IS5 in R: Understanding and Comparing Distributions (Chapter 4)

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Introduction and background

This document is intended to help describe how to undertake analyses introduced as examples in the Fifth Edition of *Intro Stats* (2018) by De Veaux, Velleman, and Bock. More information about the book can be found at http://wps.aw.com/aw_deveaux_stats_series. This file as well as the associated R Markdown reproducible analysis source file used to create it can be found at http://nhorton.people.amherst.edu/is5.

This work leverages initiatives undertaken by Project MOSAIC (http://www.mosaic-web.org), an NSF-funded effort to improve the teaching of statistics, calculus, science and computing in the undergraduate curriculum. In particular, we utilize the `mosaic` package, which was written to simplify the use of R for introductory statistics courses. A short summary of the R needed to teach introductory statistics can be found in the mosaic package vignettes (http://cran.r-project.org/web/packages/mosaic). A paper describing the mosaic approach was published in the *R Journal*: https://journal.r-project.org/archive/2017/RJ-2017-024.

Chapter 4: Understanding and Comparing Distributions

```r
library(mosaic)
library(readr)
library(janitor)
HopkinsForest <- read_csv("http://nhorton.people.amherst.edu/is5/data/Hopkins_Forest.csv") %>%
  clean_names()
```

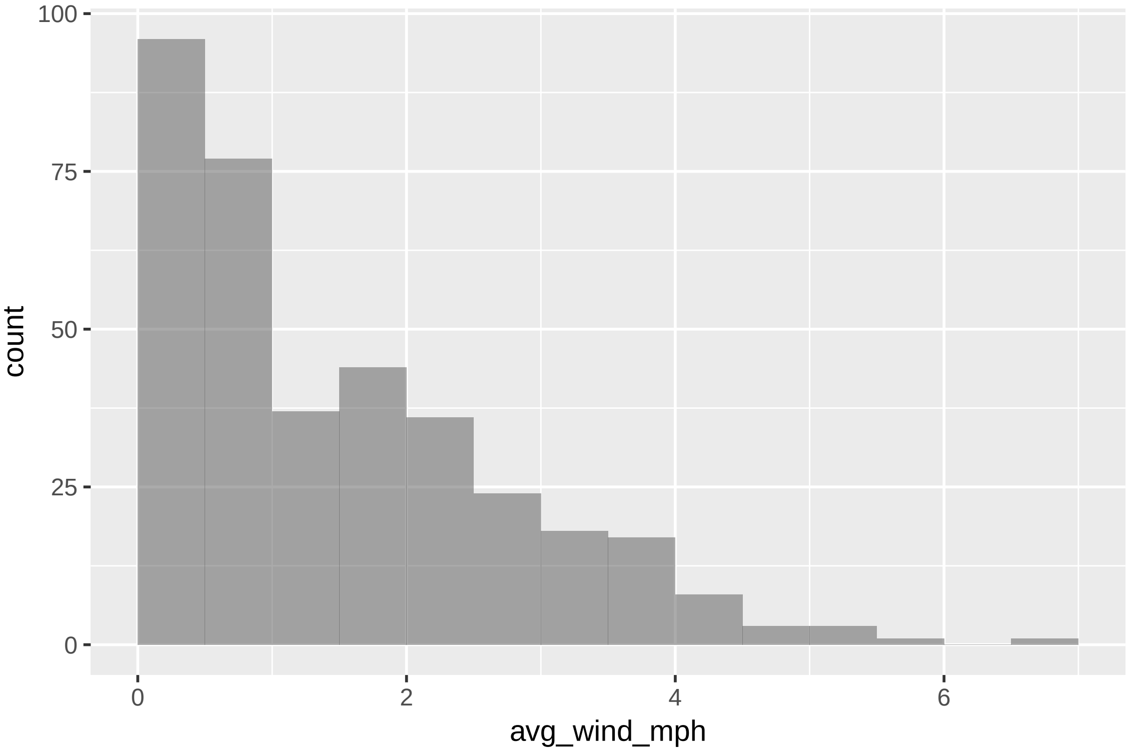
```
## Parsed with column specification:
## cols(
##   .default = col_double(),
##   Date = col_character(),
##   Year = col_integer(),
##   Month = col_integer(),
##   Day = col_integer(),
##   `Day of Year` = col_integer(),
##   `Max Sol Rad (w/m^2)` = col_integer(),
##   `Min Sol Rad (w/m^2)` = col_integer(),
##   `Total Sol Rad (w/m^2)` = col_integer(),
##   `Min Wind (mph)` = col_integer(),
##   `Max Barom (mb)` = col_integer(),
##   `Min Barom (mb)` = col_integer()
## )
```

```
## See spec(...) for full column specifications.
```

```r
names(HopkinsForest)
```

```
##  [1] "date"                "year"                "month"
##  [4] "day"                 "day_of_year"         "avg_temp_c"
##  [7] "max_temp_c"          "min_temp_c"          "avg_temp_f"
## [10] "max_temp_f"          "min_temp_f"          "avg_rel_hum_percent"
## [13] "max_rel_hum_percent" "min_rel_hum_percent" "avg_sol_rad_w_m_2"
## [16] "max_sol_rad_w_m_2"   "min_sol_rad_w_m_2"   "total_sol_rad_w_m_2"
## [19] "avg_wind_mph"        "max_wind_mph"        "min_wind_mph"
## [22] "avg_barom_mb"        "max_barom_mb"        "min_barom_mb"
## [25] "precip_in"           "deep_well_ft"        "shallow_well_ft"
## [28] "x80_cm_soil_c"       "x10_cm_soil_c"
```

```
gf_histogram(~ avg_wind_mph, data = HopkinsForest, binwidth = 0.5, center = 0.25)
```



```
favstats(~ avg_wind_mph, data = HopkinsForest)
```

