Chapter 3
Transportation and the environment

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3.1 Transportation and environmental issues

The 21st century has been called the "century of the environment," and the relationship between transportation and the environment has greatly changed due to changes in modes of transportation and the environmental issues being focused upon. For example, in "*Kotsu to Kankyo,*"[1] the Japanese translation of the 1988 OECD report "Transport and the Environment,"[2] issues such as air pollution and noise are raised as examples of the effects of land transportation on the environment, but there is no mention of global warming. The Framework Convention on Climate Change was only adopted at the 1992 Earth Summit in Rio de Janeiro, and was finally put into force in 1994. At that time, the Convention on Biological Diversity was hardly recognized, both in Japan and across the world.

In the Comparative Study on Urban Transport and the Environment (CUTE), sponsored by the Special Interest Group on Transport and Environment at the World Conference on Transport Research Society between 2001 and 2004, the focus of research was on environmental issues such as automobile emissions and noise, in particular localized air pollution and greenhouse gases.[3] This attests to the fact that, upon entering the 21st century, global warming was finally gaining widespread attention.

However, the environmental effects of transportation cover quite a wide range. The focus is most commonly placed upon automobile-related air pollution and global warming, as in the case in CUTE, to the extent that there is very little discussion regarding the relationship between the environment and other forms of transportation. Table 1 shows a listing of the environmental effects of major forms of transportation, and is based on the table in the above-mentioned OECD report,[2] with extensive additions and revisions by the author.

Regarding the effects on air pollution, automobiles are most commonly examined due to the scale of their effects, but marine and other water-based transportation, rail transportation, and air transportation also exhibit a variety of effects. For example, in 2011 air transportation accounted for only 3.9% of carbon emissions for the transportation sector as a whole, but the demand for international aviation services is expected to grow rapidly and reach a sixfold increase by 2050[4] compared to the demand in 2010. Before global warming took center stage, acid rain was a central topic, particularly in Europe. In recent

Table 1. The effects of transportation on the environment (Table 1 from reference 2, with additions by the author)

Transportation mode	Air	Land	Water (including groundwater)	Waste	Noise, vibration	Ecological impact	Landscape
Maritime transportation and inland waterways	CO_2 emissions Air pollution	Port facility construction Canal construction	Port facility construction Drilling and dredging rivers and coasts	Facilities, ship disposal	Noise around the port	Expansion of invasive species by ballast water Endocrine disruption of organisms by paint on ships	Loss of natural coast, rivers Landscapes with ships
Rail transportation	Carbon dioxide emissions Air pollution	Railway and station construction	Division of underground water veins by tunnel construction, etc.	Facilities and vehicle disposal	Noise and vibration near stations and along railways	Habitat fragmentation Collision accidents	Disruption of natural and traditional landscapes Creation of a new landscape resources (vehicles, bridges)
Road transportation	Carbon dioxide emissions Air pollution (In particular, fuel additives such as CO, HC, NOx, dust, and lead)	Construction of related facilities, including roads Terrain modification due to road construction Procurement of materials for road construction	Division of underground water veins by tunnels, etc. Development of water regions and changes in water system due to road construction Surface and groundwater contamination	Facilities and vehicle disposal, waste oil Battery disposal (especially for hybrid and electric vehicles)	Automobile noise and vibrations in cities and along major routes	Habitat fragmentation Collision accidents Disruption due to pollutants Contamination by anti-freeze agents Light pollution by streetlights	Disruption of natural and traditional landscapes Creation of new landscape resources (bridges, etc.)
Air transportation	Carbon dioxide emissions Air pollution	Airport facility construction	Development of water regions due to airport construction	Disposal of aircraft	Noise and shock waves near airports	Habitat destruction by airport development Collisions with airplanes (mainly birds)	Loss of natural landscapes Landscapes with airplane

years, however, fine particulate matter with particles of diameter 2.5 μm or less (PM 2.5) is the primary cause of pollution in China and other developing nations.

