Main Points

1) Estimating community properties

2) Non-detection and unequal sampling effort, for communities
-- species accumulation curves for freshwater fish
-- species rarefaction curves for freshwater fish, and for birds

3) Extra credit #1 answers

4) Introduction to the role of landscape complexity in population ecology

Pre-reading: Tues 10 Oct = Stoner et al; Thurs 12 Oct = King et al

Extra credit #2 will be available at 5pm today, due 5pm Tues 17 Oct.

Terms: species richness, species diversity, species evenness, species accumulation curve, non-detection, species rarefaction curve, metapopulation, matrix, source-sink dynamic, connectivity

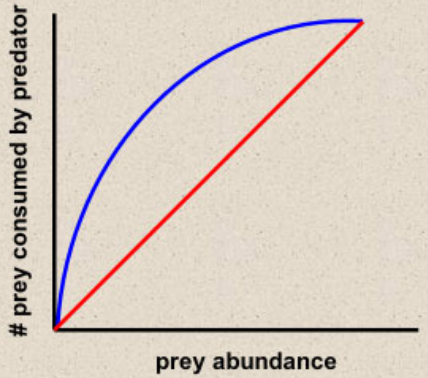
In one sentence, state the punchline of Beston et al.

Hint: it was the title of the paper.

Punchline #1: functional responses describe how the abundance of prey leads to a behavioral change in how many of those prey a predator eats. Type 2 and Type 3 functional responses occur most commonly in nature.

Predation and variation in prey density

- functional response = the response of a predator to changes in the abundance of prey.

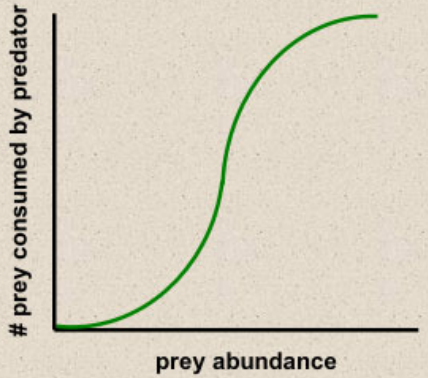


Type 2 Functional Response
The number of prey consumed increases really quickly at first, then levels off with predator satiation.

13

Predation and variation in prey density

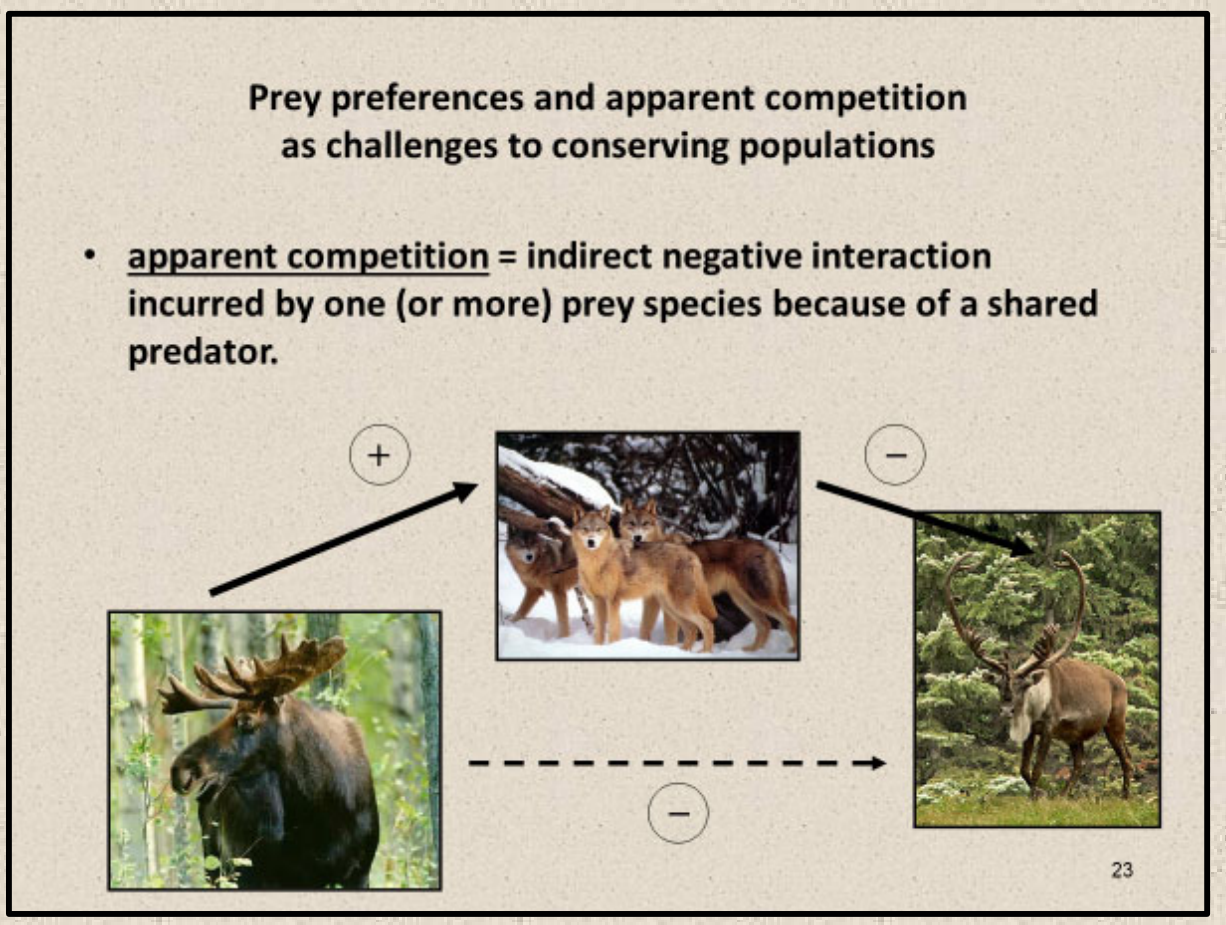
- prey switching = predators switch between different species of prey when alternative sources of prey are abundant, reducing pressure on the rare population of prey.



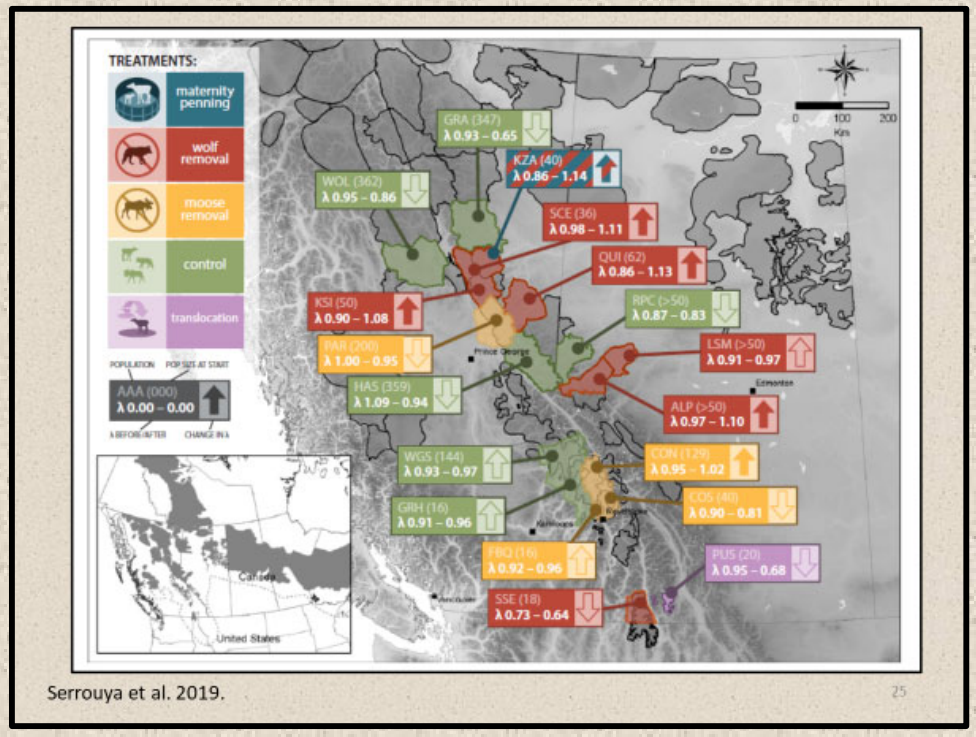
Type 3 Functional Response
The number of prey consumed increases slowly at first, then quickly as prey switching occurs, then finally levels off.