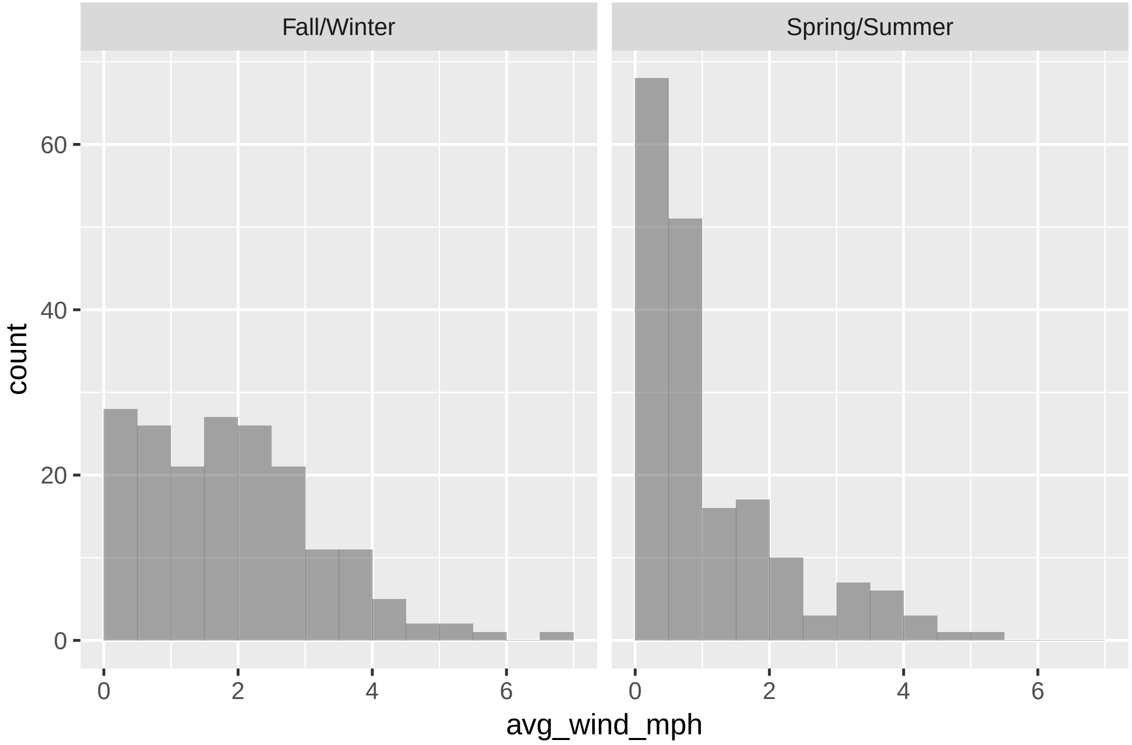
```
##  min   Q1 median   Q3  max     mean       sd   n missing
##    0 0.46   1.12 2.28 6.73 1.507808 1.260161 365       0
```

By default, `read_csv()` prints the variable names. These messages can be suppressed using the `message = FALSE` code chunk option to save space and improve readability.
Here we use the `clean_names()` function from the `janitor` package to sanitize the names of the columns (which would otherwise contain special characters or whitespace). You can use the `names()` function to check the cleaned names.

Section 4.1: Displays for Comparing Groups

Histograms

```
HopkinsForest <- HopkinsForest %>%
  mutate(catmonth = ifelse(month <= 9 & month >= 4, "Spring/Summer", "Fall/Winter"))
gf_histogram(~ avg_wind_mph, data = HopkinsForest, binwidth = 0.5, center = 0.25) %>%
  gf_facet_wrap(~ catmonth)
```



```
favstats(~ avg_wind_mph | catmonth, data = HopkinsForest)
```

```
##        catmonth  min   Q1 median     Q3  max     mean       sd   n missing
## 1   Fall/Winter 0.02 0.84   1.72 2.6575 6.73 1.904176 1.287233 182       0
## 2 Spring/Summer 0.00 0.35   0.71 1.6150 5.47 1.113607 1.102176 183       0
```

Example 4.1: Comparing Groups with Stem-And-Leaf

```
NestEgg <- read_csv("http://nhorton.people.amherst.edu/is5/data/Nest_Egg_Index.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   State = col_character(),
##   Nest.Egg.Index = col_double(),
##   Region = col_character()
## )
```

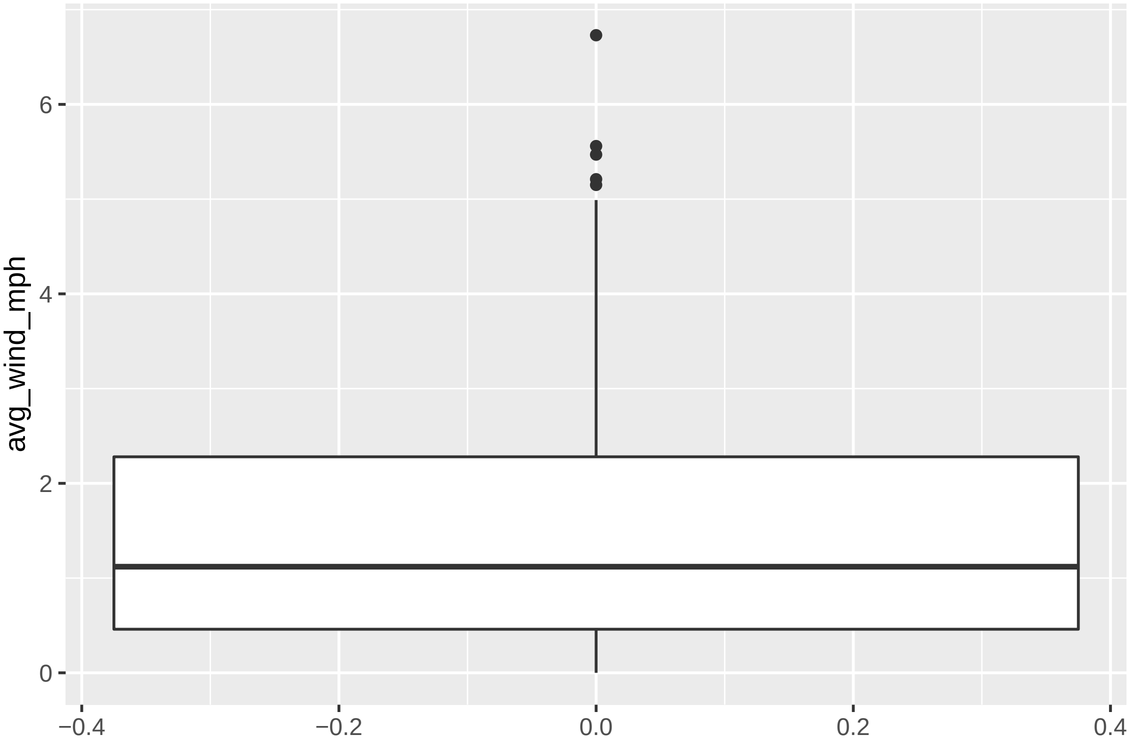
```
with(NestEgg, stem(nest_egg_index))
```

```
##
```

```
##   The decimal point is 1 digit(s) to the right of the |
##
##    8 | 57789
##    9 | 0123344
##    9 | 667777888899
##   10 | 0012233333344
##   10 | 5566779
##   11 | 122444
```

