Individual Project:Exoplanets

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The Dataset

- Data on all Exoplanets discovered including data on the planet itself, the star it orbits, and the discovery method.

What are we looking at?

- Characterizing Earthlike planets (Radius <= 1.5 Earth Radii) and Super Earths (radius 1.5-5 Earth Radii) by discovery method and discovery facility

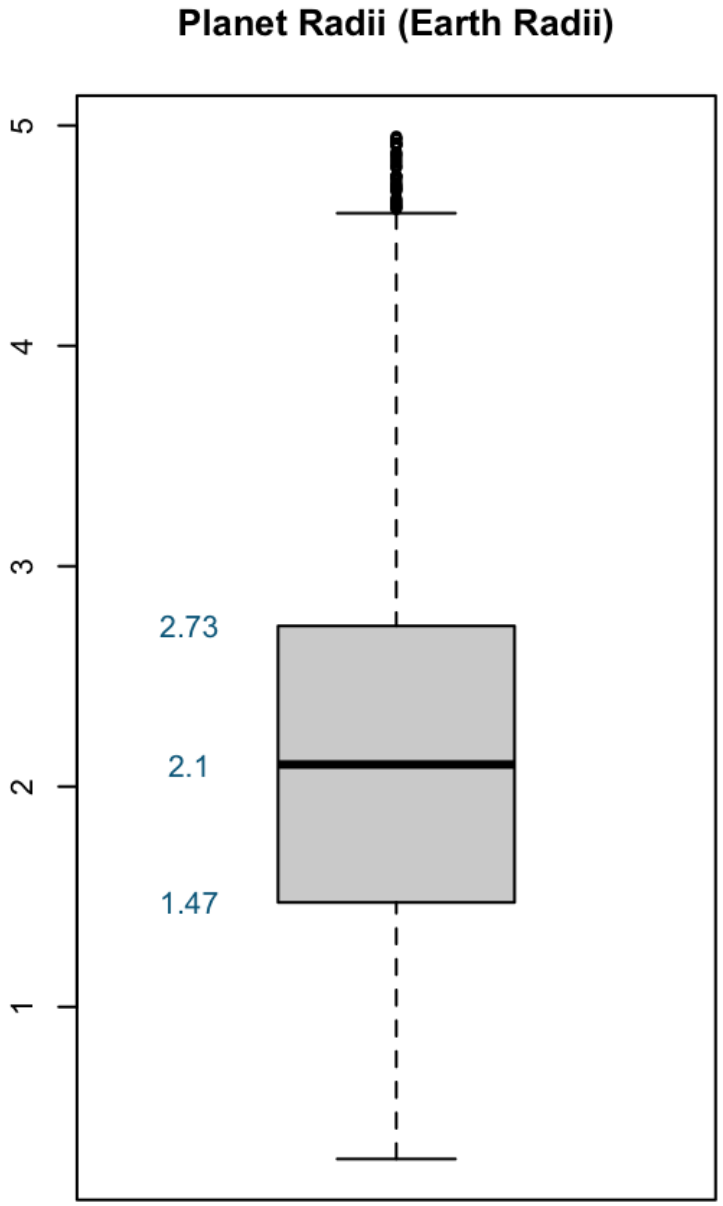
Data Cleaning: Removing Unused Data

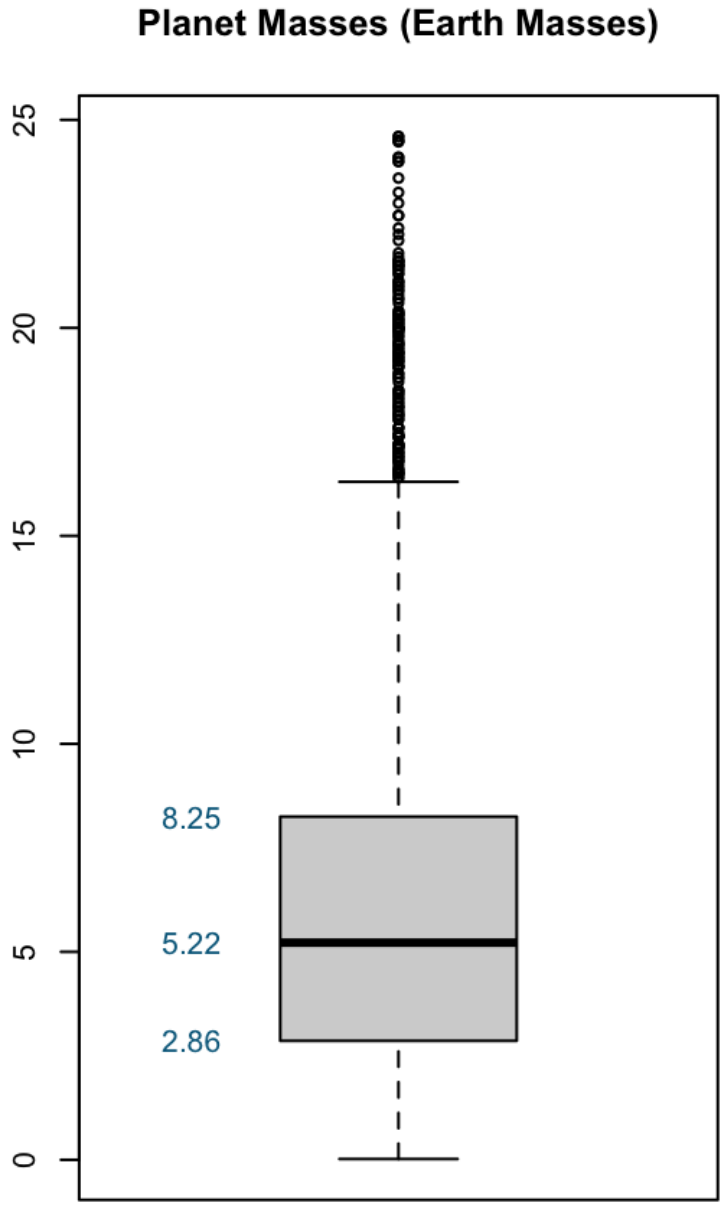
- Starting dataset is 5458 rows x 25 columns.
- Remove: NAs for mass and radius,
- Remove: Radius >5 Earth Radii or >25 Earth Mass
- Discovery Method and Discovery Facility converted to factors
- Rechecking summary reveals many NAs for columns we don’t care about but none for the columns we do care about.
- Dimensions now 3522 x 25

