NRDC Food Miles Factsheets: Methodology and Sources

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SCOPE OF PROJECT

This project was designed to estimate the California air quality and total greenhouse gas emissions from the transportation of imported food into California, as compared with the transportation of California-grown food. Other components of the food system, including production, processing, storage, and preparation, also result in environmental impacts which are not captured in this report.

We calculated the amount of pollution produced by importing seven specific commodities along with an overall estimate of the pollution caused by importing food (excluding meat, dairy, and fish). We compared those numbers with calculations of the amount of pollution produced by transporting those same commodities from growing areas to major consumption areas within California. We selected commodities that met the following criteria: (1) they are among the top food commodities imported into California; (2) they are grown commercially in California both for domestic consumption and export; and (3) the major countries of origin represent a range of locations from around the globe. The U.S. Census Bureau Foreign Trade Database provided data on the quantity of each commodity, the country of origin, and the mode of transport for those commodities imported by ship or airplane. The U.S. Department of Agriculture provided the same information for commodities entering California by truck from Mexico.

We focused on three important pollutants caused by the burning of fossil fuels during transportation that have significant impacts on public health and the environment. These pollutants include carbon dioxide, the leading pollutant causing global warming, and two major air pollutants—nitrogen oxides and particulate matter (soot).

Table 1: Commodities Included in the California Food Transportation Analysis

Commodity	Country of Origin	Transport Method	Tons Imported Into CA in 2005
Table Grapes	Chile	Ship	129,721
Navel Oranges	Australia	Ship	33,095
Wine	France	Ship	47,464
Garlic	China	Ship	24,610
Rice	Thailand	Ship	207,374
Fresh Tomatoes	Mexico	Truck	90,096
Fresh Tomatoes	Netherlands	Airplane	830

HEALTH AND ENVIRONMENTAL IMPACTS OF IMPORTING FOOD

We calculated the environmental and health impacts of importing food into California by estimating the following: 1) the distance individual commodities travel from the field in the country of origin to California markets, and the main modes of transportation by which they travel; 2) the quantity of global warming pollution produced per mile per ton for each mode of transport; 3) the quantity of major air pollutants produced within California from importing individual commodities; and 4) the health effects experienced by Californians resulting from nitrogen oxides and particulate matter from the importation of food into California seaports. We then compared these impacts to estimates of the pollution produced by the transport of food grown in California to markets within California and to the pollution caused by passenger vehicles and power plants.

Total Miles Traveled

We divided the transportation of imported foods into three sections; transport within the country where the food was grown, transport from the country where it was grown to California and transport within California. For each section we calculated the distances traveled by the individual commodity. The sum of these distances represents an estimate of the distance traveled by each commodity from the field where it was grown to markets in California.

Transport Within the Source Country

We used Internet searches and email communications with representatives from the source country to determine the major growing regions for each commodity within the source country. We defined the major growing regions as those producing the largest amount of the commodity so that the total was equal or greater than 75% of the total amount of that commodity grown in 2005 (or the most recent year for which data was available). We then calculated the distance between each growing region and the major port through which that commodity could be expected to be sent to California. We weighted these distances by the percent of the commodity grown in each region[1] and averaged them to estimate a weighted average of the distance traveled by each commodity within the country where it was grown.

We calculated the distance between the port in the country where the commodity was grown and the California port where the majority of the commodity entered California[2] using an online distance calculator. This calculator used latitude and longitude coordinates to estimate distances between cities "as the crow flies". For commodities imported from European countries by ship, where transport involves passing through the Panama Canal, shipping routes were consulted and used to determine the total distance. For wine imported from France, the distances for each leg of the shipping route described by Evergreen shipping was calculated. This included calculating the distance from Le Havre, France to New York using an online distance calculator and then consulting the National Ocean Service document, the Distances Between United States Ports, to determine the distance between the port of NY and the port of Oakland by way of the Panama Canal.

Transport within California

To estimate the distances traveled by each commodity within California, we calculated the distance between the ports where each commodity entered into the state and the major population centers in California. We defined major population centers as those counties with the largest population in January of 2006 according to the State of California Department of Finance so the total of those counties represent at least 75% of the total population of California. We calculated the distance between the port city and the city within each county with the largest population using an online road travel service. To estimate the distance traveled within the port cities of Los Angeles, San Diego and Oakland, we used the distance between the port (seaport or airport) and the downtown of each city. We weighted these distance by the percent of the total population found in each county and averaged these distances to calculate a weighted average of the distance traveled by each commodity to reach the market.