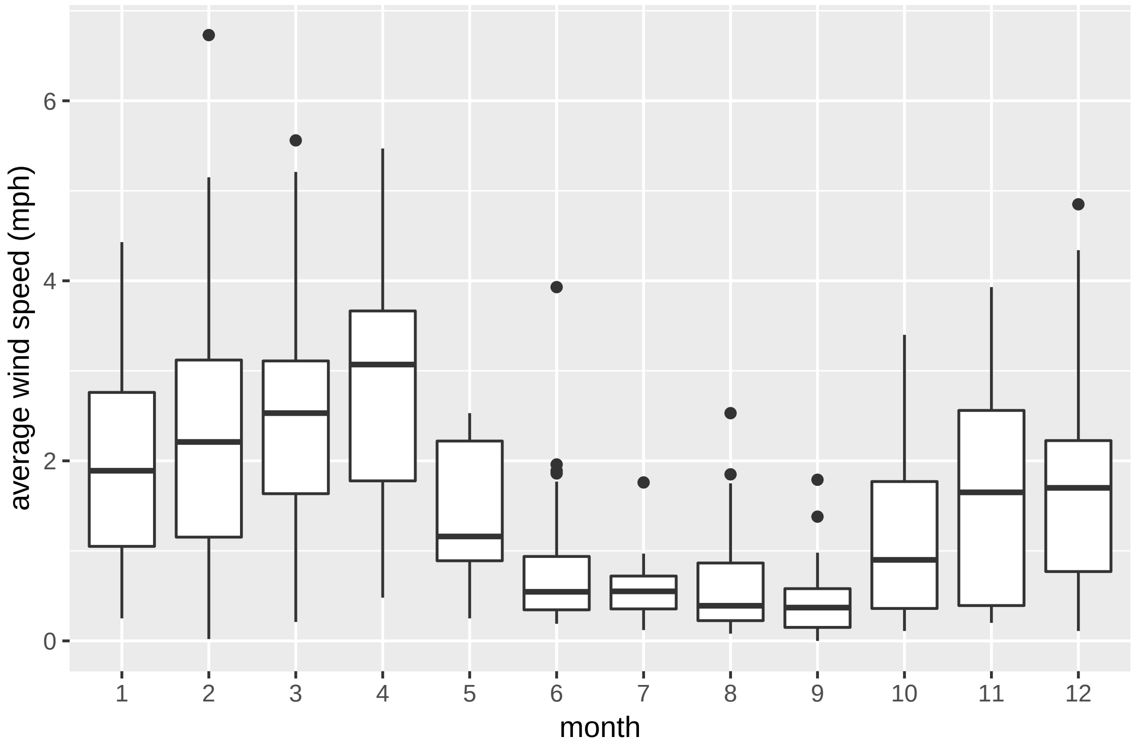
Boxplots

```
gf_boxplot(~ avg_wind_mph, data = HopkinsForest)  # or gf_boxplot(X ~ 1)
```



As noted in the book, boxplots are most useful to compare distributions. Here we replicate the single boxplot from page 98 but don't recommend the use of single boxplots.

```
gf_boxplot(avg_wind_mph ~ as.factor(month), data = HopkinsForest) %>%
  gf_labs(x = "month", y = "average wind speed (mph)")
```



Here we replicate the results from Figure 4.3 (page 99).

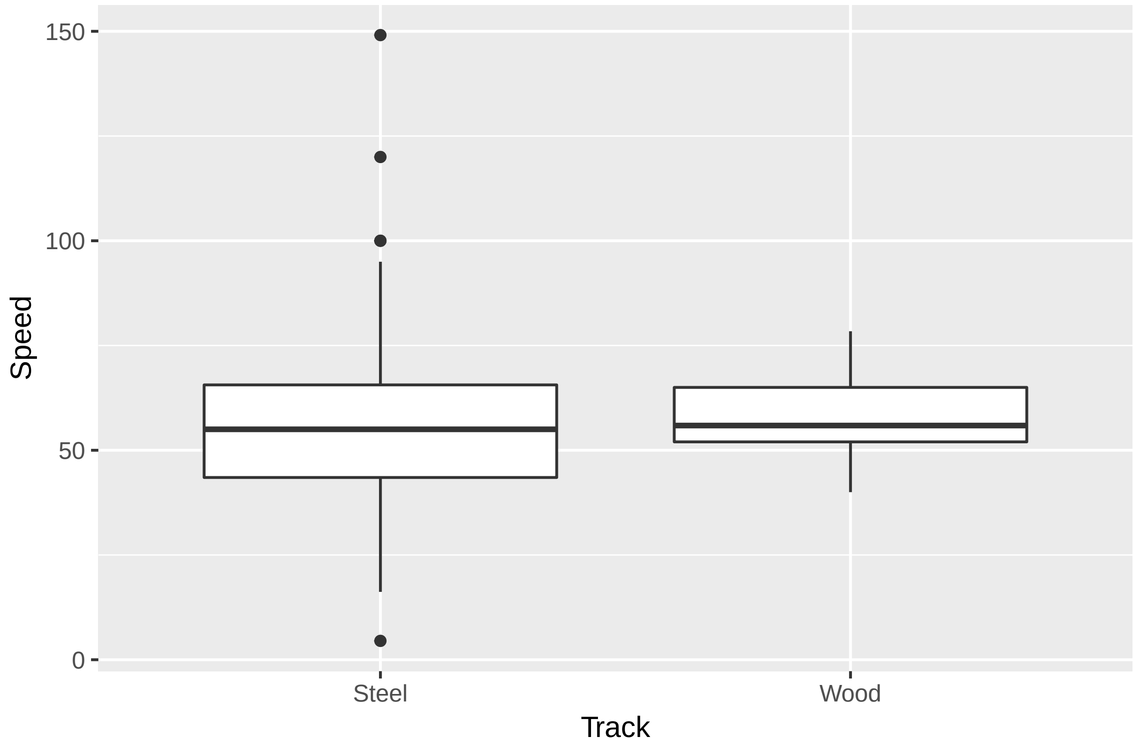
We use `as.factor()` to convert a variable into a factor.

Example 4.2: Comparing Groups with Boxplots

```
Coasters <- read_csv("http://nhorton.people.amherst.edu/is5/data/Coasters_2015.csv")
```

```
## Parsed with column specification:
## cols(
##   Name = col_character(),
##   Park = col_character(),
##   Track = col_character(),
##   Speed = col_double(),
##   Height = col_double(),
##   Drop = col_double(),
##   Length = col_double(),
##   Duration = col_integer(),
##   Inversions = col_integer()
## )
```

```
gf_boxplot(Speed ~ Track, data = Coasters)
```



