

# The Cost of Moving Food

Exploring Food Sustainability Through the Lens of Transport  
Time, Resources, Environmental Impact and Price

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# Motivation – Why I care about this topic

- “Food” is a subject of great interest and passion for me: not just recipes and foodie-trends, but also in the topics of gastro-anthropology, socio-ethics, accessibility, and sustainability
- I desire to live a more deliberately sustainable lifestyle, including in the decisions I make regarding the food I choose to purchase and consume
- I wish to better understand the impact of the choices that I make, both in how they affect my own life, and how they affect the world around me





# Motivation – Why you should care about this topic

- Food systems (including production, processing, and transport) are one of the leading sources of global greenhouse gas emissions, accounting for nearly 35% of the global total
  - \* Sustainable healthy diets – Guiding principles. Food and Agriculture Organization of the United Nations and World Health Organization, 2019.
- As a consumer, the decisions that we make (as an individual, a family, or a food-centric business) can have a significant cumulative effect on food production prices, practices, and environmental impact
- Sustainability is a hot topic of conversation right now within business and commercial institutions, academic study, government policy, geo-politics, and public interest

# Data Questions

- How fast does cargo travel via different methods?
- How much fuel does it take to move one ton of cargo by these methods?
- How much CO<sub>2</sub> is produced to move one ton of cargo?
- How much is spent (USD) in fuel to move one ton of cargo?



# Approach

- Find and collect data
  - Most data found in CSV format from US Dept. of Transportation & US Dept. of Energy
  - Some data found in published graphs or charts in US.gov publications, or cited by US.gov, United Nations, or peer-reviewed publications
    - Charts converted to csv using Adobe Acrobat
    - Graphs converted to csv using GetData Graph Digitizer
  - Some data found as text information within articles on the subject
- Clean data
  - Drop unneeded columns and irrelevant rows
  - Rename select columns and variables for clarity
  - Reshape datasets into more useable arrangements
  - Fill gaps with cited data from relevant articles
- Exploratory data analysis
  - Understand the data
  - Build calculated columns and queries based upon the data available to find the answers to my data questions
- Data visualization
  - Isolate important metrics within my data, and convert the information into easily understandable visuals
  - Formatting and editing of visuals to maintain thematic consistency
  - Assembling visuals into a short presentation



# Challenges



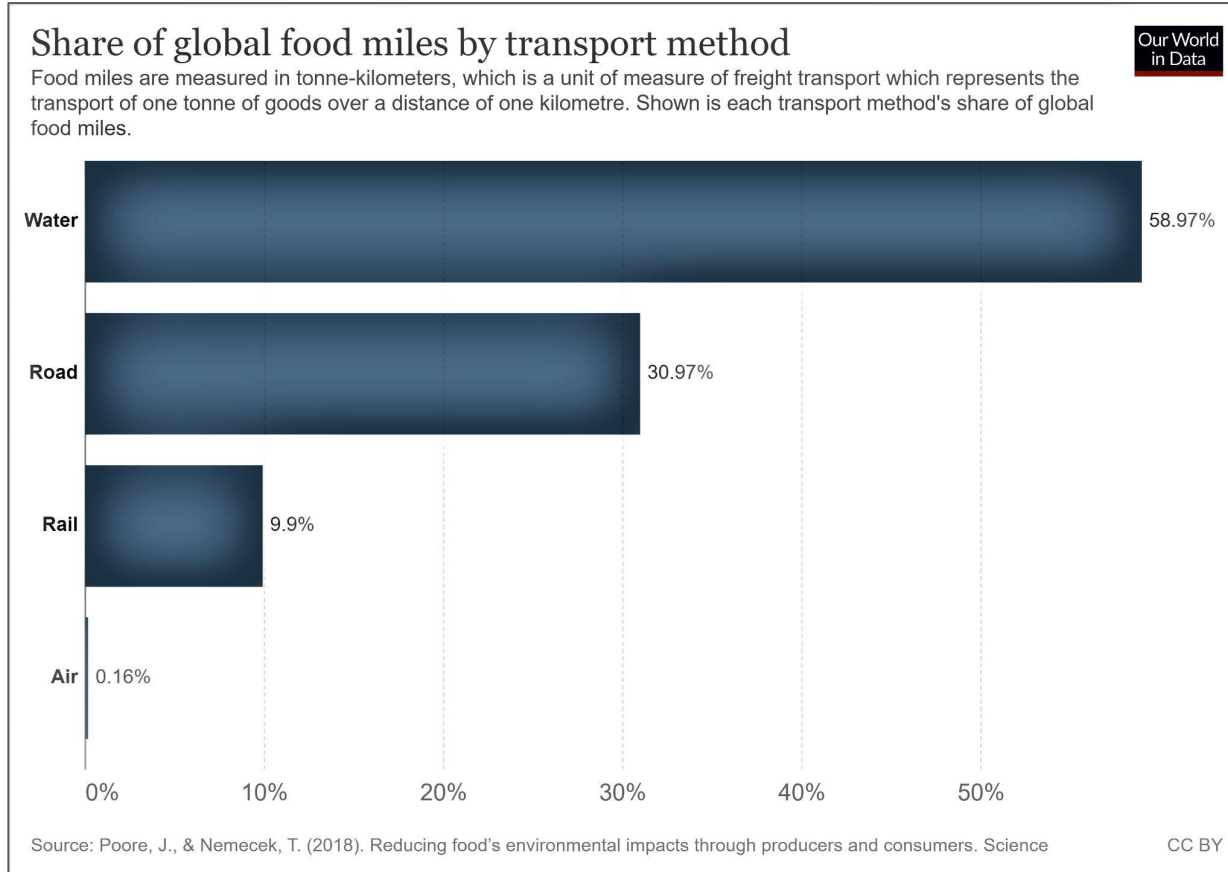
- Variable diversity within the scope of my data questions
  - Many of my questions center on how much fuel is consumed when moving cargo, but that depends upon the kind of fuel being used, the kind of vessel using it, and how much total weight that vessel is carrying
  - The data can be further complicated by a nearly infinite amount of sub-variables such as idling times, age and maintenance of the vessel, individual company policies, urban congestion, and the weather. These were not factors that I included in my data analysis, which necessitates an unknown measure of inaccuracy in my findings
- Variable diversity within the data itself
  - Some fuel measurements were listed in tons, others in gallons. And different types of fuel weigh different amounts
  - Fuel consumption levels were sometimes provided by amounts of fuel consumed by day, other times by hour, and other times by distance
  - Speed data was listed in kilometers per hour, miles per hour, and nautical knots across different data sets and different transportation types
  - The weight of a shipping container, or how much weight a transport vessel is carrying, can vary significantly depending upon what is in the container, necessitating a consistent method of determining averages in cargo weights across my datasets

# Methodology

- **Convert all speeds to miles per hour (MPH)**
- **Convert all fuel measurements to gallons**
- **Determine average weights for cargo loads – convert all to tons**
  - For ships, ship size was given in ranges of standard TEU measurements – Twenty-foot Equivalent Unit, the size of a cargo container.
    - Maximum gross mass of dry goods (which excludes non-packaged liquid food cargo) per TEU is 52,910 lbs (5,140 container + 47,770 cargo). I used the total maximum weight of a TEU times the mean TEU capacity per ship-size-class to determine average ship cargo weights.
    - I dropped the largest size category of my dataset – 10,000+. As I had no information on what the upper ceiling was on that range, it was impossible to guess average cargo loads with any degree of accuracy.
  - For planes, most cargo planes are the same size and make as passenger planes, and the average size plane (Boeing 737) carries an average weight of 45,000 lbs of cargo \*Smithsonian National Air and Space Museum
  - For trucks, my data provided maximum truck carrying weights (in lbs) by the old truck-class system (class 1-8), but my truck fuel consumption data was given using a newer government classification system of 3 categories. To determine an average cargo load of the new system, I filtered the old 8-class system into the new 3-category system and used the mean of the lower maximum weight plus the higher maximum weight within that category as the average cargo weight for trucks within that category.
  - For trains, I found the average non-liquid cargo load stated clearly within a published article as 30,000 tons per train
- **Filter all information through the lens of efficiency via ton-mile**
  - How far a ton of cargo can travel using the different methods
  - Calculated by multiplying how much weight a vessel is carrying by the miles-per-gallon of that vessel
  - The impact of different methods of transport, measured by 1-ton of cargo

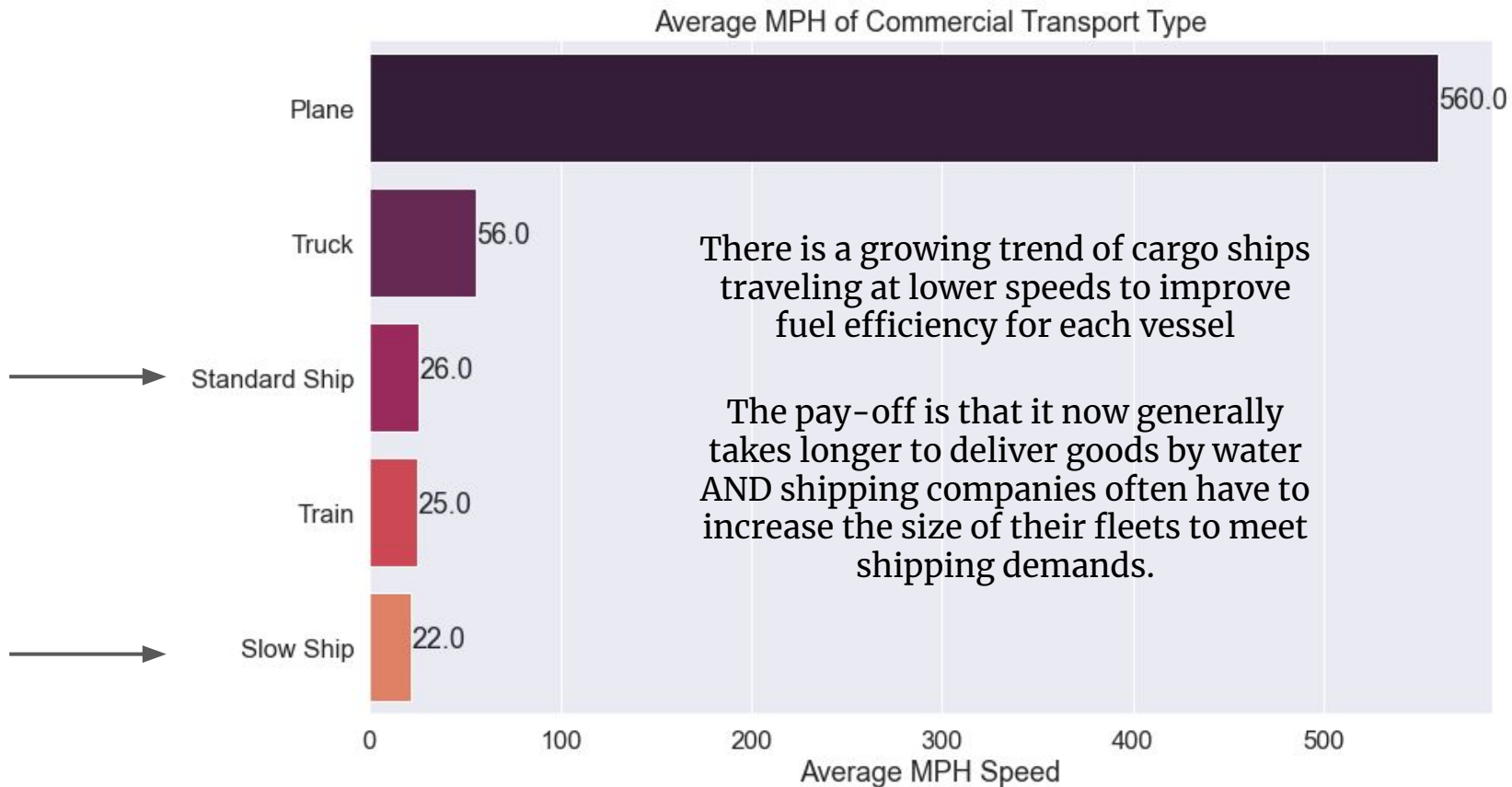
# Where to start:

## How does food get from the source to the market?





# How fast does food travel by these different methods?



How fuel efficient are these modes of transport?  
~~How many miles per gallon (MPG) does each type  
get?~~

IT DEPENDS

Smaller Truck

10 tons

10 mpg

2 gallons  
10 mi.



Larger Truck

20 tons

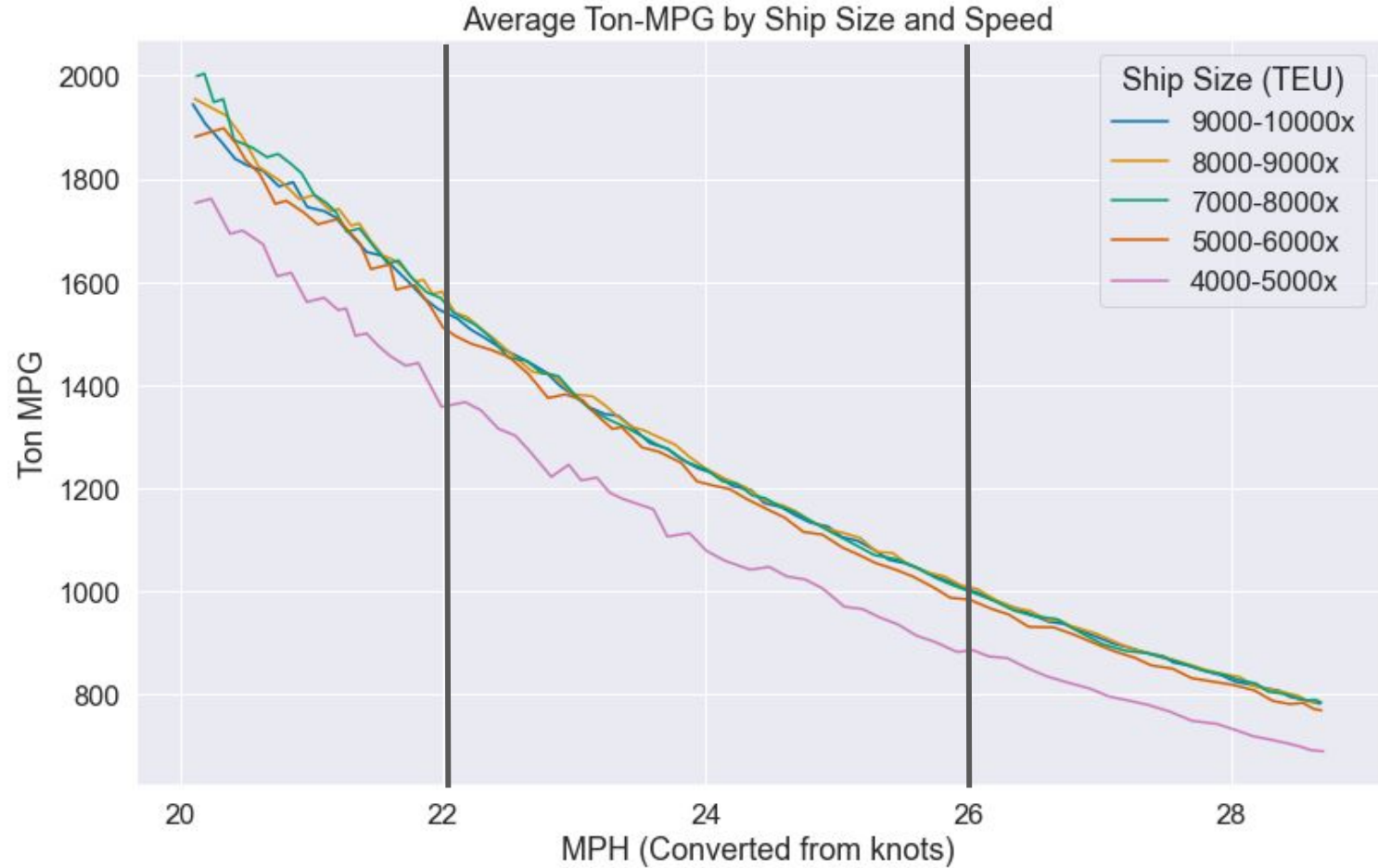
7 mpg

1 gallon  
14 mi

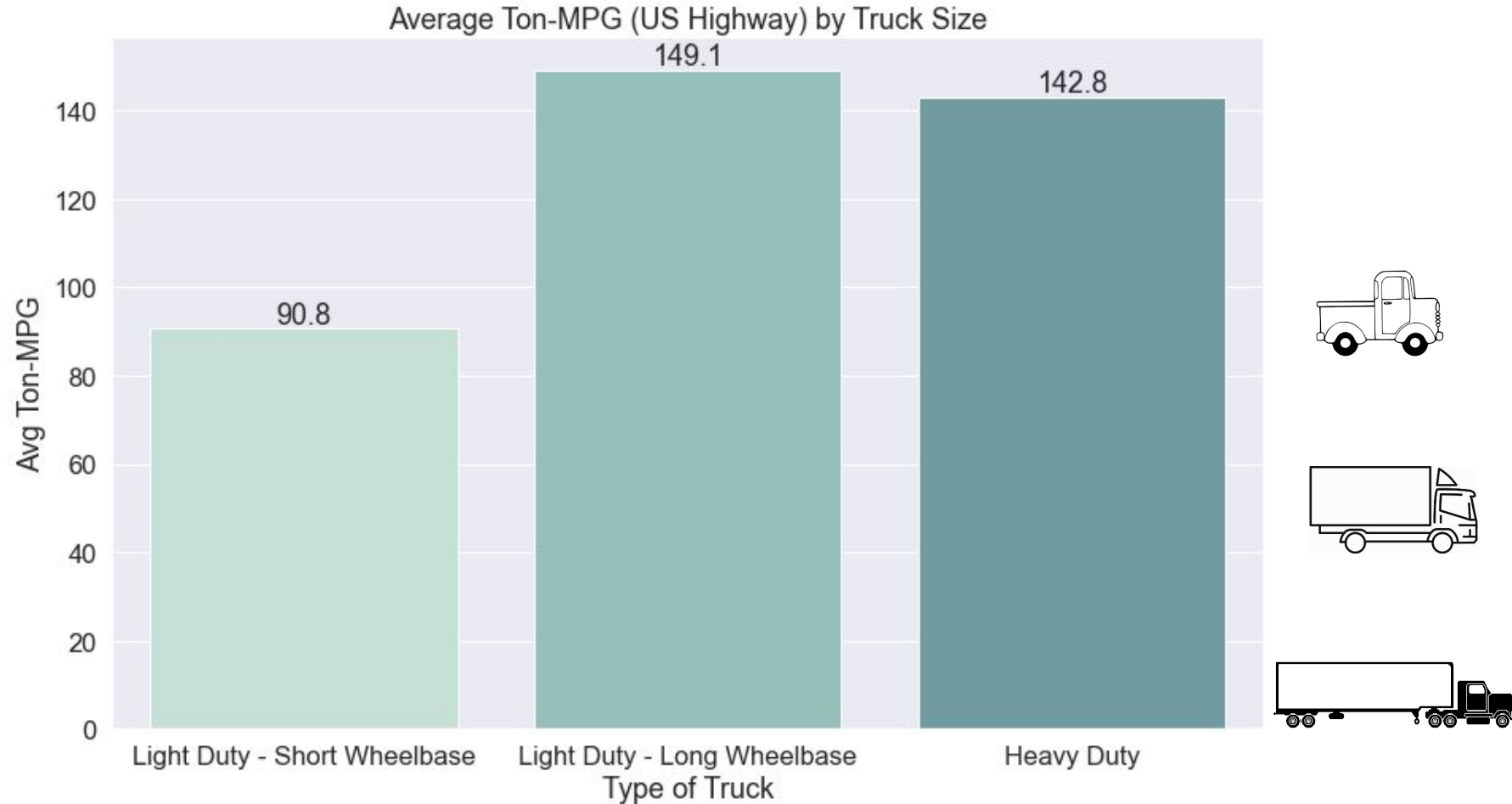
How fuel efficient are these modes of transport?

How many miles can a ton of cargo travel on a gallon of fuel (on average)?