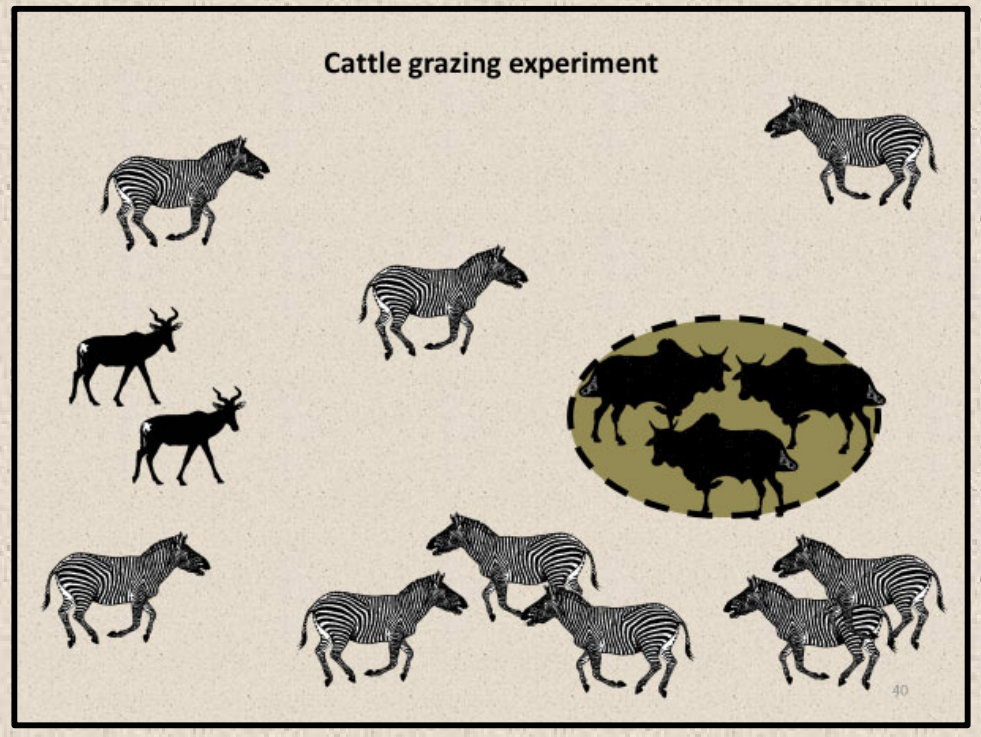
15

Punchline #2: apparent competition occurs when (1) two or more species of prey are consumed by the same predator; and (2) one of those prey is preferred by the predator, such that it is at greater risk of being killed when it occurs in close proximity to the less-preferred prey.



Punchline #3: we discussed two examples of apparent competition in ungulate communities, one involving mountain caribou, moose, and wolves, another involving hartebeest, zebra, and lions. We discussed management interventions to reduce apparent competition in attempt to boost caribou and hartebeest populations.