Step-By-Step Example: Comparing Groups

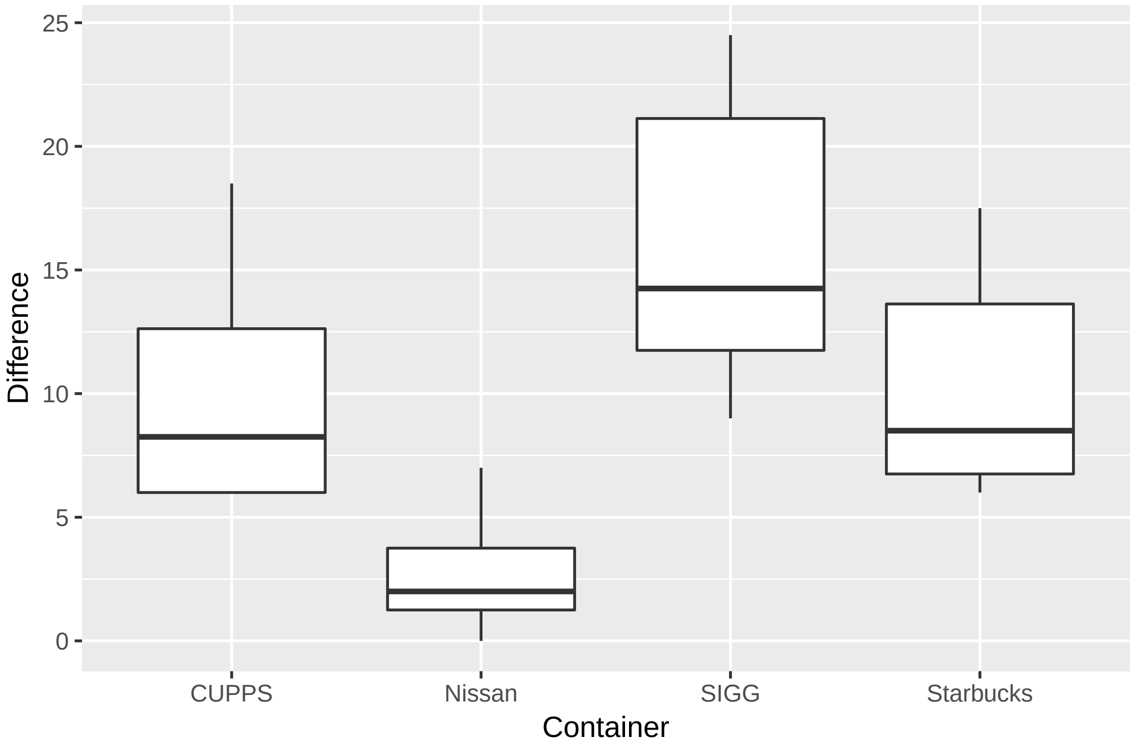
```
Cups <- read_csv("http://nhorton.people.amherst.edu/is5/data/Cups.csv")
```

```
## Parsed with column specification:
## cols(
##   Difference = col_double(),
##   Container = col_character()
## )
```

```
favstats(~ Difference | Container, data = Cups)
```

```
##   Container min    Q1 median     Q3  max    mean       sd n missing
## 1     CUPPS   6  6.00   8.25 12.625 18.5 10.1875 5.202592 8       0
## 2    Nissan   0  1.25   2.00  3.750  7.0  2.7500 2.507133 8       0
## 3      SIGG   9 11.75  14.25 21.125 24.5 16.0625 5.900590 8       0
## 4 Starbucks   6  6.75   8.50 13.625 17.5 10.2500 4.551295 8       0
```

```
gf_boxplot(Difference ~ Container, data = Cups)
```

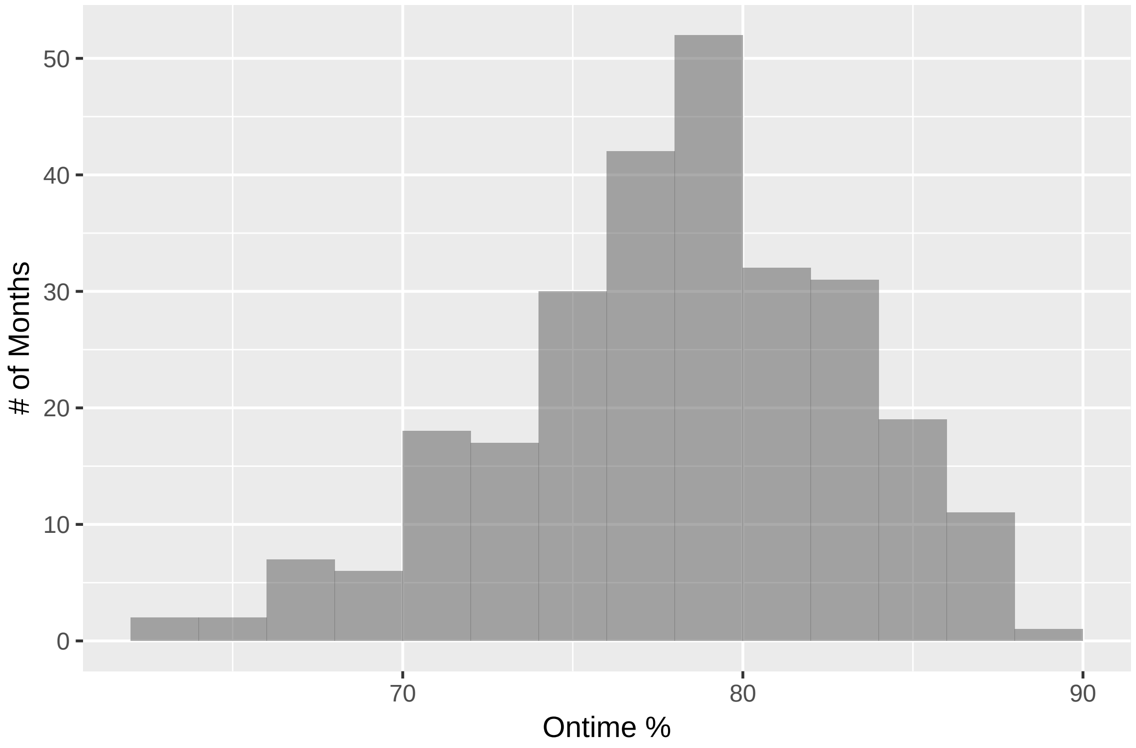


Just Checking

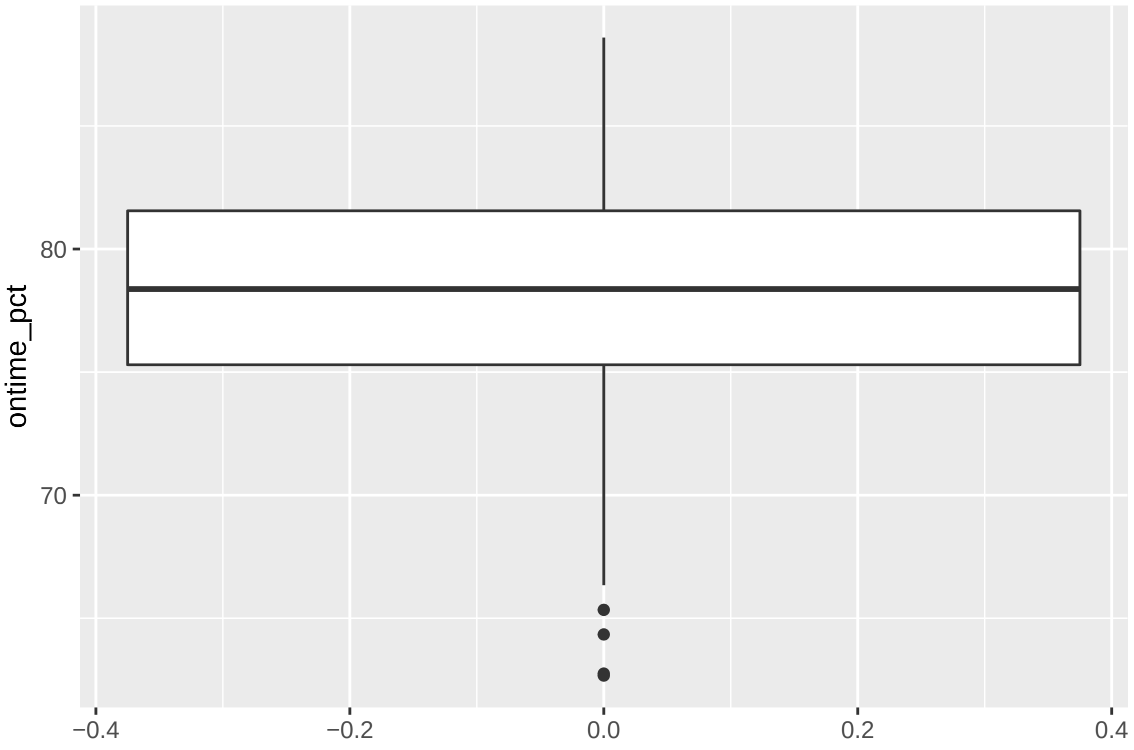
```
Flights <- read_csv("http://nhorton.people.amherst.edu/is5/data/Flights_on_time_2016.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   Year = col_double(),
##   Month = col_character(),
##   Onetime.Arrivals = col_integer(),
##   Ontime.pct = col_double(),
##   Arrival.Delays = col_integer(),
##   Delayed.pct = col_double(),
##   Flights.Cancelled = col_integer(),
##   Cancelled.Pct = col_double(),
##   Diverted = col_integer(),
##   Flight.Operations = col_integer()
## )
```

