Statistics 120
Multipanel Conditioning Plots

Trellis Graphics

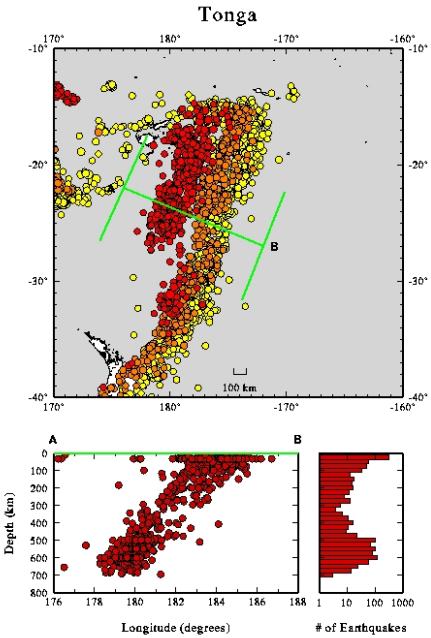
- Trellis Graphics is a family of techniques for viewing complex, multi-variable data sets.
- The ideas have been around for a while, but were formalized by researchers at Bell Laboratories during the 1990s.
- The techniques were given the name *Trellis* because they usually result in a rectangular array of plots, resembling a garden trellis.
- A number of statistical software systems provide multi-panel conditioning plots under the name *Trellis* plots or *Crossplots*.

Conditioning

- Trellis plots are based on the idea of *conditioning* on the values taken on by one or more of the variables in a data set.
- In the case of a categorical variable, this means carrying out the same plot for the data subsets corresponding to each of the levels of that variable.
- In the case of a numeric variable, it means carrying out the same plots data subsets corresponding to intervals of that variable.

Example: Earthquake Locations

- R contains a data set called `quakes` which gives the location and magitude of earthquakes under the Tonga Trench, to the North of New Zealand.
- The spatial distribution of earthquakes in the area is of major interest, because this enables us to "see" the structure of the earthquake faults.
- Here is a plot from the Geology department at Berkeley, which tries to present the the spatial structure.



Tonga Trench Earthquakes

Yellow: 0 – 70 km

Orange: 71 – 300 km

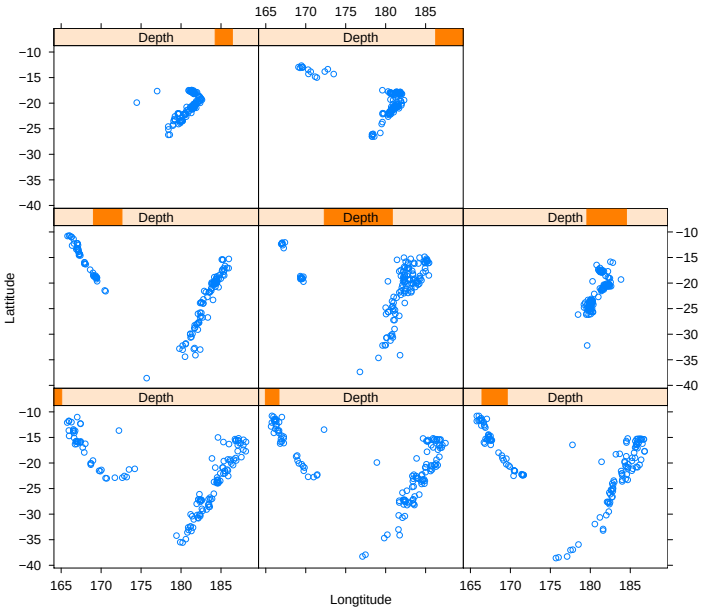
Red: 300 – 800 km.

Problems with this Presentation

- There is a good deal of overplotting and this makes it hard to see all of the structure present in the data.
- The map makes it clear that we are looking down from above on the scene, but deeper quakes appear to be plotted on top of shallower ones.
- The division of depths into three intervals and presentation using colour is relatively crude.