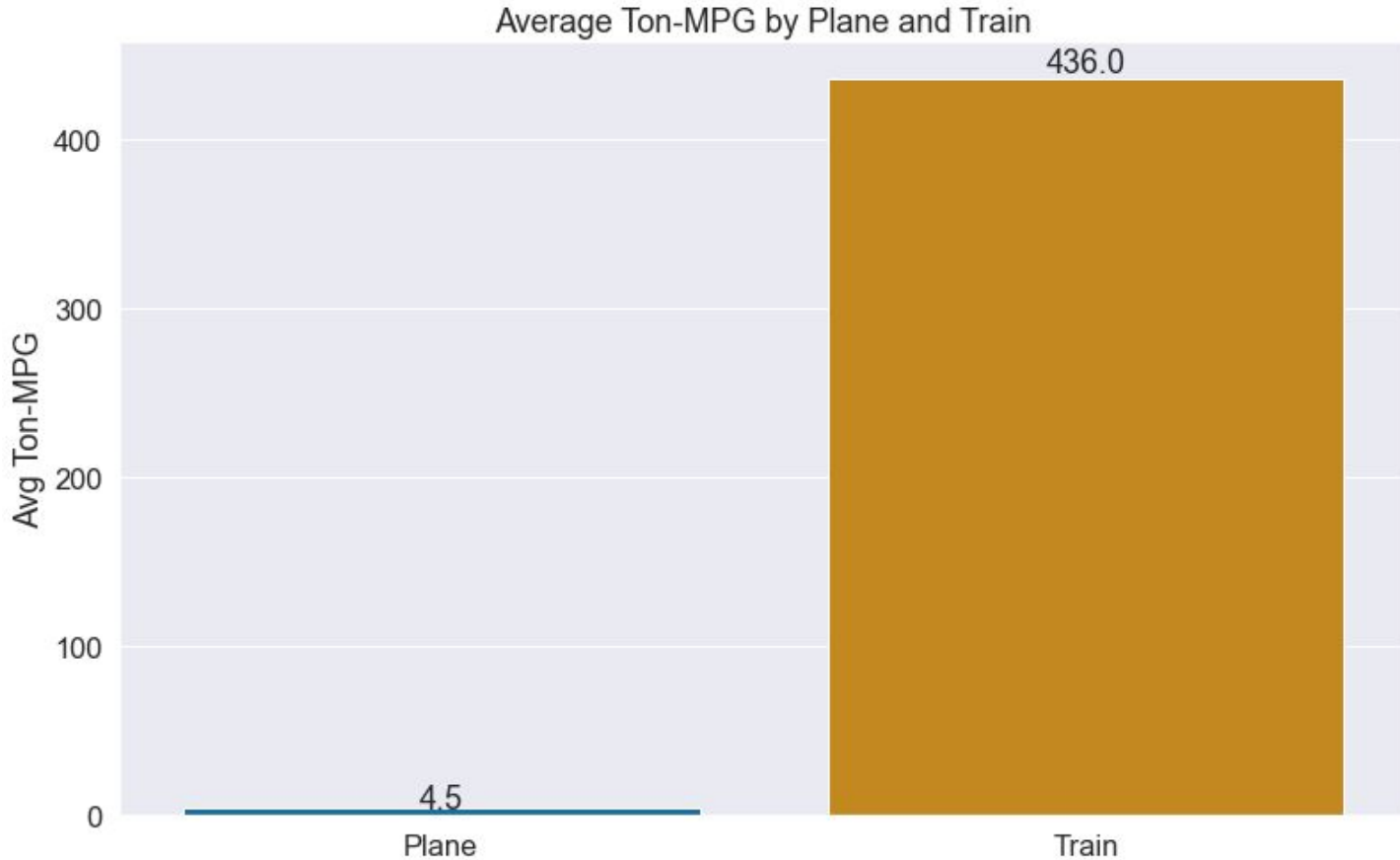
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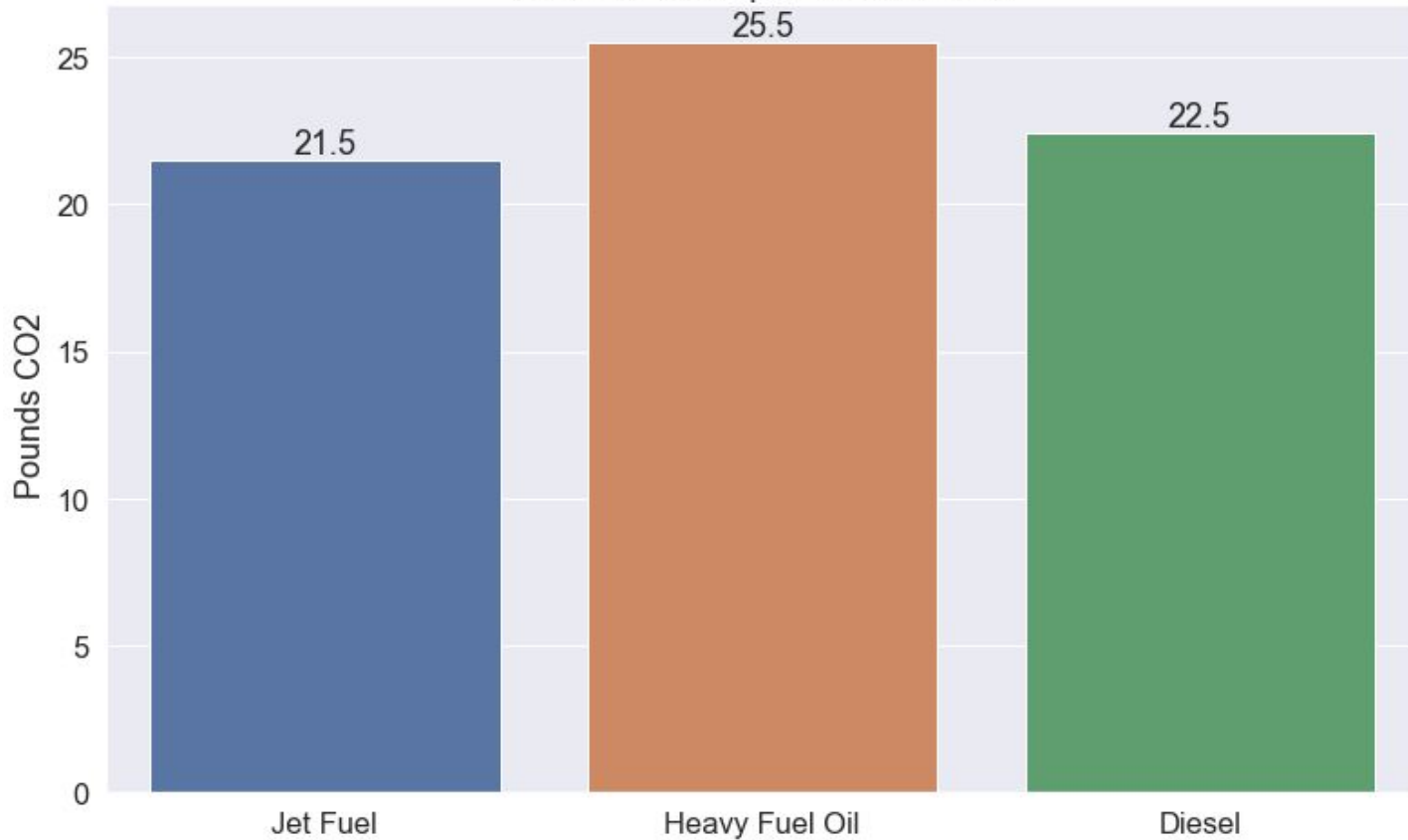
How many miles can a ton of cargo travel on a gallon of fuel (on average)?



# What kind of environmental impact do these different methods of transport have?

- The most direct impact when discussing transport, are greenhouse gas emissions from fuel consumption
- Fuel = CO<sub>2</sub>
- For every pound of carbon burned, three pounds of CO<sub>2</sub> are produced

CO2 Emissions per Gallon of Fuel

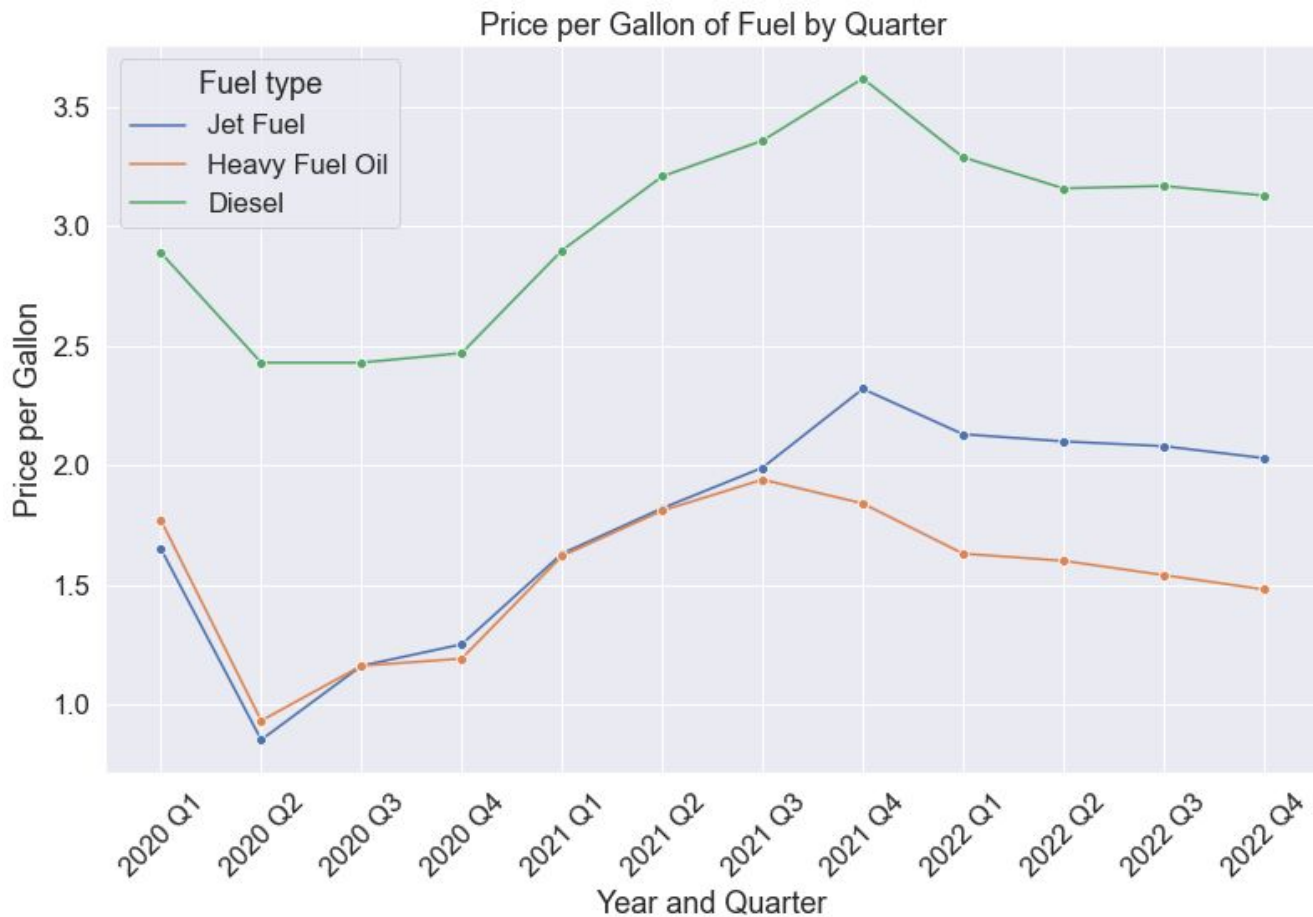




How much does fuel cost?