GLOBAL WARMING (CO_2)

To estimate the amount of global warming pollution produced by importing foods into California we calculated the amount of CO_2 produced by the transportation of each commodity from the field to the port in the country where it was grown, the port in the source country to the California port, and from the California port to California markets.

In order to accomplish this we used emission factors developed by scientists at the Natural Resources Defense Council (NRDC) (see Table 2). These factors were developed using published estimates of characteristics of each transport mode such as efficiency and fuel energy content.

Table 2: Transport Carbon Dioxide Emission Factors

Transport Mode	Calculations			Data Sources
Heavy Truck 75,000 lbs GVW	Efficiency	miles/gal	5	EIA AEO 2006, Table 55
	Emission factors			
	Vehicle	lb CO_2/gal	22.4	Direct vehicle emissions based on 22.4 lbs/gal No. 2 diesel (DOE: http://www.eia.doe.gov/oiaf/1605/coefficients.html)
	Fuel	lb CO_2/gal	4.7	Upstream emissions from diesel fuel production. GREET 1.7
	Total	lb CO_2/gal	27.1	
		g CO_2/gal	12290	
		g CO_2/mi	2458	
		g CO_2/ton-mi	65.5	
		g CO_2/tonne-km	45	
Rail	Efficiency	Btu/ton-mi	370	GREET 1.7 for fuel transport
	Fuel energy content	Btu/gal	128,450	Conventional diesel. Source: GREET 1.7
		gal/ton-mi	0.0028805	
	Emission factor	g CO_2/gal	12290	Same as heavy truck diesel above.
		g CO_2/ton-mi	35	
		g CO_2/tonne-km	24	
Ocean Tanker (at sea operations)	Efficiency	kg fuel/ton-mi	0.0018	CARB/CEC "Benefits of Reducing Demand for Petroleum and Diesel (Task 1)", P600-03-005A1, Table C-35, page C-76.
	Bunker Fuel energy content	btu/kg	40,350	
		g CO_2/kg	3,300	
		g CO_2/ton-mi	6	
		g CO_2/tonne-km	4	
Air Cargo	Efficiency	seat-miles/gal	57	EIA AEO 2006, Table 54
	Wgt per seat	ton/seat	0.15	Estimate based on passenger weight and luggage (300 lbs/seat)
		ton-mi/gal	8.55	
	Emission factors			
	Aircraft	lb CO_2/gal	21.1	Jet fuel. (DOE: http://www.eia.doe.gov/oiaf/1605/coefficients.html)
	Fuel	lb CO_2/gal	4.7	Assumed to be same as diesel.
	Total	lb CO_2/gal	25.8	
		lb CO_2/ton-mi	3.02	
		g CO_2/ton-mi	1369	
		g CO_2/tonne-km	937	

Transport within Source Country

We used the Internet and available information to determine the main transport mode used to transport the commodity from the fields where it was grown to the port for export. For all of the commodities we evaluated this was found to be truck transport. We then applied an emission factor which estimates the quantity of CO_2 produced for each kilogram transported and each kilometer traveled to the distances and amounts of each commodity coming from each of the major growing regions. To estimate the amount of CO_2 produced by transporting the commodity from the remaining growing areas, we applied the emission factor to the weighted average of the distance from the major growing areas. We summed the quantity of CO_2 produced due to the transport of each commodity from each of the growing regions to the port to estimate the total amount of CO_2 produced due to transport within the source country.

Transport from Source Country to California

We used the US Census Bureau Foreign Trade database to determine the mode of transport by which each commodity was transported from the source country to California. We then applied an emission factor which estimates the quantity of CO_2 produced for each kilogram transported and each kilometer traveled to the distance between the two ports.

Transport within California

We assumed that the majority of each commodity was transported within California using trucks and that the quantity of each commodity that was imported into California was distributed to California markets according to population. We then applied an emission factor which estimates the quantity of CO_2 produced for each kilogram transported and each kilometer traveled to the distances and quantities of each commodity distributed to each the major population centers. To estimate the amount of CO_2 produced by transporting the commodity to the remaining consumption areas, we applied the emission factor to the weighted average of the distance from the port to the major consumption areas.