The impact of transportation on the environment can be roughly divided into the effects due to roads and other infrastructure, and the effects due to automobiles and other transportation vehicles. Transportation vehicles have greater impact in the atmosphere, but on the ground the primary impact is due to infrastructure maintenance. This is divided into facilities such as ports, stations, and airports, and the construction of linear routes such as canals, railways, and roads. Transportation routes must be continuous, and therefore necessarily separate natural environments and land use. Furthermore the scale of facilities such as airports is quite large, and this can have a significant impact on both natural environments and land use.

Transportation infrastructure is also the cause of much of the impact on water regions. The effects of transportation on rivers and coastal areas have been pointed out in many past studies, most of which

show a degradation of water quality due to development. Disruption of underground water veins due to underground transportation via tunnels has also been shown to reduce and pollute underground water, and to increase maintenance costs for drainage of water. There are also many cases where transportation machinery leads to the pollution of water areas. Regarding ground transportation, the various chemical products emitted by automobiles are concentrated along roads, and then dispersed into the surrounding environment.

Large amounts of waste are produced when transportation-related infrastructure is abandoned or renewed, and when the vehicles that utilize such infrastructure exceed their serviceable lifetimes, these too must be treated as waste. In Japan, the Act for Automobile Recycling mandates that such vehicles be recycled, and recycling rates have reached approximately 99%.[5)] However, there is a possibility that the rapid spread of hybrid vehicles, and the expected increased popularity of electric automobiles and next-generation environmentally friendly vehicles, will result in increased battery disposal, so the cost of recycling may increase.

Regarding noise, with the exception of marine transportation, there has been extensive research, and a variety of measures have been attempted. Infrastructure maintenance exceeding a certain scale is subject to the Environmental Impact Assessment Law, and must meet certain legally determined standards. There has also been continued development for the suppression of noise and vibration due to transportation vehicles. Japan is currently developing a maglev train line and continues to expand Haneda Airport, so new issues related to noise and vibration are likely to develop.

There have been few investigations into the effects of transportation on organisms, despite various indications for doing so from the fields of biology and ecology. The largest impacts are habitat fragmentation and loss. As I explain in more detail below, the most frequently discussed measures are environmental mitigation and eco-roads. Various other effects are also seen, but two particular features of marine and other water-based transportation are extended distribution ranges of invasive species due to ballast water, and endocrine disruption due to the paint used on ships. In the case of air transportation, collisions between airplanes and birds are the major problem, which can also pose danger to human lives.

One final impact is that on landscapes. The OECD report[2)] makes no mention of this point. Nonetheless, transportation-related infrastructure has a significant impact both on natural scenery and on traditional and historic views that have been cultivated over many years.[6)] An interesting feature of this issue, however, is that transportation machinery and infrastructure itself can become a scenic resource. For example, one does not need a particular interest in railways to feel a sense of beauty when viewing a photograph of a train crossing over a bridge that straddles a valley, and there are many instances where transportation infrastructure itself becomes a popular landscape spot, such as in the cases of the Yokohama Bay Bridge or the Akashi Kaikyo Bridge.

3.2 Road greening and parkways

The environment and transportation infrastructure have developed in close association with each other. For example Hirasawa[7] describes how rows of trees were planted as far back as the early 7th century as a form of road greening in Japan, and how records from the 8th century state that the planting of these trees was mandated, as they provided traveling farmers with shade in which to rest and fruit to eat when they were hungry. The Tokugawa Shogunate later developed tree-lined roads throughout Japan, and the beginning of using stands of cherry trees for recreation was in the first half of the 18th century, when Tokugawa Yoshimune opened orchards in the area around Edo.[7] This can be viewed as the birth of Japanese-style open space planning.

The development of green space in the West received a major boost when Friedrich Franz Leopold III, the Lord of Dessau, became strongly influenced by the landscape gardens of England, and thereby renovated Wörlitz Castle into a landscape garden between 1768 and 1770. Landscaping was thereafter promoted throughout the territory, forming the birth of open space planning in Europe. It was the United States that first established a park system coupled with road planning.