A Trellis Plot

- We can overcome many of the problems of the previous plot by using a trellis display.
- We create the display by producing a sequence of graphs, each of which presents a different range of depths.
- In this case we will have a slight overlap of the intervals being plotted.


Depth
Depth
Depth
Depth
Depth
Depth
Depth
Depth
Depth
Lattitude
Longtitude
165
170
175
180
185
−10
−15
−20
−25
−30
−35
−40

Explanation

- The plot is read left-to-right and bottom-to-top.
- Depth increases progressively through the plot.
- There are eight different depth intervals, each containing approximately the same number of earthquakes.
- Consecutive depth intervals overlap by a small amount.
- The range of depths covered by each interval is indicated in the bar above each plot.

Intepretation

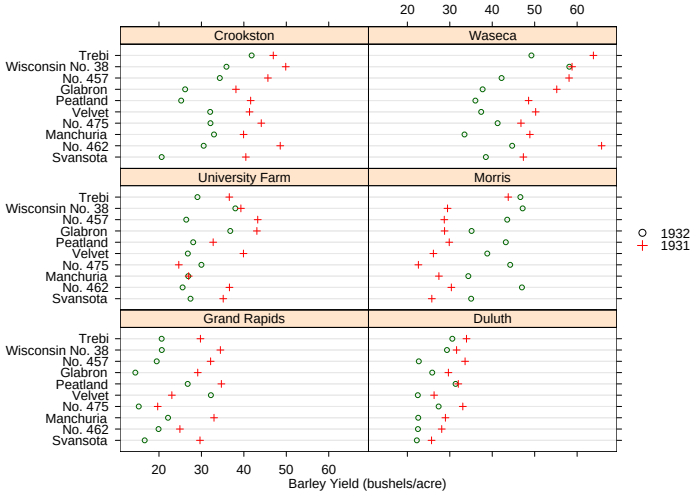
- The shallower earthquakes are concentrated on two inclined fault planes.
- The most easterly of these fault planes is the one which bisects New Zealand.
- The Westerly fault plane has mainly shallow earthquakes, while the Easterly fault plane has both shallow and deep earthquakes.
- The deep earthquakes show distinct small angular fishhook structure which is not visible in the earlier plot.

Example: Barley Yields

- This example is concerned with the yields obtained from field trials of barley seed.
- The data comes from the 1930s so there is no direct genetic modification going here.
- The trials were conducted in 1931 and 1932, using:
  - 10 different strains of barley
  - 6 different growing sites
- There are $2 \times 10 \times 6 = 120$ observations.
- It was suspected for a long time that there was something odd about this data set.

The Trellis Plot

- The plot we will look at shows that barley yields for each of the 10 strains at the 6 sites and for each year.
- The results for each site are plotted on a separate graph – i.e. we are working conditional on the site.
- The yields from the two years are superimposed on each of the plots.


Crookston
Waseca
University Farm
Morris
Grand Rapids
Duluth
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
20
30
40
50
60
1932
1931
Barley Yield (bushels/acre)

Interpretation

- When the data are present in this way it is easy to see what is odd about them.
- The yields for 1931 were higher than those for 1932 at all sites except Morris, where the pattern is reversed.
- The clear implication is that the yield values at Morris were switched at some point.

The Trellis Technology

- There are a variety of displays which can be produced by Trellis, including:
  - Bar Charts
  - Dot Charts
  - Box and Whisker Plots
  - Histograms
  - Density Traces
  - QQ Plots
  - Scatter Plots
- A common framework is used to produce all these plots.

Some Terminology

- Every Trellis display consists of a series of rectangular *panels*, laid out in a regular row-by-column array.
- The indexing of the array is left-to-right, bottom-to-top.
- The *x* axes of all the panels are identical. This is also true for the *y* axes.
- Each panel of the a display corresponds to conditioning, either on the levels of a factor, or on sub-intervals of the range of a numeric variable.

Shingles

- The conditioning carried out in the earthquake plot is described by a *shingle*.
- A shingle consists of a number of overlapping intervals (like the shingles on a roof of a house).
- Assuming that the earthquake depths are contained in the variable `depth`, the shingle is created as follows.

```
> Depth = equal.count(depth,
                      number=8,
                      overlap=.1)
```

- The shingle assigned to `Depth` has 8 intervals with adjacent intervals having 10% of their values in common.

