# Status and trend

What we want to know about populations

# Status and trend

- Status = a snapshot of a population's properties
  - Instantaneous
  - Over short durations
  - a.k.a. system state
- Trend = change over time
  - Increasing
  - Decreasing
  - Stable
  - a.k.a. system dynamics

*Best when both are assessed together*

# Status – current conditions

- For populations of organisms, status could include measures of:
  - Population size
  - Density
  - Age class distribution
  - Sex ratio
  - Geographic distribution
- Status without trend → know the current state, don't know if it's improving, stable, or getting worse
- We will learn how to assess various measures of population status later

# Trend – change over time

- Need to know how the population is changing, usually done by:
  - Measuring demographic rates, then using life tables or matrix models to estimate population growth rate from them (later!)
  - Estimating abundance repeatedly over time, estimating the change over time (using regression, or similar)
  - Using an **index** of abundance to indicate relative numbers, and then use regression to assess change over time
- Using an index gives you trend without knowing the population's status

# What is an index?

- An index is any quantitative measure that changes predictably as a population changes
- Usually based on easily observable things, including:
  - Sign counts
  - Cocoon counts
  - Call counts
  - Counts of individuals
- If we knew the quantitative relationship between the index and population size, we could use the index to estimate population size
- But, even without this, a change in the index is a measure of change in population size – trend without status

# Examples


# Why use an index?

- Seems it would always be better to have an actual estimate of abundance – why settle for less?
- But, estimating abundance is difficult
  - Organisms that hide, camouflage, seasonally absent from the area
  - Some of the best population estimation methods require more than one year to obtain estimates
- An index is often faster and cheaper to measure – better for monitoring in real time
- If our decisions will be driven by whether a population is increasing, decreasing, or stable, then we may only need an index

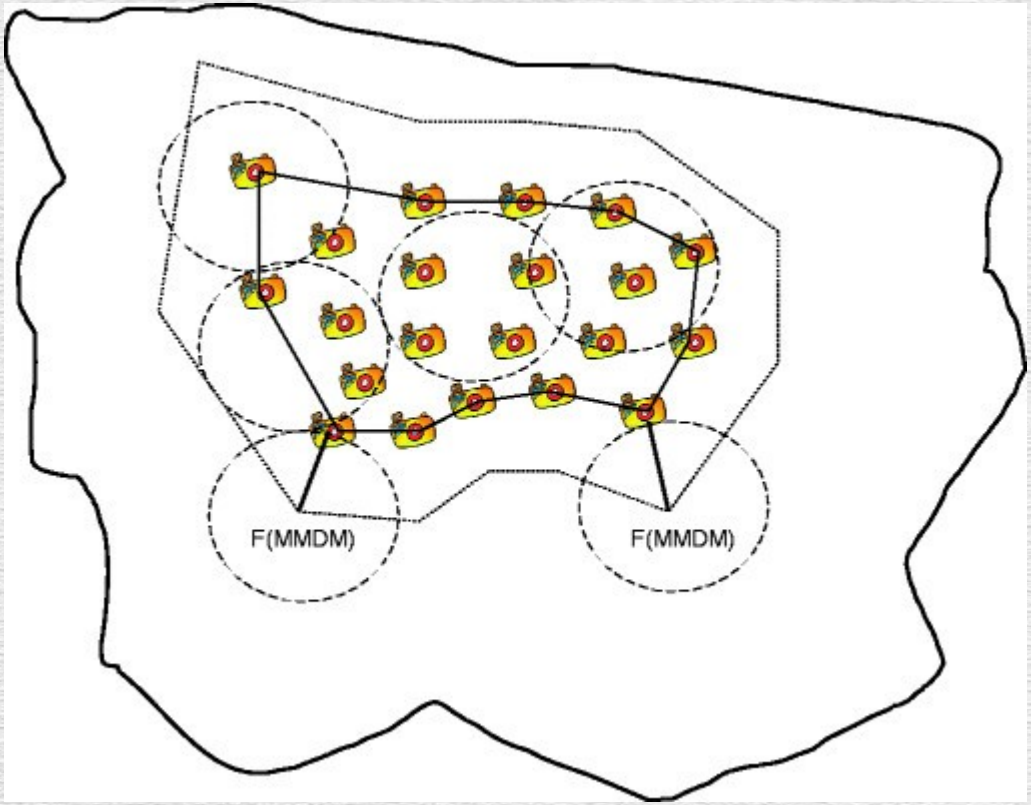
# Complications

- For an index to be reliable, it has to:
  - Indicate the current conditions
  - Change over the time period of interest
- It may be necessary to establish consistent conditions
  - Sweep old fecal piles
  - Use a track bed, track plate
  - Use traps, baits – but, need to be careful about changing the area sampled

**Figure 2**—Track-plate box station in the field. Note how the back of the box is against the base of a tree and how the box is covered with debris to stabilize and camouflage it.

# Scale issues

*If the samples are close together relative to the home range size of the animal, you may be counting the same individual repeatedly – not independent*