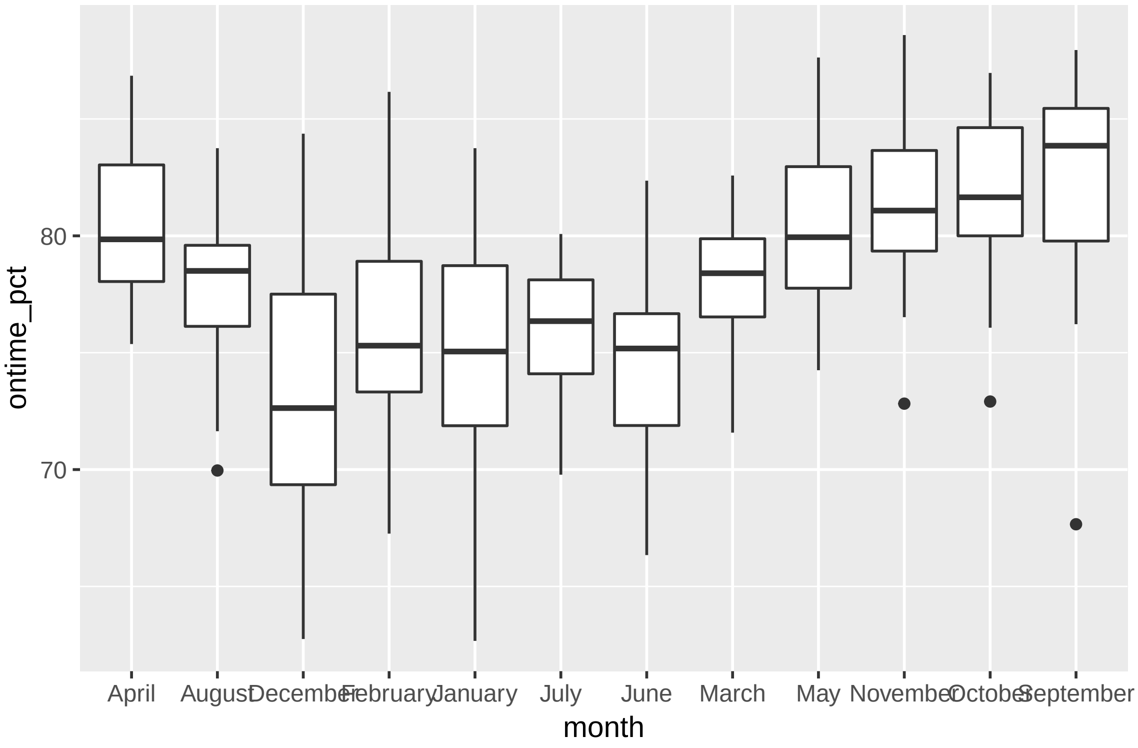
```
gf_histogram(~ ontime_pct, data = Flights, binwidth = 2, ylab = "# of Months", xlab = "Ontime %",
             center = 1)
```



```
gf_boxplot(~ ontime_pct, data = Flights)
```



```
gf_boxplot(ontime_pct ~ month, data = Flights)
```

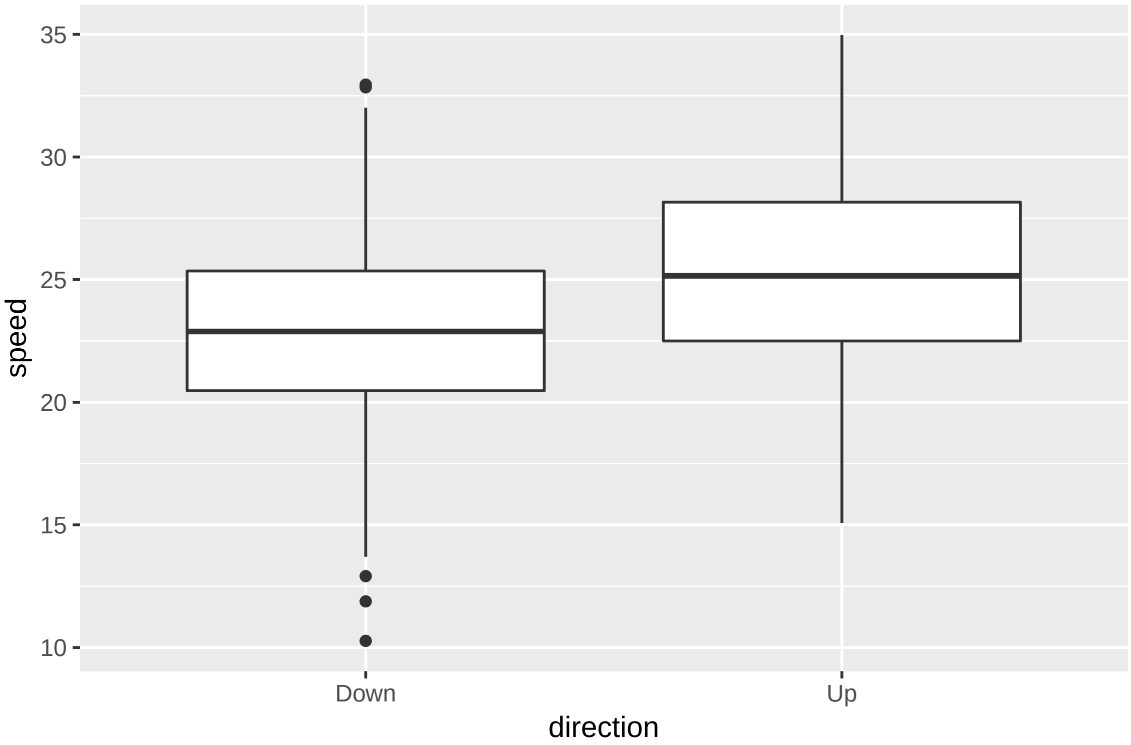


Random Matters

```
CarSpeeds <- read_csv("http://nhorton.people.amherst.edu/is5/data/Car_speeds.csv")
```

```
## Parsed with column specification:
## cols(
##   direction = col_character(),
##   speed = col_double()
## )
```