The need for parks and green spaces was strongly felt as a result of the expansion of American cities in the early 19th century. New York's Central Park was designed by Frederick Law Olmsted in 1873. This was the first large-scale urban park to be built in the United States. At around the same time (1868) the first parkway—a road developed along with a park—was built in Brooklyn.[8] The definition of "parkway" remains unclear, and already has diverged from its original meaning, but later developments in Boston, Minneapolis, and Kansas City featured a variety of axial roadways combined with green spaces, also called parkways.[8] In late 19th-century Boston, the development of parkways and green spaces was sublimated into open space planning in the form of a park system.[9] This occurred before automobile usage was widespread, in a time where roads were generally used for horse-drawn carriages.

After automobile usage rapidly spread in the early 20th century, parkways appeared as roads designated for automobile use only. This was done to allow automobiles to travel at higher speeds than horse-drawn carriages, as exemplified by the development of the Long Rheinland State Parkway in the 1930s.[8] Parkways later began to spread throughout the world in various forms, such as national park roads and pay roads through scenic areas. American-style parkways were soon introduced into Japan, starting with the Shonan Coast Park Road (now part of National Highway Route 134), which began construction in 1931 and was completed in 1936, as the first parkway in Japan[10] (Fig. 1).

Figure 1. Current National Highway Route 134
(taken by the author in June 2014, near the Hamamiyama Kobanmae intersection)

3.3 Ecological mitigation and eco-roads

The development of railway and automotive technologies has realized high-speed movement, and automobiles in particular make possible high mobility that allows any-time, anywhere movement. The high-density development of supporting railways and roads has arisen alongside the development of high-speed ground transportation. Following World War II in particular, global political stability and economic development caused transportation infrastructure development to rapidly expand, and this began to have a large impact on the natural environment. In 1969 the United States enacted its National Environmental Policy Act and institutionalized various forms of environmental impact assessment in order to avoid, to the extent possible, the effects of various kinds of development on the natural environment. While falling far behind the countries of the West, in 1997 Japan too enacted its Environmental Impact Assessment Law. Development exceeding a certain scale is now required to undergo environmental assessment, the possible effects of business on natural environments are investigated, and furthermore follow-up surveys after project completion are also required. However, the institutionalization of mandatory environmental impact mitigation has gone even further in Western countries such as the United States and Germany. Environmental mitigation (often simply called "mitigation") is a method for ensuring "no net loss" of wildlife habitats before and after development and other such activities through (1) avoiding effects by refraining from certain activities, (2) reducing effects by limiting certain activities, (3) correcting effects through repair, rehabilitation, and restoration, and (4) reducing or eliminating long-term negative effects through protection measures and management, supplying alternate resources, and making up for negative effects through replacement, with steps taken preferentially in that order.[11] Figure 2 shows a railway near Frankfurt, Germany, in which quadruple tracks are being planned to meet the increased demands of recent years. Such artificially created railway embankments are a habitat for the sand lizard (*Lacerta agilis*), an endangered species in Germany, so this rail construction is likely to have a significant impact. Measures to develop alternative living spaces in the surrounding areas are therefore planned prior to construction so that the lizard populations can be maintained. The above-mentioned procedures for quantifying the total amount and quality of organism habitats are operated in the United States using a system called mitigation banking,[12] which had begun to be utilized before the greenhouse gas emissions trading system was established.

Figure 2. Railway embankments are an important habitat for the endangered sand lizard (*Lacerta agilis*)
(taken by the author in July 2014, in Wetterau, Hessen, Germany)