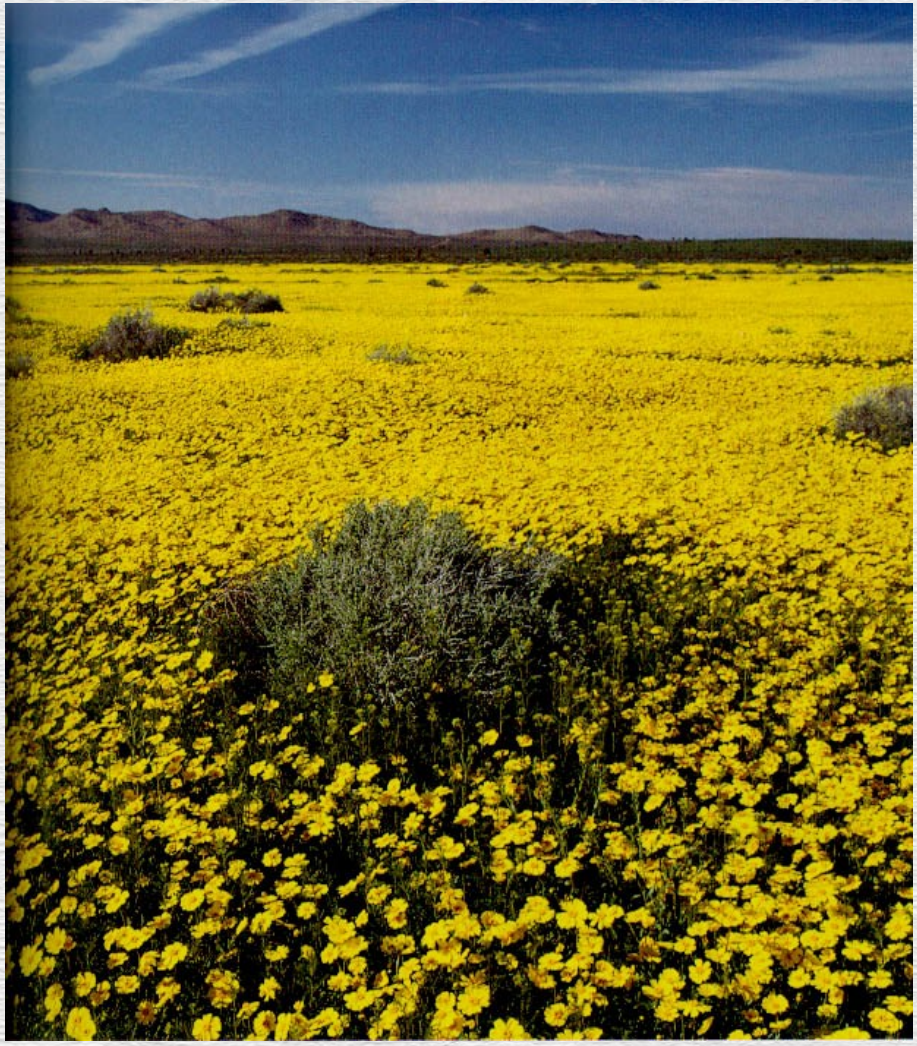


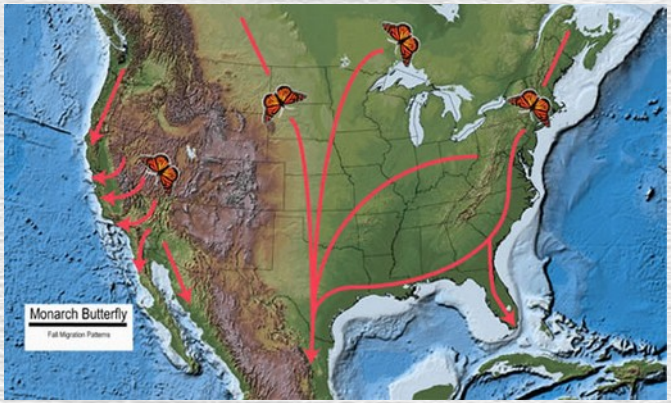

*Effective area – the cameras at the edge are sampling from outside of the area of interest*

# Seasonal effects

- In seasonal environments, reproduction and survival are seasonal as well
  - Breeding season
  - High mortality over winter
- The numbers you will count will depend on when you do the counting
- Need to standardize, and/or account for seasonal effects