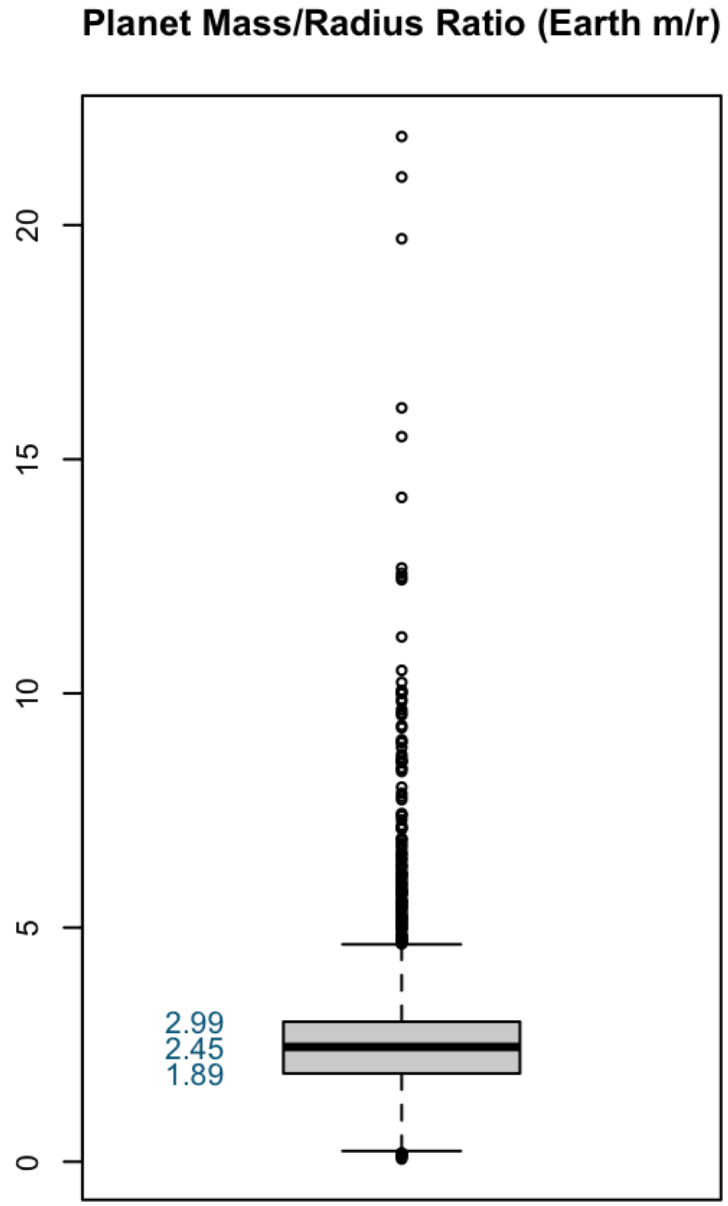
Data Cleaning: Classification

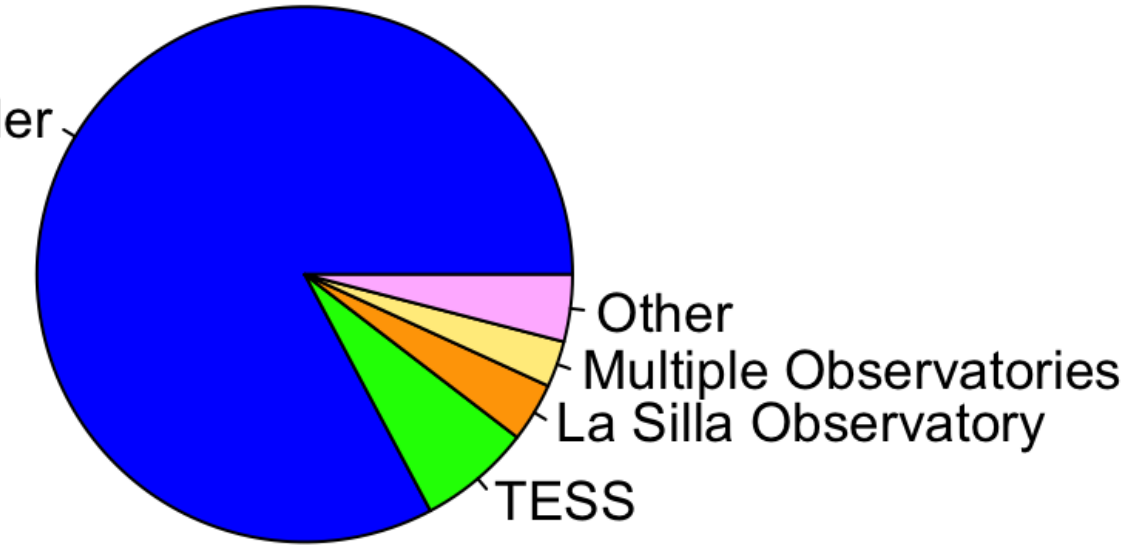
- Classify into Earthlike and Super Earth based on radius by creating a separate vector and then binding it to the dataframe.
- There are 28 discovery facilities but only 4 with more than 100 discoveries.
  - Using vectors with facility names and for loops we characterize all the facilities into: "Kepler", "TESS”, "La Silla Observatory", "Multiple Observatories", "Other”
- There are 6 discovery methods but only 3 with more than 50 discoveries
  - Using vectors with method names and for loops we characterize all the discovery methods into: "Transit", "Radial Velocity", "Microlensing", "Other”
- Lastly, we want to look at the mass/radius ratio of the various planets, so we add mass/radius as a column.
  - Important to realize this means multiples of Earth’s density