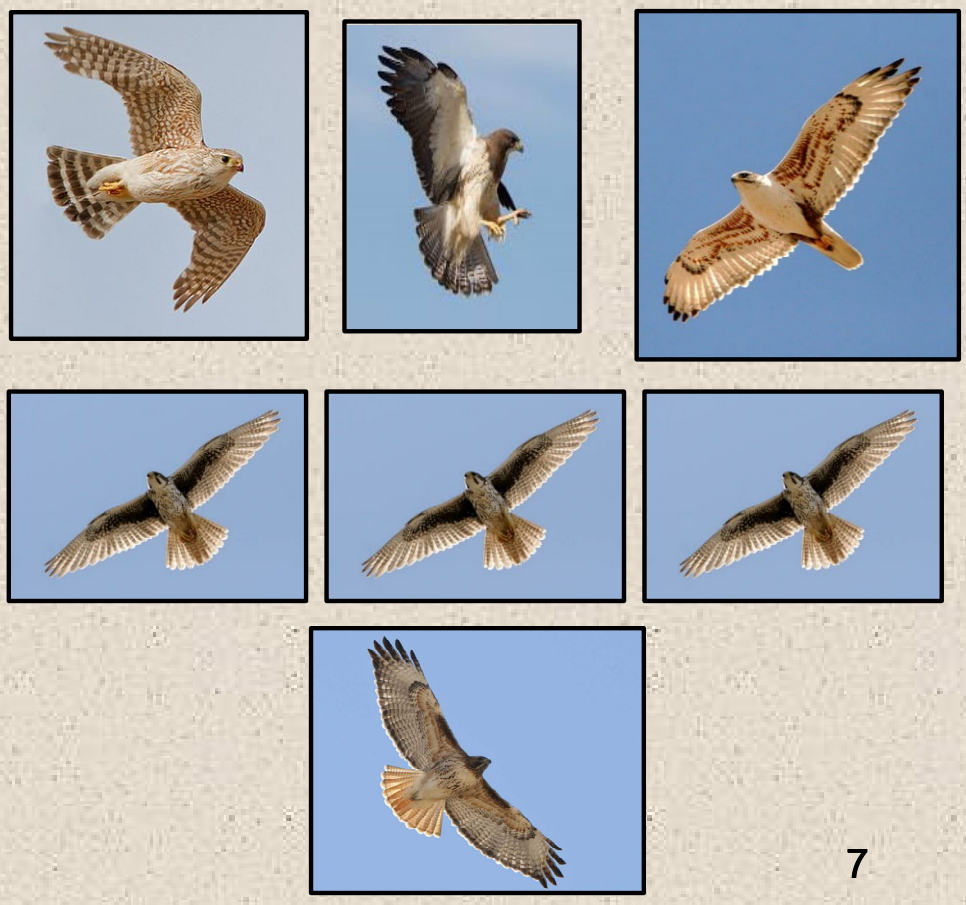


Estimating properties of communities

- <u>species richness</u> = the number of species in a region, site, or sample

sagebrush-steppe

shortgrass prairie

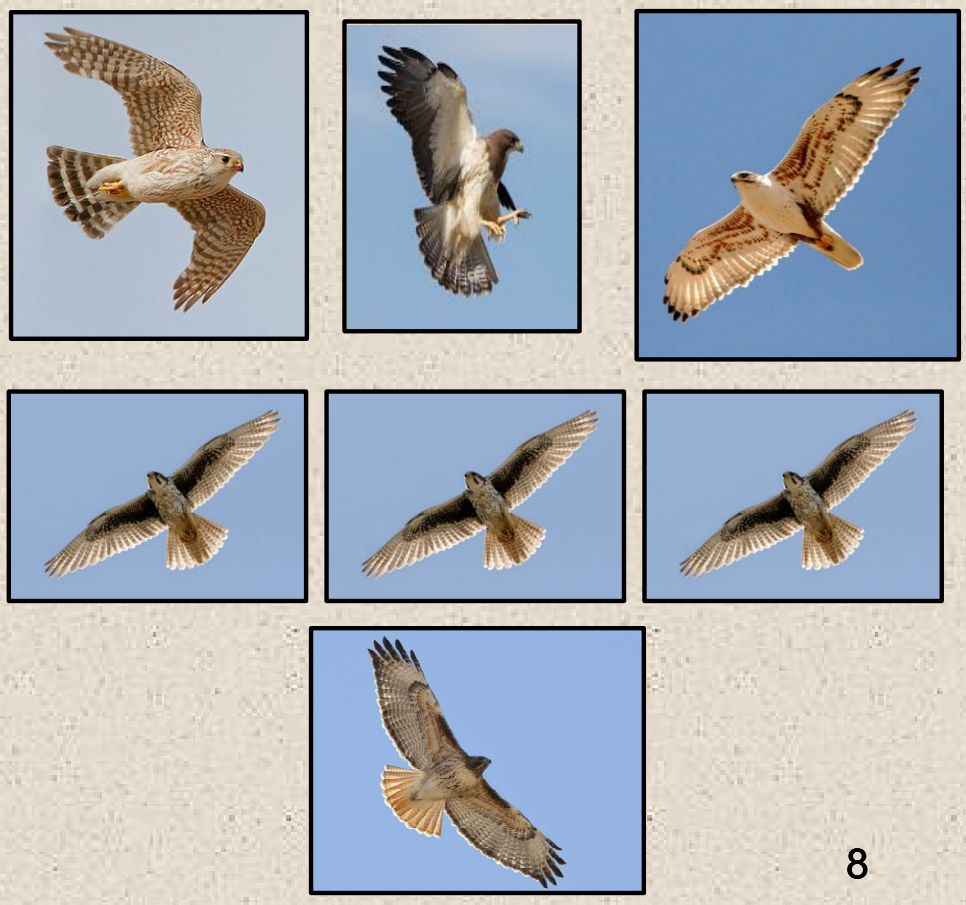


Estimating properties of communities

- <u>species evenness</u> = the degree to which individuals are divided equally among species in a sample and/or community

sagebrush-steppe

shortgrass prairie



Estimating properties of communities

- **species diversity (Shannon) = an index combining species richness and species evenness**

sagebrush-steppe

Estimating properties of communities

- **species diversity (Shannon) = an index combining species richness and species evenness**

$$H = -\sum_{i=1}^{S} (p_i * \ln (p_i))$$

$$H = -\Sigma (0.86 * -0.15) + (0.14 * -1.95)$$

$$= 0.41$$

sagebrush-steppe

Estimating properties of communities

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$$= 0.41$$

$$H_{max} = \ln (S) = 0.69$$

$$J = \text{evenness} = H/H_{max} = 0.59$$

sagebrush-steppe

<u>Discussion:</u> estimate Shannon diversity (H) for the shortgrass prairie raptor community.

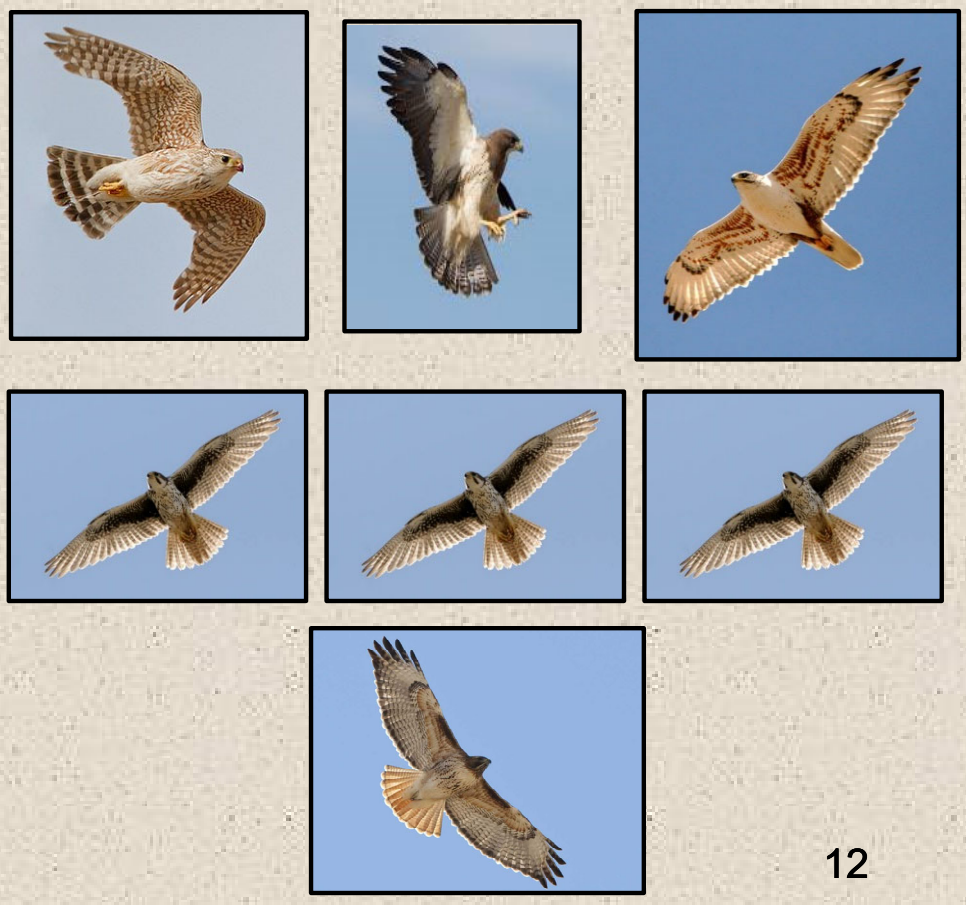
$$H = -\sum_{i=1}^{S} (p_i * \ln(p_i))$$

S = total number of species sampled

p_i = relative abundance of species I

Remember, your p_i's need to sum to ~1.

