cognostics
metrics for data visualization

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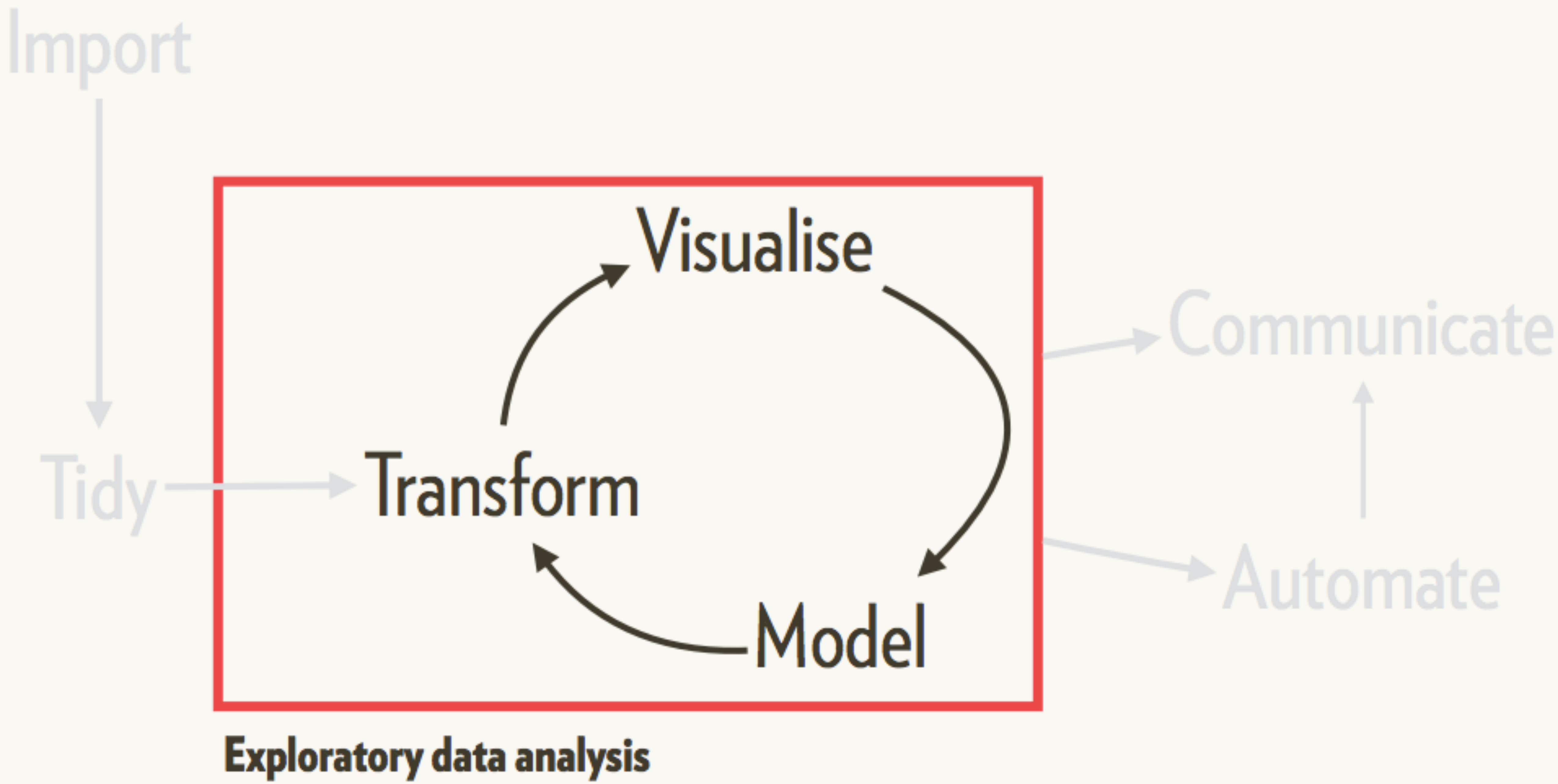
About myself

- **Purdue University**
  - 4th Year PhD Candidate in Statistics
  - Research in large data visualization using R - www.tessera.io
    - Dr. William Cleveland and Dr. Ryan Hafen
- Metamarkets.com - 1.5 years
  - Front end engineer - node.js
- **Iowa State University**
  - B.S. in Computer Engineering
  - Research in statistical data visualization with R
    - Dr. Di Cook, Dr. Hadley Wickham, and Dr. Heike Hofmann