Environmental mitigation is involved in all forms of development not just transportation infrastructure, but continuous linear developments such as roads and railways are characterized by the potential to divide organism habitats. This results in loss of habitat, as well as animal deaths due to vehicle collisions

while trying to cross the road, disruption of life-cycles for amphibians and other animals that must travel between forests and waters, and reduced genetic diversity due to reduced chances for mating between adjacent populations. Therefore, there have been efforts toward reducing to the extent possible such effects on organisms, particularly with regard to animal movement, and such attempts are collectively referred to as "eco-roads." As in the case of environmental assessment, various cases have already been accumulated in the West and have begun to be introduced to Japan, starting with the 11th Five-year Road Development Plan, which called for the increased development of eco-roads.[13] A wide variety of specific measures have been implemented, to protect not only fauna, but flora as well. The development of eco-roads is often positioned in the above-described environmental mitigation procedures in the West. Various cases have been seen in Japan too, but in most cases road construction is decided first, with tunnels and bridges for animals prescribed as symptomatic treatments, so in many cases it becomes questionable as to whether the effects are sufficient to allow calling such projects "eco-roads." A recent study[14] indicated that somewhere between 89 and 340 million birds die in America each year due to collisions with automobiles, so further measures will likely be needed in the future.

3.4 Transportation and invasive species

I began by discussing global warming, but there is also a need to confront declines in biodiversity as a global environmental issue of the 21st century. Alongside the Framework Convention on Climate Change, the Earth Summit held in Rio de Janeiro in 1992 adopted the Convention on Biological Diversity, which entered into force in 1993. While previously having less recognition than global warming issues, the Convention on Biological Diversity's tenth meeting of the Conference of the Parties (also known as COP10) held in Aichi Prefecture in 2010 suddenly brought biological diversity to the spotlight in Japan. Japan's National Biodiversity Strategy[15] gives detailed information regarding factors that threaten biodiversity, but another issue related to its relationship with transportation is the transfer of invasive species. One famous example is the white clover (*Trifolium repens*) commonly found in grasslands throughout Japan, having been brought here in the form of cushioning materials for packaging when trade between United States and Japan opened up. In manners such as this, when moving from place to place humans bring with them a variety of organisms, whether intentionally or not.

As an example characteristic of transportation, invasive species can be mixed in with the ballast water of ships. Seawater is held in ballast tanks to help stabilize ships, especially when they are traveling under light loads. This seawater will often contain many forms of aquatic life, and is released at a different port when the ships take on loads, and so can be carried quite a distance. Many aquatic organisms contained within can survive until release, especially considering the higher-speed vessels that have been developed in recent years. A well-known example of an invasive species attracting caution in Japan is the Mediterranean mussel (*Mytilus galloprovincialis*). Of course, there are also cases where native Japanese species are transferred to other locations. One such example is wakame seaweed (*Undaria pinnatifida*), which grew explosively in Australia, resulting in major damage to its fishing industry.

Increased demand for air travel has also promoted the migration of species, resulting in risks to humans. The most significant uninvited guests transported by aircraft are pathogens and viruses. Examples have been known ever since air travel became a common mode of transportation for tourists, but the risks associated with increased air travel finally gained wide recognition after 2000 due to severe acute respiratory syndrome (SARS) and the avian flu. Regarding the latter, the possibility of propagation overseas via wild birds had already been known, but the danger of the virus being transported by infected air passengers led to various areas worldwide measuring travelers' body temperatures using thermal sensors. Regarding SARS, an infected air passenger in 2003 lead to emergency measures being implemented in China and throughout the world. Another potential danger is illnesses such as West Nile fever which are transmitted not directly from person to person but through a vector that can also be carried on aircraft. Such dangers led to the Ministry of Health, Labour, and Welfare issuing a notice in 2003 titled "Measures against mosquitoes carrying West Nile fever arriving via aircraft from North America."

3.5 Toward a low-carbon transportation society

As mentioned earlier, global warming is generally recognized as the single most serious adverse effect of transportation. Figure 3 gives statistics for 2012, showing that the transportation sector makes up 18% of Japan's total carbon dioxide emissions, and this amount would certainly increase, were the manufacturer of transportation vehicles included as well. However, there has been a significant decrease of carbon emissions from the transportation sector since 2000. What was once a consistent upward trend has now become a major transformation.

