

Data Visualization With R

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Philosophy

Good visualizations are useful at every stage of the data analysis process from exploration to publication.

R has multiple graphics systems. We will use two:

- ▶ Base R graphics are often intuitive, but limited.
- ▶ `ggplot2` is robust and widely used. It takes some acclimatization.

Many older resources use `lattice` graphics, which started dropping in popularity as `ggplot2` took over.

Be wary of inference based on purely exploratory data analysis. If you look at your data until you find a pattern, and then test for that pattern, the significance levels of that test are inflated.

Loading data

Step 0 of visualizing your data with R is loading it.

- ▶ Clean your data spreadsheet:
 - ▶ Remove non-data (summaries, etc.)
 - ▶ Fix typos
 - ▶ Make good variable names
 - ▶ meaningful
 - ▶ not too long
 - ▶ no spaces - use `under_score` or `camelCaps` instead
 - ▶ don't start with a number
 - ▶ More good advice from [Data Carpentry](#)
- ▶ Save data as a `csv`.
- ▶ Put it in the working directory, possibly in a *data* subdirectory.
- ▶ Read it in with `read.csv` or `read_csv`.

Check the data loaded correctly

- ▶ Use `str` to check that all the variables have been coded correctly (factors, dates), and fix anything that needs fixing.
- ▶ use `head` or `View` to see that the data look right.

```
str(ReedfrogPred); head(ReedfrogPred) # data in emdbook
```

```
## 'data.frame':    48 obs. of  5 variables:
## $ density : int  10 10 10 10 10 10 10 10 10 10 ...
## $ pred     : Factor w/ 2 levels "no","pred": 1 1 1 1 1 1 1 1 2 2 ...
## $ size     : Factor w/ 2 levels "small","big": 2 2 2 2 1 1 1 1 2 2 ...
## $ surv     : num   9 10 7 10 9 9 10 9 4 9 ...
## $ propsurv: num   0.9 1 0.7 1 0.9 0.9 1 0.9 0.4 0.9 ...

##   density pred  size surv propsurv
## 1      10   no   big    9      0.9
## 2      10   no   big   10      1.0
## 3      10   no   big    7      0.7
## 4      10   no   big   10      1.0
## 5      10  no small    9      0.9
## 6      10  no small    9      0.9
```

Exploration

Data are in R, now what?

- Check numerical summaries.

```
summary(ReedfrogPred) # data in emdbook
```

##	density	pred	size	surv	propsurv
##	Min. :10.00	no :24	small:24	Min. : 4.00	Min. :0.1143
##	1st Qu.:10.00	pred:24	big :24	1st Qu.: 9.00	1st Qu.:0.4964
##	Median :25.00			Median :12.50	Median :0.8857
##	Mean :23.33			Mean :16.31	Mean :0.7216
##	3rd Qu.:35.00			3rd Qu.:23.00	3rd Qu.:0.9200
##	Max. :35.00			Max. :35.00	Max. :1.0000

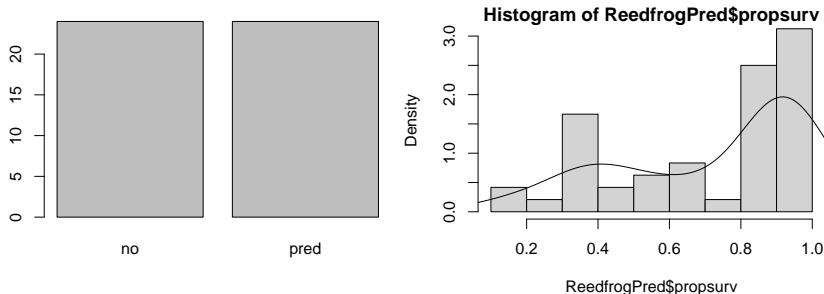
- Make some graphics!
 - Are there patterns that you expected to see?
 - Or didn't expect to see?
 - Are there problems with the data?