Summary Statistics


Planet Radii (Earth Radii)
5
4
3
2
1
2.73
2.1
1.47


Planet Masses (Earth Masses)
25
20
15
10
5
0
8.25
5.22
2.86

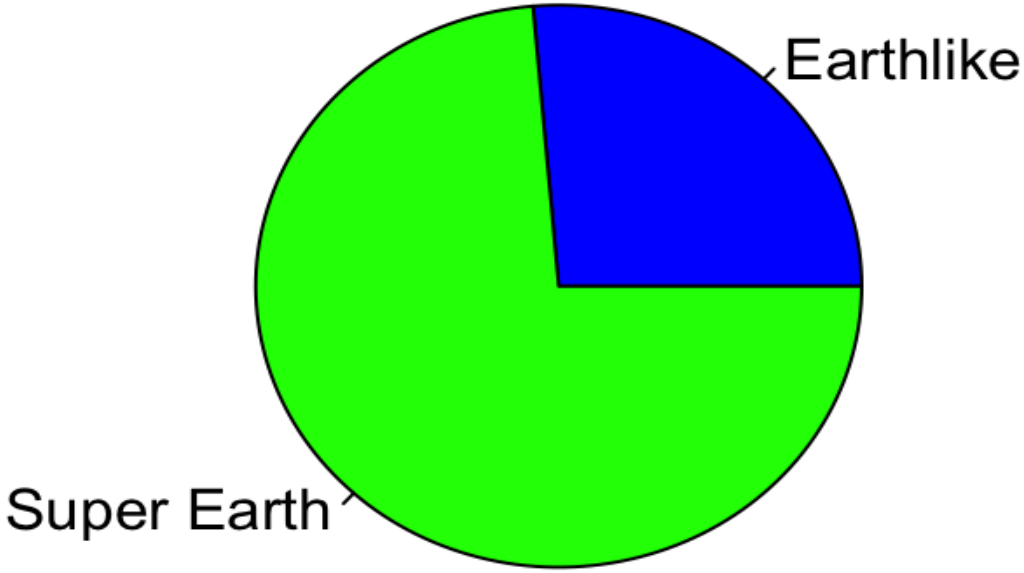

