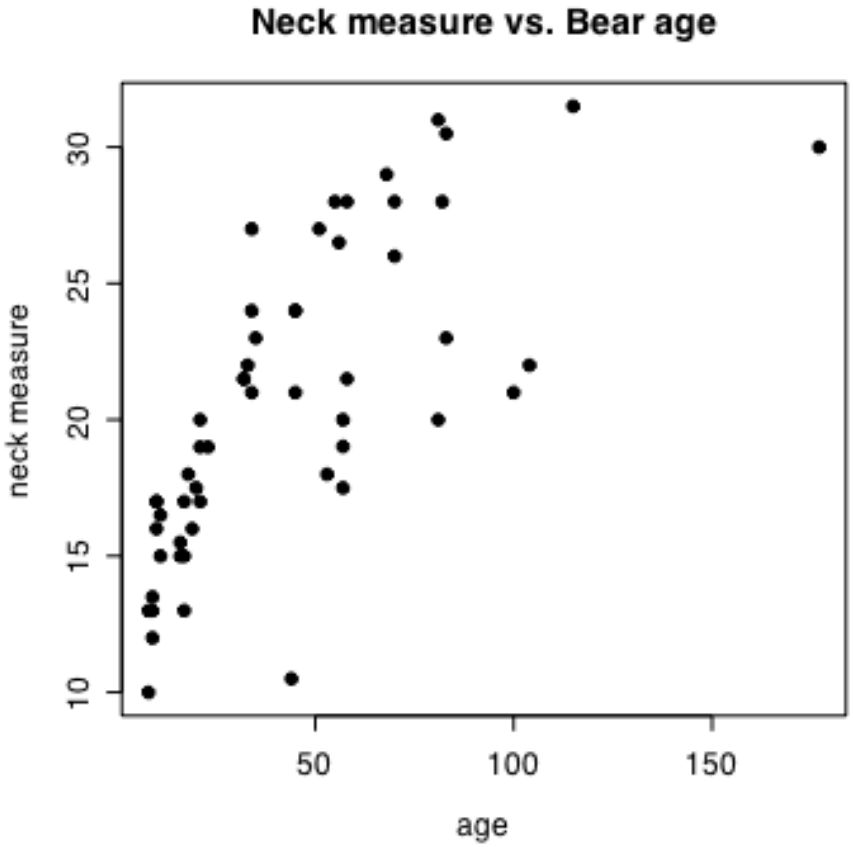
Chapter 7

- Scatterplots,
  Association,
  and Correlation

Scatterplots & Correlation

- Here, we see a **positive** relationship between a bear's age and its neck diameter.

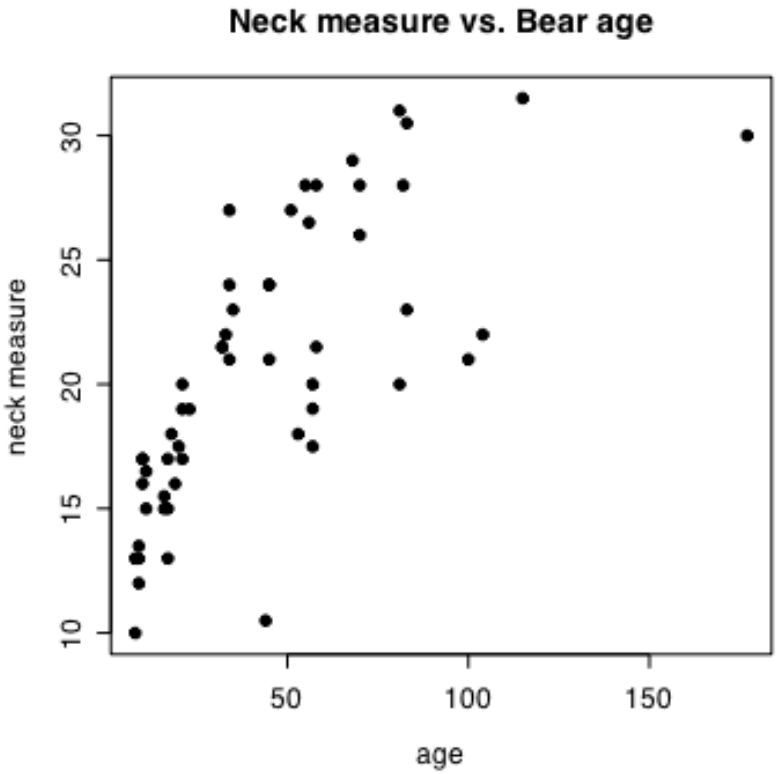


As a bear gets older, it tends to have a larger neck.