AIR QUALITY

To estimate the impact of importing food into California on air quality in California we utilized existing reports documenting the amount of pollution caused by different sectors involved in food imports such as seaports, airports, and truck transport. For those commodities imported by ship or by airplane, we calculated the portion of this pollution that could be attributed to individual or groups of commodities based on the fraction, by weight, each commodity represented of the total transported by each method. To estimate the pollution caused by truck transport in California, we used established estimates of the amount of each pollutant produced by an average truck, per kilogram transported per kilometer traveled.

Commodities Imported by Ship

We obtained estimates of the amount of NOx (394,200 tons/year) and PM (19,309 tons/year) produced by the importing and exporting of goods into California seaports from the Emission Reduction Plan for Ports and Good Movement in California produced by the California Environmental Protection Agency, Air Resources Board in March of 2006. We then apportioned these amounts by the fraction of the total amount of goods imported and exported through California seaports in 2005, obtained from the US Census Bureau Foreign Trade database, represented by each commodity we analyzed (see Table 3).

Table 3: Commodities Imported by Ship

Commodity	Quantity Transported Into CA Seaports in 2005 (metric tons)	Fraction of International trade
Total imports and exports	155,920,082	100.00%
Total food	2,391,427	1.53%
Chilean Grapes	117,965	0.08%
Australian Oranges	30,086	0.02%
French Wine	43,149	0.03%
Chinese Garlic	22,373	0.01%
Thai Rice	188,522	0.12%

Commodities Imported by Airplane

We obtained estimates of the amount of NOx (6,100 tons/year) and PM_{10} (164 tons/year) produced by activities at the Los Angeles International Airport (LAX) in 2005 based on 2001 conditions from the Air Quality Impact Analysis contained in the Environmental Impacts Report for the LAX Master Plan. Using data from the LAX Master Plan and volumes of air traffic for 2005, published by Los Angeles World Airports, we were able to estimate the fraction of total activity at the airport involved with the importing and exporting of freight cargo (2.5%), as defined by the average number of flights. We then used data obtained from US Census Bureau Foreign Trade database to calculate the percent of cargo imports and exports attributable to each of the commodities we analyzed. This allowed us to apportion the total amounts of NOx and PM_{10} produced by the airport by the amount of each commodity we analyzed for the report. For ease of calculation, we based all calculations of the impacts from airports on LAX numbers.[3] In addition, we used the method described below to estimate the amount of NOx and PM_{10} produced by the transport of commodities by truck from the airport throughout California for sale to consumers.

Table 4: Commodities Imported by Airplane

Commodity	Quantity Transported Into CA Airports in 2005 (metric tons)	Fraction of Airport Acitivty
Total food	9,598	0.028%
Dutch Tomatoes	754	0.002%

Commodities Imported by Truck

We obtained estimates of the amount of NOx and PM_{10} produced per mile traveled by an average Heavy Duty Diesel Truck in California by using emission factors extracted from the California Environmental Protection Agency, Air Resources Board's EMFAC2002 (version 2.2) Burden Model. We converted these emission factors to a per weight basis by dividing each factor by an estimate of the weight of the truck. Using these emissions factors and the distances between the ports of entry and the locations of the major markets in the state we were able to estimate the amount of pollution in California caused by transporting imported foods by truck (see Table 5).

Table 5: Commodities Imported by Truck

Commodity	Quantity Transported Into CA Land Ports in 2005 (metric tons)	NOx Emission Factor (g/tonne-km)	PM_{10} Emission Factor (g/tonne-km)
Fruits and Vegetables	990,841	0.43	0.008
Mexican Tomatoes	81,905		

HEALTH IMPACTS

Due to the lack of published estimates of the health impacts of importing goods into California by airplane or truck, we were only able to calculate these impacts for those foods imported through California's seaports. We used estimates of the number of cases of asthma (62,000), premature deaths (2,400), hospitalizations (2,830), and missed school days (1,100,000) in California that result from the import and export of goods into the seaports from the Emission Reduction Plan for Ports and Good Movement in California produced by the California Environmental Protection Agency, Air Resources Board in March of 2006. We then apportioned these amounts by the fraction of the total amount of goods imported and exported through California seaports in 2005 (see Table 1), obtained from the US Census Bureau Foreign Trade database, represented by each commodity we analyzed.