Standard routines - one variable

Graphing the distribution of a single variable means representing how often it takes each possible value.

- ▶ Barplots for categorical variables. Same information as a table.
- ▶ Histograms for numeric variables. Can add a density estimate.

```
par(mfrow=c(1,2)) # show multiple base R plots at once
barplot(table(ReedfrogPred$pred))
hist(ReedfrogPred$propsurv,freq=F); lines(density(ReedfrogPred$propsurv))
```

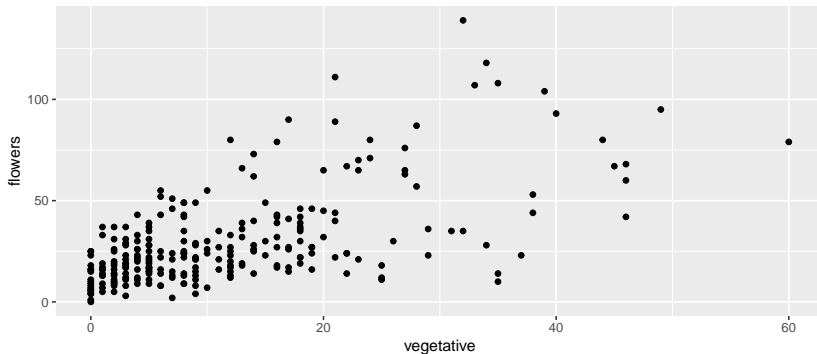


Standard routines - two numeric variables

Scatterplots show codistribution.

► Put the response variable on the y axis.

```
p <- ggplot(Lily_sum, aes(vegetative, flowers)) + # data are in emdbook  
  geom_point()  
p
```



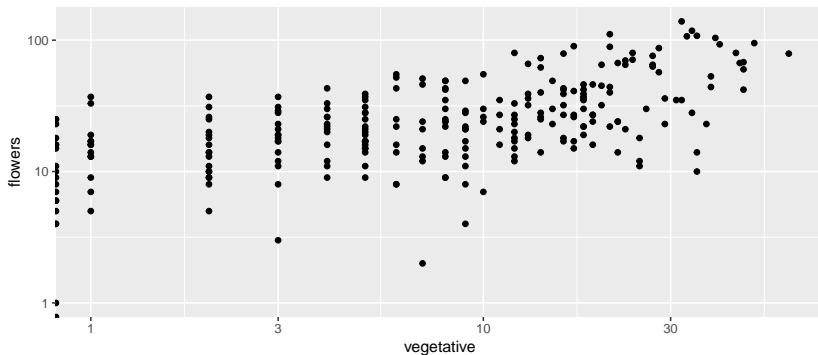
Log scales

Sometimes the data look better with axes on log scales.

- ▶ Counts
- ▶ Dimesnional data

Recall $\log(0)$ is undefined so 0 values will produce warnings or errors.

```
p + scale_x_log10() +  
  scale_y_log10()
```



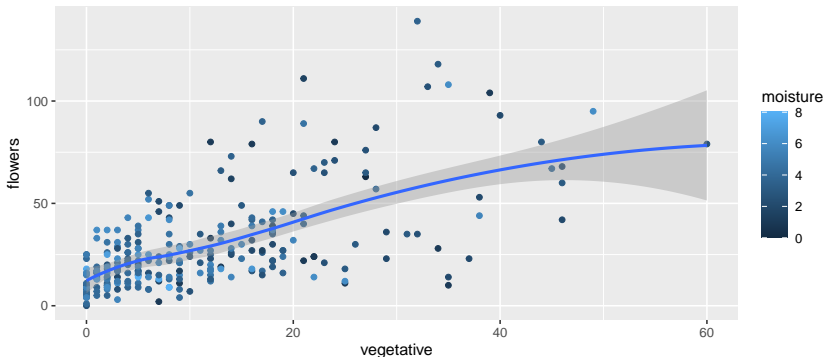
Additional aesthetics

Map additional variables to color, size or shape (plotting symbol).