Exploratory Data Analysis



Exploratory data analysis

http://wombat2016.org/slides/hadley.pdf

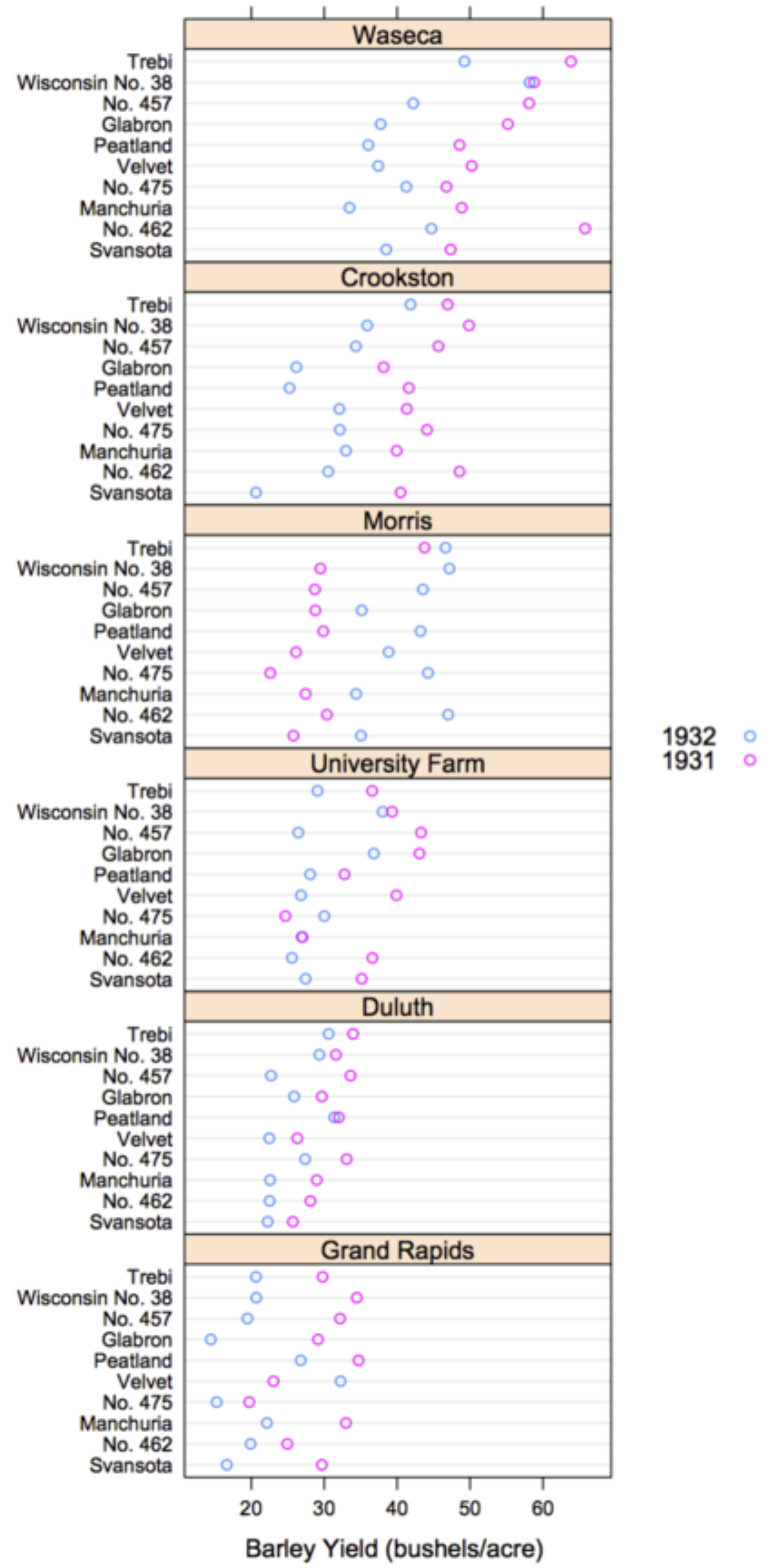
Visualization of Large Data

- Most large data visualization tools or approaches either
  - Summarize the large data to create a single plot
  - Are very specialized and heavily engineered for a particular domain
- Summaries are critical but can hide very interesting phenomena (e.g. Simpson's Paradox)
- Specialized tools can be useful but do not fit Exploratory Data Analysis paradigm (slow implementation)

We must be able to flexibly visualize complex data in detail even when the data is large!