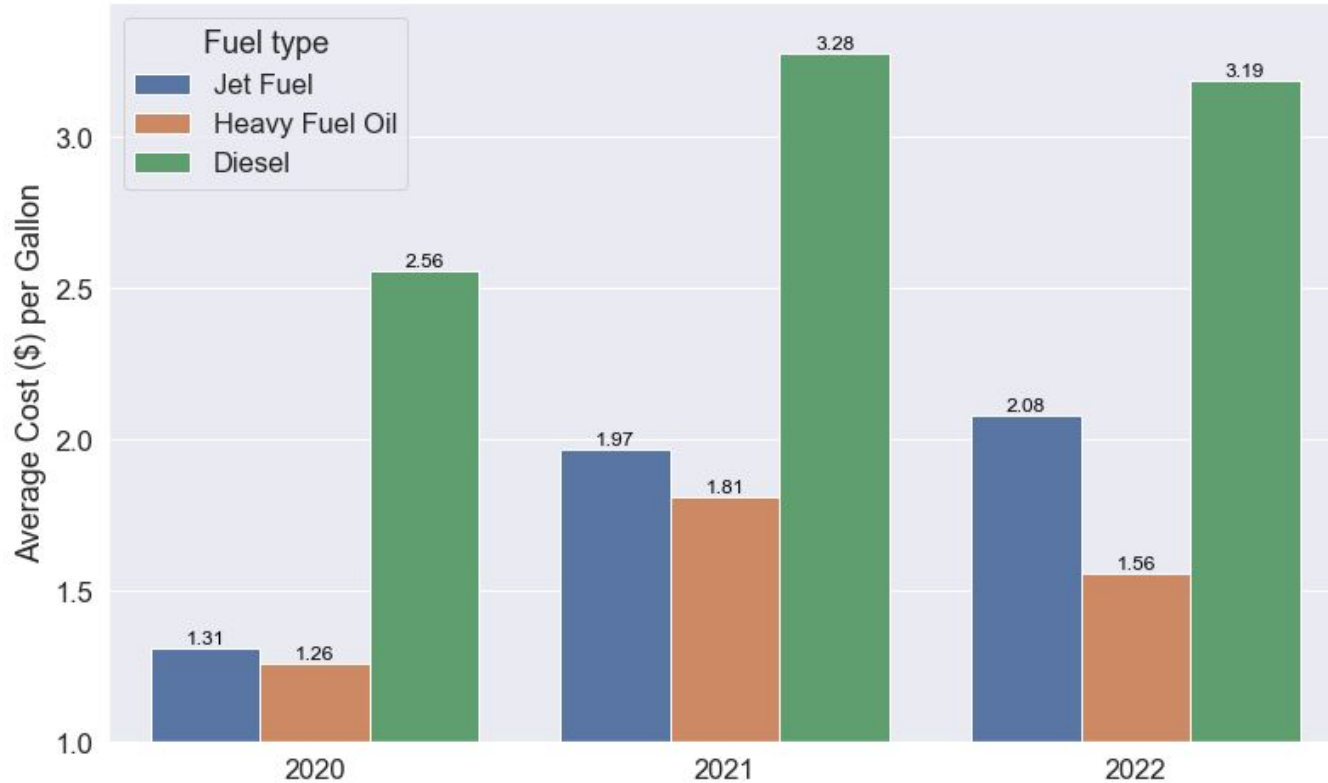
# How much does fuel cost?



# How much does fuel cost?

## Average Cost (USD) per Gallon of Fuel by Year

(2022 projections from US Department of Energy)



# What does this all mean?

How is all this data relevant to any decisions I make?

Leopold Center for Sustainable Agriculture

Iowa State University, 2001

“Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions”