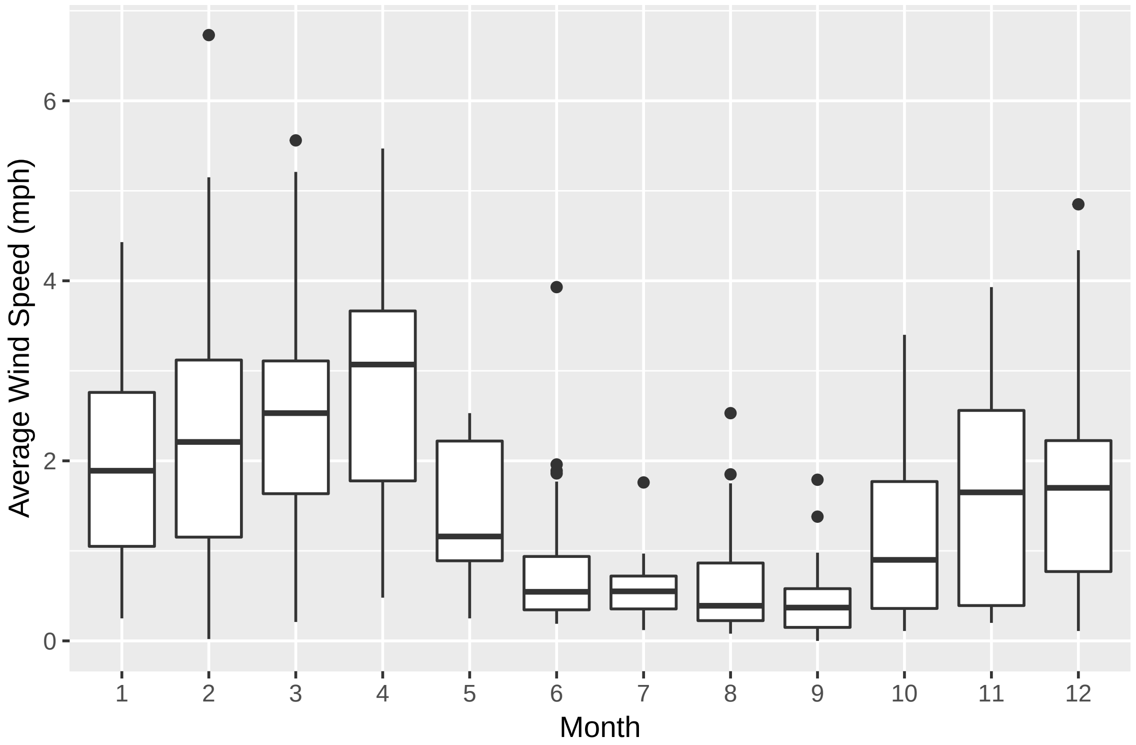
```
gf_boxplot(speed ~ direction, data = CarSpeeds)
```



See histogram on page 103.

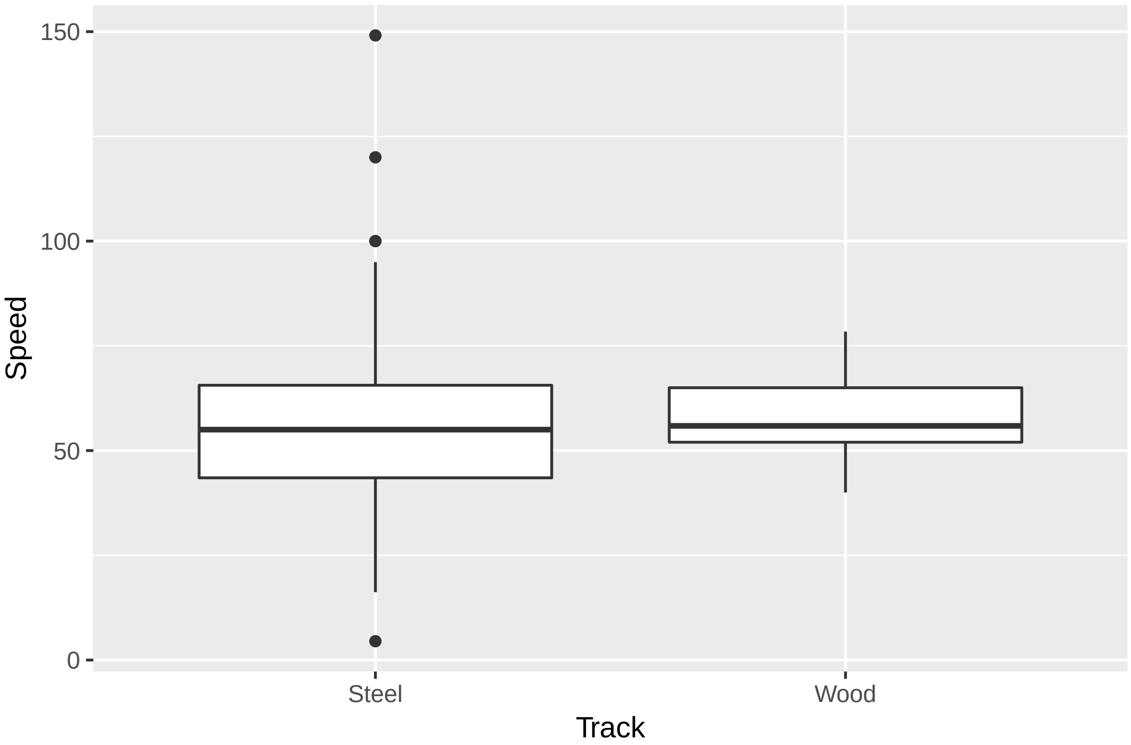
Section 4.2: Outliers

```
gf_boxplot(avg_wind_mph ~ as.factor(month), data = HopkinsForest) %>%
  gf_labs(x = "Month", y = "Average Wind Speed (mph)")
```



Example 4.3: Checking Out the Outliers

```
gf_boxplot(Speed ~ Track, data = Coasters)
```