COMPARISON TO CALIFORNIA-GROWN COMMODITIES

We then compared estimates of the amount of pollution due to transportation caused by importing each commodity into California to estimates of the amount of pollution caused by transporting each California-grown commodity from the field to markets in California. Due to the unavailability of records documenting the quantity of each commodity produced in California and sent to California markets, we estimated the amount of pollution that would be created if the same amount of each commodity imported in 2005 was grown in California instead.

We used California County Agricultural Commission Statistics to determine the major growing regions within California for each commodity. We defined the major growing regions as those producing the largest amount of the commodity so that the total was equal or greater than 75% of the total amount of that commodity grown in 2005, or the most recent year for which data was available. We apportioned the total amount of each commodity according to the percent grown in each county. We then calculated the distance between a major city in each county and the major population centers identified earlier. Similar to the previous analysis, we estimated the amount of pollutants produced by transporting the commodity to the remaining consumption areas by applying the emission factor to the weighted average of the distance from each growing area to the major consumption areas. The amount of each commodity not accounted for by the major growing areas was assigned a distance equal to the weighted average of the average distances between each growing area and the major consumption areas. In the case of counties that are both major growing areas and major population centers, the distance traveled was assumed to be 20 miles. Using these numbers, estimates of the amount produced in each county and the distance to major markets, we were able to estimate the amount of pollution by applying emission factors for CO_2, NOx and PM_{10}. We used the same emission factors to estimate the emissions from transporting commodities grown in California to major markets within California as to estimate the emissions from transporting imported commodities from the ports to major markets within California. We do not expect any differences in the size of the trucks to greatly influence these estimates.[4]

COMPARISON TO OTHER SOURCES OF POLLUTANTS

After generating estimates of the amount of pollution caused by importing each commodity into California we compared these estimates to estimates of the amount of pollution caused by other polluting entities such as cars and power plants. We used national and statewide published estimates of the amount of pollution caused by passenger vehicles and by power plants. With the exception of the yearly amount of CO_2 produced by the average passenger car, the other estimates were calculated by dividing the total amount of pollution produced in California in a given year by the number of passenger vehicles or coal, oil and gas power plants in the state (see Table 6).

Table 6: Amount of Pollution Generated

Pollution Source	CO_2 (tons/year)	NOx (tons/year)	PM_{10} (tons/year)	Source
Passenger Car	5.7			US EPA (2002)
Passenger Vehicle		0.004	0.0002	CalEPA, ARB (2006)
Average CA power plant (Coal, oil & gas)	100,927	23.3	5.6	Bemis and Allen (2005)
				CalEPA, ARB (2006)

DETERMINING OVERALL FOOD IMPACTS

In addition to determining the amount of pollution caused by importing individual commodities into California we also roughly estimated the amount of pollution caused by importing all food (excluding meat, dairy, and fish) into California. In order to accomplish this, we modified the methods outlined previously for individual commodities to facilitate the calculation process. We used the US Census Bureau Foreign Trade Database to determine the total amount of fruits, vegetables, wine, and cereals that were imported into California by ship or airplane in 2005. This database also provided the

major countries from which each of the different commodity types originated and the main California port into which the commodity arrived. We defined major countries as those from which the largest amount of the commodity originated so that the total was equal or greater than 75% of the total amount of that commodity imported into California. In addition, the US Department of Agriculture Fruit and Vegetable Market News Shipping Point Report provided the quantity of Fruits and Vegetables imported into California by truck from Mexico in 2005. Due to lack of data, imports of food commodities by truck from Canada were not included in this analysis.

Global Warming Pollution

Similar to the calculations we performed for individual commodities, we estimated the following: 1) amount of CO_2 produced during transport from the fields where the commodity was grown to the port in the source country 2) the amount of CO_2 produced during transport between the source country and the California port and 3) the amount of CO_2 produced during transport from the California port to markets in California.