Planet Mass/Radius Ratio (Earth m/r)
20
15
10
5
0
2.99
2.45
1.89

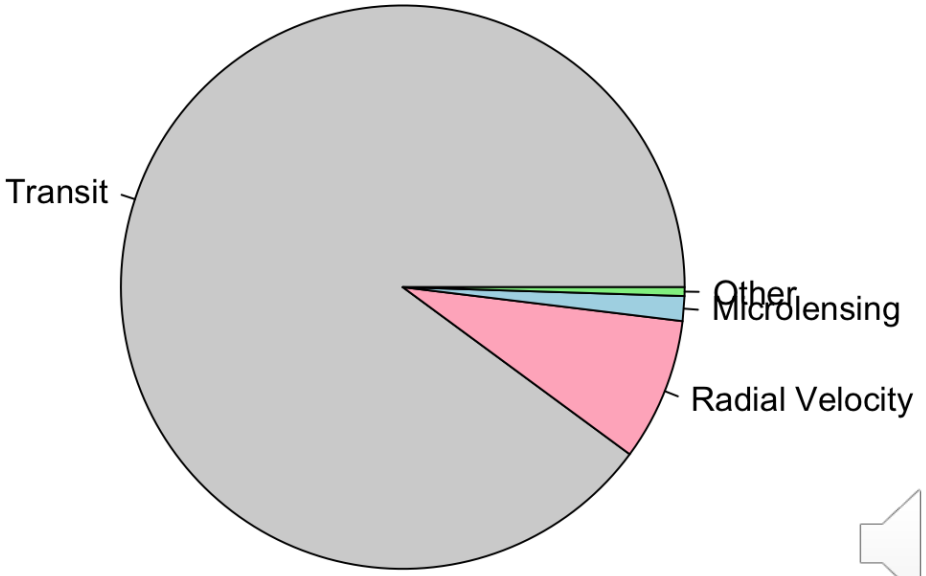


Planet Type

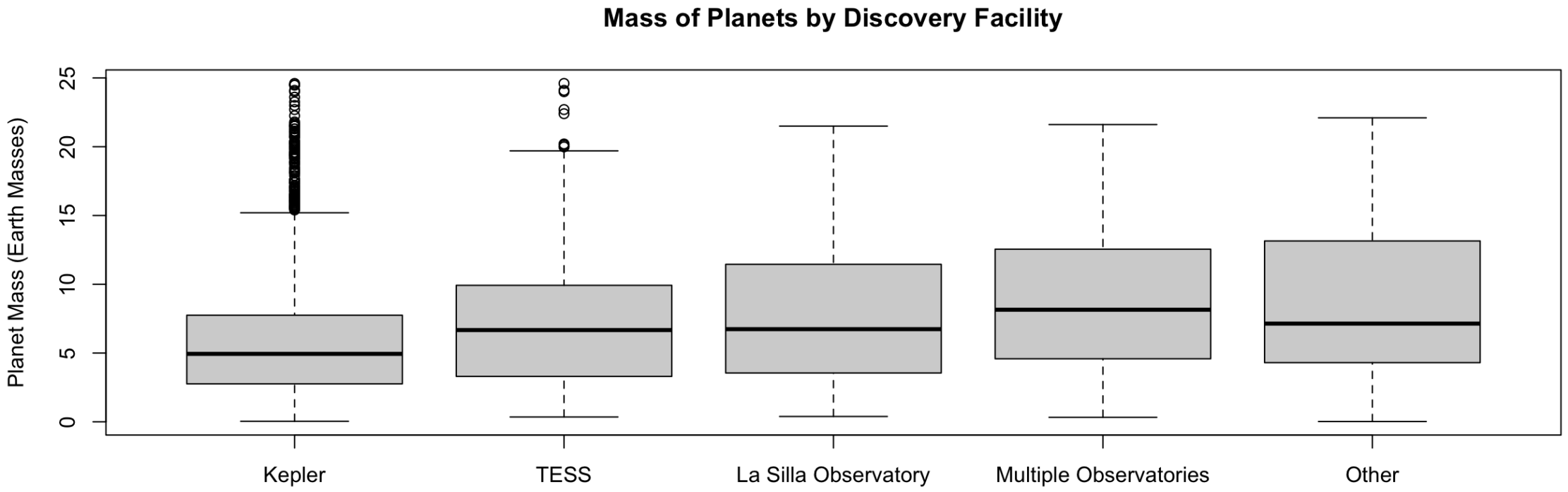