shortgrass prairie

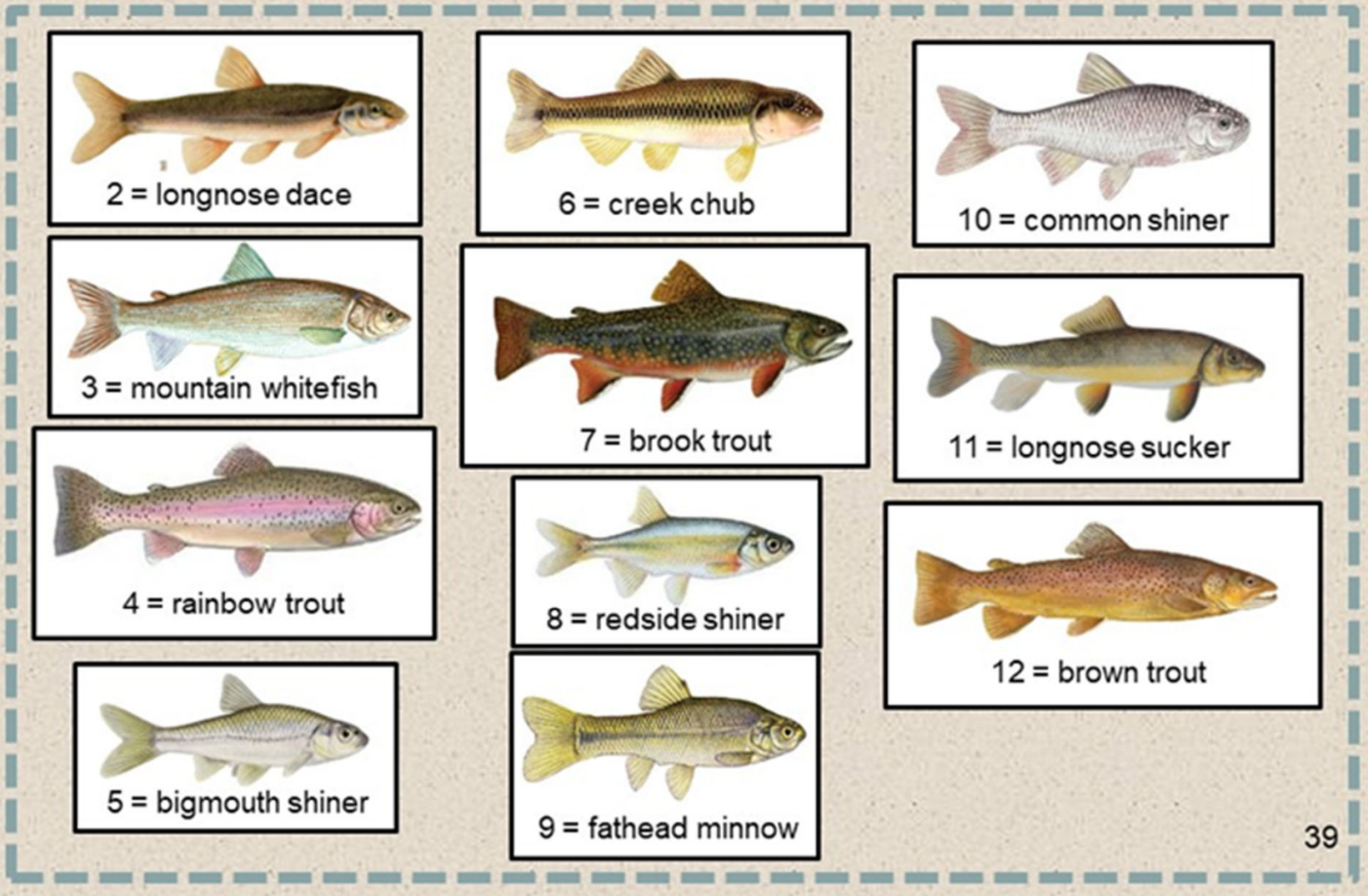


Accumulation curves:
what they are, why they're used

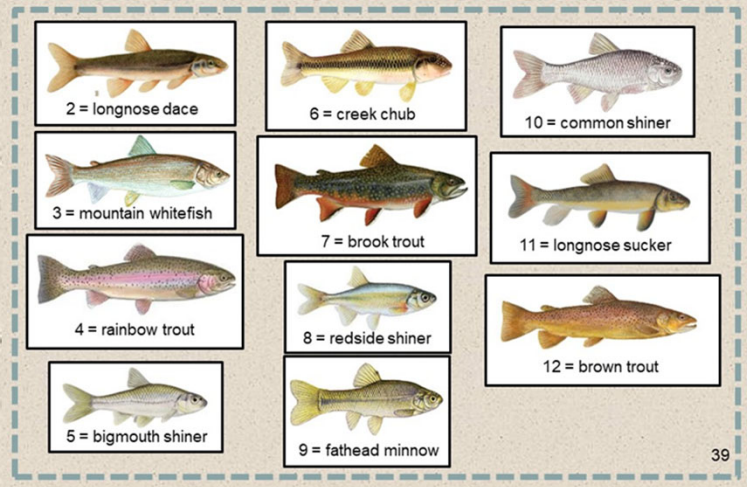
- **species accumulation curve = graph depicting the total number of species sampled during data collection as additional individuals/samples are added to the total of previously-sampled individuals/samples.**

- **used to visualize how species are added (or accumulated) with increasing individuals/samples.**

Accumulation curves:
what they are, why they're used

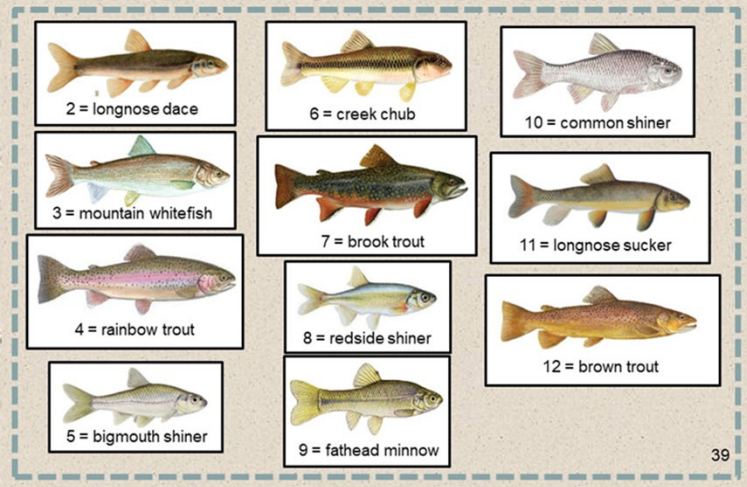


<u>Discussion:</u> generate accumulation curves for different numbers of samples (dice rolls) from this community. Match each dice roll to a species, and keep track of how species accumulate with dice rolls.



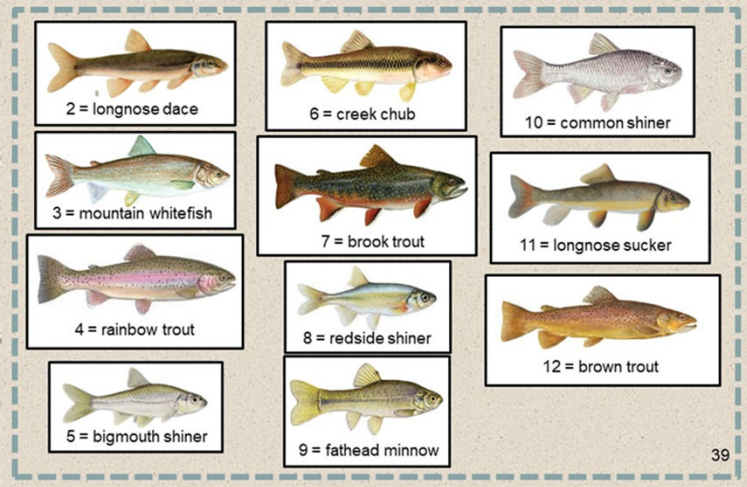
roll (# from dice)
7
9
9
12
9
8
6

<u>Discussion:</u> generate accumulation curves for different numbers of samples (dice rolls) from this community. Match each dice roll to a species, and keep track of how species accumulate with dice rolls.



roll (# from dice)	roll (sample)	species	# species recorded
7	1	Brk. Trout	1
9	2	FH minnow	2
9	3	FH minnow	2
12	4	Brn. trout	3
9	5	FH minnow	3
8	6	RS shiner	4
6	7	Creek chub	5

<u>Discussion:</u> generate accumulation curves for different numbers of samples (dice rolls) from this community. Match each dice roll to a species, and keep track of how species accumulate with dice rolls.