Scatterplots & Correlation

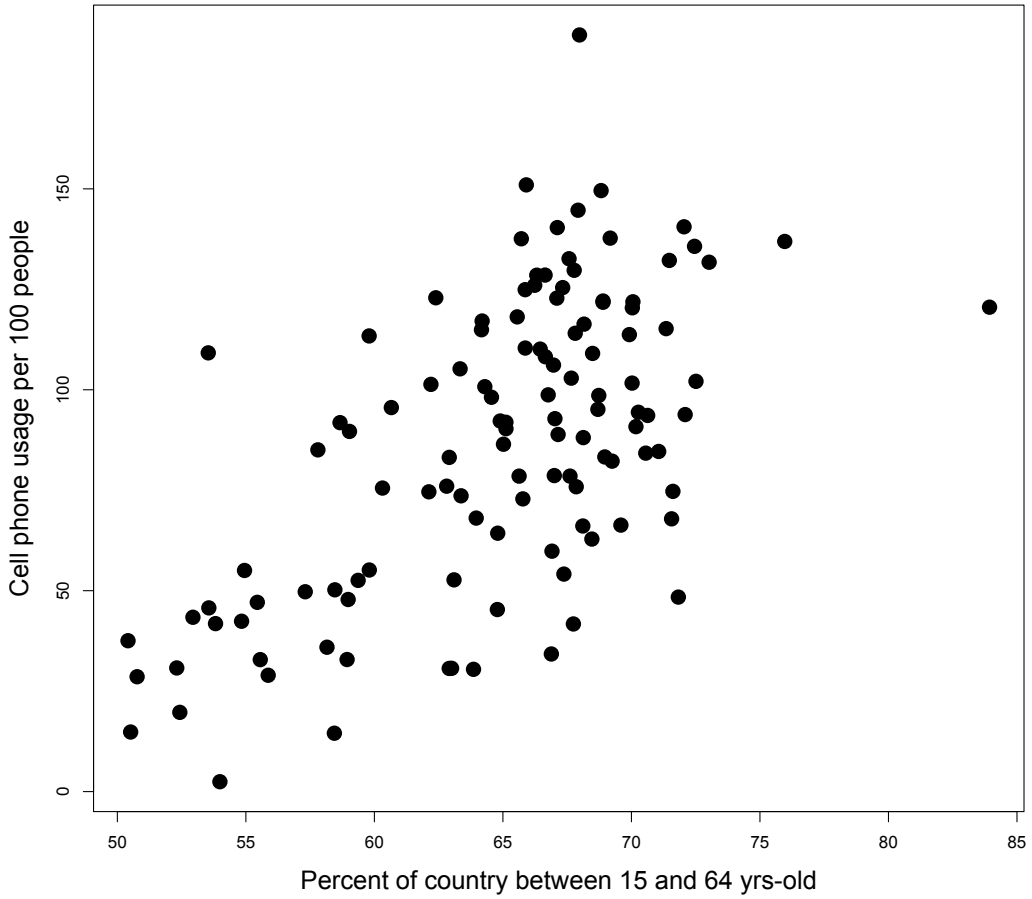
- Statistics is about … **variation**.