Discovery Facility

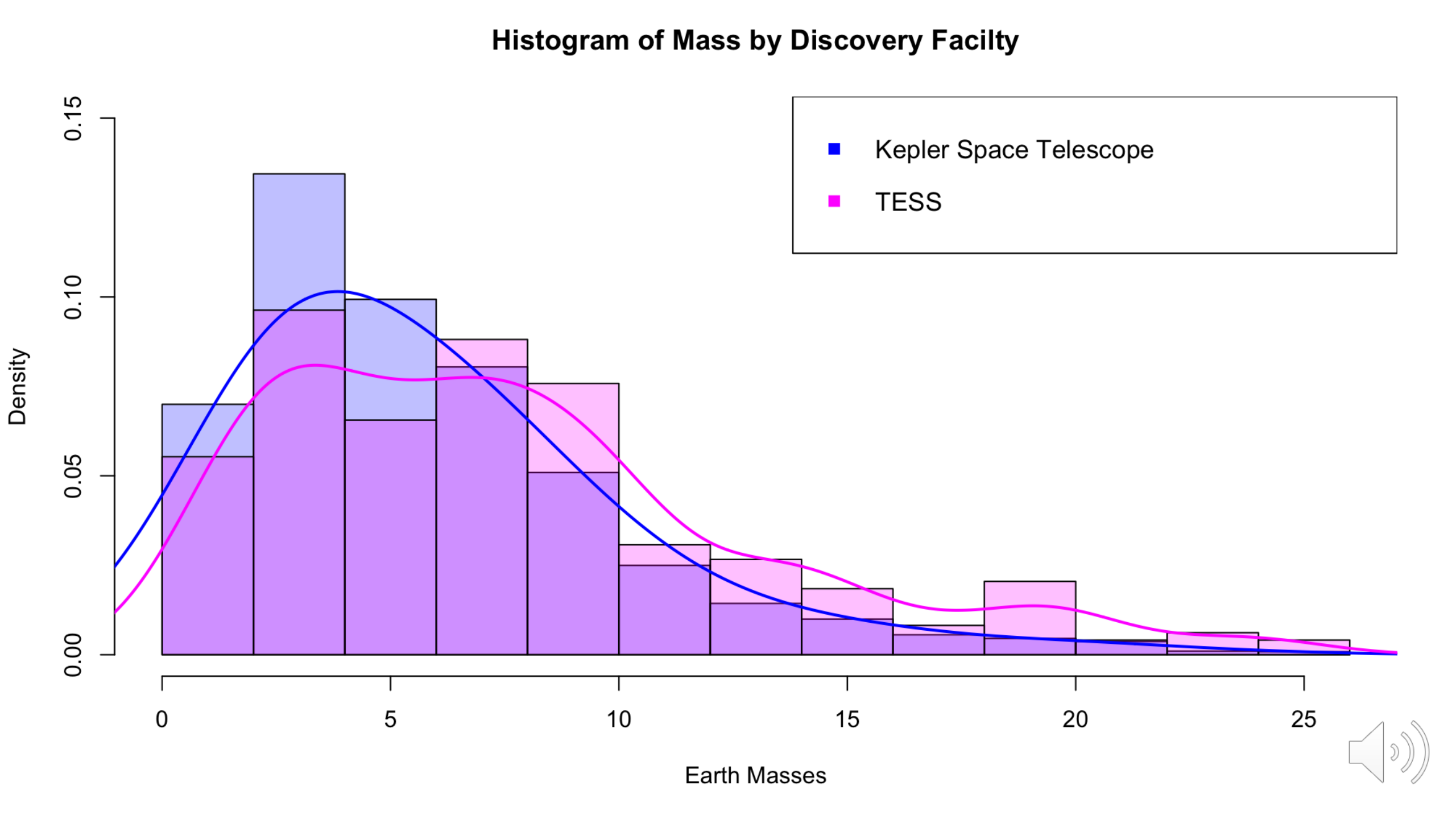
Discovery Technique



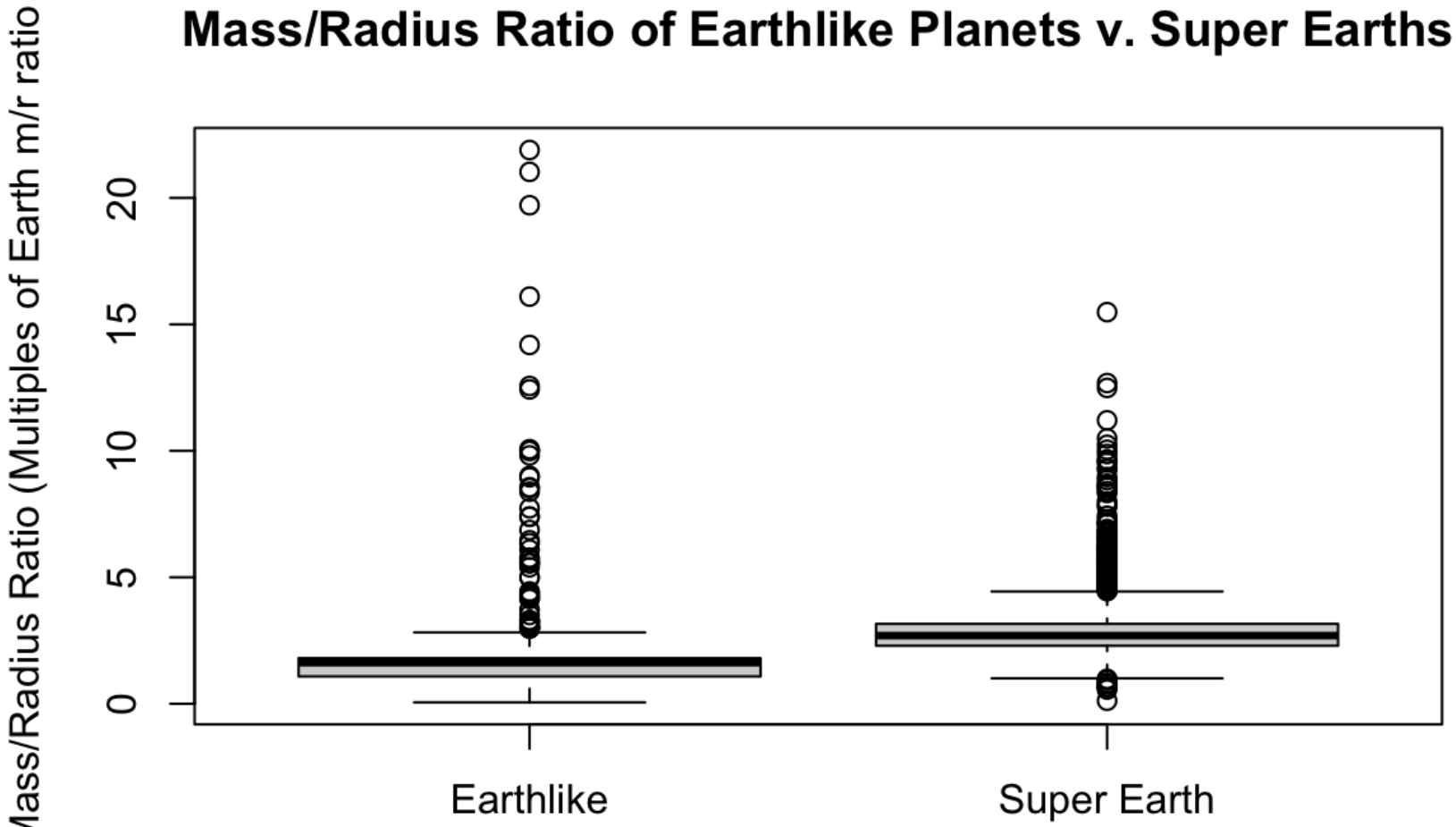


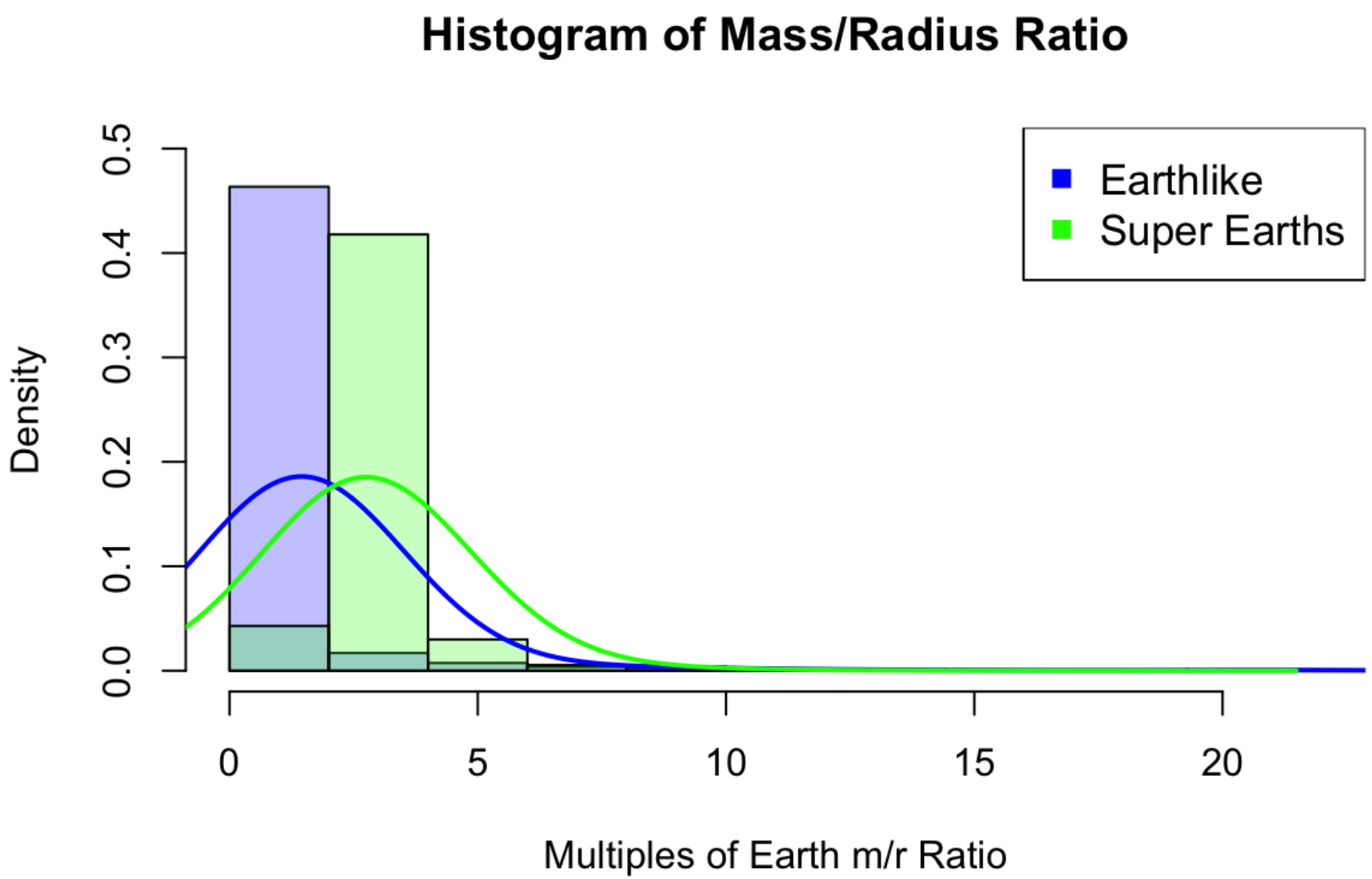
Comparisons by Discovery Facility


Mass of Planets by Discovery Facility
Planet Mass (Earth Masses)
0
5
10
15
20
25
Kepler
TESS
La Silla Observatory
Multiple Observatories
Other