## Average Distances from Farm to Market

### **Terminal Market vs. Ferry Plaza Farmers Market**

Apples: 1,555 miles vs. 77 miles

Tomatoes: 1,369 miles vs. 117 miles

Grapes: 2,143 miles vs. 134 miles

Beans: 766 miles vs. 101 miles

Peaches: 1,674 miles vs. 173 miles

Winter Squash: 781 miles vs. 98 miles

Greens: 889 miles vs. 99 miles

Lettuce: 2,055 miles vs. 102 miles

# How much time does it take food to travel 1000 miles?

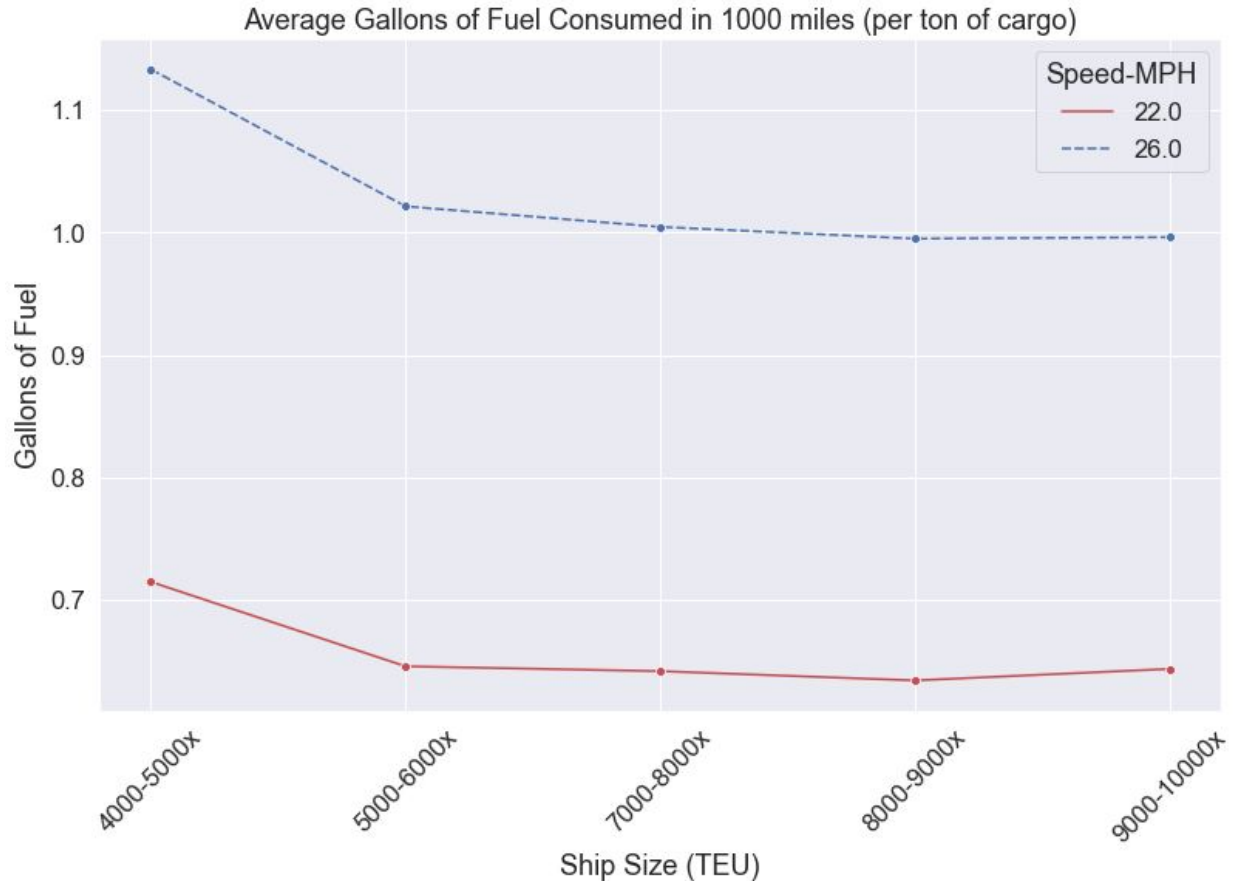


\*1000 LAND miles - adjusted



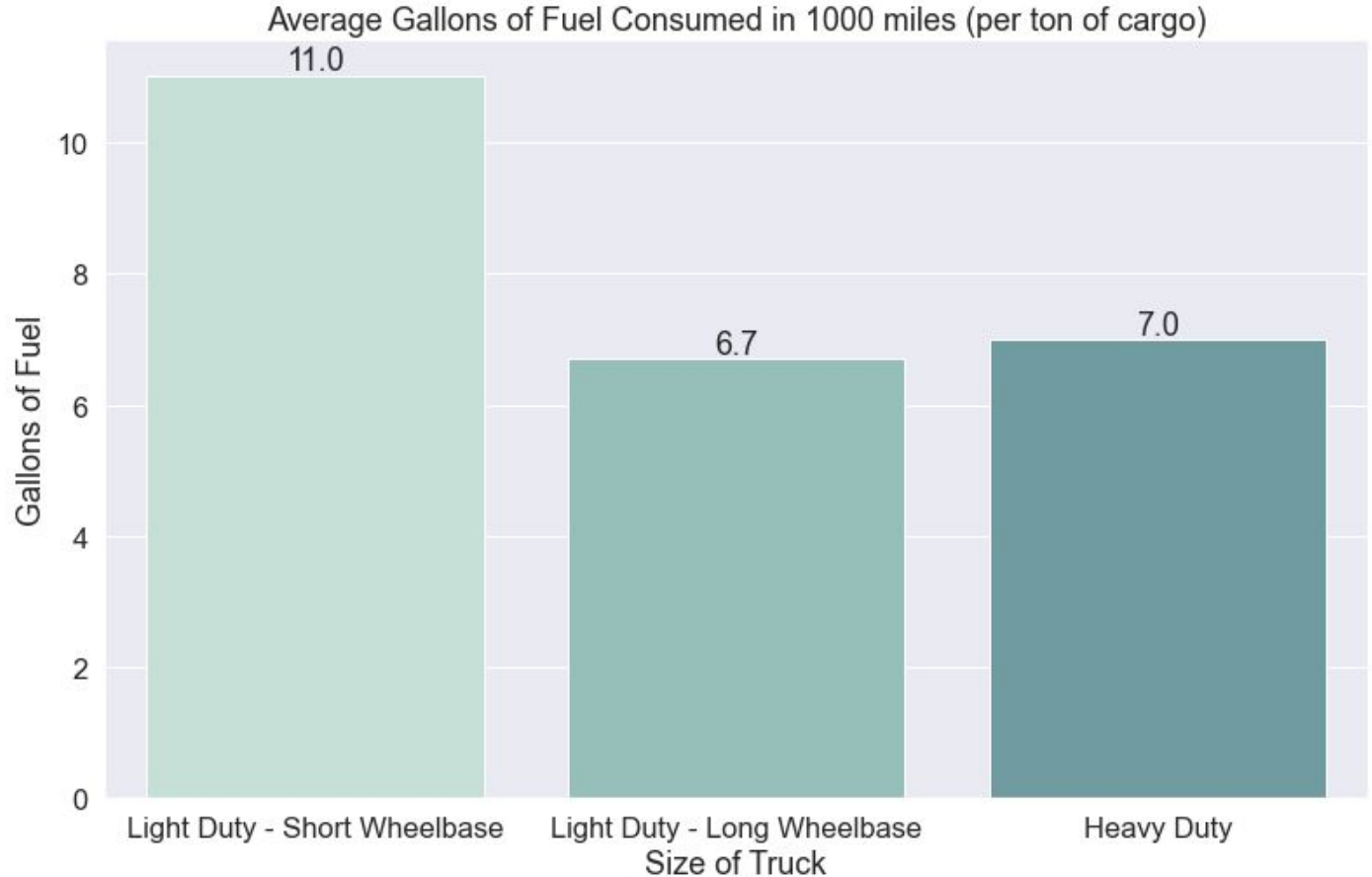
# How many gallons of fuel does it take for food to travel 1000 miles?

## By Ship



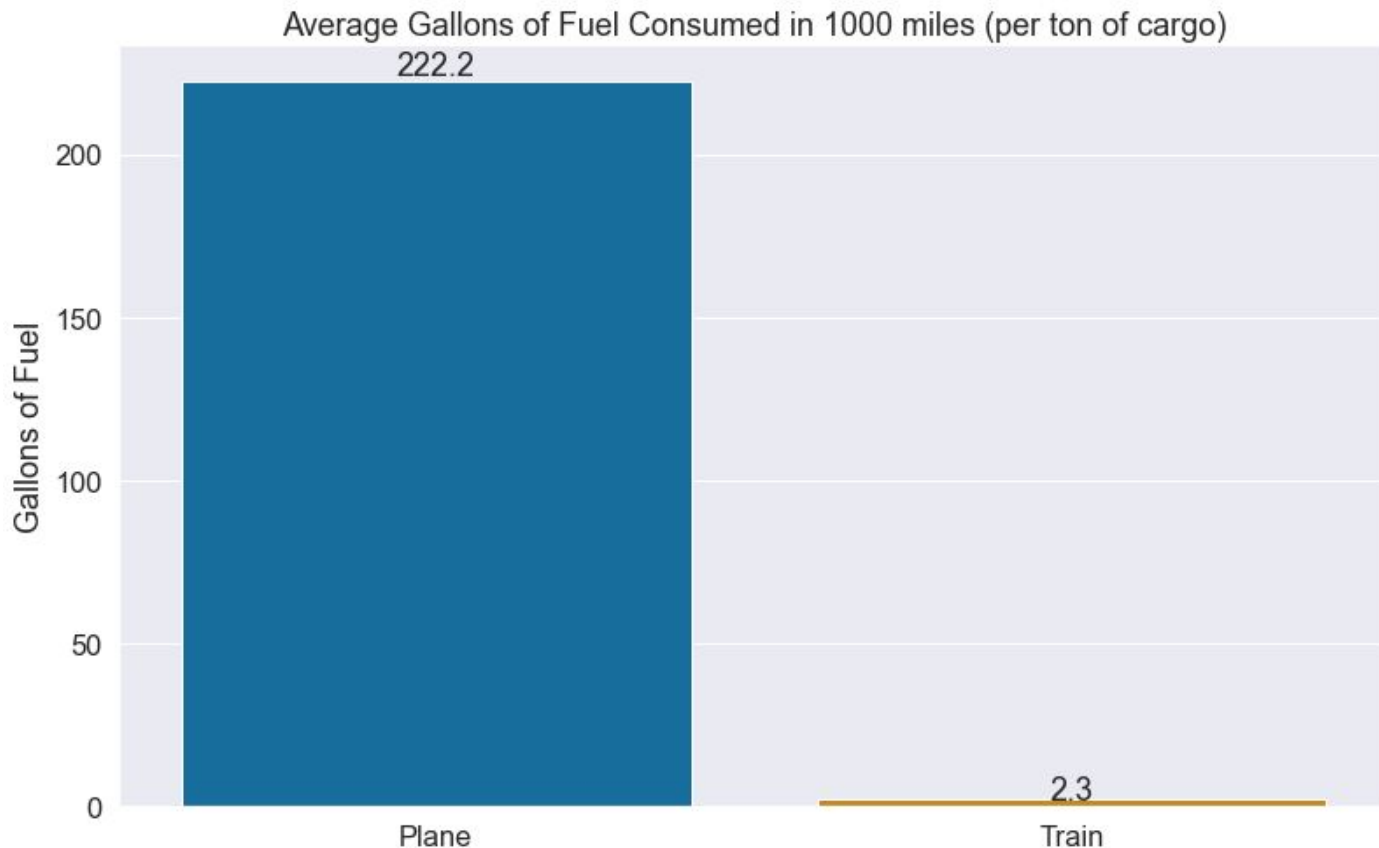
# How many gallons of fuel does it take for food to travel 1000 miles?