- Recognize, quantify and try to explain variation.
  - Variation in neck measurements can be explained, at least in part, by the age of the bear.
  - Older bear → Larger neck



Positive Association

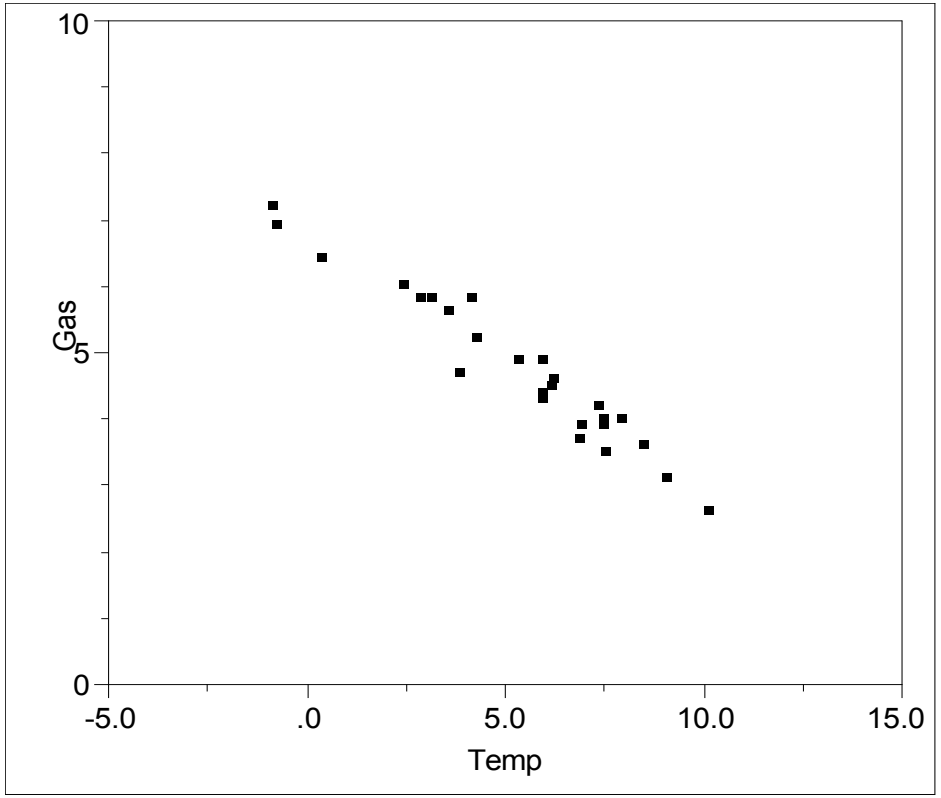
Cell phone usage per 100 people vs. Percent of individuals between 15 & 64



- Data from 2008.
- These variables have a **positive** correlation…
  - A country with a larger percentage of people between 15-64 tends to have more cell phone users.

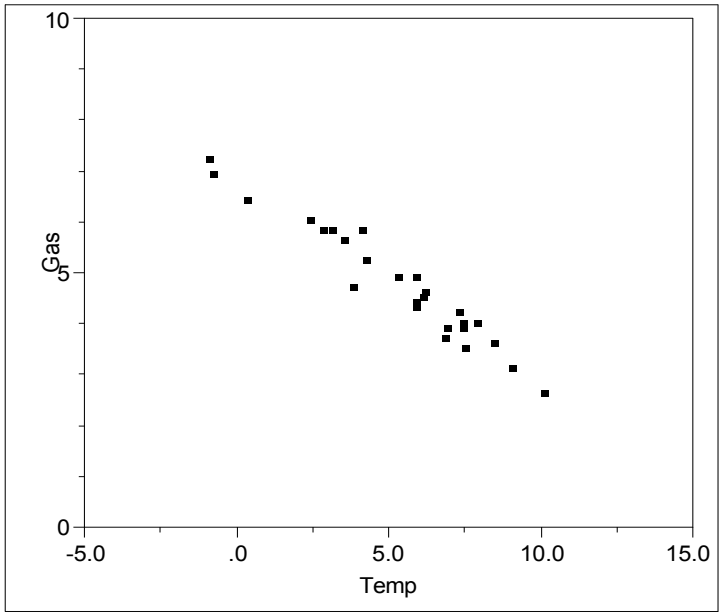
Negative Association

- Outside temperature and amount of natural gas used.
- These variables have a **negative** correlation…
  - Days with higher temperature tend to use less natural gas.
  - Higher temperature→ Less gas used