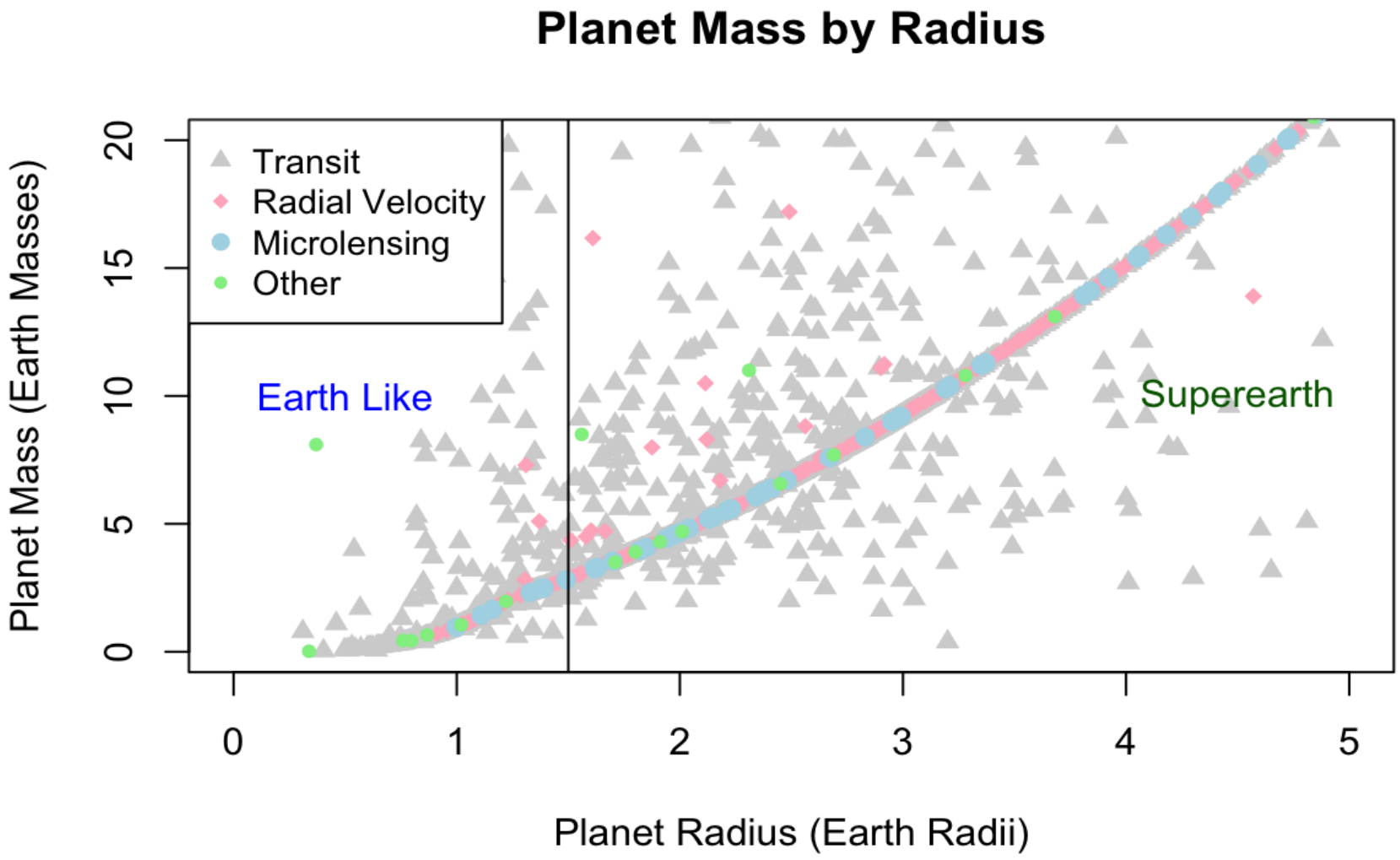

Histogram of Mass by Discovery Facilty
Kepler Space Telescope
TESS
Density
0.00
0.05
0.10
0.15
0
5
10
15
20
25
Earth Masses