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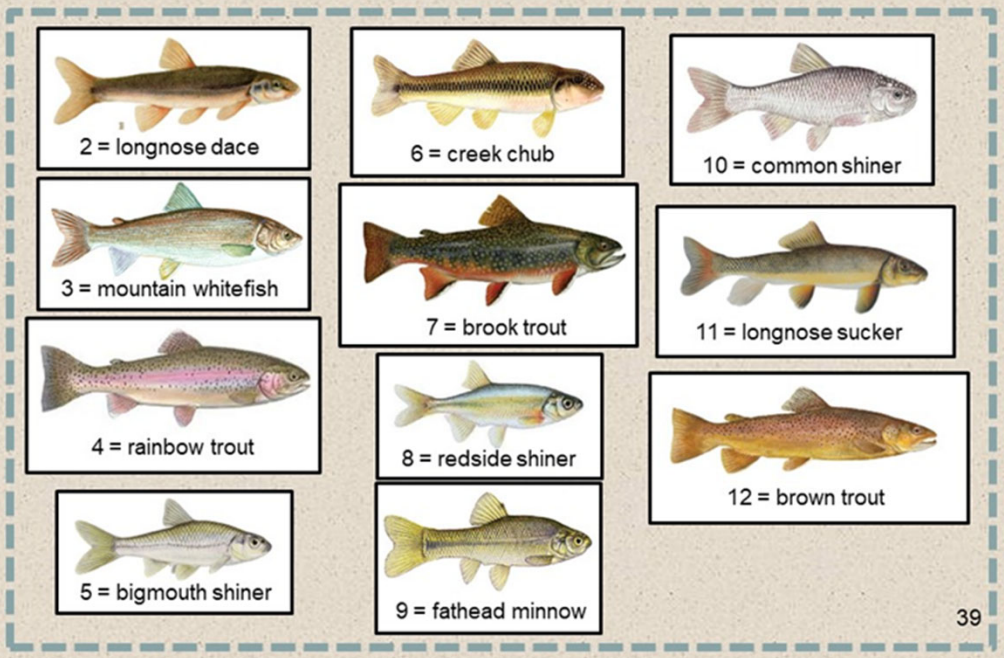
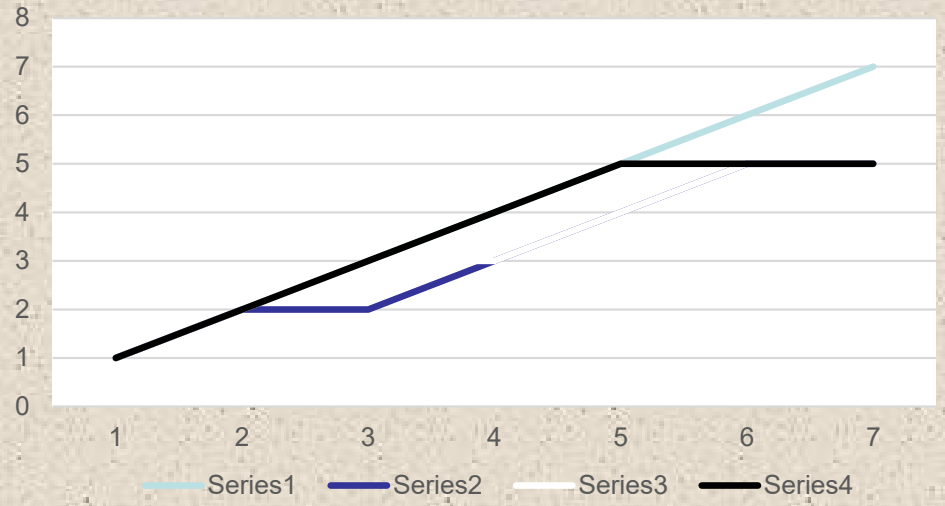
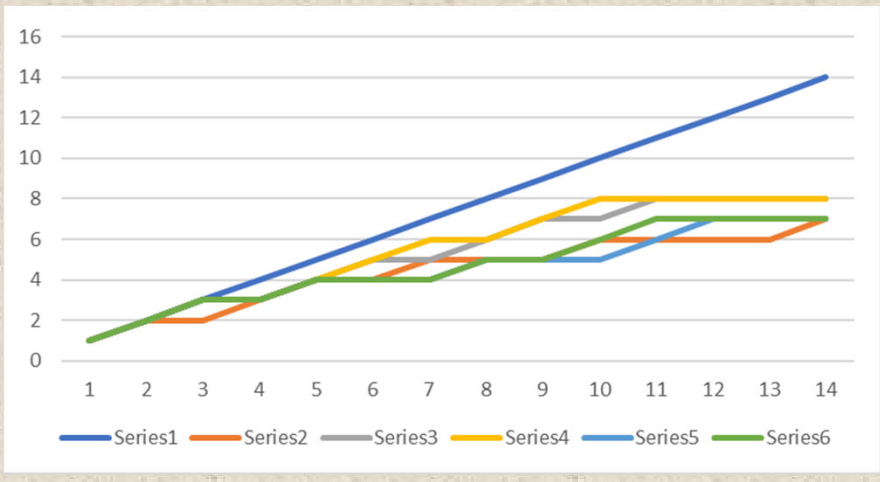