Scatterplots & Correlation

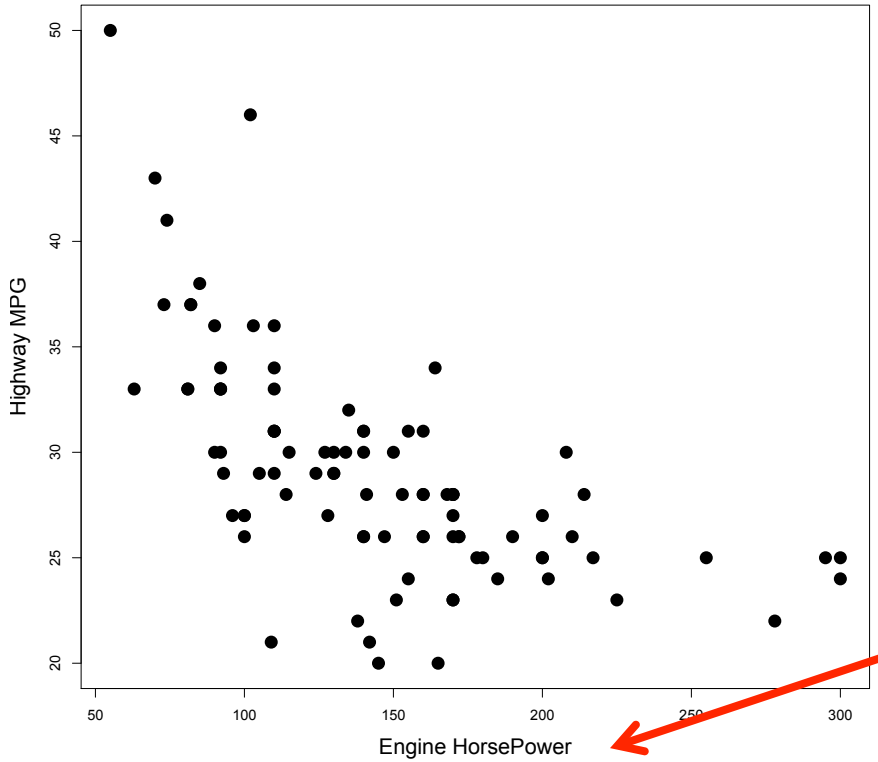
- When the two variables of interest are **continuous variables**, we can plot their relationship with a **scatterplot** (or scatter diagram).



- A scatterplot gives you a quick look at the general relationship between the variables.
- Each observation provides one point on the plot.

- Response variable – plotted on the vertical axis.
  - Also called the dependent variable.
- Explanatory variable – plotted on the horizontal axis.
  - Used to try to explain variation in the response variable.
  - Also called the independent variable.

HWY-mpg is the response variable



Here, we use Engine HPW to explain the variability in HWY-mpg.