Shingles

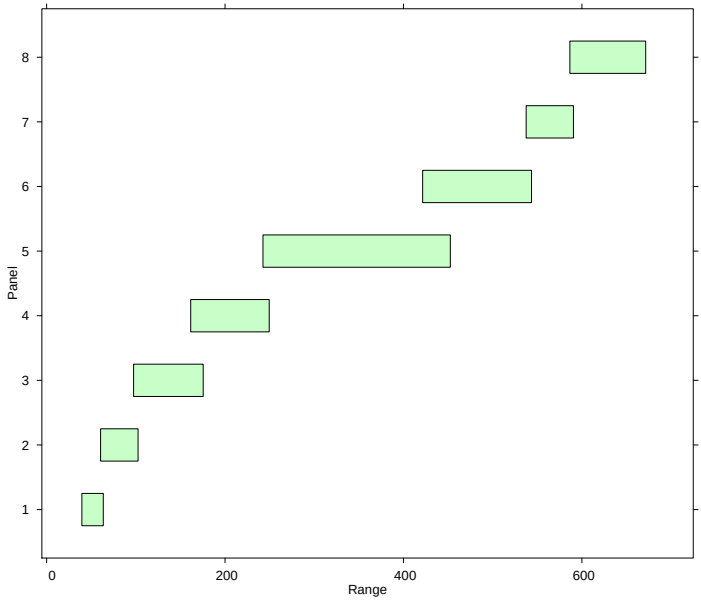
- A shingle contains the numerical values it was created from and can be treated like a copy of that variable. For example:

```
> range(Depth)
[1]  40 680


> range(depth)
[1]  40 680
```

- A shingle also has the information attached to it. This can be displayed by printing or plotting the shingle.

```
> plot(Depth)
```


Panel
8
7
6
5
4
3
2
1
0
200
400
600
Range

Producing the Plot

- The display of the earthquakes is produced by the function `xyplot`, which is the Trellis variant of a scatter plot function.
- The plot was produced as follows:

```
> data(quakes)
> Depth = equal.count(quakes$depth,
                      number=8,
                      overlap=.1)
> xyplot(lat ~ long | Depth, data = quakes,
       xlab = "Longtitude", ylab = "Lattitude")
```

- There are three steps here (i) loading the data, (ii) creating the shingle and (iii) producing the display.

The Plot Formula

- The first argument to `xyplot` is a symbolic formula describing the plot.
- In this case the formula is:

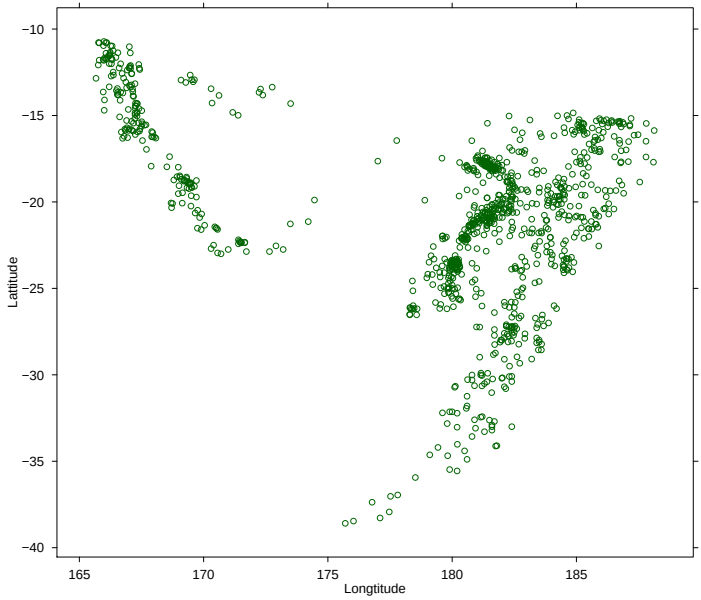
  ```
  lat ~ long | Depth
  ```

  which is an instruction to plot `lat` on the *y* axis against `long` on the *x* axis with conditioning intervals as described in `Depth`.
- The second argument to `xyplot` specifies which data frame the data for the plot should be obtained from.
- Additional arguments control other aspects of the plot.