# Phenology in plants

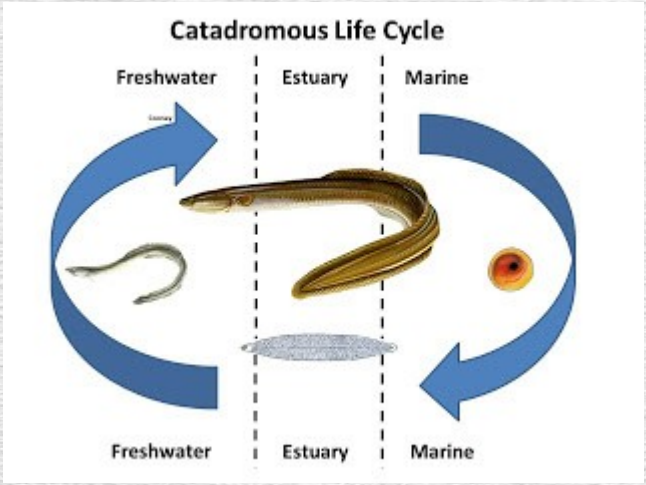




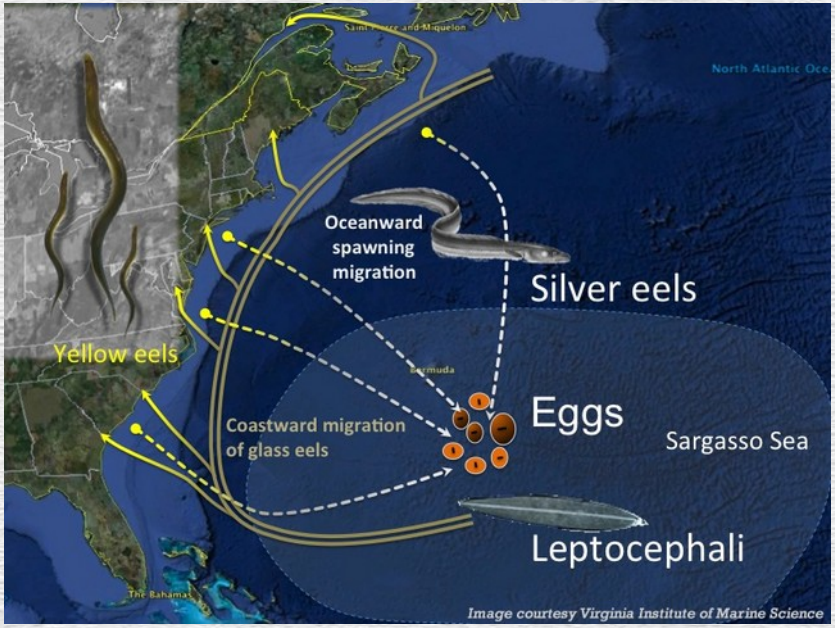


# Migration

Good YouTube video on monarch migration




American eel

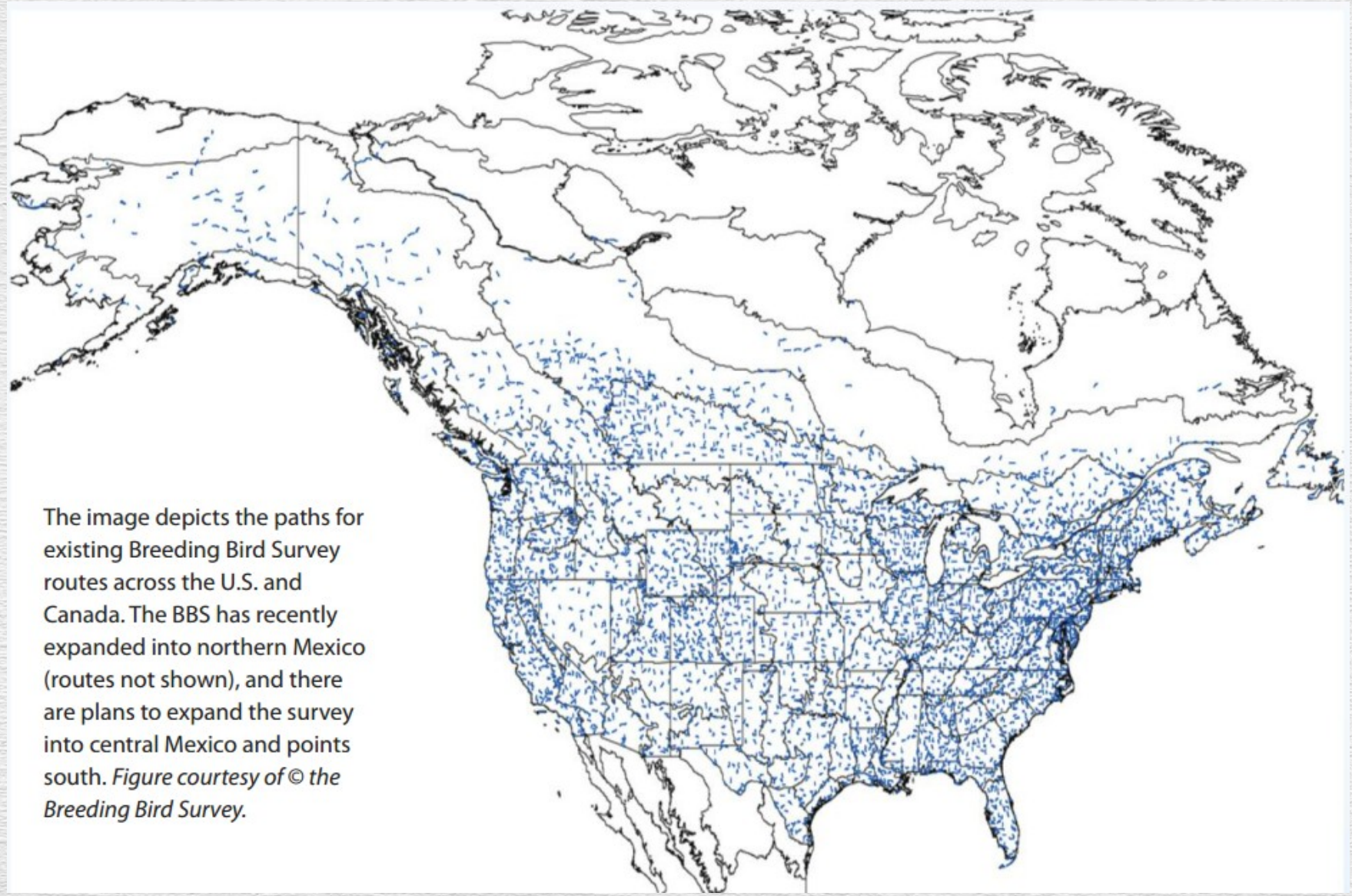


# Measuring trend

- Regression analysis (linear, non-linear) over time can be used to assess trend
  - Slopes indicate the rate of change
  - Non-significant change over time indicates a stable population (p-value, or 95% CI compared with 0)
  - A significant change, with a negative sign on the slope, indicates decline
- Example: Breeding Bird Survey, and data from Hawk Mountain

# Breeding Bird Survey

- Counts of breeding birds at a sample of locations throughout North America
- Has been ongoing since 1966
- Based on routes
  - Fixed locations, 24.5 miles long each
  - Stops every 0.5 mile
  - Conduct a 3 minute point count at each stop, record any bird seen or heard
  - At the height of the breeding season for the region (June)
  - Start at ½ hour before sunrise, for five hours
  - Experienced birders
- Trend analysis is done in a way that lack of independence among counts of the same route over time are accounted for

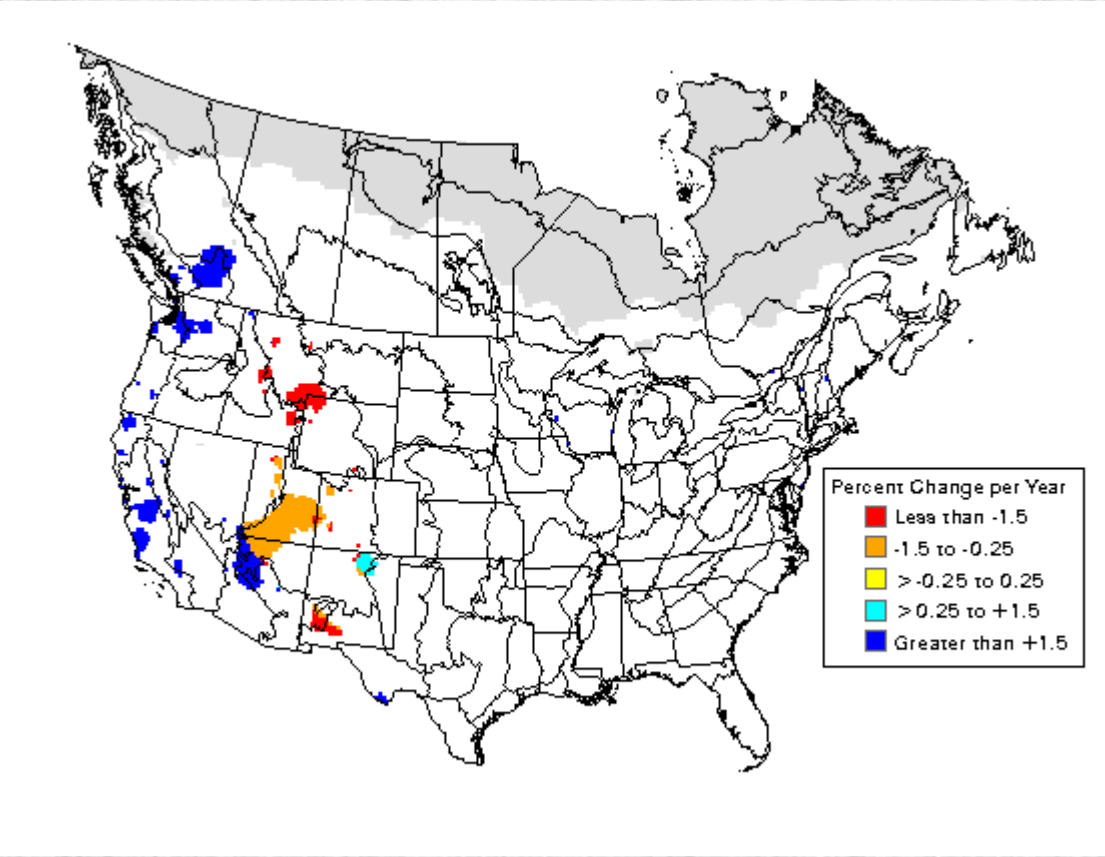


The image depicts the paths for existing Breeding Bird Survey routes across the U.S. and Canada. The BBS has recently expanded into northern Mexico (routes not shown), and there are plans to expand the survey into central Mexico and points south. *Figure courtesy of © the Breeding Bird Survey.*