- ▶ Shape can only be a categorical variable.
- ▶ Size can only be a numerical variable.

Can also superimpose trendlines or other model graphs.

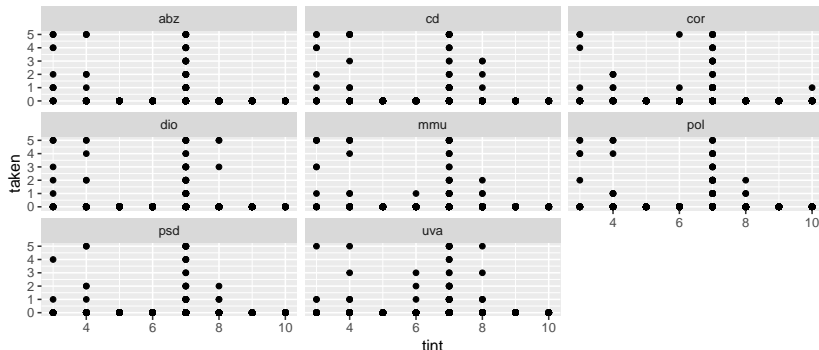
```
ggplot(Lily_sum, aes(vegetative, flowers, color = moisture)) +  
  geom_point() +  
  geom_smooth()
```



Faceted plots

Categorical variables can also be represented by making multiple plots. Add facets to a ggplot and specify the variable or variables with `facet_wrap(~varA)` or `facet_grid(varB~varA)`.

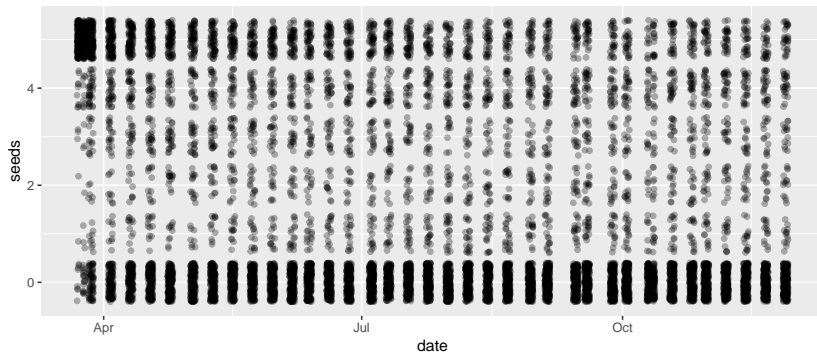
```
ggplot(SeedPred, aes(tint, taken))+ # data in emdbook
  geom_point()+
  facet_wrap(~species)
```



Jittering and transparency

If there are many data points that take the same values, adding a jitter to the points' position and some transparency can make patterns easier to see.

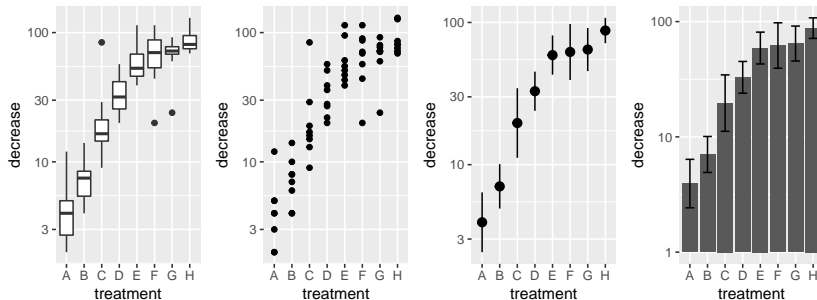
```
ggplot(SeedPred, aes(date, seeds)) + # data in emdbook  
  geom_jitter(alpha= 0.3)
```



Standard routines - numeric and categorical

If the response is numeric and all predictors are categorical, you have some options.