Unconditional Plots

- The `xyplot` function can be used to produced an unconditional plot by omitting the conditioning specification from the plot formula.

```
> xyplot(lat ~ long, data = quakes,
       xlab = "Longtitude",
       ylab = "Lattitude")
```


−10
−15
−20
−25
−30
−35
−40
Latitude
165
170
175
180
185
Longtitude

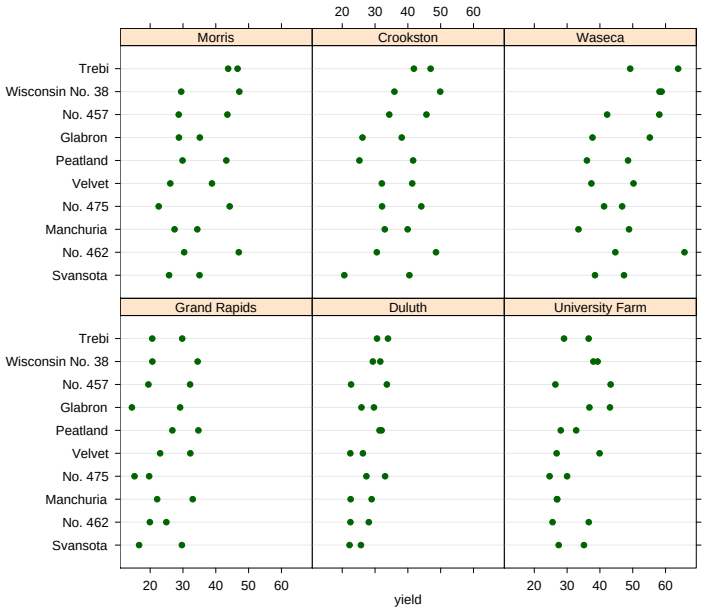
The Barley Yield Plot

- The barley yield plot is produced by the function `dotchart` which can be used to numeric values against a categorical variable.
- In this case, the numeric variable is the barley yield and the categorical variable is the seed strain.
- We also condition on the value of another variable, the growing site.

A First Attempt

- The following code is a simple attempt at creating a dot chart using similar code to that for the earthquakes.

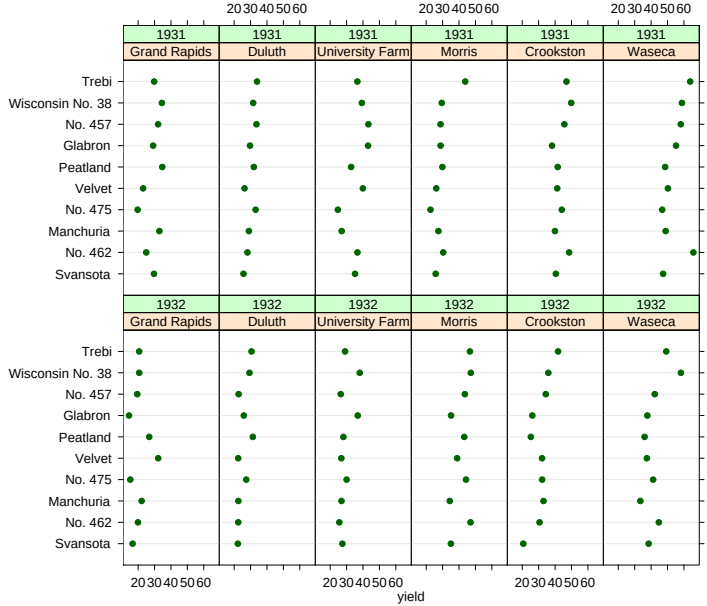
```
> dotplot(variety ~ yield | site,
          data=barley)
```


Morris
Crookston
Waseca
Grand Rapids
Duluth
University Farm
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
20
30
40
50
60
yield

A Second Attempt

- We could also try conditioning on both site and year.