# Peregrine Falcon results

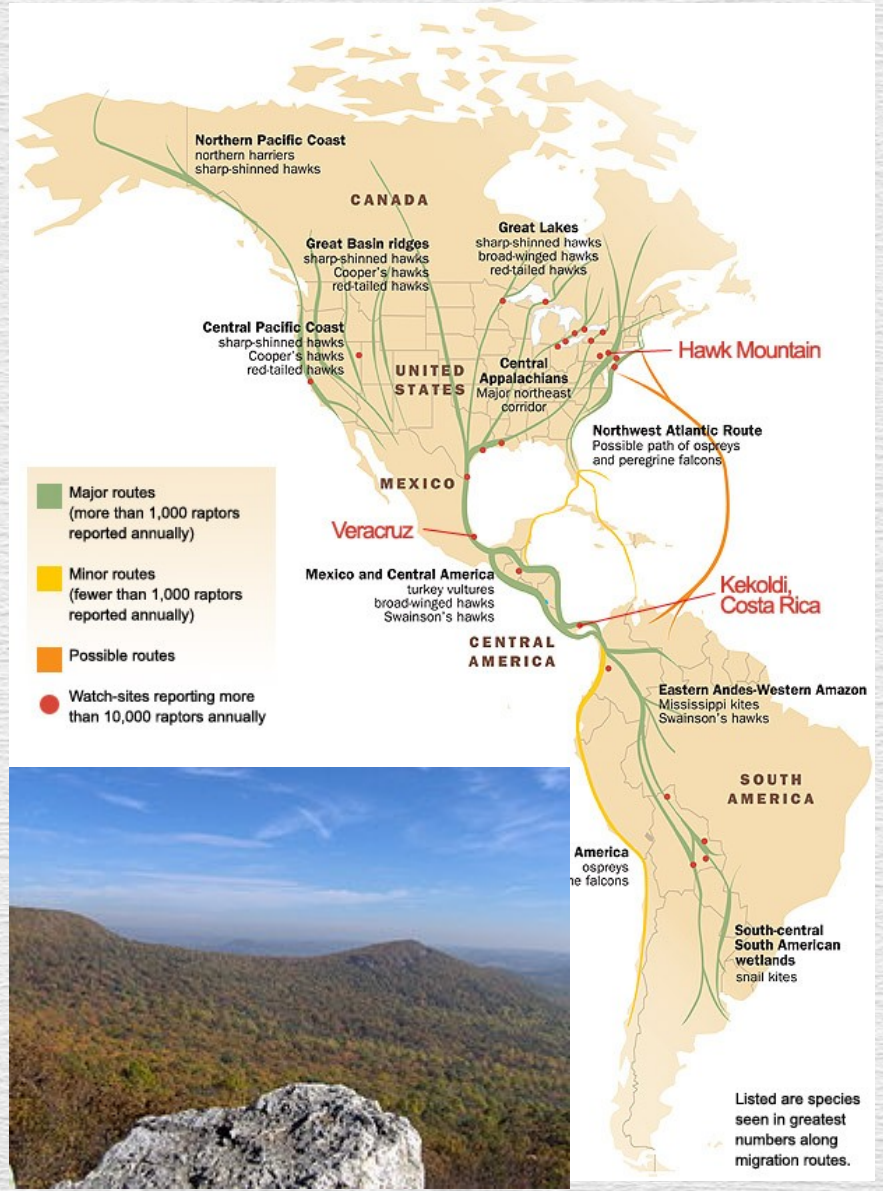
| Region | N | 1966-2012 Trend | 1966-2012 95% CI | 2002-2012 Trend | 2002-2012 95% CI | RA |
|---|---|---|---|---|---|---|
| Northern Pacific Rainforest | 19 | 6.17 | ( 1.68, 11.12) | 11.09 | ( -0.01, 27.45) | 0.01 |
| Great Basin | 19 | 11.71 | ( 1.06, 30.28) | 11.52 | ( -7.54, 38.86) | 0.00 |
| Northern Rockies | 16 | 1.66 | ( -4.70, 8.54) | 4.50 | ( -7.20, 17.89) | 0.01 |
| Southern Rockies/colorado Plateau | 39 | 1.57 | ( -4.54, 6.01) | 5.54 | ( -2.93, 15.26) | 0.02 |
| Coastal California | 10 | 9.40 | ( 3.30, 18.06) | 11.08 | ( 1.73, 47.00) | 0.00 |
| Sierra Madre Occidental | 8 | 2.23 | ( -10.22, 25.00) | 3.11 | ( -37.73, 92.29) | 0.04 |
| Arizona | 15 | 2.01 | ( -7.28, 11.91) | 3.59 | ( -10.12, 23.51) | 0.04 |
| British Columbia | 8 | 12.07 | ( 2.07, 26.64) | 13.03 | ( -3.65, 53.24) | 0.00 |
| California | 22 | 4.18 | ( 0.43, 8.23) | 7.39 | ( -0.07, 23.36) | 0.01 |
| Colorado | 11 | 21.49 | ( 6.98, 45.70) | 18.66 | ( -9.11, 53.15) | 0.00 |
| Idaho | 6 | 5.41 | ( -6.42, 25.59) | 5.41 | ( -21.85, 54.13) | 0.00 |
| Montana | 5 | -0.61 | ( -9.21, 8.43) | -0.48 | ( -20.24, 24.62) | 0.02 |
| New Mexico | 7 | 21.83 | ( 2.77, 231.82) | 17.88 | ( -20.15, 150.76) | 0.00 |
| Oregon | 7 | 15.36 | ( 1.91, 40.21) | 14.32 | ( -11.33, 49.98) | 0.00 |
| Utah | 23 | 0.77 | ( -3.10, 4.95) | 2.65 | ( -3.91, 11.37) | 0.03 |
| Wyoming | 8 | 10.74 | ( 0.92, 25.59) | 8.70 | ( -11.47, 26.11) | 0.00 |
| Western BBS Region | 119 | 2.42 | ( -2.39, 5.71) | 7.84 | ( 1.66, 15.72) | 0.01 |
| Canada | 18 | 12.07 | ( 2.07, 26.64) | 13.03 | ( -3.65, 53.24) | 0.00 |
| United States | 132 | 1.94 | ( -2.86, 5.24) | 6.76 | ( 0.53, 14.05) | 0.02 |
| Survey-wide | 150 | 2.42 | ( -2.39, 5.71) | 7.84 | ( 1.66, 15.72) | 0.01 |