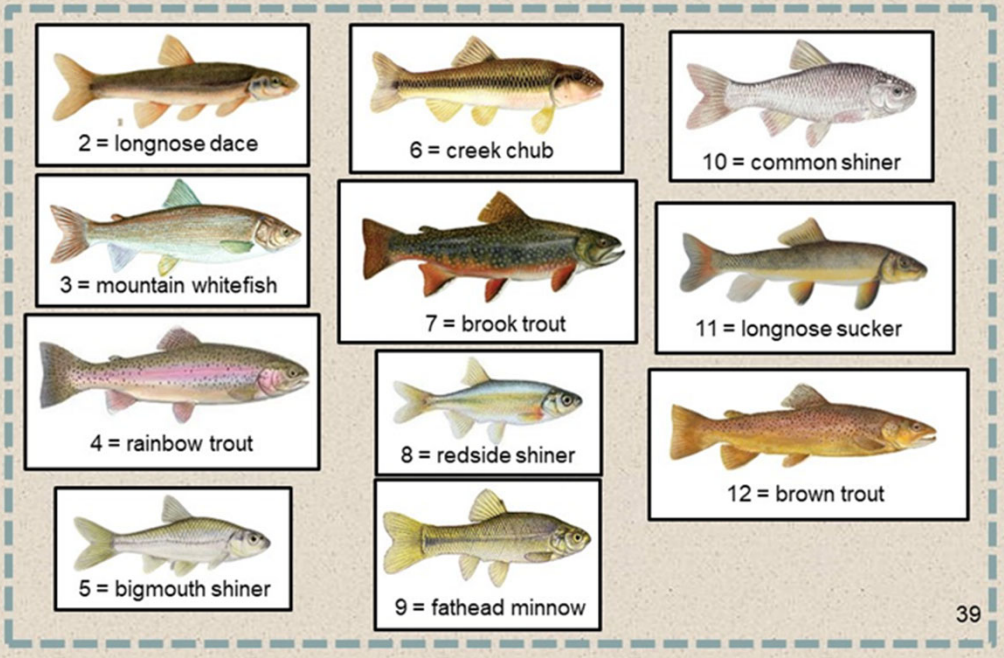
Accumulation of freshwater fish species

8 samples, each with 7 individuals



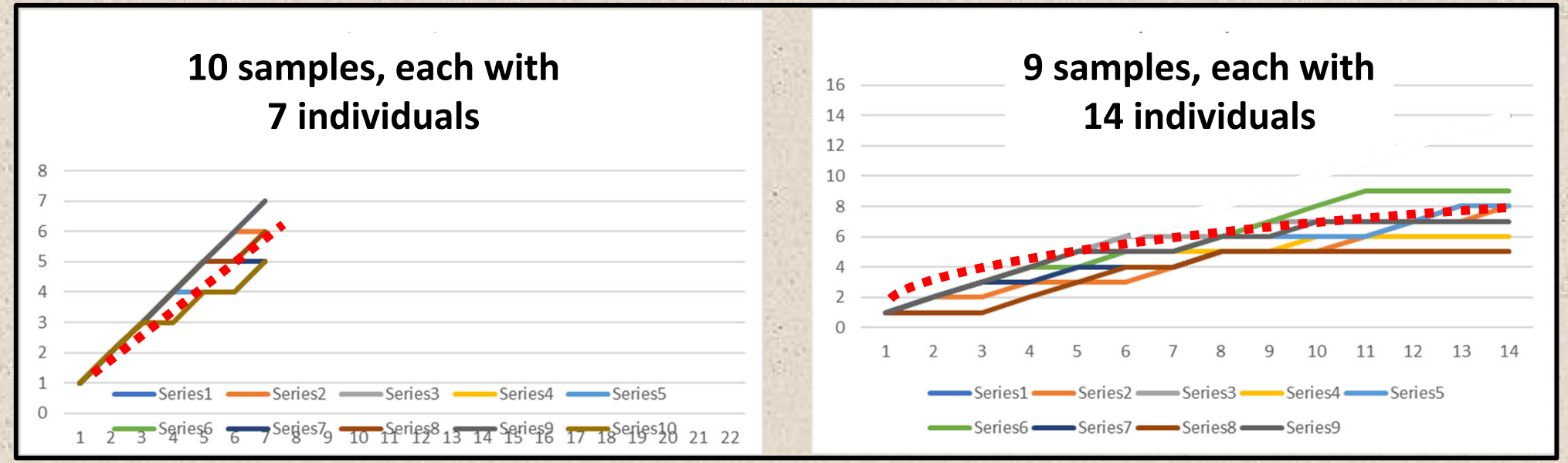
7 samples, each with 14 individuals

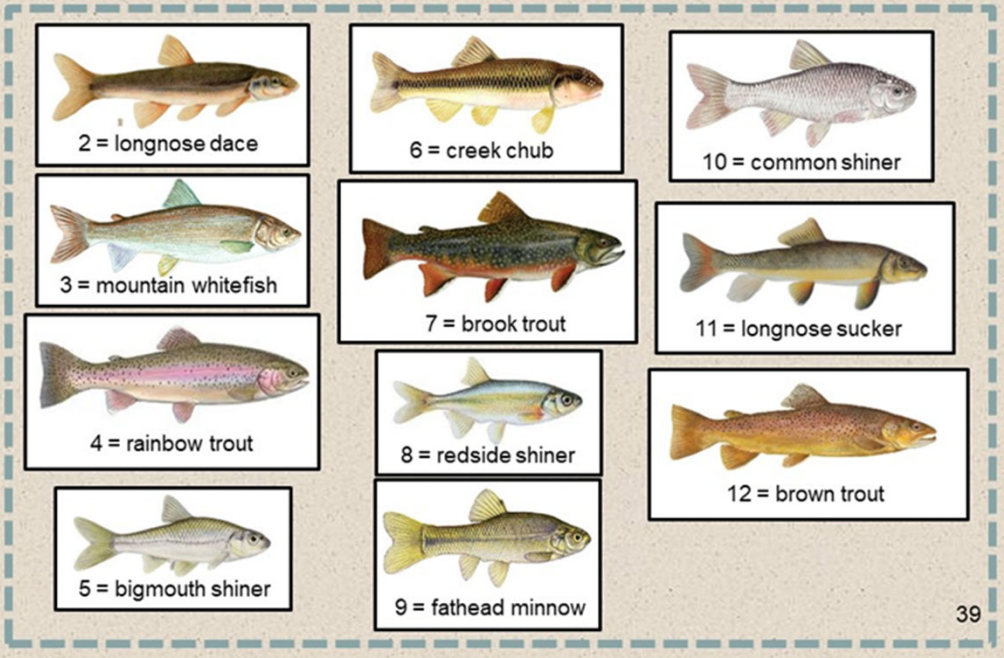




- **<u>species rarefaction curve</u> = graph produced by plotting the average number of species represented by 1, 2, … n individuals or samples.**

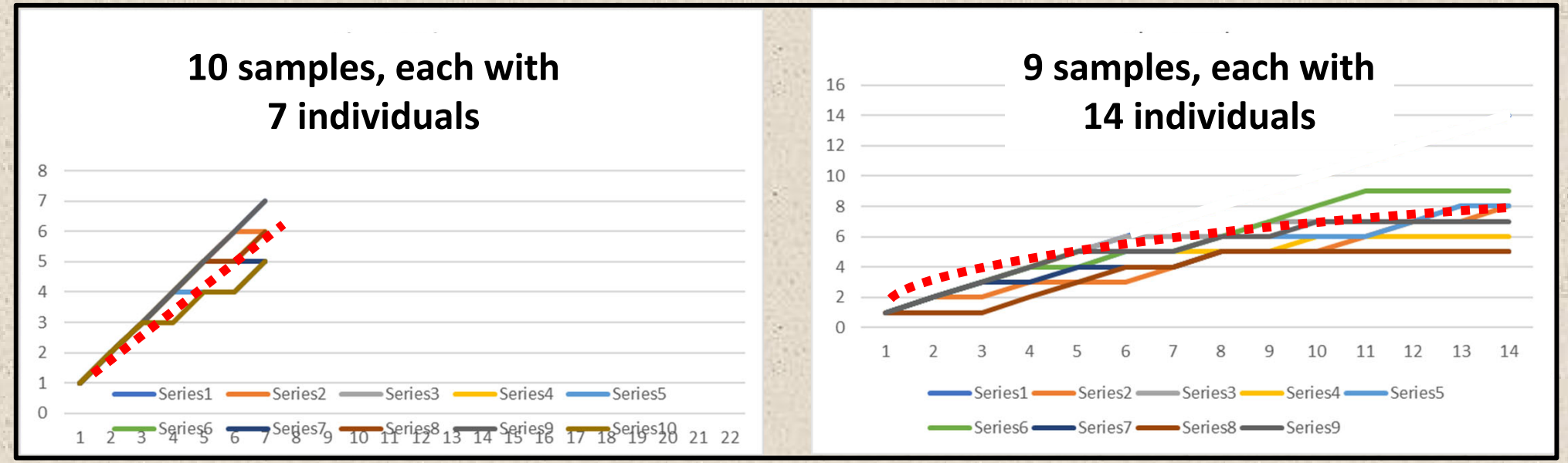
Rarefaction of freshwater fish species





- **the more we sample, the closer we get to representing species richness in the "real" community.**
- **but, *<u>we can still miss some species and get non-detection errors</u>* even if our community is well sampled.**