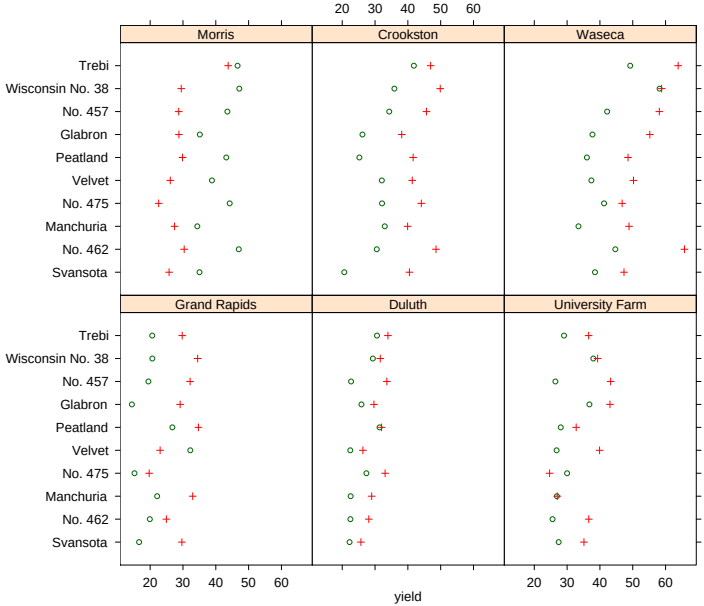
```
> dotplot(variety ~ yield | site * year,
          data=barley)
```


20 30 40 50 60
1931
Grand Rapids
Duluth
University Farm
Morris
Crookston
Waseca
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
1932
yield

A Third Attempt

- What we need is to superimpose the two years for each site on a single panel.

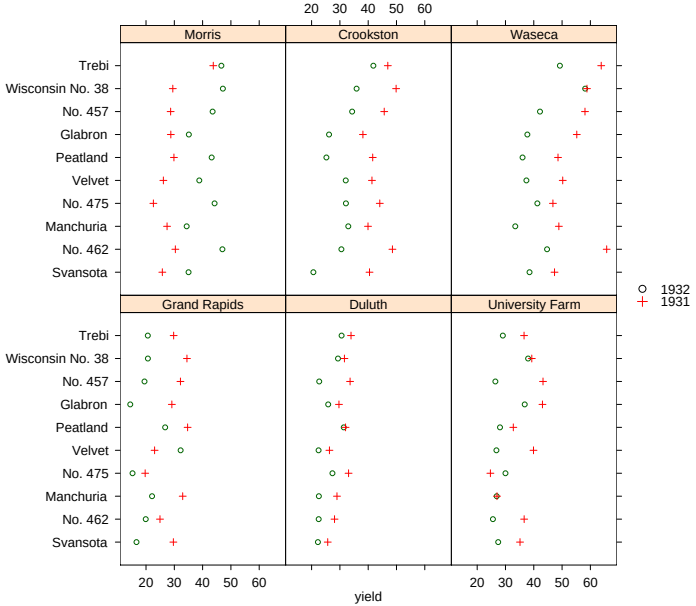
```
> dotplot(variety ~ yield | site, data=barley,
          panel = panel.superpose,
          group = year,
          pch = c(1,3))
```


Morris
Crookston
Waseca
Grand Rapids
Duluth
University Farm
Trebi
Wisconsin No. 38
No. 457
Glabron
Peatland
Velvet
No. 475
Manchuria
No. 462
Svansota
20
30
40
50
60
yield

A Fourth Attempt

- The last plot is quite close.
- We need to add a legend which indicates which year is which.

```
> dotplot(variety ~ yield | site, data=barley,
          panel = panel.superpose,
          group = year, pch = c(1,3),
          key = list(space="right",
                     transparent = TRUE,
                     points=list(pch=c(1,3),
                     col=1:2),
                     text=list(c("1932",
                                 "1931"))))
```


Morris
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Velvet
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20
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yield
1932
1931