# Peregrine Falcon – trend map

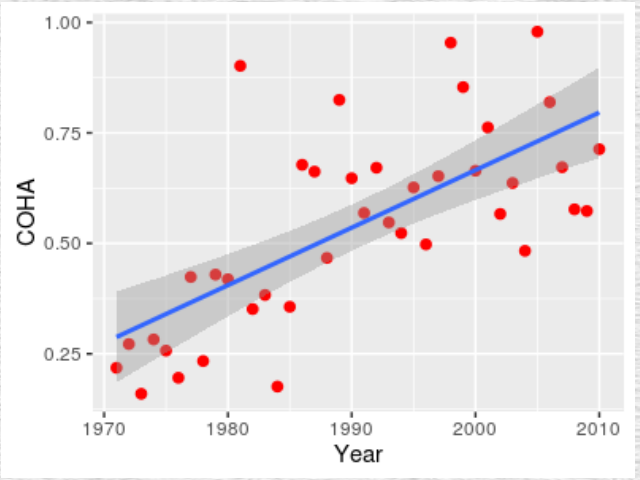


# Hawk Mountain, PA

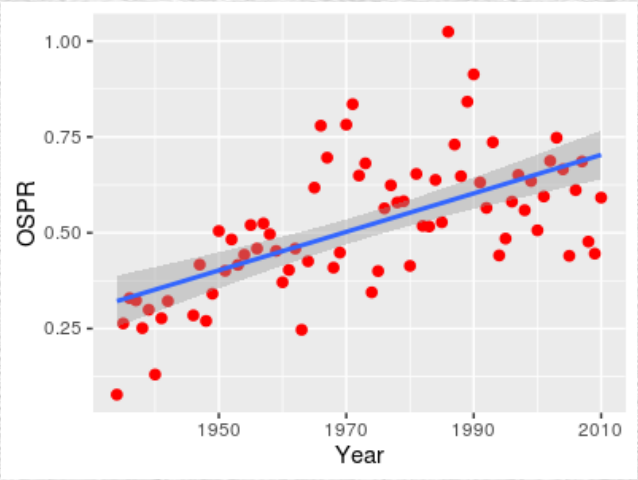
- Many species of raptors migrate along the Blue Ridge and Appalachian Mountains
- Birders have conducted Fall counts at Hawk Mountain since 1934
- The data are available through the Ecological Society of America's Ecological archives
- We will use the average number per hour counted, averaged by year



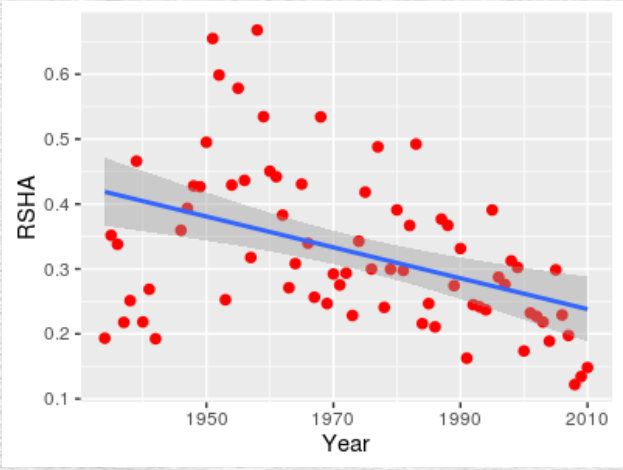
# A couple of examples



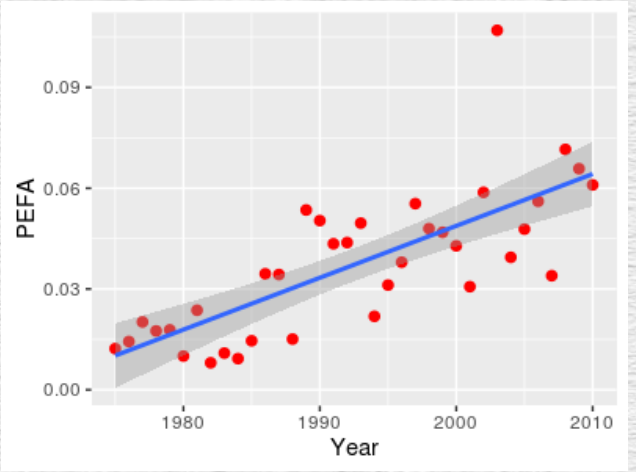

Cooper's Hawk




Osprey

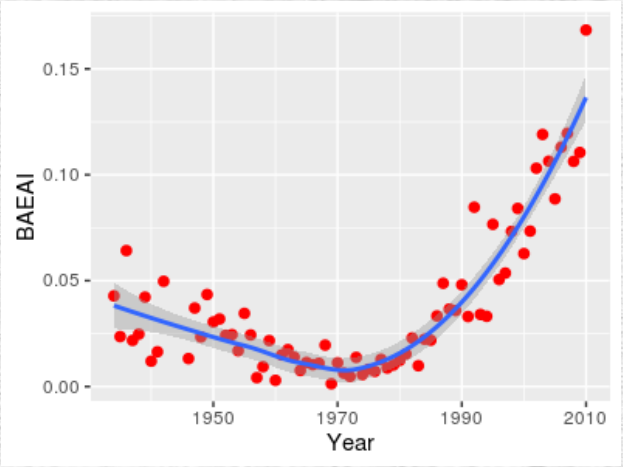



Red-shouldered Hawk

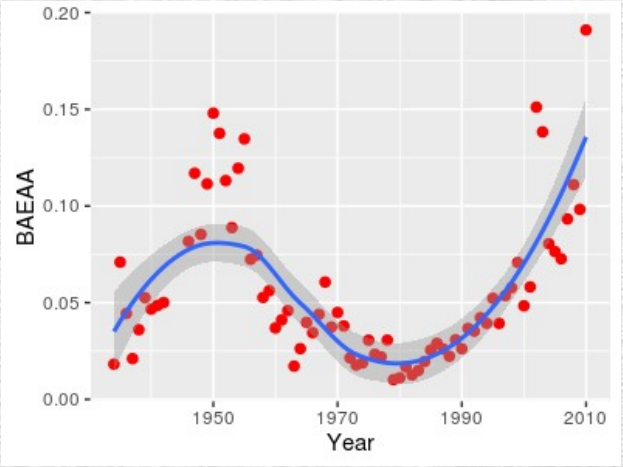



Peregrine Falcon

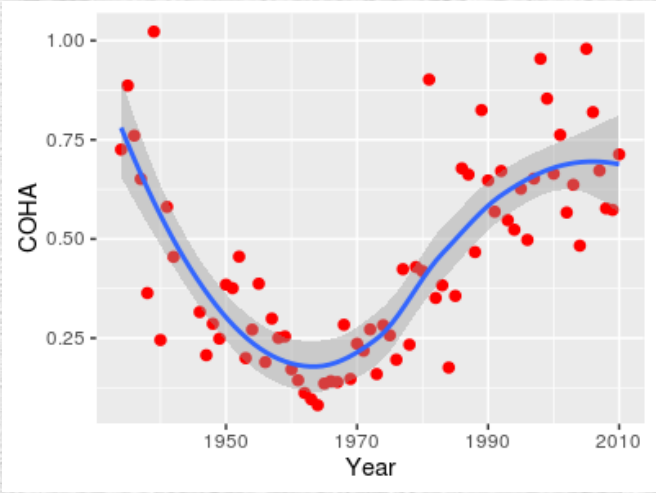
# If it's not linear, don't use linear regression