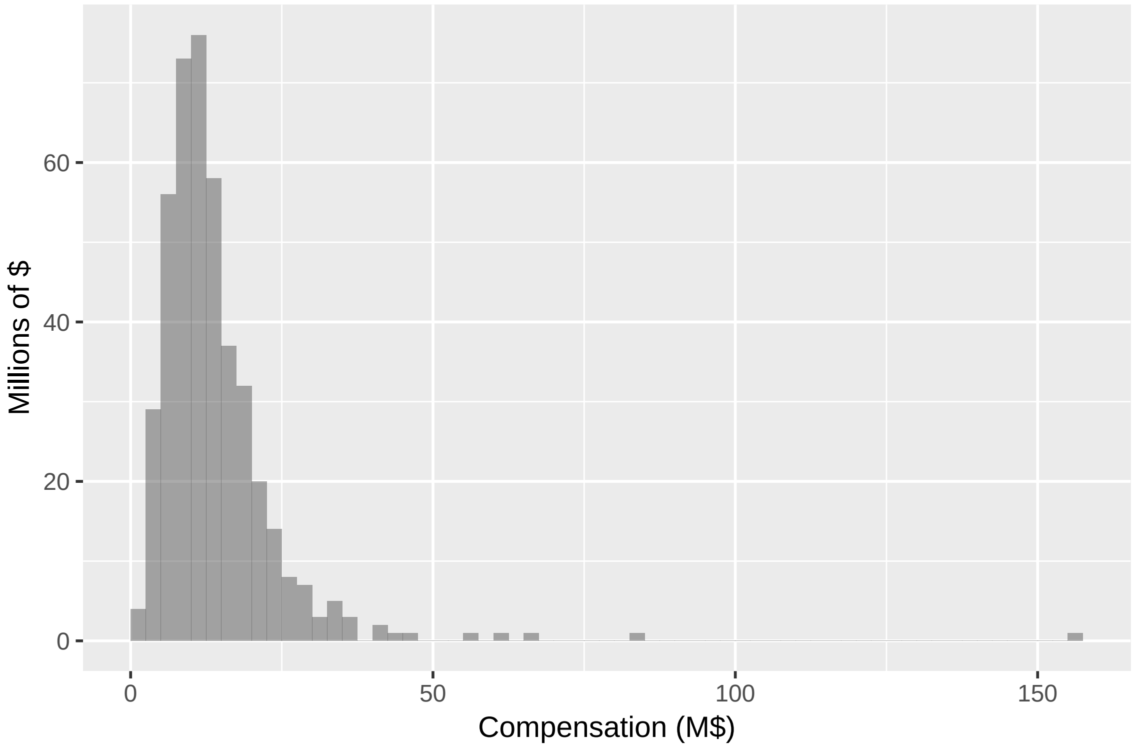
Section 4.3: Re-Expressing Data: A First Look

Re-Expressing to Improve Symmetry

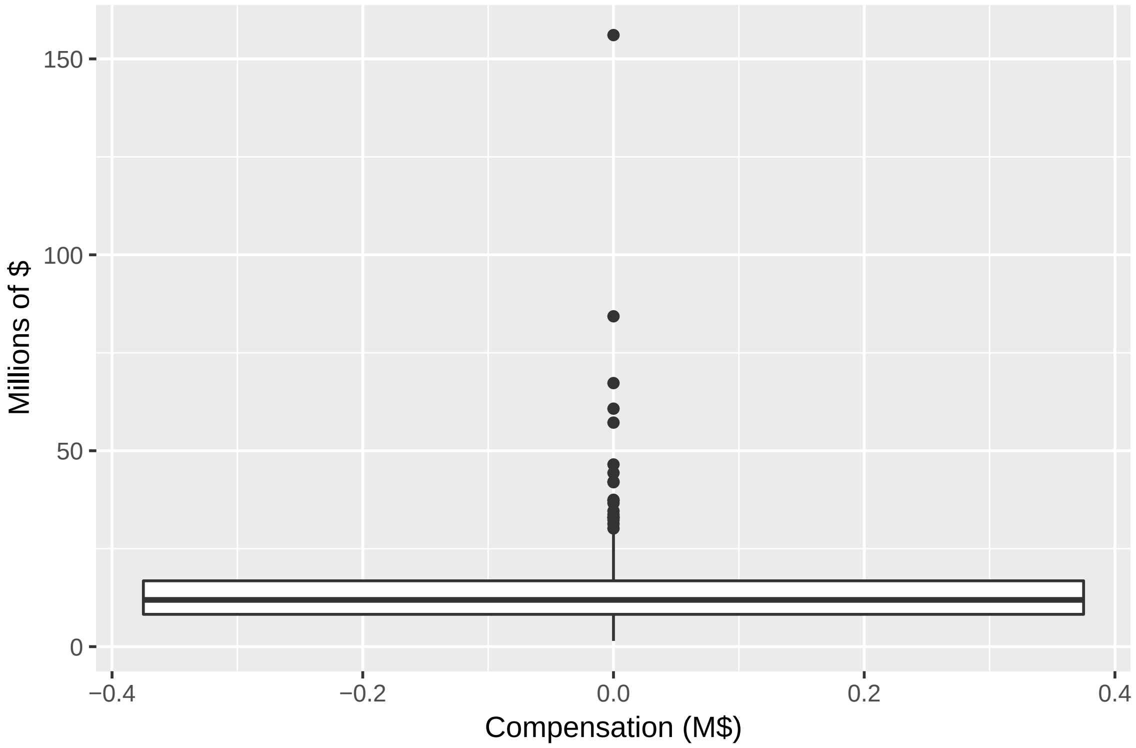
```
CEOComp <- read_csv("http://nhorton.people.amherst.edu/is5/data/CEO_Compensation_2014.csv") %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   Employer = col_character(),
##   CEO = col_character(),
##   CEO_Compensation = col_integer(),
##   Median_Worker_Comp = col_integer(),
##   Ratio = col_integer(),
##   Company_Rating = col_double(),
##   `CEO_Compensation_($M)` = col_double()
## )
```

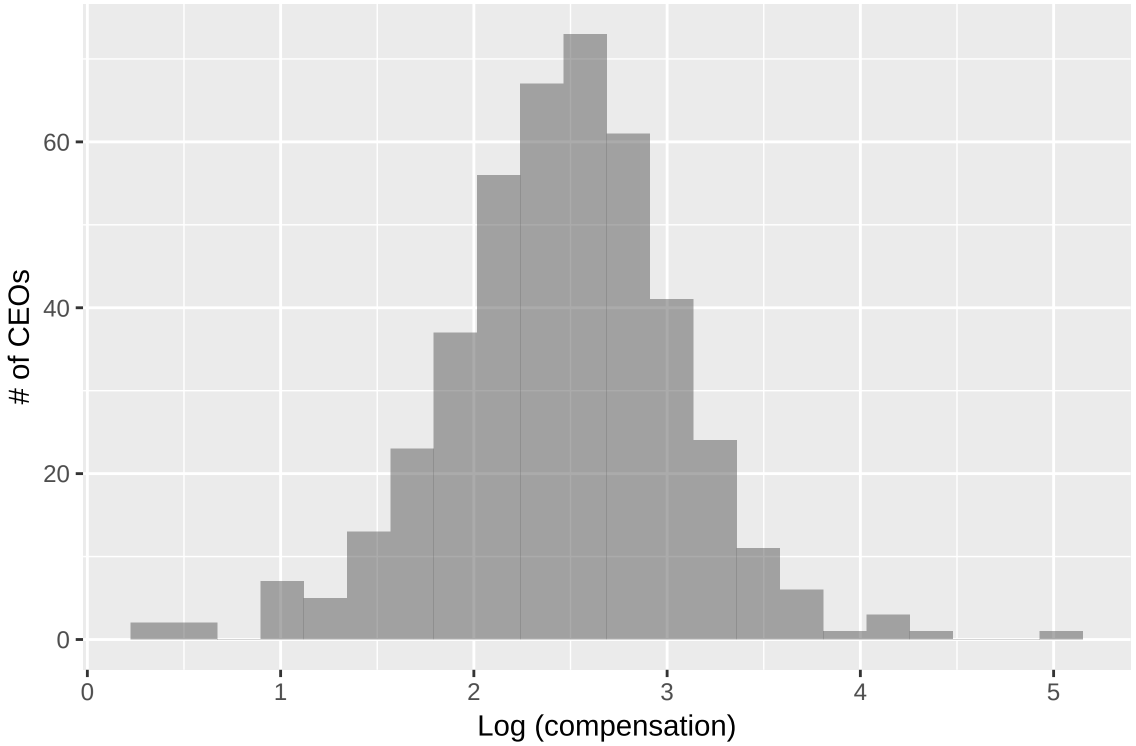
```
# Figure 4.6, page 105
gf_histogram(~ ceo_compensation_m, xlab = "Compensation (M$)", ylab = "Millions of $",
             data = CEOComp, binwidth = 2.5, center = 2.5/2)
```



```
gf_boxplot(~ ceo_compensation_m, xlab = "Compensation (M$)", ylab = "Millions of $",
           data = CEOComp)
```



```
# Figure 4.7, page 106
gf_histogram(~ log(ceo_compensation_m), xlab = "Log (compensation)", ylab = "# of CEOs",
             data = CEOComp, binwidth = .224, center = .112)
```

