

Data Visualization in R with ggplot2

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About ggplot2

- ▶ Developed by Hadley Wickham in 2005.
- ▶ Implements the graphics scheme described in the book *The Grammar of Graphics* by Leland Wilkinson.
- ▶ Uses a standardized system of syntax that makes it easy(-ish) to learn.
- ▶ It takes care of a lot fiddly details such as colors, scales, and legend placement.
- ▶ It does not do 3D or interactive graphics.

The Grammar of Graphics

The *Grammar of Graphics* boiled down to 5 bullets, courtesy of Wickham (2016, p. 4):

- ▶ a statistical graphic is a mapping from data to **aesthetic** attributes (location, color, shape, size) of **geometric** objects (points, lines, bars).
- ▶ the geometric objects are drawn in a specific **coordinate** system.
- ▶ **scales** control the mapping from data to aesthetics and provide tools to read the plot (ie, axes and legends).
- ▶ the plot may also contain **statistical** transformations of the data (means, medians, bins of data, trend lines).
- ▶ **faceting** can be used to generate the same plot for different subsets of the data.

Basic ggplot2 syntax

Specify data, aesthetics and geometric shapes

`ggplot(data, aes(x=, y=, color=, shape=, size=)) +
geom_point(), or geom_histogram(), or geom_boxplot(), etc.`

- ▶ This combination is very effective for exploratory graphs.
- ▶ The data must be a data frame.
- ▶ The `aes()` function maps columns of the data frame to aesthetic properties of geometric shapes to be plotted.
- ▶ `ggplot()` defines the plot; the `geoms` show the data; each component is added with `+`
- ▶ Some examples should make this clear

The Albemarle county homes data

We'll demonstrate `ggplot2` using the Albemarle County real estate data, which was downloaded from Office of Geographic Data Services.

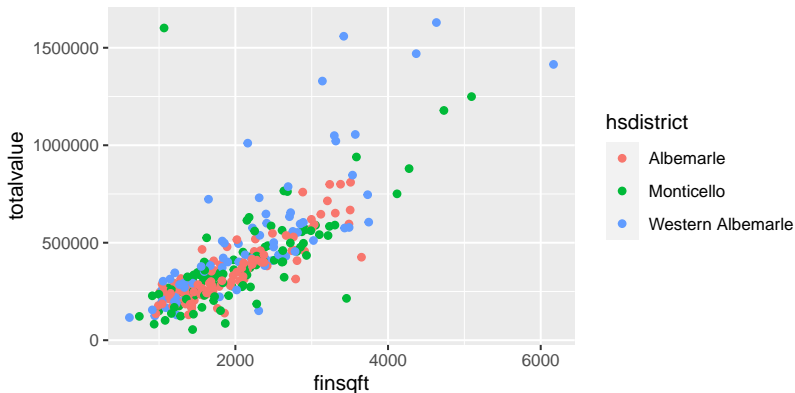
Some variables of interest:

- ▶ total value of home (`totalvalue`)
- ▶ finished square feet (`finsqft`)
- ▶ high school district in which house is located (`hsdistrict`)

Note: the following examples use a sample of the homes data.

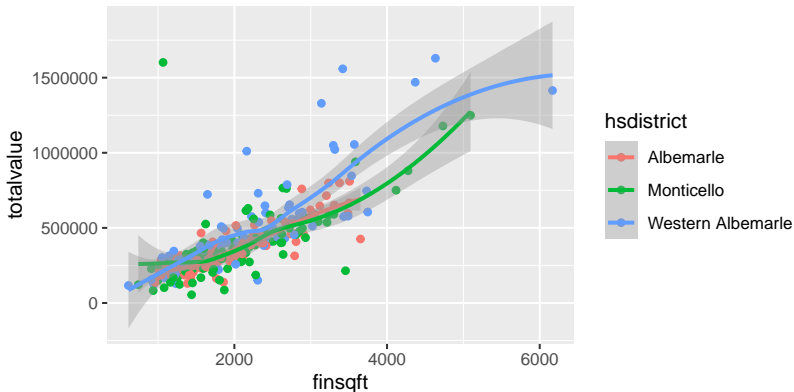
scatter plot colored by high school district

```
library(ggplot2) # or library(tidyverse)
ggplot(homes, aes(x=finsqft, y=totalvalue,
                  color=hsdistrict)) + geom_point()
```



add multiple geoms (points and smooth line)

```
ggplot(homes, aes(x=finsqft, y=totalvalue,  
                  color=hsdistrict)) + geom_point() +  
  geom_smooth()
```



Moving beyond ggplot + geoms

- ▶ A natural next step in exploratory graphing is to create plots of subsets of data. These are called facets in ggplot2.
- ▶ Use `facet_wrap()` if you want to facet by one variable and have ggplot2 control the layout. Example:
 - ▶ `+ facet_wrap(~ var)`
- ▶ Use `facet_grid()` if you want to facet by one and/or two variables and control layout yourself.