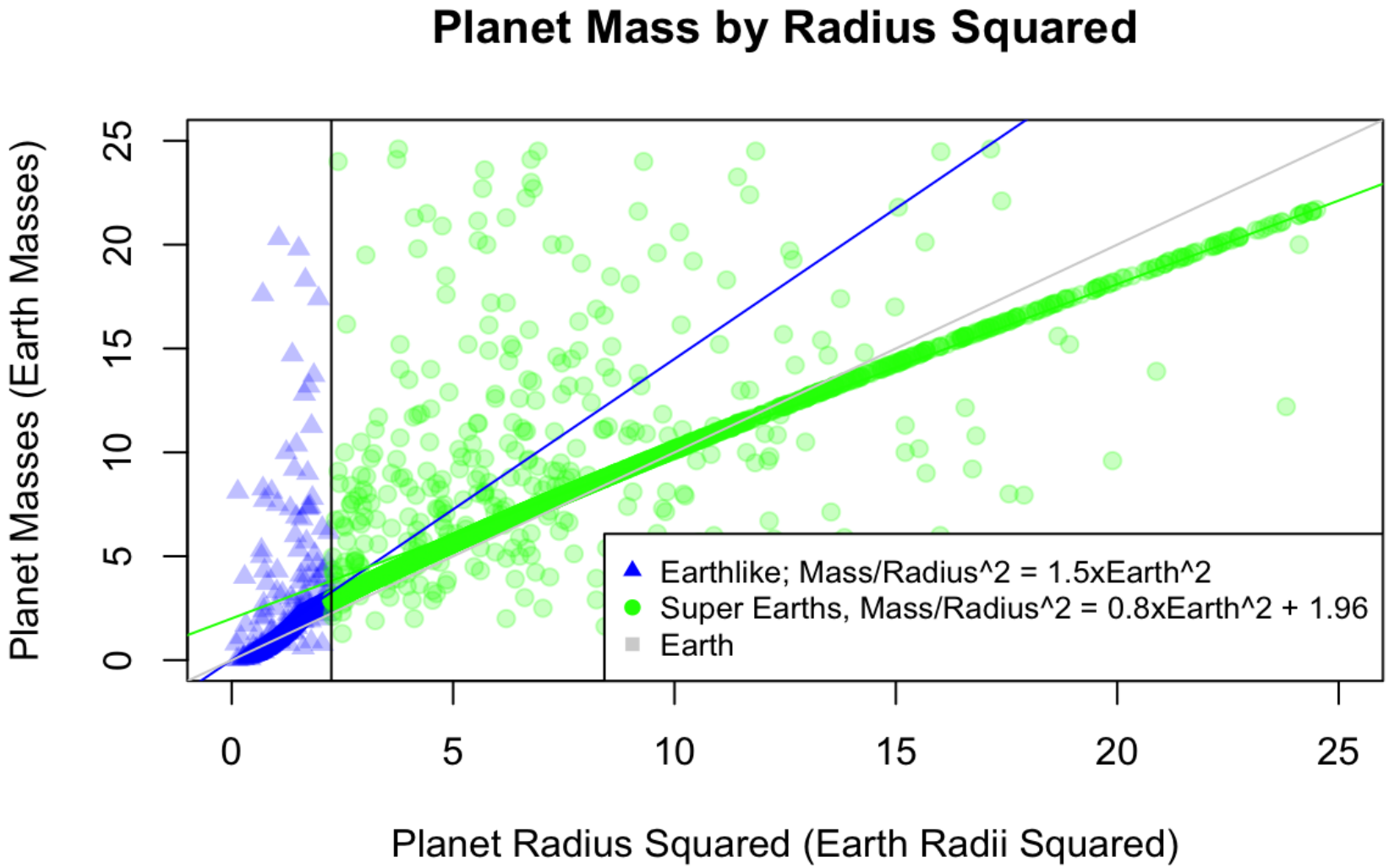
Comparisons Between Earthlike and Super Earths


Mass/Radius Ratio of Earthlike Planets v. Super Earths
Mass/Radius Ratio (Multiples of Earth m/r ratio
0
5
10
15
20
Earthlike
Super Earth


Histogram of Mass/Radius Ratio
Earthlike
Super Earths
Density
0.0
0.1
0.2
0.3
0.4
0.5
0
5
10
15
20
Multiples of Earth m/r Ratio

Plots of Mass versus Radius


Planet Mass by Radius
Transit
Radial Velocity
Microlensing
Other
Earth Like
Superearth
Planet Mass (Earth Masses)
0
5
10
15
20
0
1
2
3
4
5
Planet Radius (Earth Radii)


Planet Mass by Radius Squared
Planet Masses (Earth Masses)
0
5
10
15
20
25
Planet Radius Squared (Earth Radii Squared)
Earthlike; Mass/Radius^2 = 1.5xEarth^2
Super Earths, Mass/Radius^2 = 0.8xEarth^2 + 1.96
Earth

Limitations

- The final dataset used for analysis was only 64.5% of the total dataset
- There are a number of outliers in the data set which could affect analysis
- Mass should rise as the third power of radius as volume does but in this data set it appeared to rise as the second part of radius which may represent a decrease in density in larger planets.

Conclusions

- While many different facilities and multiple methods are involved in discovery of exoplanets, the vast majority were discovered by
  - 1 space telescope
  - 1 method
- Earthlike planets represent a relatively small percentage of overall exoplanets discovered
- Mass of exoplanets rises as the square of the radius, with a steeper gradient for earthlike planets than super earths