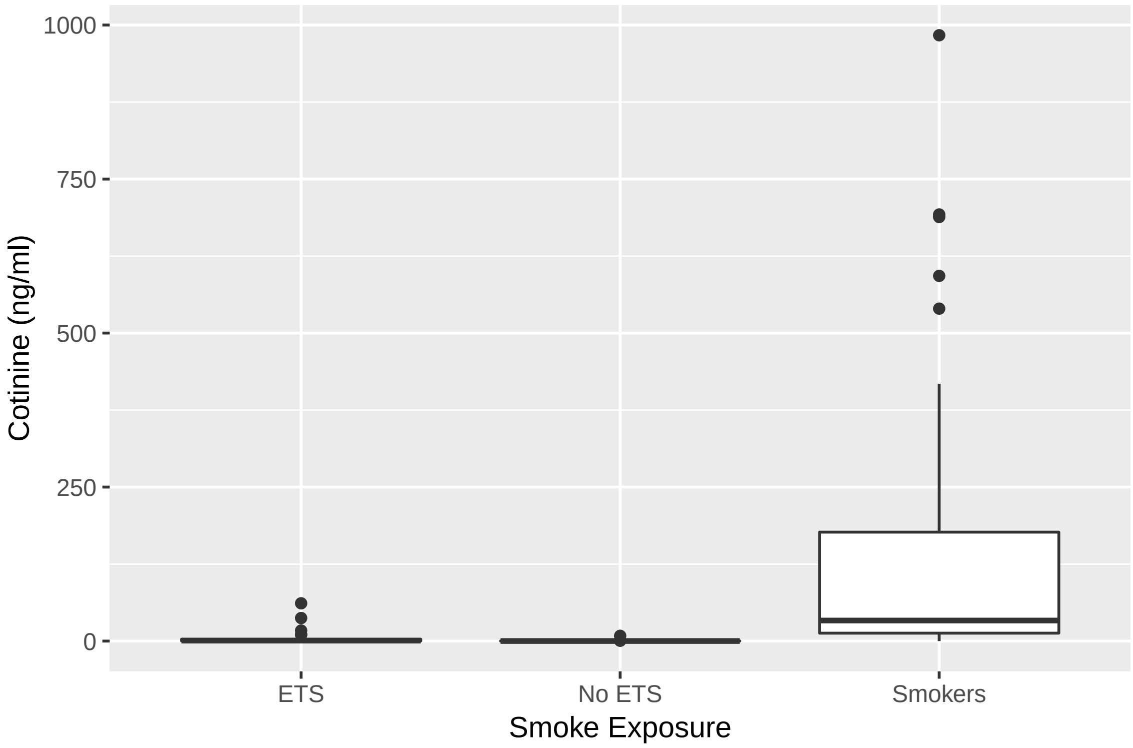


Re-Expression to Equalize Spread Across Groups

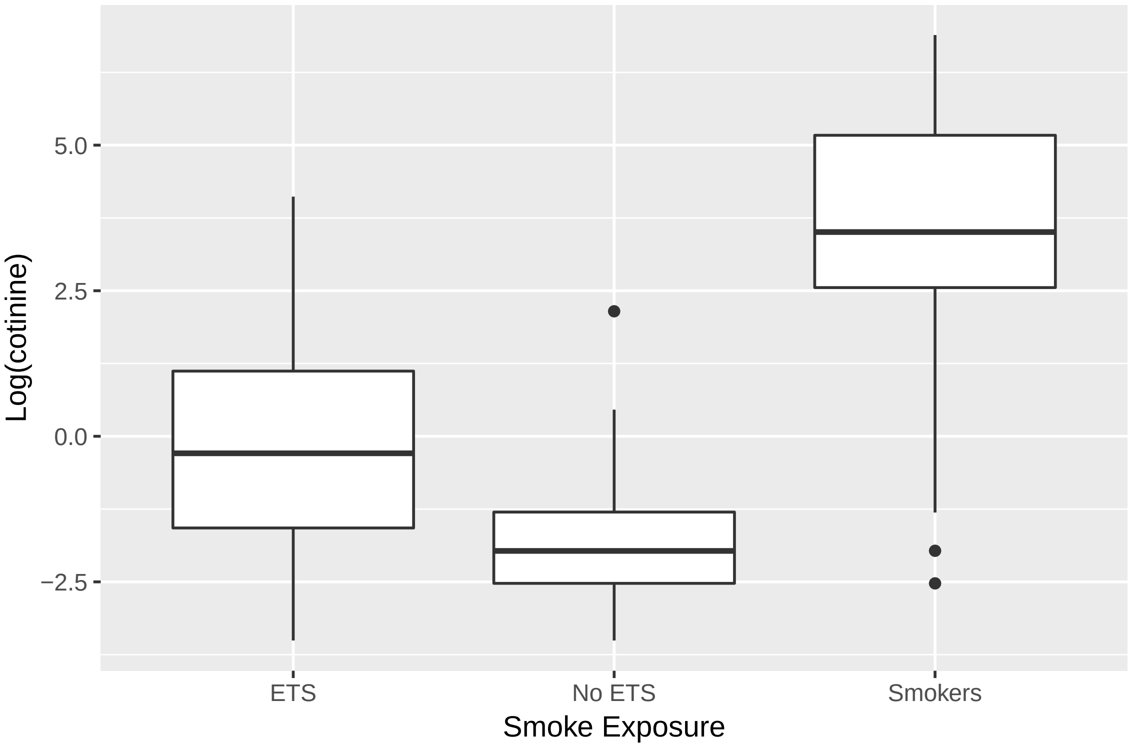
```
PassiveSmoke <- read_csv("http://nhorton.people.amherst.edu/is5/data/Passive_smoke.csv")
```

```
## Parsed with column specification:
## cols(
##   cotinine = col_double(),
##   smoke_exposure = col_character()
## )
```

```
gf_boxplot(cotinine ~ smoke_exposure, ylab = "Cotinine (ng/ml)", xlab = "Smoke Exposure",
           data = PassiveSmoke)
```



```
gf_boxplot(log(cotinine) ~ smoke_exposure, ylab = "Log(cotinine)", xlab = "Smoke Exposure",
           data = PassiveSmoke)
```


Log(cotinine)
5.0
2.5
0.0
−2.5
ETS
No ETS
Smokers
Smoke Exposure