Examples:

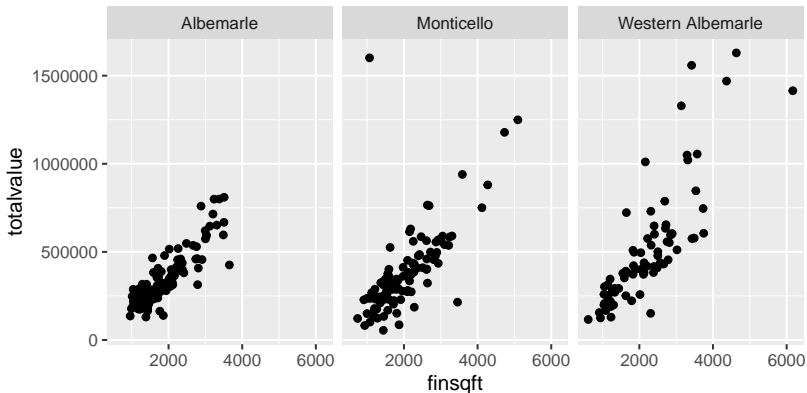
+ `facet_grid(. ~ var1)` - facets in columns

+ `facet_grid(var1 ~ .)` - facets in rows

+ `facet_grid(var1 ~ var2)` - facets in rows and columns

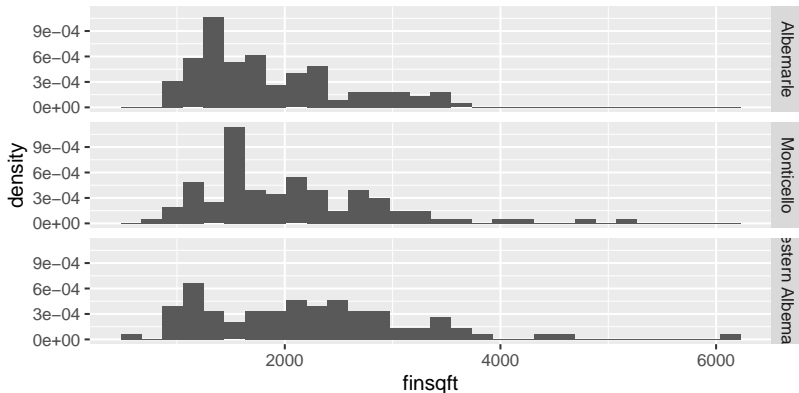
facet_wrap

```
ggplot(homes, aes(x=finsqft, y=totalvalue)) +  
  geom_point() + facet_wrap(~ hsdistrict)
```



facet_grid(histograms)

```
ggplot(homes, aes(x=finsqft, y = stat(density))) +  
  geom_histogram() + facet_grid(hsdistrict ~ .)
```

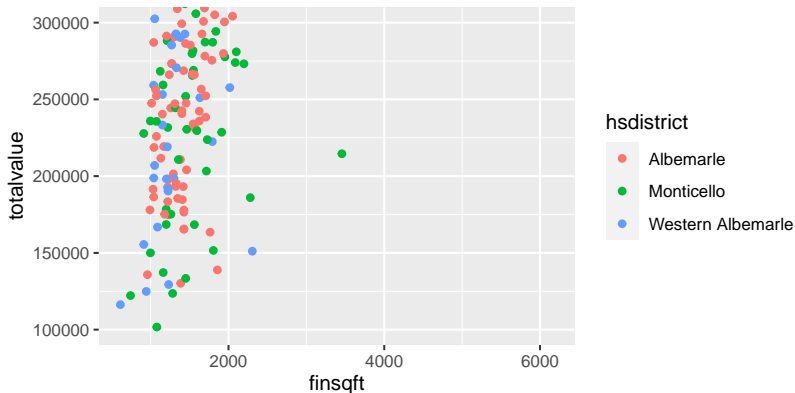


Modifying the coordinate system

- ▶ `coord_cartesian` allows us to zoom in on a plot, as if using magnifying glass
- ▶ `coord_fixed` allows us to control “aspect ratio”
- ▶ `coord_flip` allows us to flip the x and y axis

zoom in on plot

```
ggplot(homes, aes(x=finsqft, y=totalvalue,  
                  color=hsdistrict)) + geom_point() +  
  coord_cartesian(ylim = c(1e5, 3e5))
```

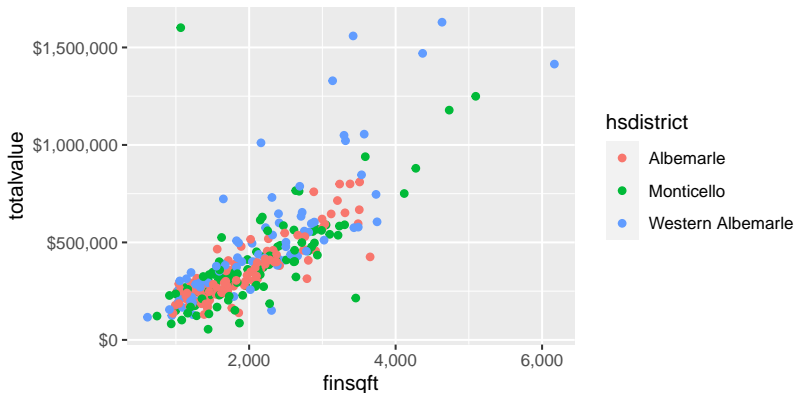


Customizing scales

- ▶ Scales control the mapping from data to aesthetics and provide tools to read the plot (ie, axes and legends).
- ▶ Every aesthetic has a default scale. To modify a scale, use a scale function.
- ▶ All scale functions have a common naming scheme:
scale _ name of aesthetic _ name of scale
- ▶ Examples: `scale_y_continuous`, `scale_color_discrete`, `scale_fill_manual`
- ▶ Heads up: The documentation for `ggplot2` scale functions will frequently use functions from the `scales` package (also by Wickham)!