Trellis Display

- Data is split into meaningful subsets, usually conditioning on variables of the dataset
- A visualization method is applied to each subset
- The image for each subset is called a "panel"
- Panels are arranged in an array of rows, columns, and pages, resembling a garden trellis
- `facet()`'ing in `ggplot2`



Why Trellis is Effective

- Flexible to create
  - Data complexity / dimensionality / size
    can be handled by splitting the data into subsets
  - Complete freedom with what is plotted in every panel
- Effective to consume
  - Understand one panel —> Understand every panel
  - Scanning across panels elicits comparisons to reveal repetition and change, pattern and surprise

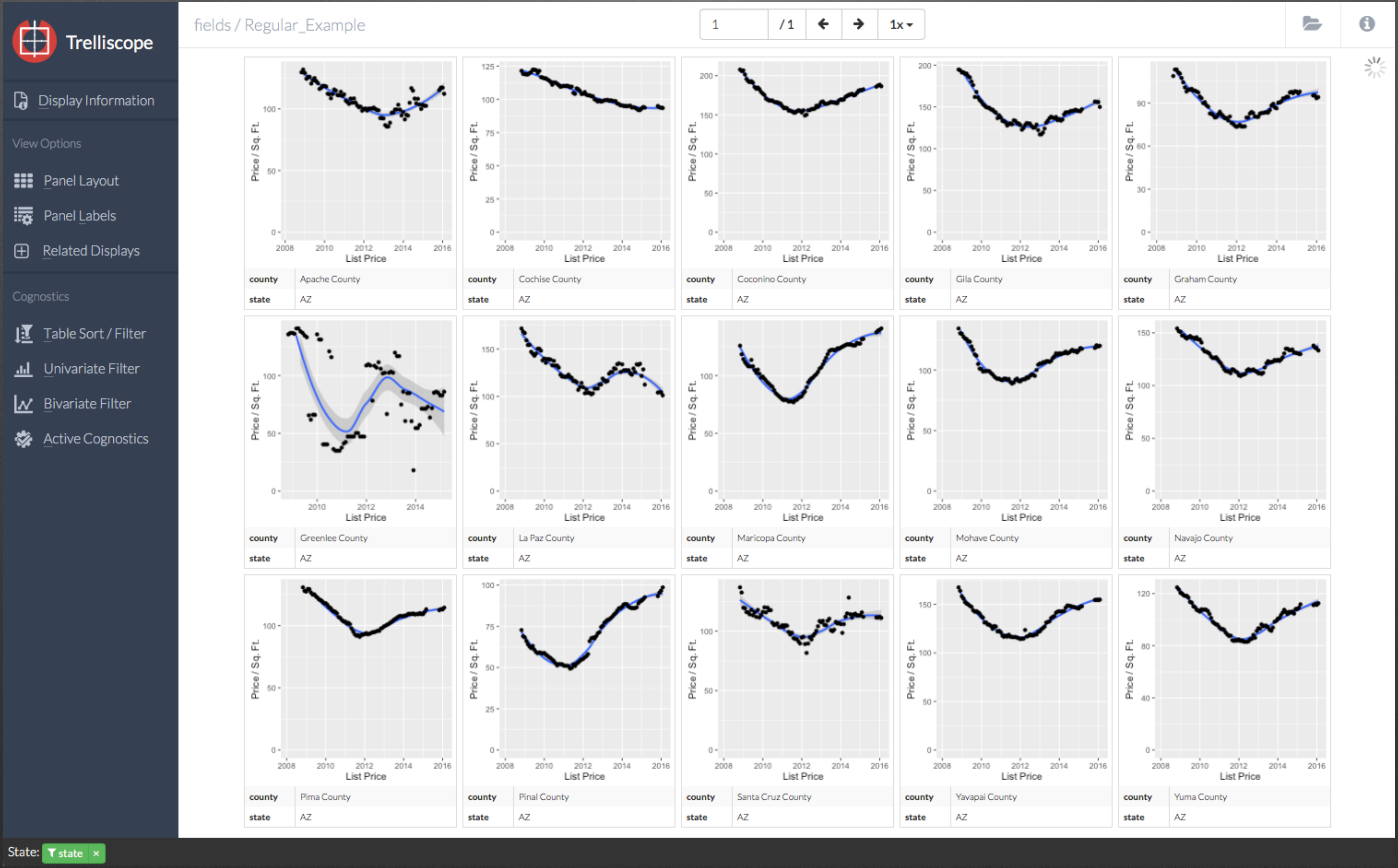
Example / Data Description

- Monthly median home listing and number of units sold for 2,984 counties in the contiguous United States From 2008 to January 2016,
- Harvested from Quandl's Zillow

```
> housing %>% dplyr::group_by(county, state)
Source: local data frame [247,082 x 7]
Groups: county, state [2,984]

     fips               county   state        time   nSold medListPriceSqft
*   <fctr>              <fctr> <fctr>      <date>   <dbl>            <dbl>
1    06037 Los Angeles County      CA 2008-01-31  505900               NA
2    06037 Los Angeles County      CA 2008-02-29  497100               NA
3    06037 Los Angeles County      CA 2008-03-31  487300               NA
4    06037 Los Angeles County      CA 2008-04-30  476400               NA
5    06037 Los Angeles County      CA 2008-05-31  465900               NA
6    06037 Los Angeles County      CA 2008-06-30  456000               NA
7    06037 Los Angeles County      CA 2008-07-31  445700               NA
8    06037 Los Angeles County      CA 2008-08-31  435300               NA
9    06037 Los Angeles County      CA 2008-09-30  426700               NA
10   06037 Los Angeles County      CA 2008-10-31  419800         273.3073
# ... with 247,072 more rows, and 1 more variables: medSoldPriceSqft <dbl>
```