## By Truck



# How many gallons of fuel does it take for food to travel 1000 miles?

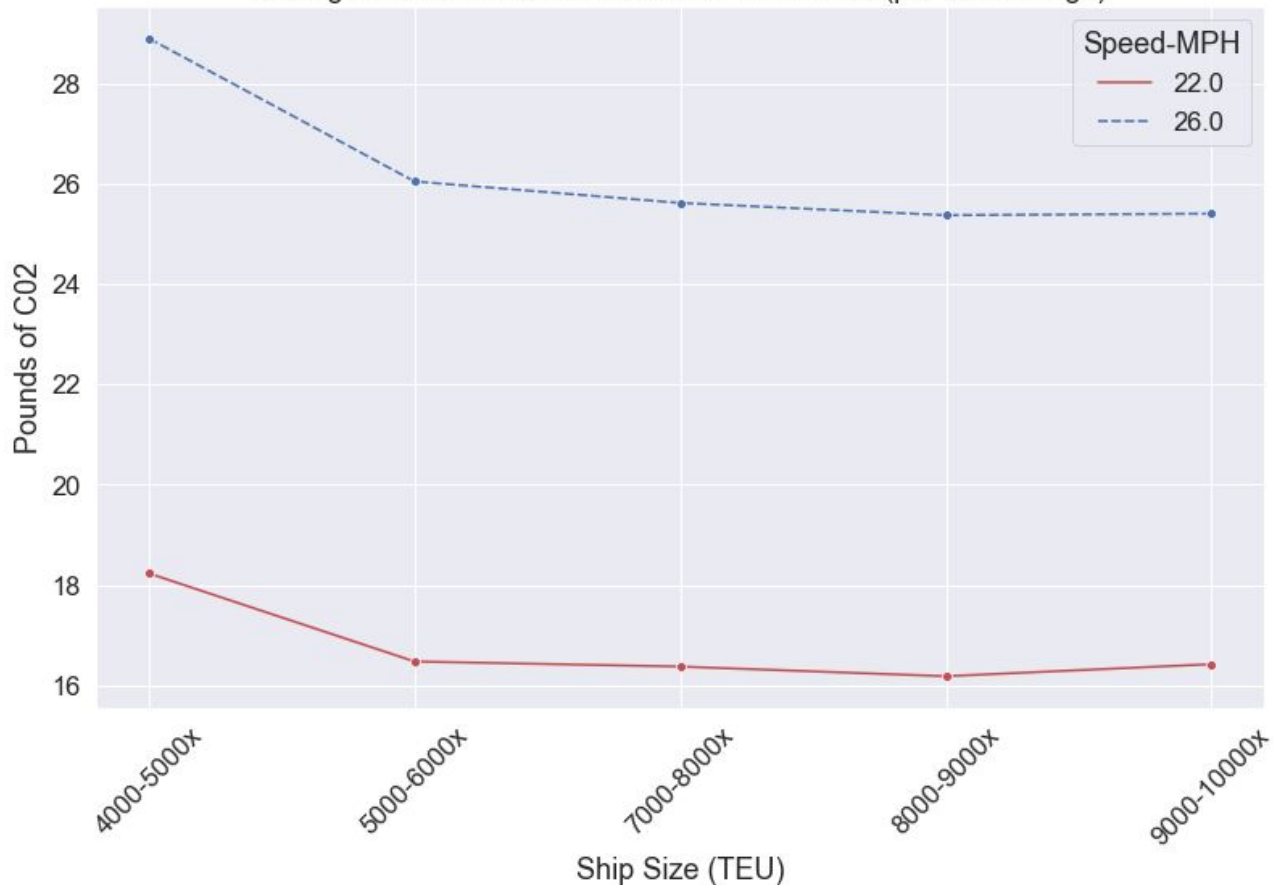
## By Train or Plane





# How many pounds of CO2 are produced to move food 1000 miles?

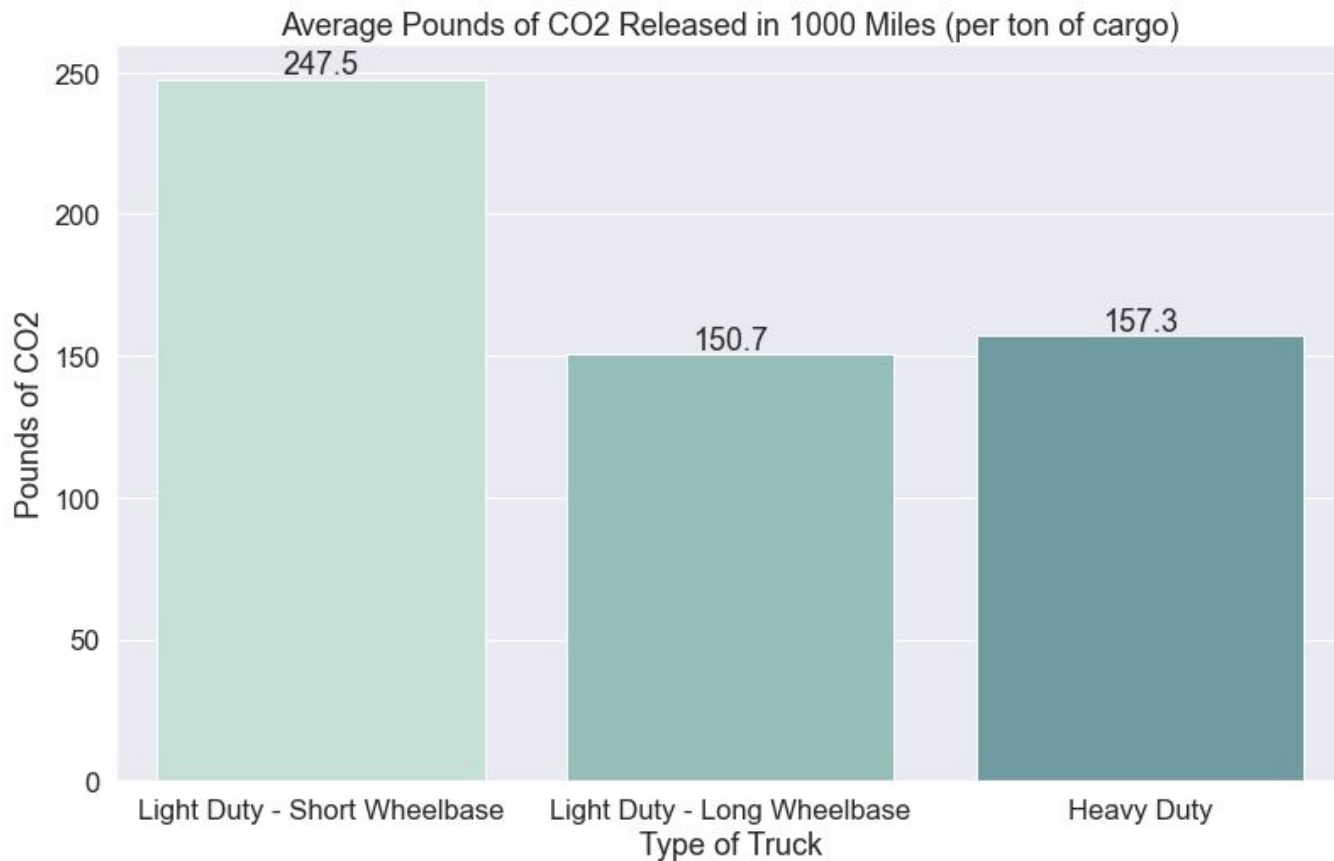
Average Pounds of CO2 Released in 1000 Miles (per ton of cargo)



## By Ship



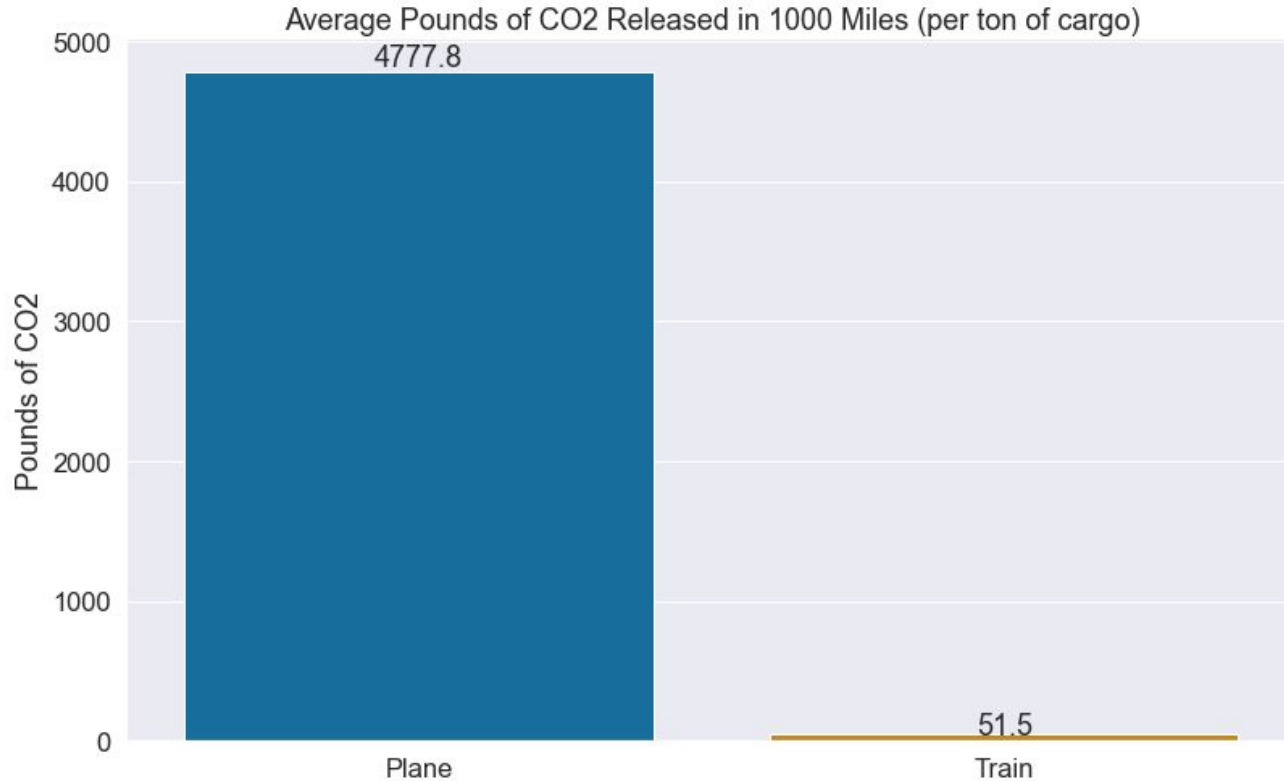
# How many pounds of CO<sub>2</sub> are produced to move food 1000 miles?



## By Truck



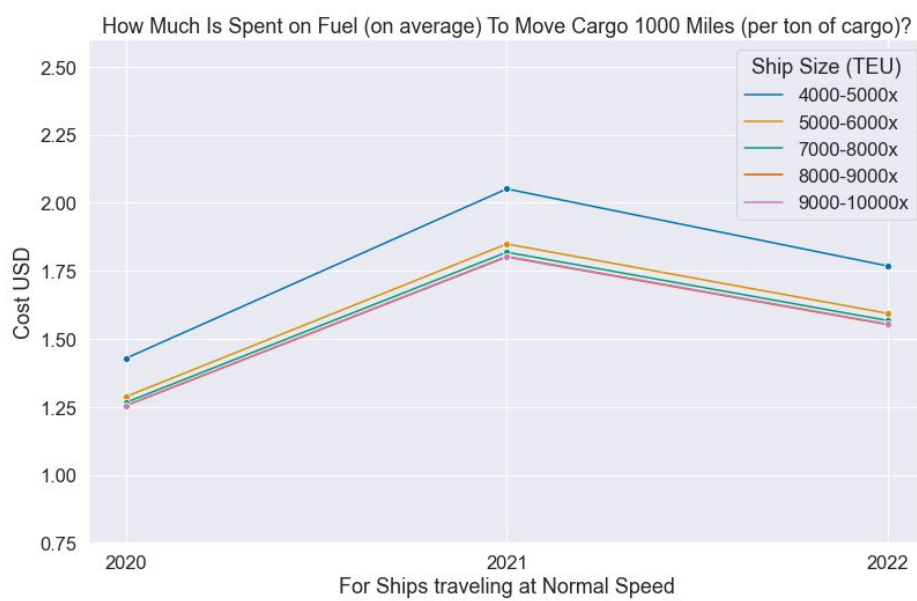
# How many pounds of CO<sub>2</sub> are produced to move food 1000 miles?



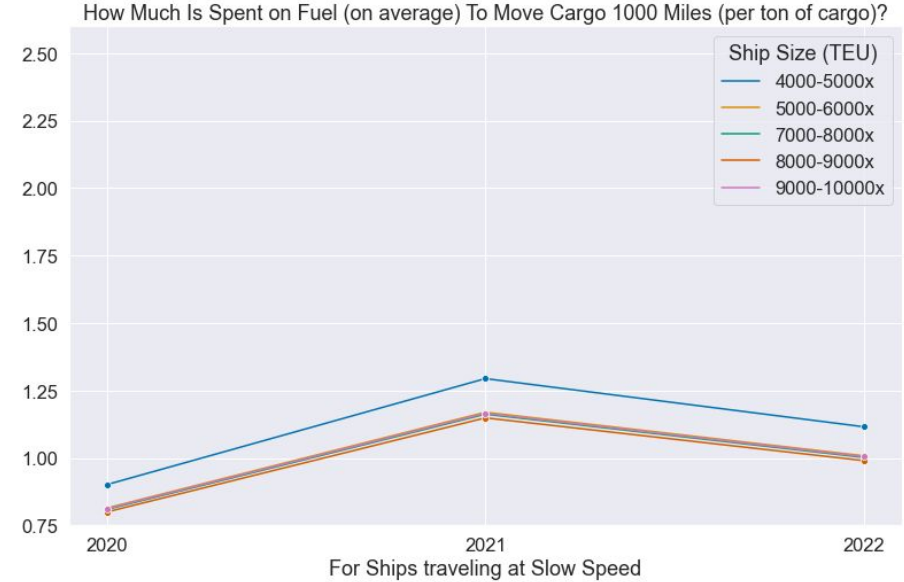
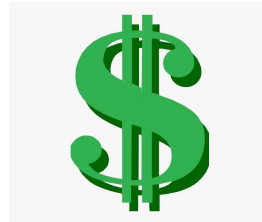
**By Plane  
or Train**