Rarefaction of freshwater fish species



2 = longnose dace

3 = mountain whitefish

4 = rainbow trout

5 = bigmouth shiner

6 = creek chub

7 = brook trout

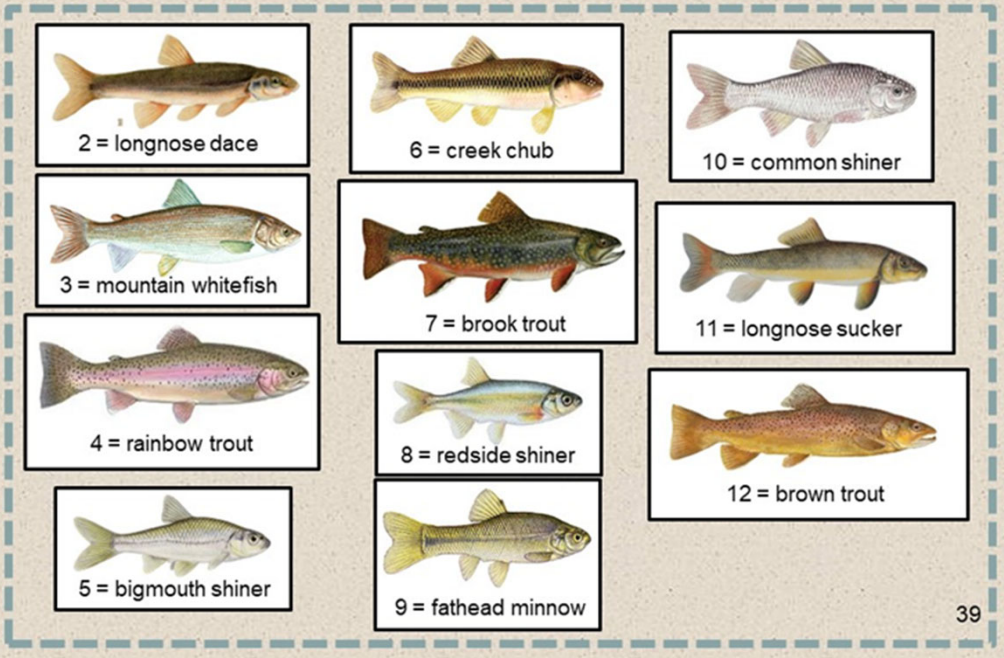
8 = redside shiner

9 = fathead minnow

10 = common shiner

11 = longnose sucker

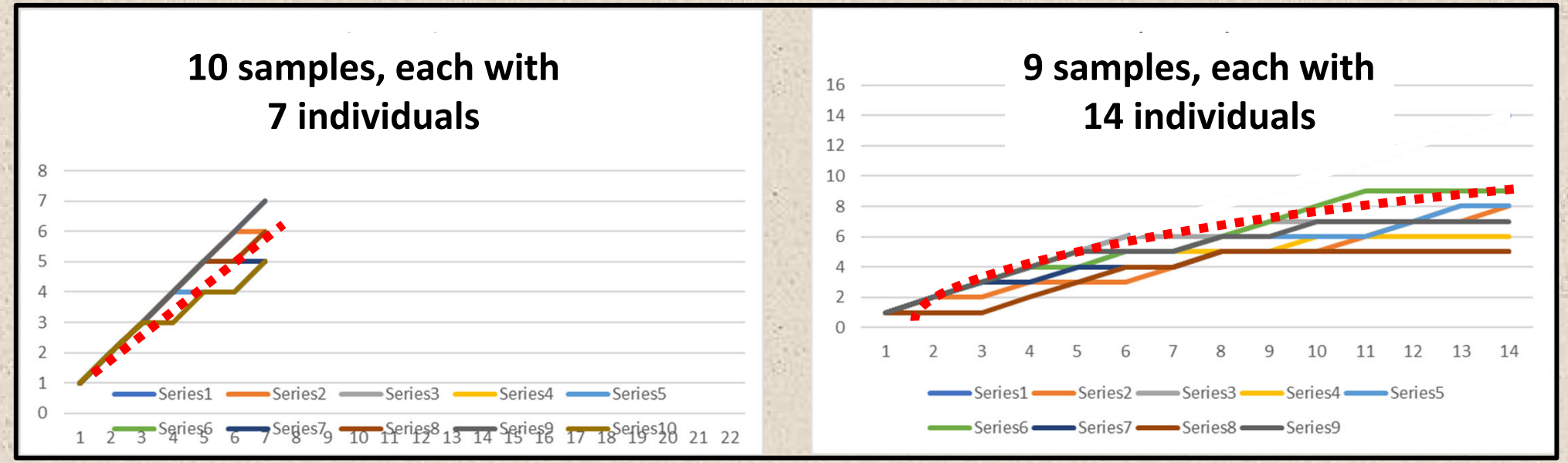
12 = brown trout

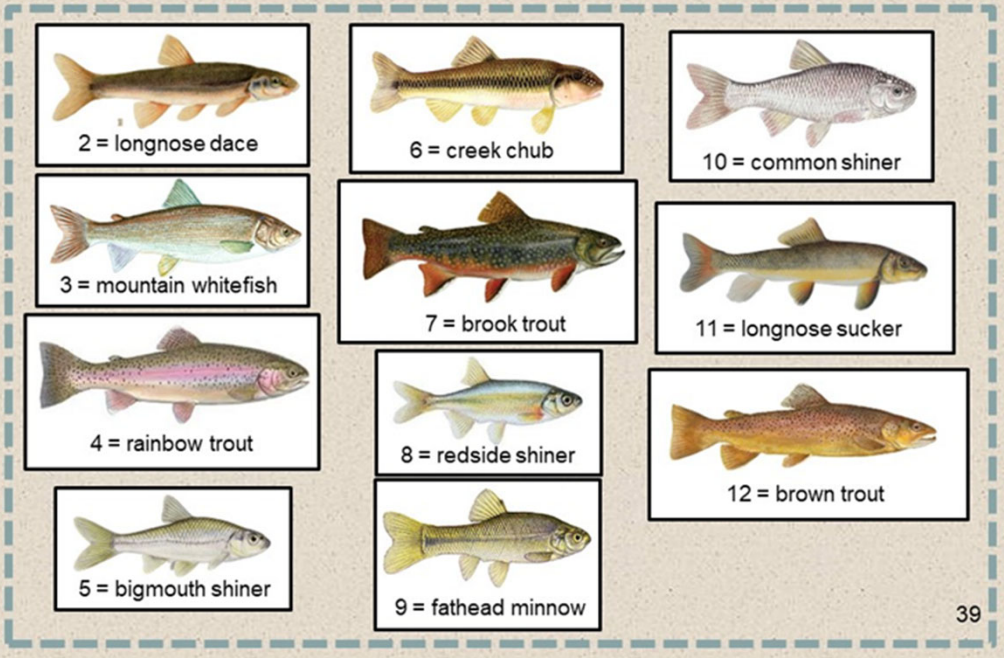


- **Rarefaction curves are useful for:**

-- telling us when we can "quit" sampling a community

Rarefaction of freshwater fish species





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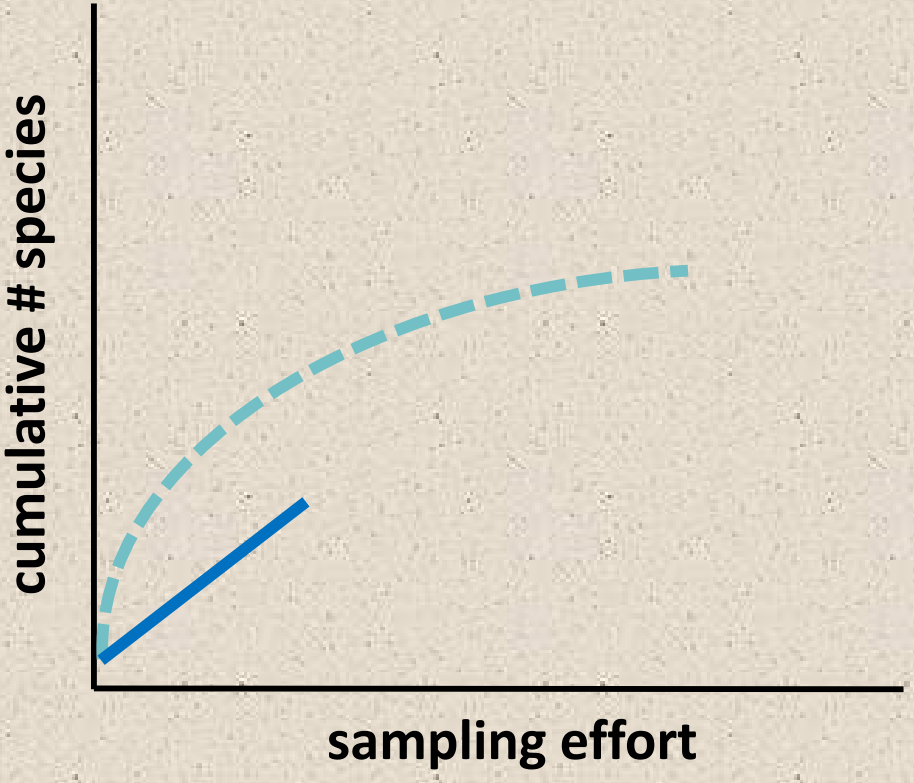
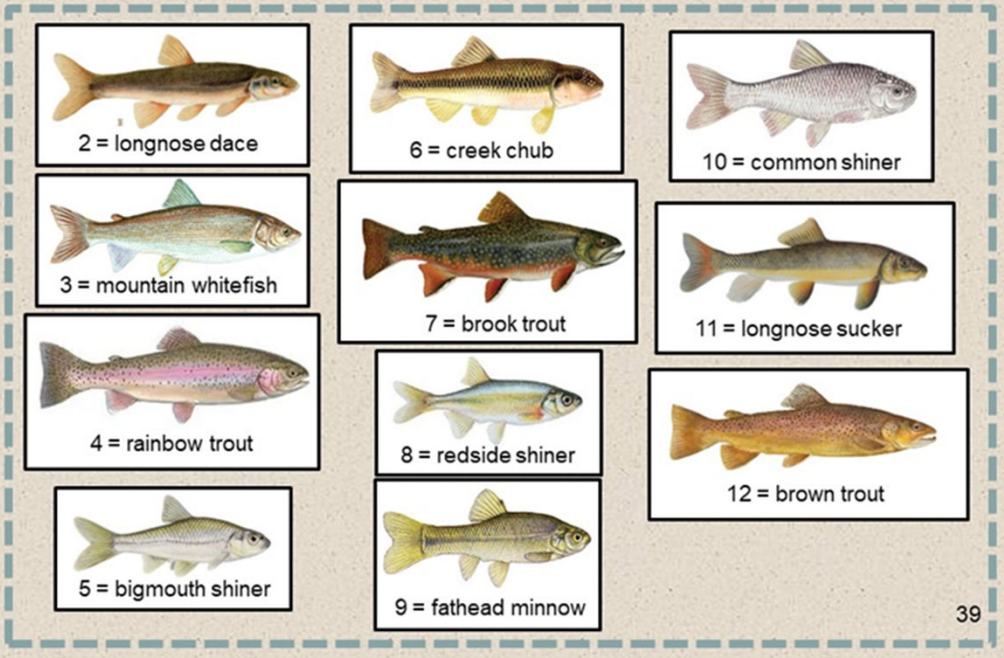