Arizona



county Apache County
state AZ

county Cochise County
state AZ

county Coconino County
state AZ

county Gila County
state AZ

county Graham County
state AZ

county Greenlee County
state AZ

county La Paz County
state AZ

county Maricopa County
state AZ

county Mohave County
state AZ

county Navajo County
state AZ

county Pima County
state AZ

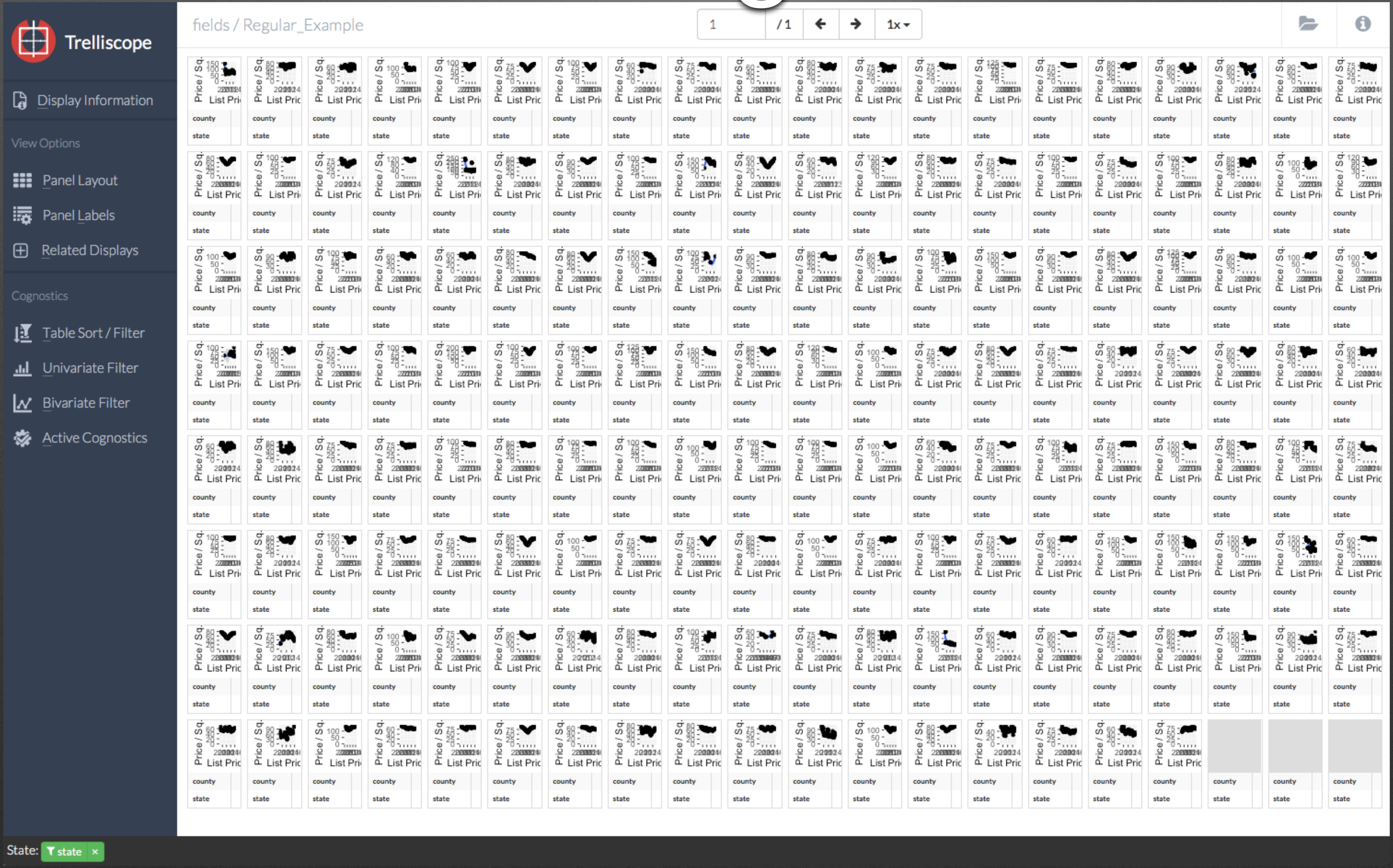
county Pinal County
state AZ

county Santa Cruz County
state AZ

county Yavapai County
state AZ

county Yuma County
state AZ

Georgia


Trelliscope
Display Information
View Options
Panel Layout
Panel Labels
Related Displays
Cognostics
Table Sort / Filter
Univariate Filter
Bivariate Filter
Active Cognostics
fields / Regular_Example
1
/ 1
1x
Price / Sq
List Price
county
state
State:
state ×

Scaling Trellis

- Large data lends itself nicely to the idea of Trellis Display
  - Typically comprised of collections of smaller data from many subjects, sensors, locations, time periods, etc.
  - It is natural to break the data up based on these dimensions and make a plot for each subset
- Potentially thousands or millions of panels
  - Will never be able to (or want to) view all of them!

Scaling Trellis with Cognostics

- Scaling Trellis:
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  - A set of cognostics that measure attributes of interest for each subset is computed
  - Panels are arranged in an array of rows, columns, and pages, resembling a garden trellis, with the arrangement being specified through interactions with the cognostics

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- Can be achieved with the Trelliscope package