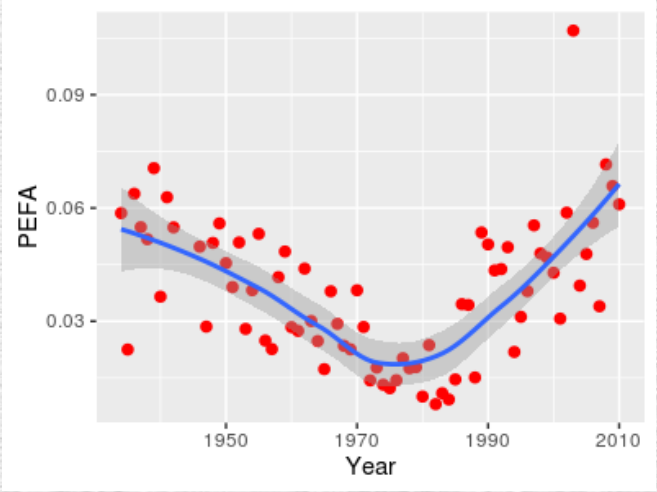

Immature Bald Eagles




Adult Bald Eagles




Cooper's Hawk




Peregrine Falcon

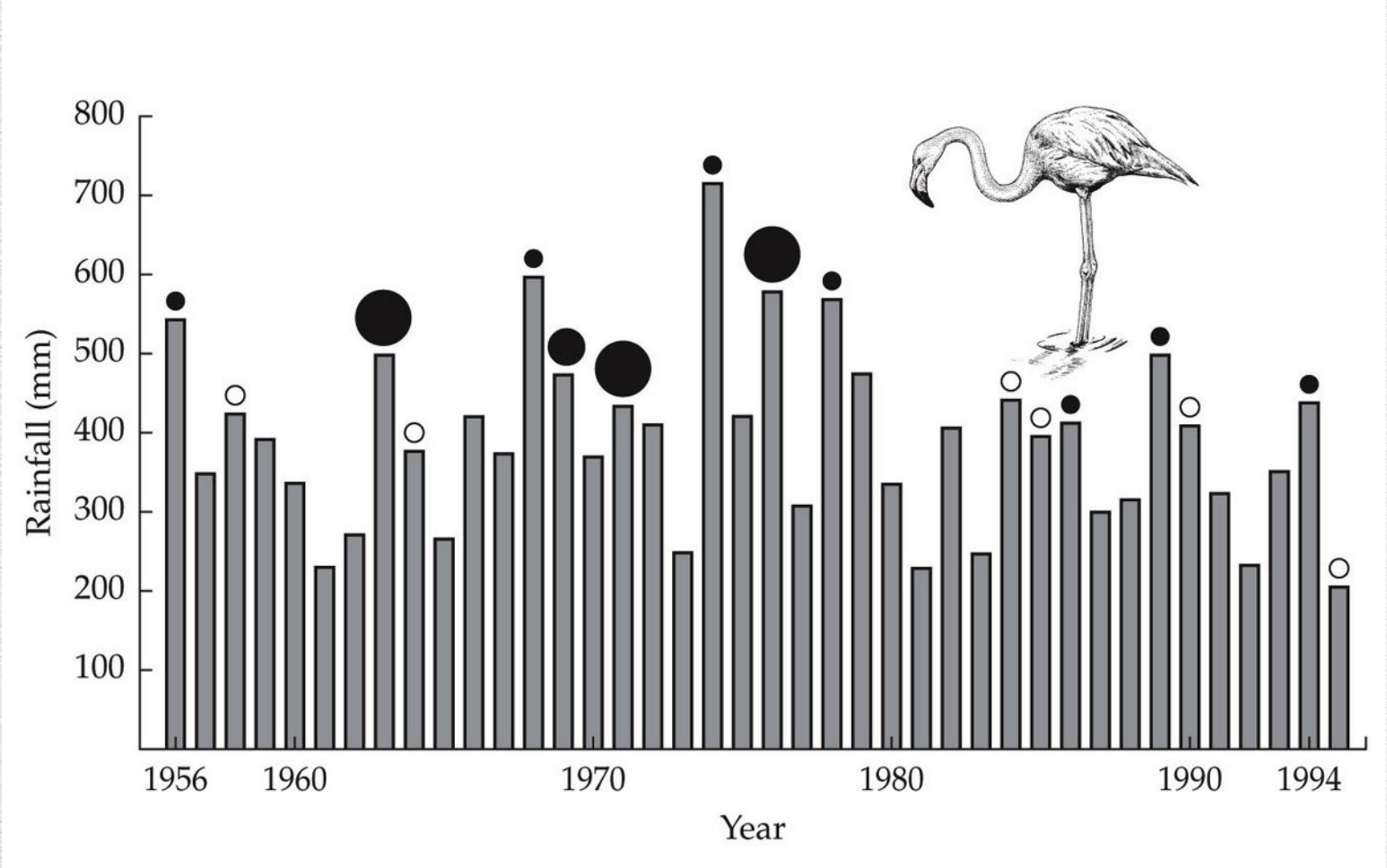
# Trend without status

- If your index is a count, and it indicates a decline of 10 individuals per year, is that a problem?
  - If the decline is from 1,000,000 to 999,990 is it a problem?
  - If the decline is from 200 to 190 is it a problem?
  - If the decline is from 20 to 10 is it a problem?
- Without an estimate of population size you don't know how much to worry about a downward trend
- Can use an index as an early warning system – if there's a decline, assess status to see how much to worry

