Invasive species may take advantage of roads and highways to spread to other areas. Research in New York State found that purple loosestrife, a common invasive species that crowds out native wetland vegetation, was able to spread via roadside ditches, culverts connecting opposite sides of a highway, and median strip vegetation.<sup>49</sup>

Finally, habitat degradation caused by roadway construction and on-going use may create favorable environments for invasive species. Indeed, many plant species thrive along roadsides, but most of these are weedy. Examples include rabbit brush in the Great Basin and creosote bush in the Mojave Desert. These species take advantage of increased light along cleared roadsides and runoff water channeled to road shoulders.<sup>50</sup> Invasive animals are also known to exploit degraded habitat. Perhaps the best

## Sprawl

Roads and highways indirectly impact wildlife by facilitating residential and commercial development. While transportation planners may shy away from taking responsibility for land development, there can be no doubt that in many cases new roadways have ushered in building booms along their corridors. A recent study of sprawl in Maryland found that 93 percent of developed properties within five miles of a major Interstate highway (I-270) were built after the adjacent section of the highway was built; further, the study found that highway corridors were much more developed than more distant areas.<sup>52</sup>

Highway-related development tends to be auto-oriented and low-density. This type of development is particularly destructive to habitat because its footprint tends to be large and because it precipitates further road development. Recent data provides evidence of this trend: from 1992 to 1997, the rate of development doubled compared to the previous ten years.<sup>53</sup> If the rate of development continues at that pace, the amount of land developed in the next 25 years will equal the total amount developed since the country's founding.<sup>54</sup>

In the 45 years since President Dwight D. Eisenhower created the Interstate highway system, the number of miles driven by every man, woman and child, has grown two and a half times to nearly 10,000 miles per year.<sup>55</sup> While it may seem intuitive, recent research supports the claim that sprawling development leads to



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known is the brown-headed cowbird, which has spread from the Great Basin to most of North America largely because of forest fragmentation. The cowbird, a brood parasite, lays its eggs in the nests of other bird species, thereby forcing the host birds to adopt the baby cowbirds, usually resulting in the death of their own offspring. Native forest birds show serious declines in areas where cowbirds have invaded.<sup>51</sup>

increased driving. In one of the most comprehensive analyses of sprawl to date published by Smart Growth America, researchers found an indisputable relationship between sprawl and driving. The study found that for every one standard deviation decline in the Sprawl Index, there is a 2-mile increase in miles driven per person. In other words, the more sprawling a metro area is, the more driving there is. The results are even more compelling at the extremes of the scale. In the 10 most sprawling metro areas, residents drove an average of 27 miles per day. This compares to 21 miles per

day in the 10 least sprawling metro areas.<sup>56</sup>

Because sprawl requires people to drive more to meet daily needs, such development results in increased emissions of pollutants that can degrade air and water quality and threaten biodiversity.<sup>57</sup> Further, sprawling development may kick off a vicious cycle of more driving leading to more traffic congestion, leading to pressure for more roads, leading to road construction, leading to more development. In the end, farmlands, forests, grasslands, and all other open space are paved over to make way for more roads.

## PRESERVING NATURE THROUGH A SMART GROWTH APPROACH TO TRANSPORTATION

Sprawling development is one of the most serious threats to wildlife and biodiversity because it results in fragmentation, degradation and loss of natural habitat across the country. Smart growth is well-planned development that protects open space and farmland, revitalizes communities, keeps housing affordable and provides more transportation choices. Combined with smart conservation, smart growth can provide for both more development and more habitat protection by charting out where growth should and should not occur. The following are five transportation solutions to ameliorating sprawl's impacts on nature:

1. Integrate transportation planning and land use planning. Citizens, land use planners, natural resource managers and transportation agencies should work together toward common goals
2. Ensure that transportation planning is compatible with water quality goals. Sprawling growth and the associated increase in impervious surfaces contribute to rapid stormwater runoff and drought.
3. Encourage mass transit. Providing Americans with additional transportation options will reduce the need for additional roads, hence protecting more habitat for wildlife.
4. Encourage transit-oriented development. By concentrating development around public transit stations and stops, communities can support economic development, offer residents more convenient places to live, and keep development out of wildlife habitat.
5. Preserve roadway capacity by preserving open space. New and expanded roads often get immediately clogged with traffic because commercial and residential development along the roads creates local traffic. Limiting road access and using transportation funds for open space conservation adjacent to highways preserves the intended mobility and scenic views.

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Smart Growth America

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