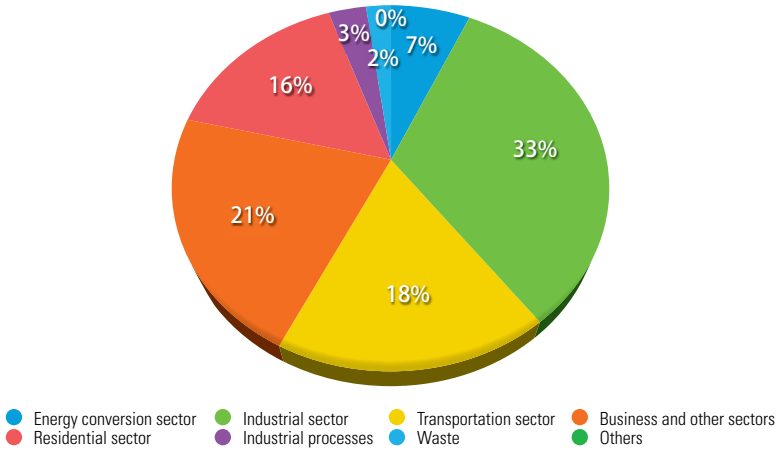

Figure 3. Carbon dioxide emissions (indirect emissions) by sector in Japan, 2012
(created by the author using data from the Greenhouse Gas Inventory Office, National Institute for Environmental Studies)

Reducing carbon dioxide emissions from transportation requires three basic approaches. One is reducing emissions from vehicles. Another is improving transportation infrastructure. The last, which is much needed, is the construction of a transportation system that can help reduce emissions for society as a whole. This third type of system would include tax reforms and other measures.

Automotive manufacturers in particular are competing to develop and improve vehicles. Spurred in part by soaring fuel costs in Japan in recent years, consumers are increasingly aware of fuel economy. Hybrid vehicles with better fuel economy than purely gasoline-fueled automobiles accounted for 17% of

new car sales in 2013. While next-generation automobiles continue to be developed, there has also been steady progress toward improving fuel efficiency and reducing carbon dioxide emissions for conventional internal combustion engines. Small cars that achieve 40 km/l fuel efficiency are expected to appear in 2015. The US and the EU have both set upcoming regulations on the amount of carbon dioxide that can be discharged by vehicles.

Carbon dioxide emissions can also be greatly reduced through transportation infrastructure improvements, for example by reducing congestion. In the Tokyo metropolitan area in particular, various measures have been taken to reduce chronic congestion, and carbon emissions have been reduced by constructing new bypasses and highways, among other methods. However, it is also possible that such improvements will result in increased traffic flow and thus increased travel distances, which will ultimately increase emissions. Recently there have been attempts at making real-time measurements of changes in traffic volumes over time, and optimizing traffic signal control according to traffic volumes. In addition, although they are scarce now, a recent movement has aimed to bring back roundabouts in various districts of Japan, given their proven carbon emissions–reducing effect.[16)]

Drastic reduction of carbon emissions will require a transformation of our transportation system. A variety of measures and technologies have been tested in European cities, including road pricing, car sharing, cycling road development, lowered public transportation fares, increased urban area parking fees, park-and-drive systems, and providing public transportation information via smartphones to promote the usage of public transportation rather than privately-owned vehicles. Vienna, Austria realized a 10-point increase in public transportation utilization between 1993 and 2012.[17)] Such efforts toward integration remain rare in Japan. However, Toyama City is frequently cited as a success story for moving toward becoming a more compact city design and for implementing light rail transit. The greening of taxation systems related to automobiles has also had a great effect on reducing carbon emissions. Western countries have undertaken tax reform that meticulously considers the environment in relation to the realities of the region.[18)] Japan too has implemented tax incentives for environmentally friendly vehicles, and from October 2012 has introduced tax measures related to global warming that add to existing taxes on petroleum and coal products. The tax rate will be raised in stages through April 2016. Leveraging revenues from taxes levied as measures against global warming issues will allow for ongoing implementation of energy source CO_2 emission reduction, for example through reduced energy usage measures, the proliferation of renewable energy, and the greening and increased efficiency of fossil fuels.

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Recommended Reading

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