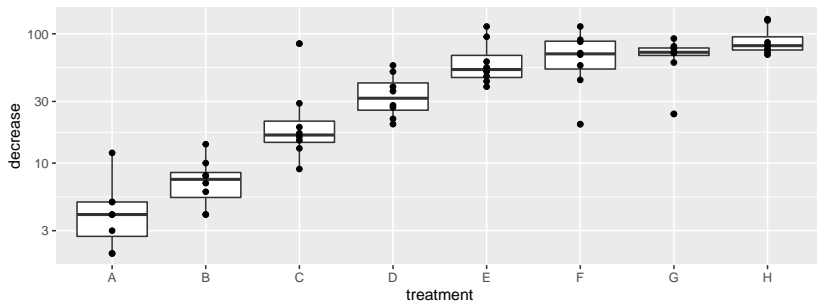
```
g0 <- ggplot(OrchardSprays,aes(x=treatment,y=decrease))+ # data in MASS
  scale_y_log10()
g_boxplot <- g0 + geom_boxplot()
g_point <- g0 +geom_point()
g_errbar <- g0 + stat_summary(fun.data=mean_cl_normal,geom="pointrange")
g_dyn <- g0 + stat_summary(fun=mean,geom="bar")+
  stat_summary(fun.data=mean_cl_normal,geom="errorbar",width=0.5)
grid.arrange(g_boxplot,g_point,g_errbar,g_dyn, nrow=1)
```



Combining layers

Multiple geoms can be added to the same plot.

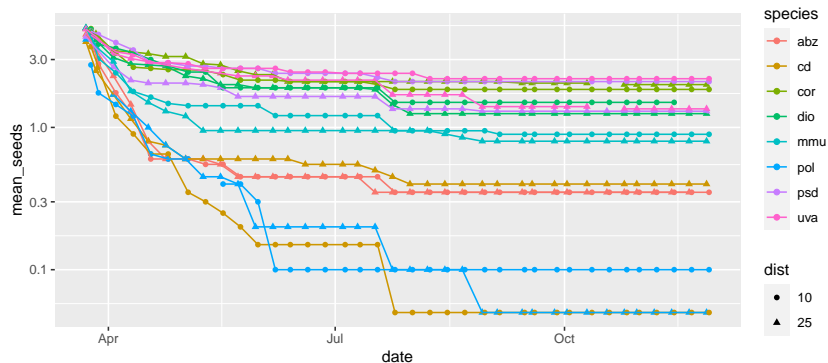
```
g0 + geom_boxplot() + geom_point()
```



Dealing with non-standard tasks

Sometimes you need to reshape or summarize your data to plot what you want. To produce Figure 2.1 from Bolker (2008):

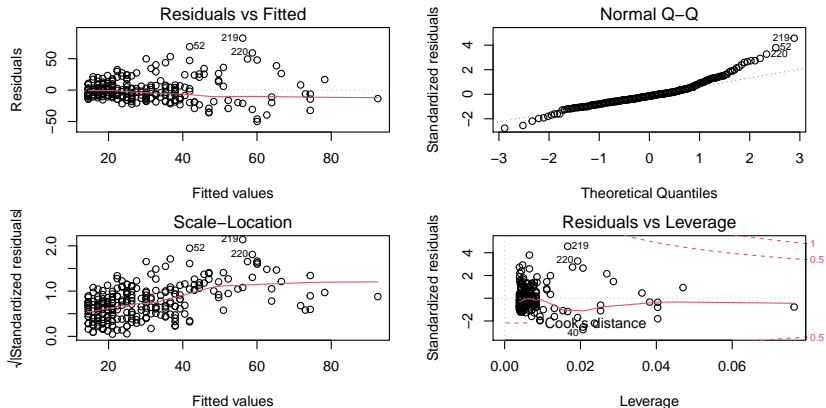
```
daily_avgs <- SeedPred %>%  
  group_by(date, species, dist) %>%  
  summarise(mean_seeds = mean(seeds))  
ggplot(daily_avgs, aes(date, mean_seeds, color=species, shape=dist)) +  
  geom_point() + geom_line() + scale_y_log10()
```