# How much is spent on fuel to move food 1000 miles?



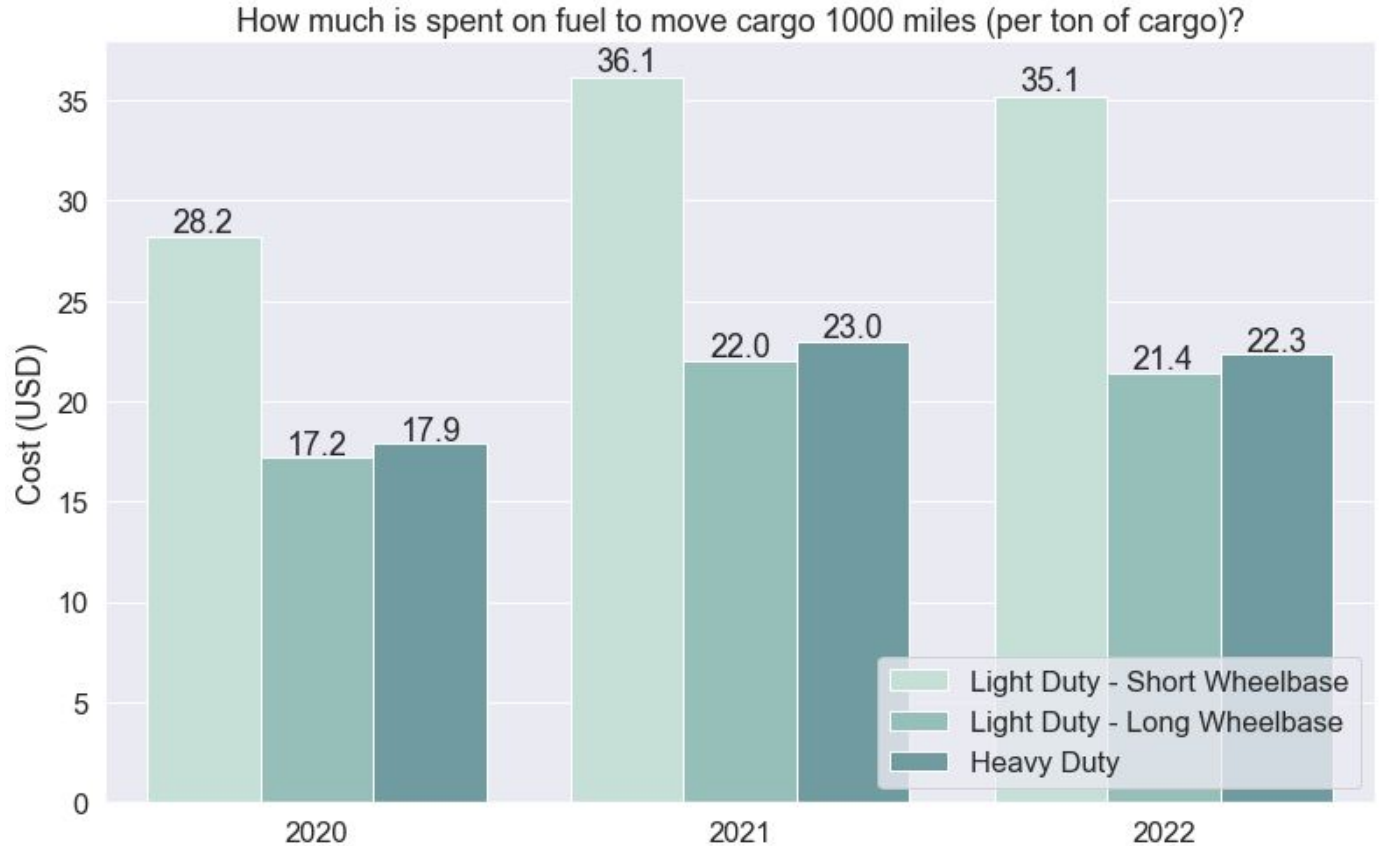
Fast Ship



Slow Ship

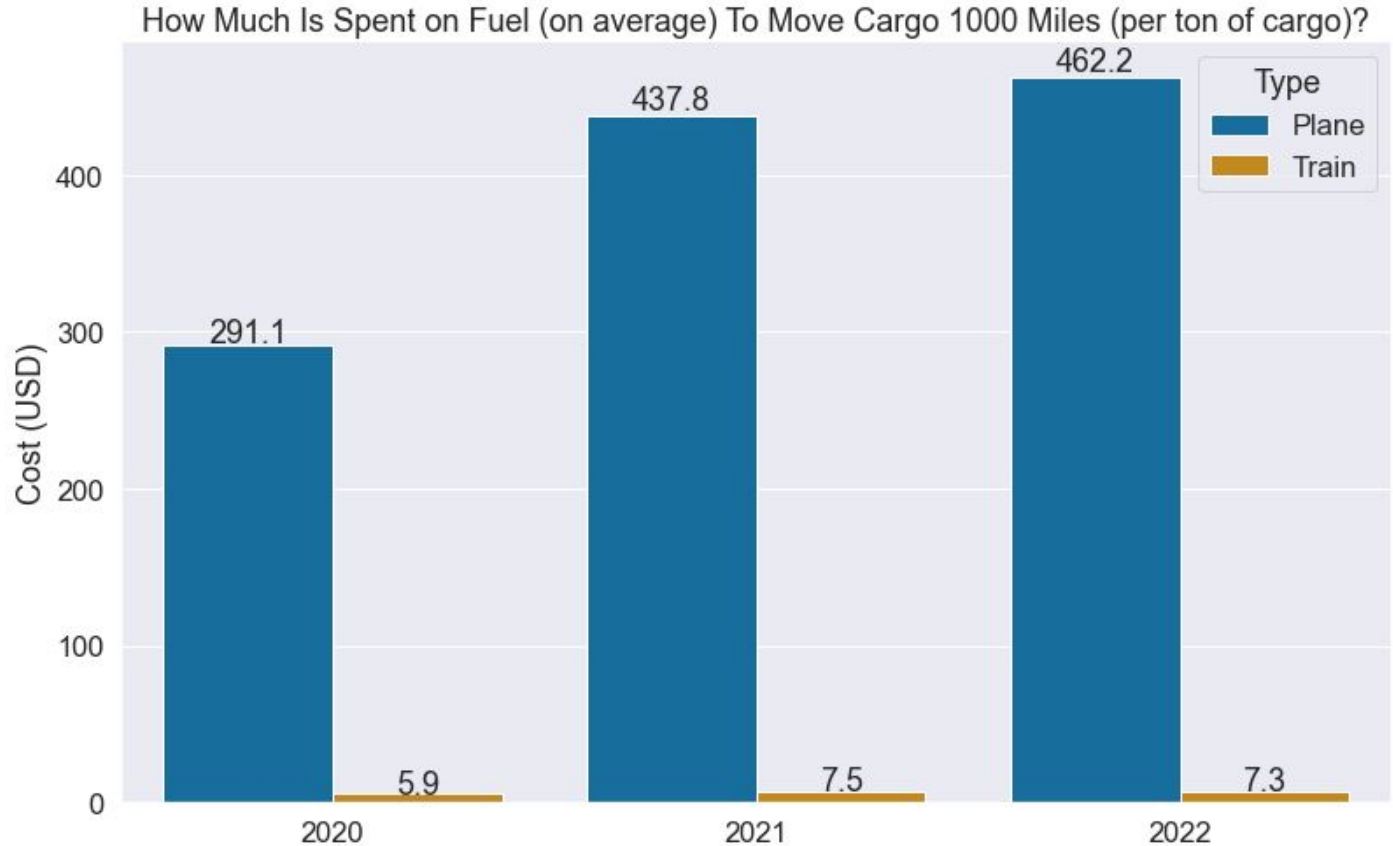
# How much is spent on fuel to move food 1000 miles?

By Truck



# How much is spent on fuel to move food 1000 miles?

By Plane  
or Train



# What's the best method (1-Ton/1000 miles)?

Fast Ship   Slow Ship   Small Truck   Medium Truck   Big Truck   Plane   Train

Time (Hours)	38.5	45.5	17.9	17.9	17.9	2	40
Gallons of Fuel	.99	.63	11	6.7	7	222.2	2.3
CO2 (lbs)	25.37	16.18	247.5	150.7	157.3	4777.8	51.5
Fuel cost 2021	1.80	1.15	36.14	22.00	22.97	437.78	7.52

Is this really the best  
option?

Fast Ship      Slow Ship

Time  
(Hours)

38.5

45.5

Gallons  
of Fuel

.99

.63

CO2  
(lbs)