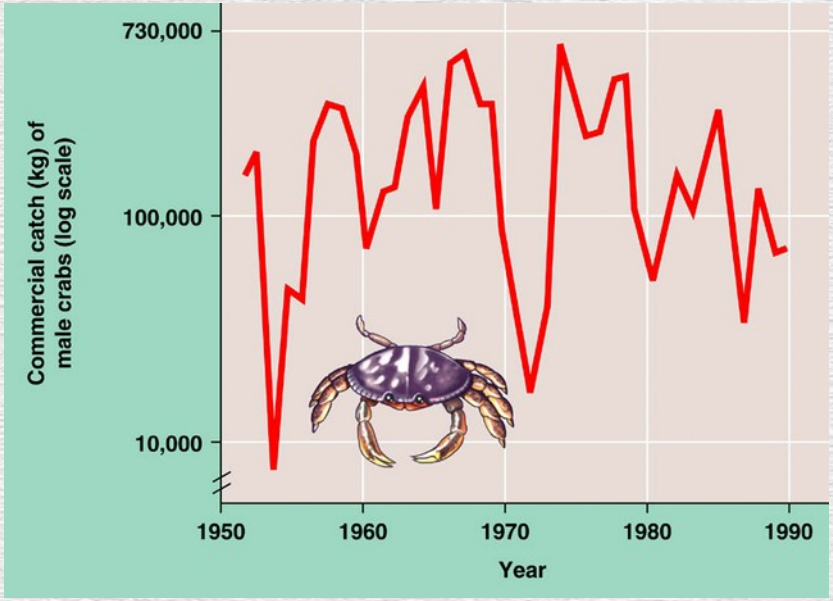
# Missing a trend

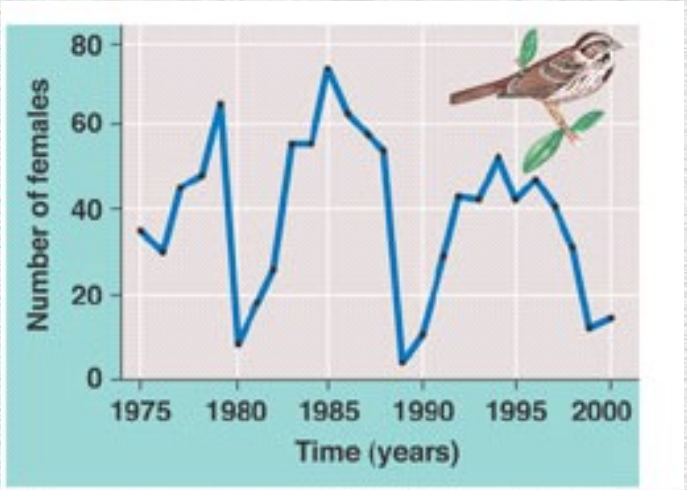
- A non-significant result is interpreted as a slope of 0, no change
- The probability of detecting a real effect with a statistical model is called **statistical power**
- Power is affected by:
  - Size of change – bigger changes easier to detect
  - Size of $s_{\bar{x}}$, which is affected by:
    - Biological variation – less variation → smaller $s_{\bar{x}}$
    - Sample size – more data → smaller $s_{\bar{x}}$
- Therefore:
  - A decline that is small compared with the amount of variability in the data is hard to detect – may take years before it's large enough
  - Have to be careful that the methods used still work well at small population sizes (if n = number of years that's good, if n = number of individuals that's bad)

# High annual variation in reproduction



# High annual variation in abundance



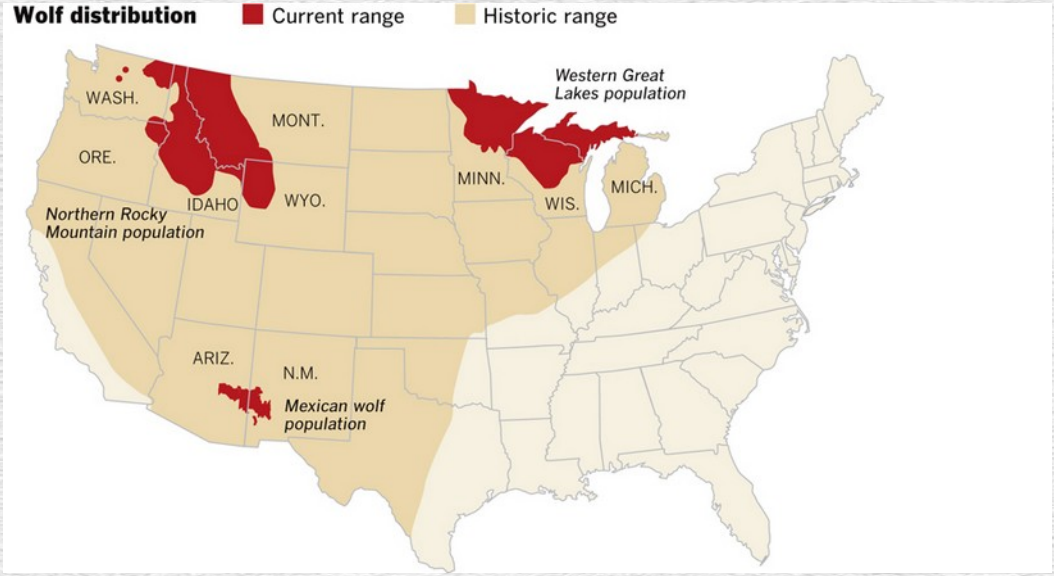




(c) A song sparrow population in its natural habitat

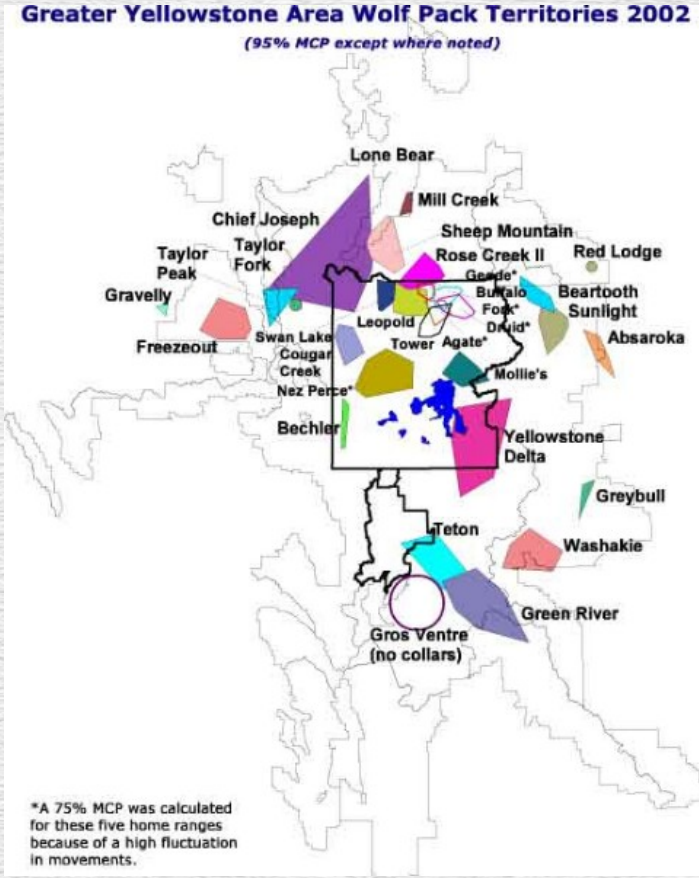
# Monitoring to detect problems

- It's good to know if your population is declining, better still to know why
- Need to monitor in a way that will indicate the causes of decline, so they can be addressed
- Need to record threats as well as population measures