Diagnostics

Assessing the validity of a model is often done graphically.

```
lm1 <- lm(flowers~vegetative, data = Lily_sum)
par(mfrow=c(2, 2), mar = c(4, 4, 2, 2)) # see all 4 plots at once
plot(lm1)
```

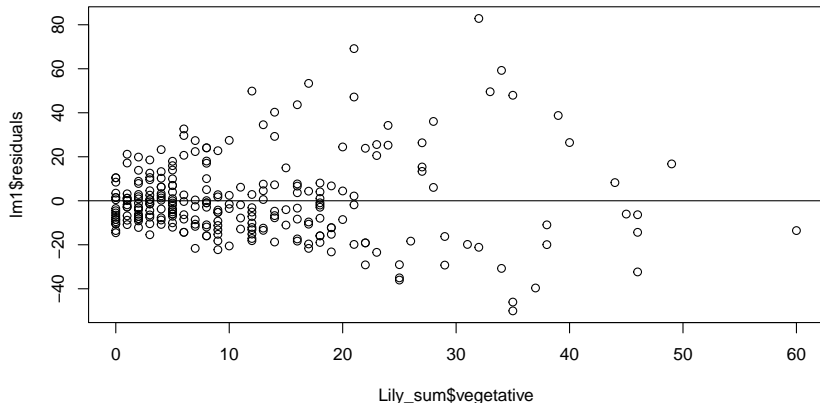


```
par(mfrow=c(1, 1), mar = c(4, 4, 0.75, 0.5)) # restore graphics parameters
```

Residuals v. predictors

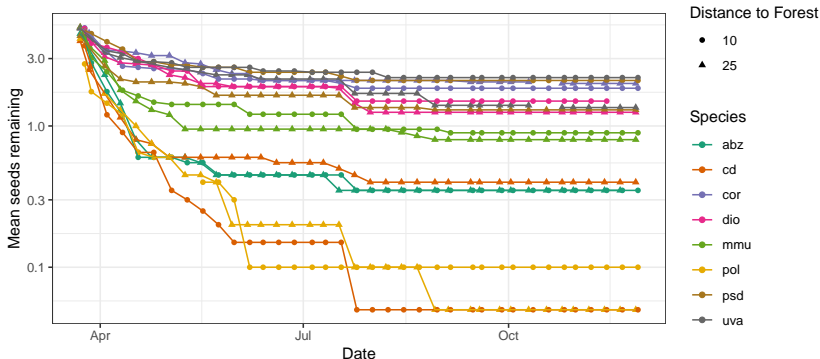
The plot method for `lm` doesn't show residuals against predictors. Do that manually.

```
plot(lm1$residuals~Lily_sum$vegetative)  
abline(h=0)
```



Fine tune and save graphics for presentation

```
emd2.1<-ggplot(daily_avgs,aes(date,mean_seeds,color=species,shape=dist))+  
  geom_point() + geom_line() + scale_y_log10() +  
  labs(y="Mean seeds remaining", x = "Date",  
       color = "Species", shape = "Distance to Forest") +  
  scale_color_brewer(palette = "Dark2") +  
  theme_bw()  
emd2.1
```



```
ggsave("figures/BolkerFig2.1.tiff", plot=emd2.1,  
       width = 10, height = 4, units = "cm", dpi = 800)
```

Opinions on graphical style

Plenty of people with good ideas about style.

- ▶ Leland Wilkinson
- ▶ Edward Tufte
- ▶ William Cleaveland
- ▶ Andrew Gelman

Some graph types are controversial. That doesn't mean never use them, but if you do, be aware of the criticisms.

- ▶ Pie charts, dynamite plots, dual-axes plots

References

Bolker, Benjamin M. 2008. *Ecological Models and Data in R*. Princeton University Press.