Engine HPW is the explanatory variable

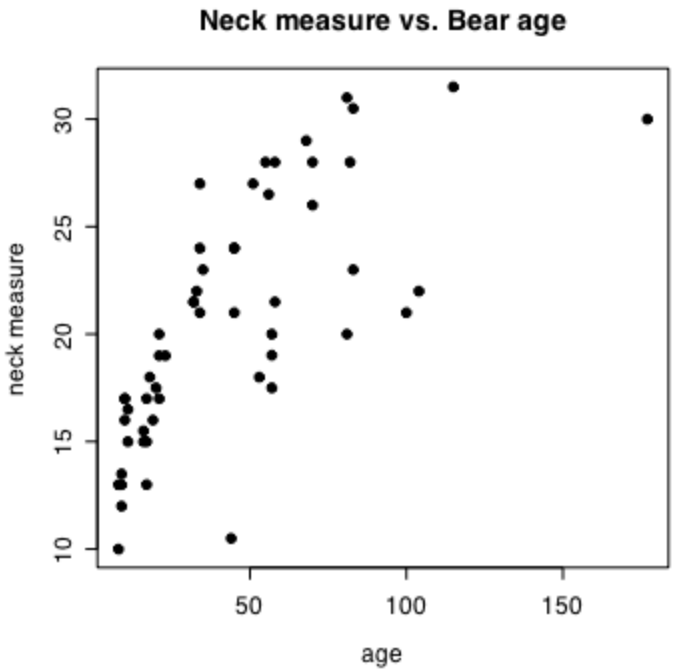
Correlation and Association

Definition

A **correlation** exists between two variables when higher values of one variable consistently go with higher values of another variable or when higher values of one variable consistently go with lower values of another variable.

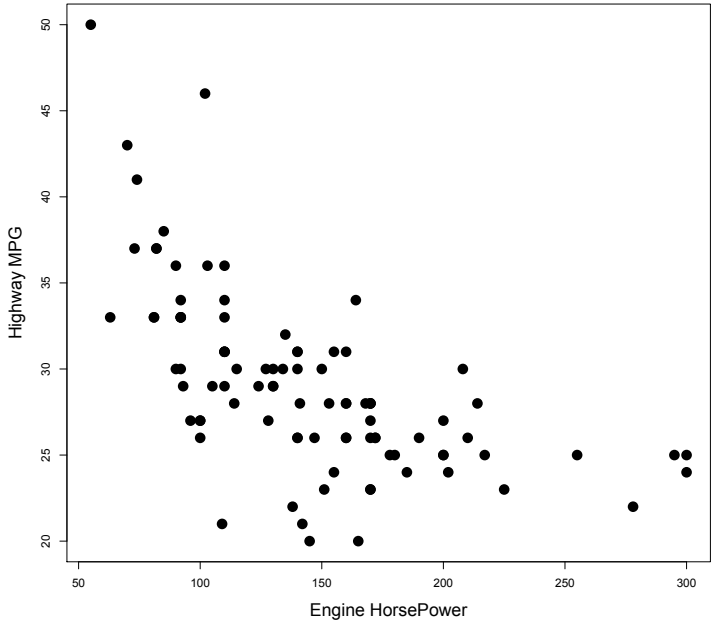
- When describing relationships, we use the terms correlation and association interchangeably. If variables are **correlated**, we say they are **associated**.

Positive Association
(correlation)



- Positive Association
  - Above average values of Age are associated with above average values of Neck Measure (age-high goes with neck-high)
  - Below average values of Age are associated with below average values of Neck Measure(age-low goes with neck-low)

Negative Association
(correlation)



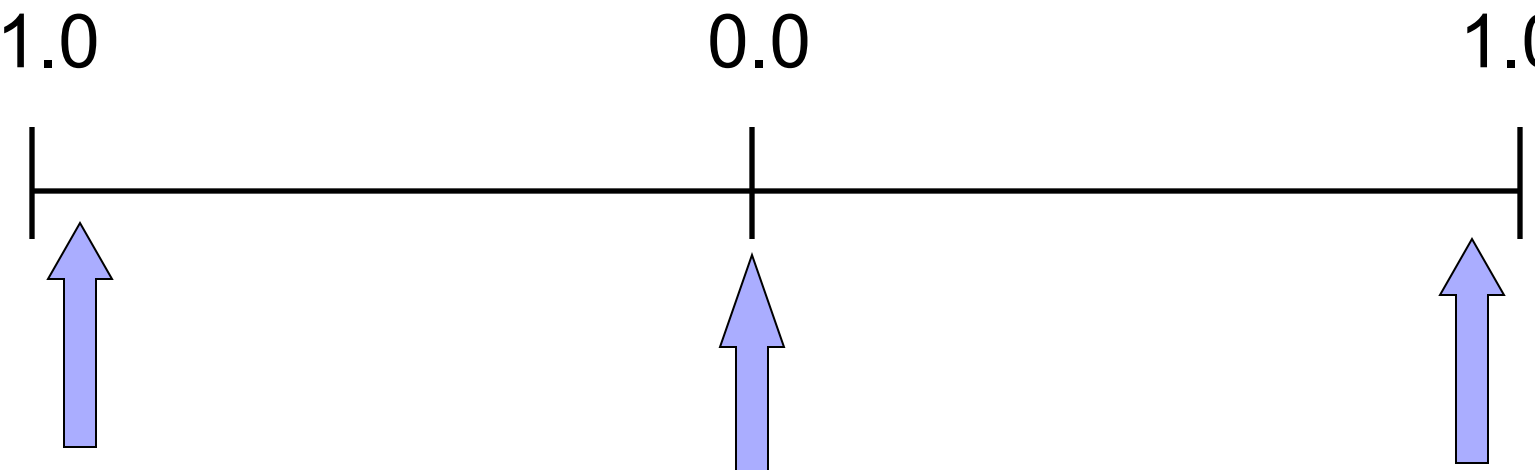
- Negative Association
  - Below average values of Engine HPW are associated with above average values of HWY-mpg (HPW-low goes with MPG-high).
  - Above average values of Engine HPW are associated with below average values of HWY-mpg (HPW-high goes with MPG-low).