# Wolf re-introductions




Wolf range



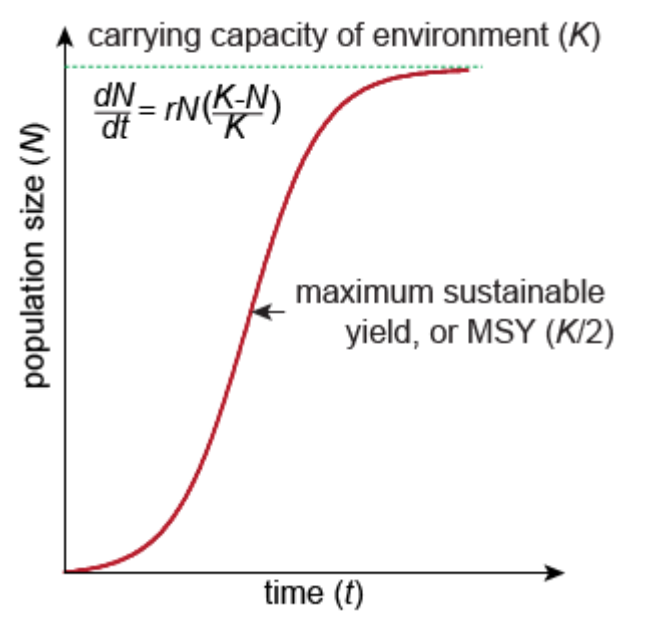

Very different management in MT, ID, WY
Monitoring each independently is needed

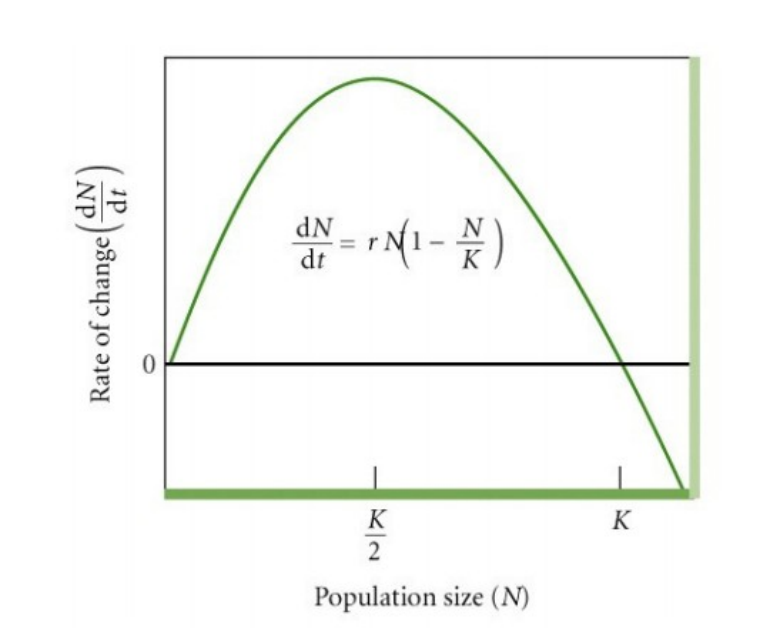
# Desert tortoise


# Monitoring fisheries

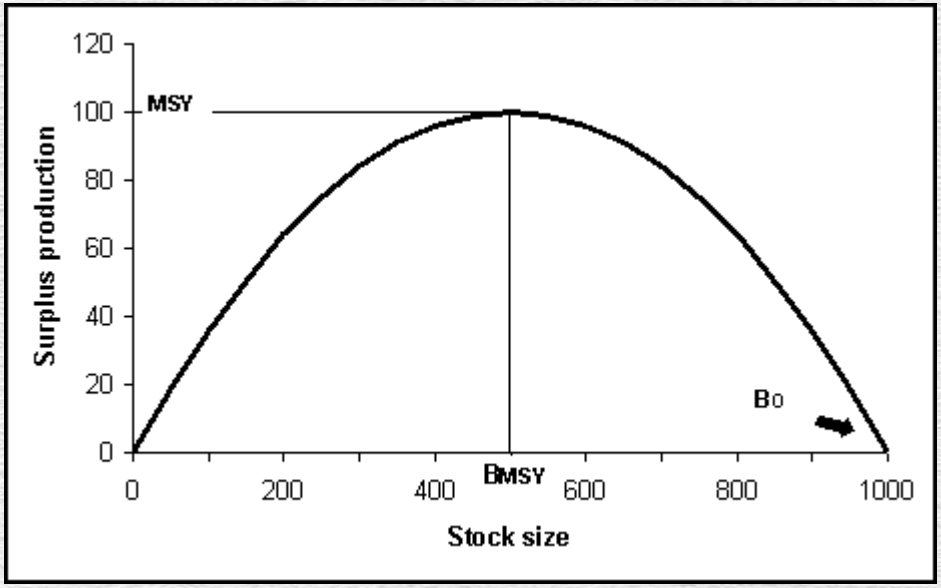
- Marine fisheries are very difficult to sample
- But, we harvest them commercially, and keep records of the catch
- The greatest catch that can be sustained by the population indefinitely is the **maximum sustainable yield**
- Can use catch as an index of population size
- Can use catch per unit effort to determine MSY

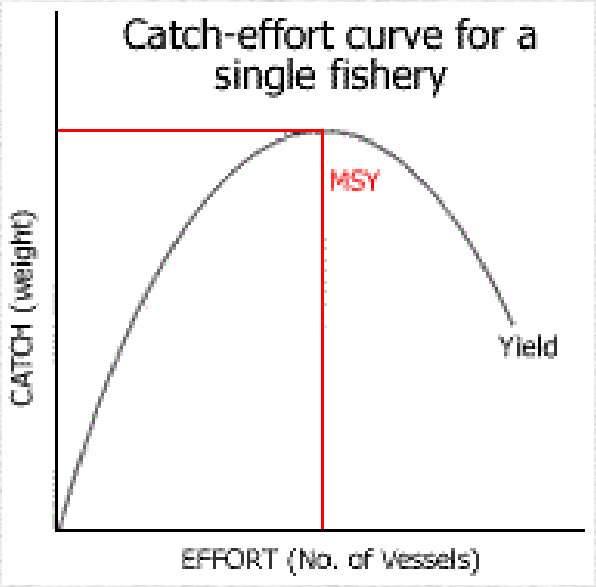
# Logistic growth, growth rate, and MSY



# Estimating MSY



# Why is the peak MSY?

- At low levels of effort, population size isn't limiting catch
  - Catch per unit effort is constant
  - Graph of catch vs. effort is positive, linear
- As catch/unit effort begins to slow down, approaching MSY
  - Catch per unit effort is not constant
  - Graph of catch vs. effort will level off
- As catch/unit effort declines, you are over-harvesting
  - The population is limiting catch, more you try the lower your catch/unit effort becomes

# Next activity

- We will use the Breeding Bird Survey's web site to assess trends in North America's bird populations
  - Their analytical methods account for potential biases
    - Routes that have different detectabilities
    - Different observers
- We will use the Hawk Mountain counts of migrating raptors for comparison