Trelliscope Demo

Calculated Cognostics

```
advanced_cog <- function(x) {
  zillow_string <- gsub(” ”, ”-”, do.call(paste, getSplitVars(x)))

  model <- loess(
    medListPriceSqft ~ as.numeric(time),
    data = subset(x, !is.na(medListPriceSqft))
  )
  residuals <- model$residuals
  list(
    res_std_err = cog(model$s, desc = ”residual standard error”),
    enp = cog(model$enp, desc = ”effective number of parameters”),
    mean_list = cogMean(x$medListPriceSqft),
    n_obs_list = cog(
      length(which(!is.na(x$medListPriceSqft))),
      desc = ”number of non-NA list prices”
    ),
    zillow_href = cogHref(
      sprintf(”http://www.zillow.com/homes/%s_rb/”, zillow_string),
      desc = ”zillow link”
    )
  )
}
```

Automatic Cognostics

- Cumbersome to manually specify many cognostics for a Trelliscope display
- Should be able to automatically compute cognostics based on the context of what is being plotted
  - Help foster a scalable Trellis system
- Analyze the plot objects and choose "best" cognostics based on the plot specification
  - `ggplot2`
  - `rbokeh`
  - `plotly`

For example…

- For scatterplot layers:
    - Number of observations
    - Number of missing values
    - Summary statistics of x and y-axis variables
- For statistical layers (such as geom_smooth)
    - RMSE of fit
    - Number of outliers
- Etc. (much research going on / to be done here…)

Future work

- Continually adding more cognostics to be created for each plotting layer
- Implement
  - Fully integrate into trelliscope
  - Parse ggplot2, rbokeh, and plotly objects

Questions?

www.tessera.io
github.com/tesseradata
github.com/schloerke