Strength of Association

- Correlation applies only to **quantitative (continuous) variables**.
- Correlation measures the strength of **linear** association.
- The **correlation coefficient** (r) gives the direction of the linear association and quantifies the strength of the linear association between two quantitative variables.
- Correlation is a `unitless' quantity (not in 'feet' or 'inches'… no units)

Strength of Association

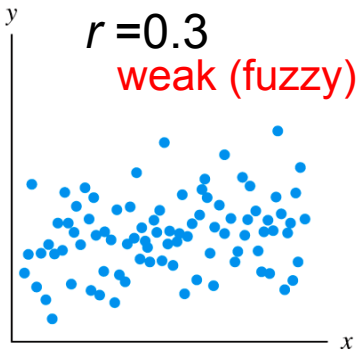
Correlation Coefficient (*r*) will be between -1 and 1.



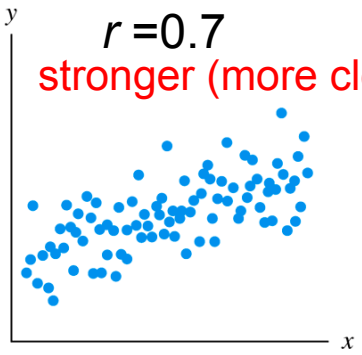
Strong Negative Linear Relationship

Very Weak or No Linear Relationship

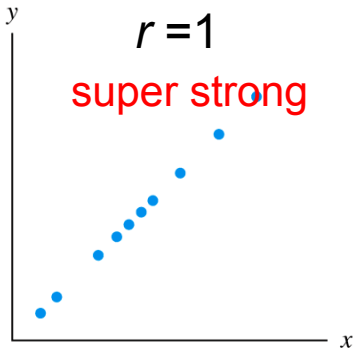
Strong Positive Linear Relationship



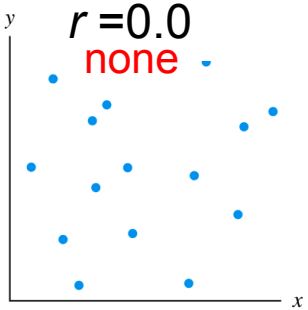
(a) Weak positive correlation between x and y



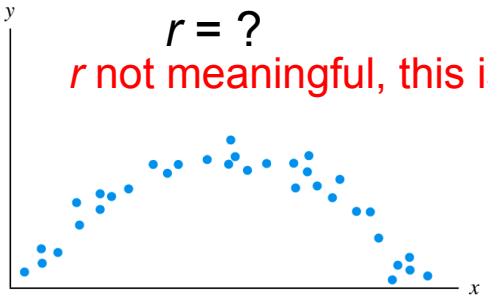
(b) Strong positive correlation between x and y