25.37

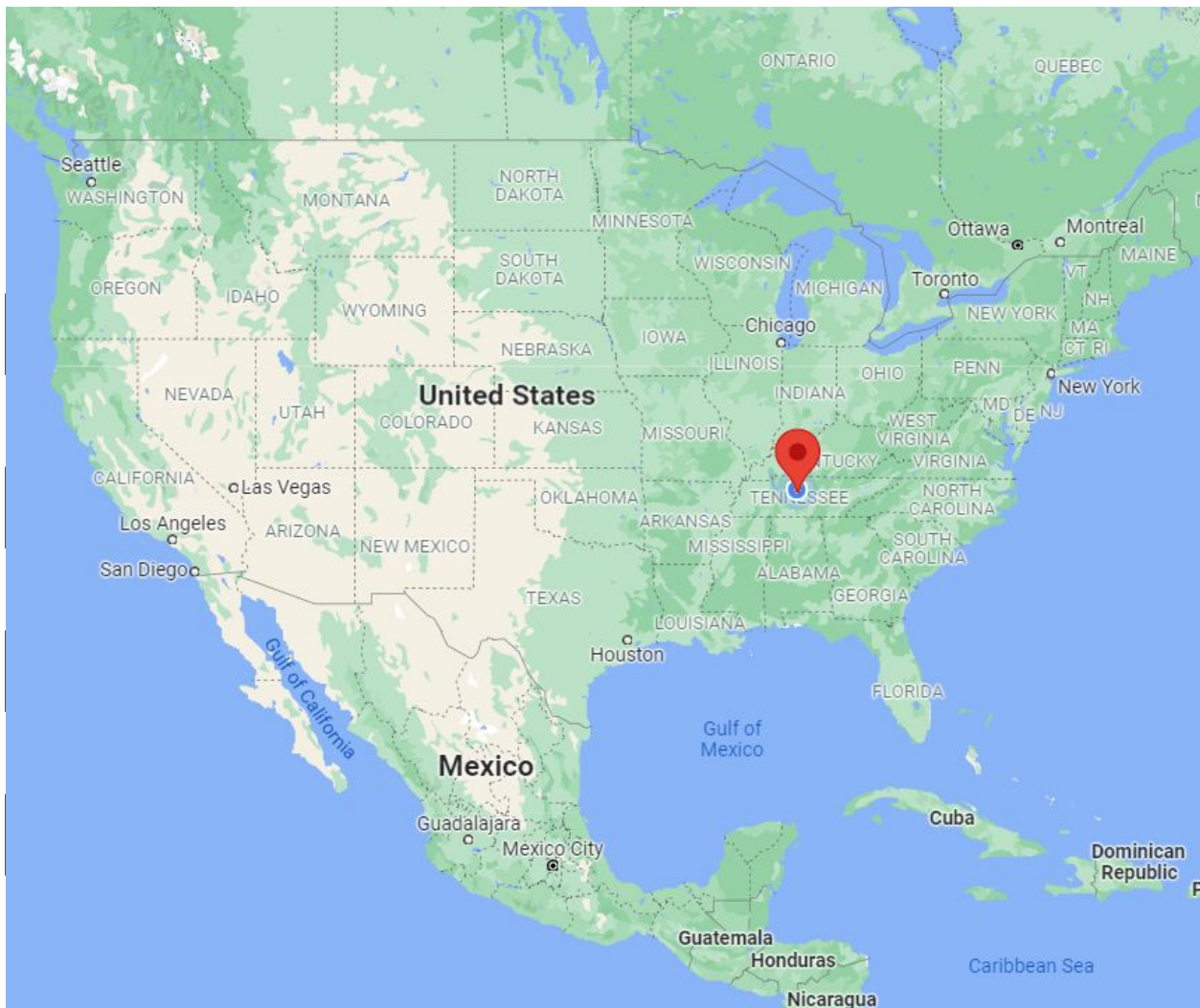
16.18

Fuel cost  
2021

1.80

1.15

Is this really the best option?



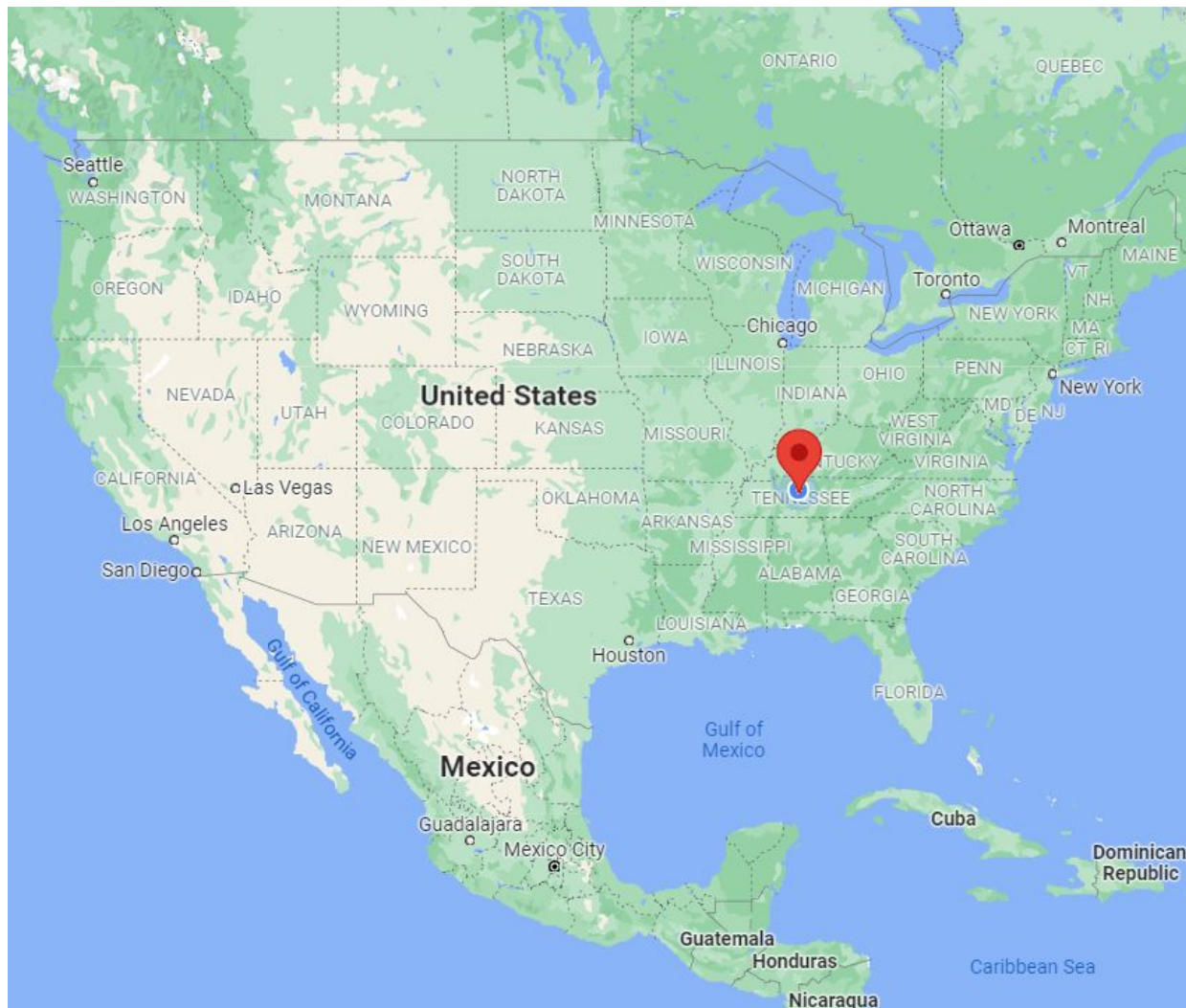


Time  
(Hours)

Gallons  
of Fuel

CO<sub>2</sub>  
(lbs)

Fuel cost  
2021



Train

40

2.3

51.5

7.52

# Transporting food by Ship or Train

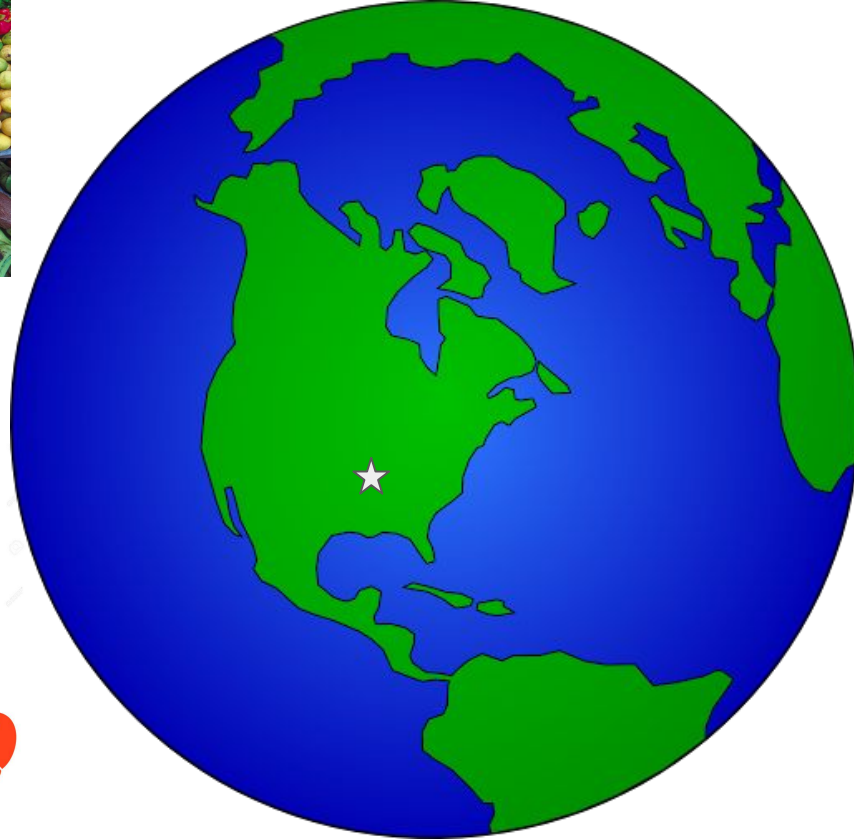
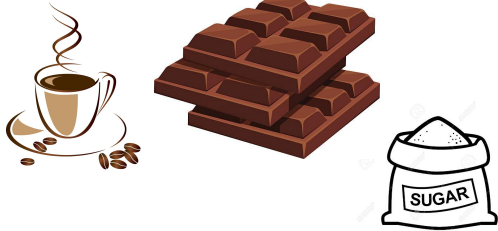
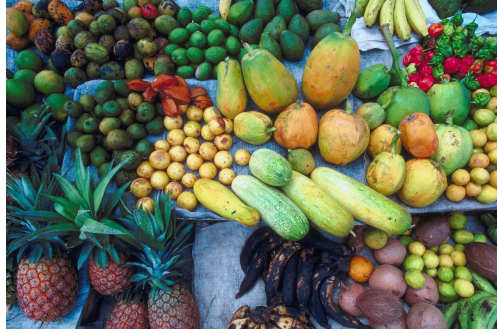
## Pros:

- Fuel efficient over long distances
- Less CO<sub>2</sub> production - by cargo weight
- Effective at moving large amounts at once

## Cons:

- Slow
- Ship and Train is not the end point of that cargo's journey
- Food most likely processed or under-ripe: less nutritious \*unless frozen

# Globalization



# Areas for Further Analysis

- Refine the data for transit by truck by including data for urban driving conditions
- It would be fascinating to further examine where exactly different ingredients are grown and how exactly they're transported, to get a clearer vision of a food-product's journey from origin to market
  - Shipping ports mapped
  - Rail lines mapped
  - Distribution centers highlighted

# Data Sources

- U.S. Department of Transportation ([National Freight Statistics](#))
- U.S. Surface Transportation Board ([Rail Service Data](#))
- U.S. Department of Energy ([Motor Vehicle Mileage, Fuel Consumption, and Fuel Economy](#))
- U.S. Department of Energy ([Short-Term Energy Outlook, December 2011](#))
- U.S. Department of Energy ([Carbon Dioxide Emissions Coefficients by Fuel](#))
- The Geography of Transport Systems, by Jean-Paul Rodrigue  
([Fuel Consumption by Containership Size and Speed](#))
- The Conservation Fund ([Moving Freight: Economy and Atmosphere](#))
- The National Air and Space Museum ([How Things Fly](#))

# Questions

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