We used internet searches to determine the largest container sea or air port in each of the source countries and assumed that this port was likely used for exporting food commodities to California. We calculated the amount of CO_2 produced during transport between the source country and the California port using the same method described earlier to calculate CO_2 pollution for individual commodities. This provided an estimate of the amount of CO_2 resulting from importing 86% of the total amount of fruits, nuts, vegetables, wine, and cereals. To estimate the amount of CO_2 produced from transport within California we applied the emission factor of 45 g/tonne-kg to the weighted average distance we calculated earlier for transportation of individual commodities from each of the major port cities. Due to the impracticality of researching the major growing regions for each of the countries exporting food to California, we estimated the within source country transport of food commodities very roughly. We assumed that we could estimate the degree to which transport within the source country exceeded transport within California based on the size of the country. Based on the ratios of CO_2 produced during transport within the source country to CO_2 produced during transport within California for the individual commodities we came up with the following factors. For larger countries the amount of CO_2 was assumed to be double that of transport within California, for smaller countries the within source country was assumed to be 1/3 that of within California transport and for medium sized countries they were assumed to be equal. Given that the remaining 14% of the commodities originated in greater than 50 distinct counties all over the world, it was very difficult to determine the amount of CO_2 resulting from importing these commodities. A rough estimate was calculated by determining the average amount of CO_2 produced per metric ton imported for each type of commodity and transport mode. This average was then applied to the 14% of the total amount of food imported and the result was added to the previous calculation.

Air Quality and Health Impacts

We used the same method, described previously in detail, to calculate a total amount of NOx and PM_{10} produced by the importing of food into California. Similarly we were able to use the same method to estimate the health effects experienced by California residents due to the importing of food into California seaports.

LIMITATIONS

The complexity and scale of importing food into California made determining the exact amount of pollution created during this transport very difficult and as a result the approximations and estimates provided in this report required a number of assumptions. Principally, there is little information documenting what fraction of the food commodities imported into California are consumed within the state as opposed to being transported to neighboring states. Therefore, this analysis estimated the amount of CO_2 produced as if all of the commodity imported into California ports was transported within California to California markets. It is likely that a portion of the commodities imported into California is transported to neighboring states resulting in even further distances than those used in this study and more pollution. Therefore this assumption, used to facilitate the analysis in this study, likely resulted in an underestimation of the total amount of pollution caused by importing food commodities into California.

Similarly the complexity of tracking each commodity from all of the growing regions to all of the cities in California necessitated steps to streamline the process. One such step was to assume that the exports of each commodity from the country of origin were proportionally distributed among the major growing regions according to the amount grown or produced in each region. Likewise, the commodities grown in California were proportionally distributed to markets in California based on the amount grown or produced in each region and the population of the consumption areas. It is likely that other factors such as proximity of growing regions to ports or markets also influence the transport of food commodities both within the countries of origin and in California. This assumption could either result in an under or overestimation of the distances and amounts of each commodity traveled depending on the individual market forces in each country and for each commodity. Another step was to identify major growing regions and consumption areas rather than account precisely for every ton of each commodity. Average amounts and distances were used to estimate the amount of pollution resulting from the transport of commodities from non-major growing areas to non-major consumption areas. Given that the amounts and distances involved in the non-major growing areas and non-major consumption areas were relatively minor, this assumption for individual commodities is likely not to radically affect the estimates of the quantities of pollution. However, in the case of estimating the pollution resulting from importing all food commodities into California, this likely resulted in an underestimation of the total amount of pollution resulting from this activity.

Other limitations include using latitude and longitude to estimate distances between countries. This "as the crow flies" estimate is likely an underestimate of the distances as trade routes are determined by many more factors. Similarly, the accuracy of the estimations of emission factors and amounts of pollution are all approximations and the conclusions of this study are limited by the quality of these estimates. As a whole the assumptions and limitations of the methods used to approximate the pollution caused by importing food commodities into California are relatively conservative and therefore likely underestimate the total amount of pollution produced.

Lastly, we only compared the environmental impacts due to transportation between in imported versus California grown food commodities. In some cases, differences in production, processing, and preparation practices could outweigh the reductions we found when looking solely at transportation related impacts. A full life-cycle analysis is needed to fully evaluate the relative climate and air quality impacts of imported versus locally grown foods.

End Notes

1. Due to difficulties locating agricultural statistics for Thailand the percentages of rice grown in each region were approximated based on available reports describing the cultivation of rice in Thailand.

2. In the case of garlic imported from China where roughly equal amounts enter California from the port of LA and the Port of Oakland, a weighted average of the two distances was calculated.

3. Although the majority of food imported into California by airplane arrives in LAX, a large portion of the wine imported into California by air comes into San Francisco International Airport as well.

4. We did not include in our estimates the emissions from small trucks going to individual farmers markets.

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