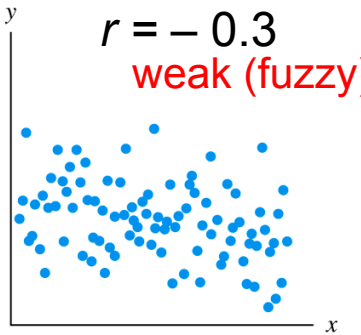
(c) Perfect positive correlation between x and y



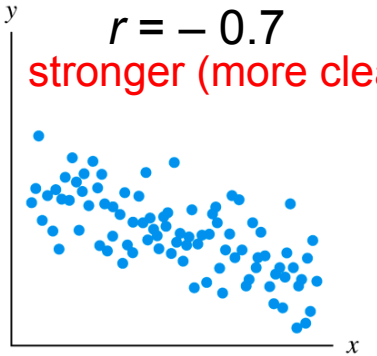
(g) No correlation between x and y



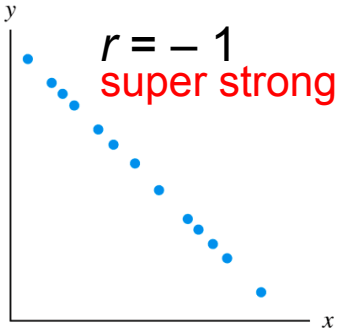
(h) Nonlinear correlation between x and y



(d) Weak negative correlation between x and y

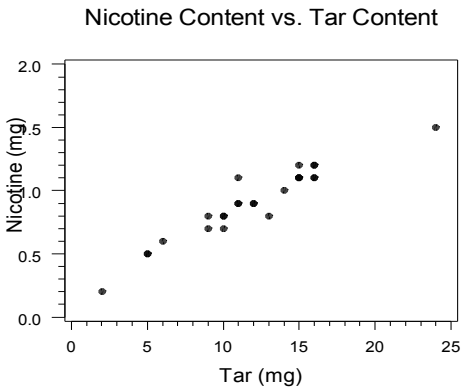


(e) Strong negative correlation between x and y



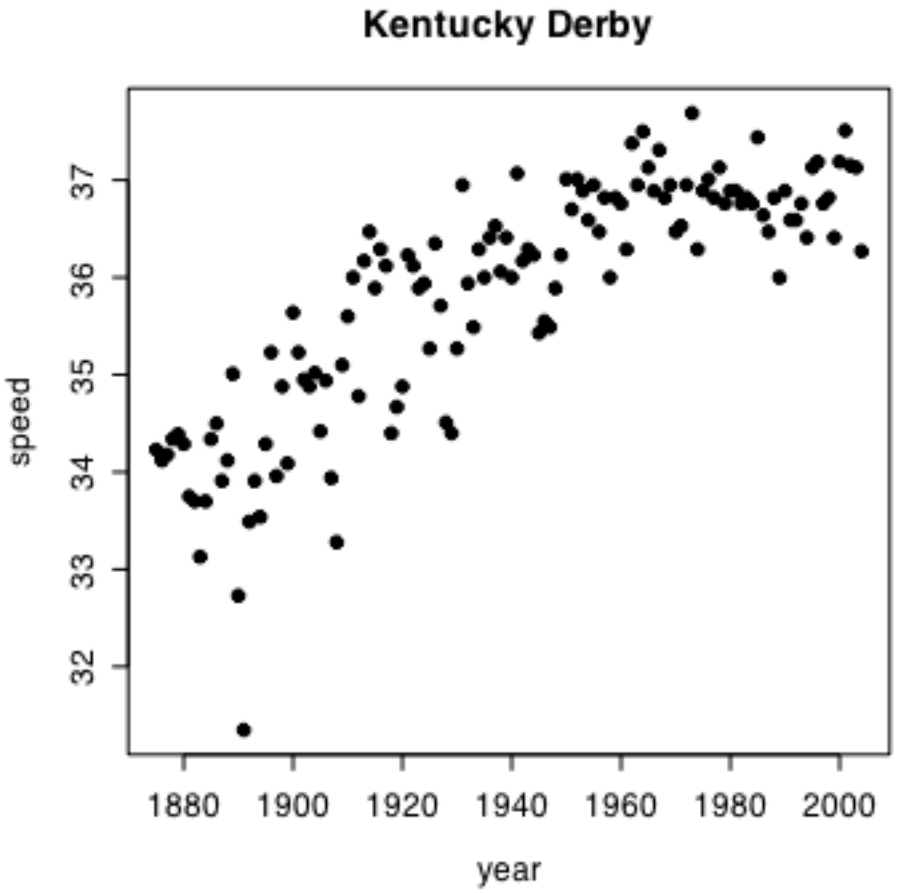
(f) Perfect negative correlation between x and y