update scales for x- and y-axis

```
ggplot(homes, aes(x=finsqft, y=totalvalue,  
                  color=hsdistrict)) + geom_point() +  
  scale_y_continuous(labels = scales::dollar) +  
  scale_x_continuous(labels = scales::comma)
```

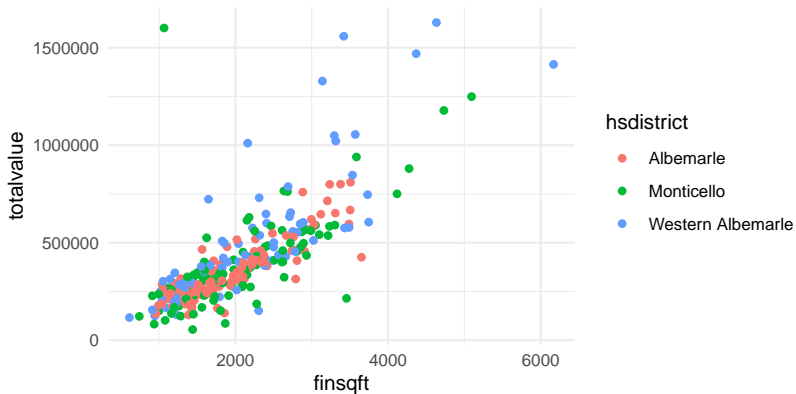


Update themes and labels

- ▶ The default ggplot2 theme is excellent. It follows the advice of several landmark papers regarding statistics and visual perception. (Wickham 2016, p. 176)
- ▶ However you can change the theme using ggplot2's themeing system. To date, there are seven built-in themes: `theme_gray` (*default*), `theme_bw`, `theme_linedraw`, `theme_light`, `theme_dark`, `theme_minimal`, `theme_classic`
- ▶ You can also update axis labels and titles using the `labs` function.

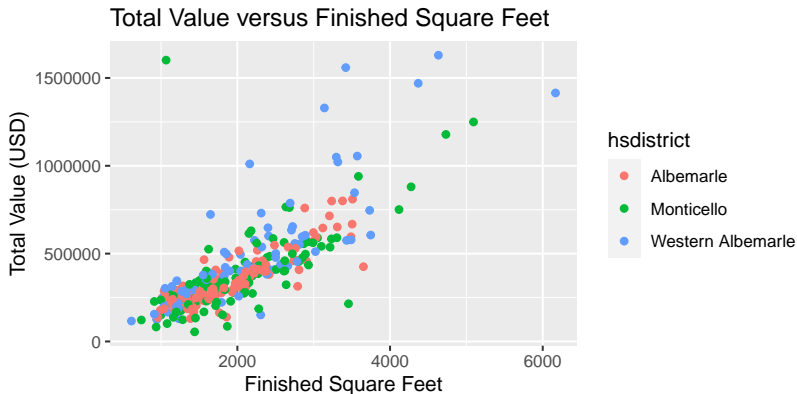
change theme

```
ggplot(homes, aes(x=finsqft, y=totalvalue,  
                  color = hsdistrict)) + geom_point() +  
  theme_minimal()
```



update labels

```
ggplot(homes, aes(x=finsqft, y=totalvalue,  
                  color = hsdistrict)) + geom_point() +  
  labs(title="Total Value versus Finished Square Feet",  
        x="Finished Square Feet", y="Total Value (USD)")
```



ggplot2 - some tips

- ▶ Can do a lot with `ggplot(data, aes()) + geom!`
- ▶ Data must be a data frame (not a matrix or collection of vectors)
- ▶ The ggplot2 documentation has many good examples
- ▶ Prepare to invest some time if you want master ggplot2; the RStudio ggplot2 cheat sheet can help.

Let's go to R!

References

- ▶ Wickham, H. (2016), *ggplot2: Elegant Graphics for Data Analysis* (2nd ed), Springer. <https://ggplot2-book.org/>
- ▶ Wickham, H. and Grolemund G. (2017), *R for Data Science*. O'Reilly. <http://r4ds.had.co.nz/>

ggplot2 cheat sheet

<https://github.com/rstudio/cheatsheets/raw/master/data-visualization-2.1.pdf>

Thanks for coming

- ▶ For statistical consulting: statlab@virginia.edu
- ▶ Sign up for more workshops or see past workshops:
<http://data.library.virginia.edu/training/>
- ▶ Register for the Research Data Services newsletter to be notified of new workshops:
<http://data.library.virginia.edu/newsletters/>