Things to look for in a scatterplot



- 1. Direction of association
  - Positive or negative.
- 2. Form of association
  - Linear, curved, clustered, scattered (no relationship).
- 3. Strength of association
  - How closely the points follow a clear form.
- 4. Outliers
  - A point that lies outside of the general pattern.

Example



Direction _____

Form _____

Strength _____

Outliers? _____

Association vs. Causation

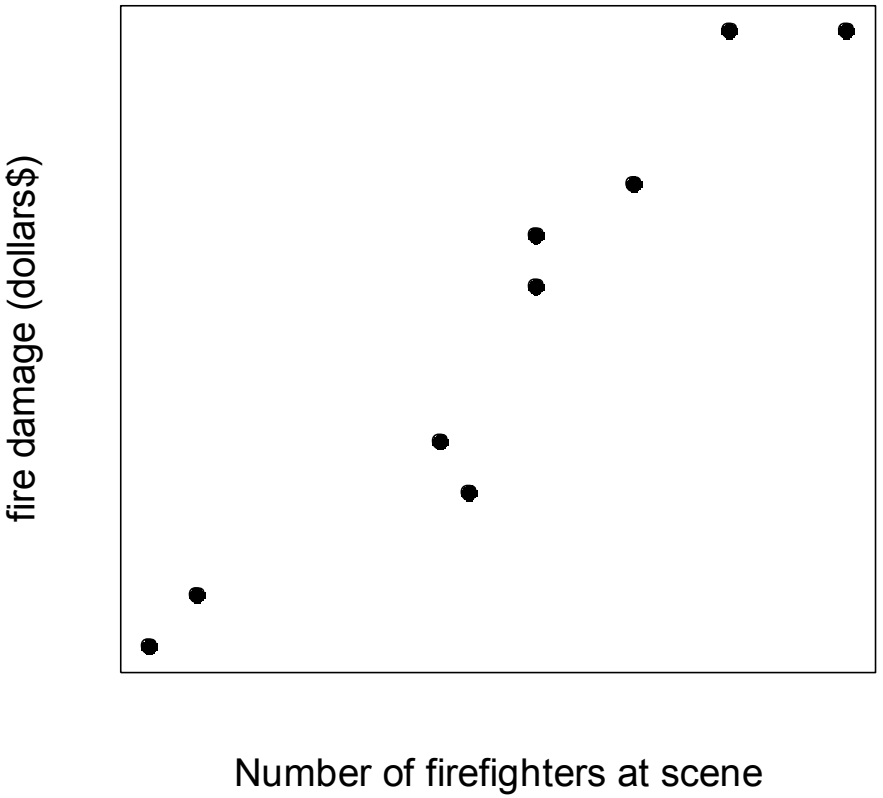
- The existence of an association does not equate to causation.
- To imply that a change in one variable **causes** a change in another is a *very* strong statement – use ‘association’ for our relationships in this class.

Correlation Cautions

- Don't confuse correlation with causation.
  - There is a strong positive correlation between shoe size and intelligence.
- Beware of lurking variables.

Beware of lurking variables

- **Lurking variable** – a hidden variable that stands behind a relationship and affects the other two variables.



Size of fire?

Association vs. Causation

- Increasing the size of the fire will cause greater damage.
- Increasing the number of firefighters at the fire will not cause greater damage, but we do tend to see more firefighters at larger fires.
- Correlation does NOT imply causality.