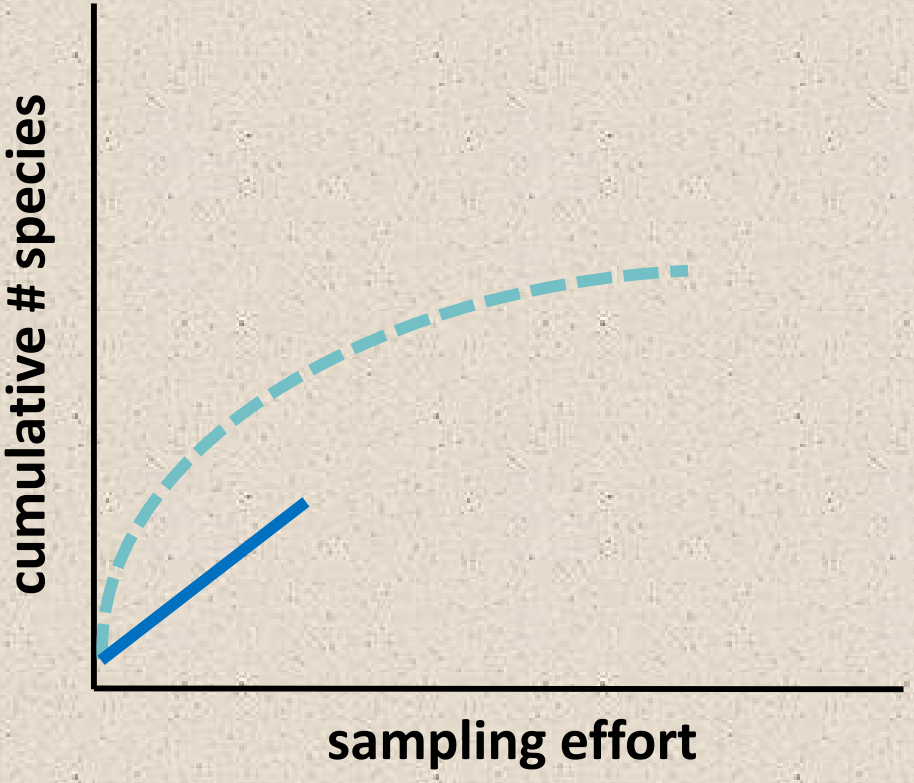
Clark's fork

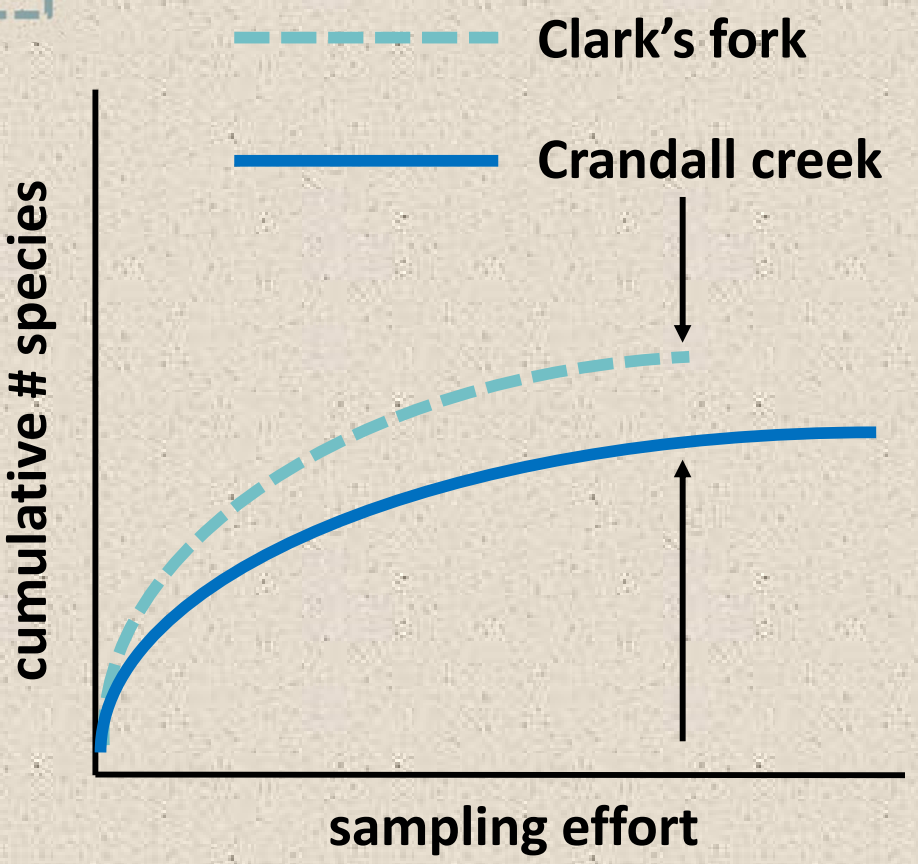
Crandall creek



- **Rarefaction curves are useful for:**

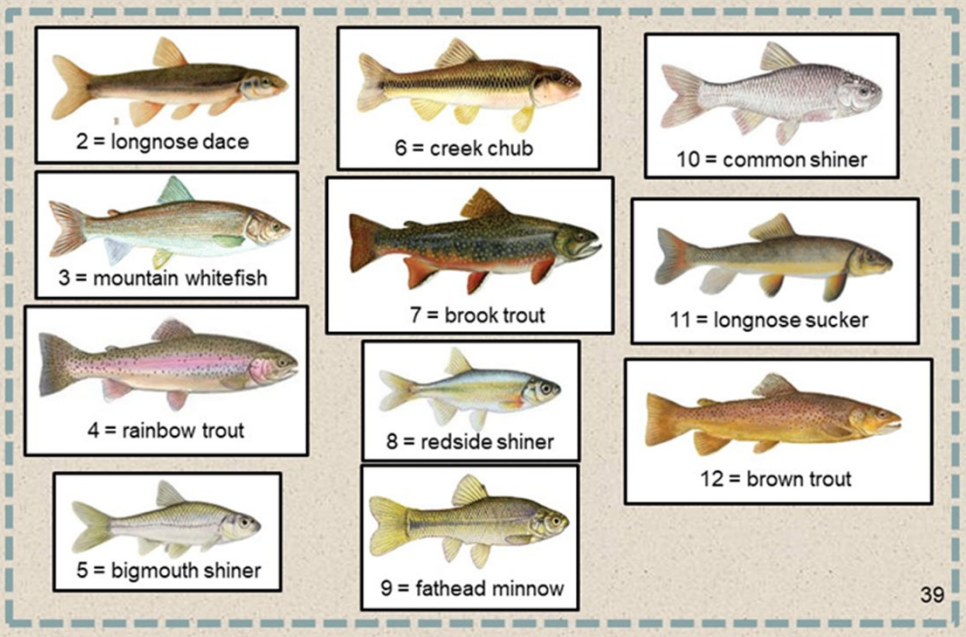
-- controlling for unequal sampling effort between ≥2 communities, when we want to know whether species richness, diversity, etc differ between those ≥2 communities

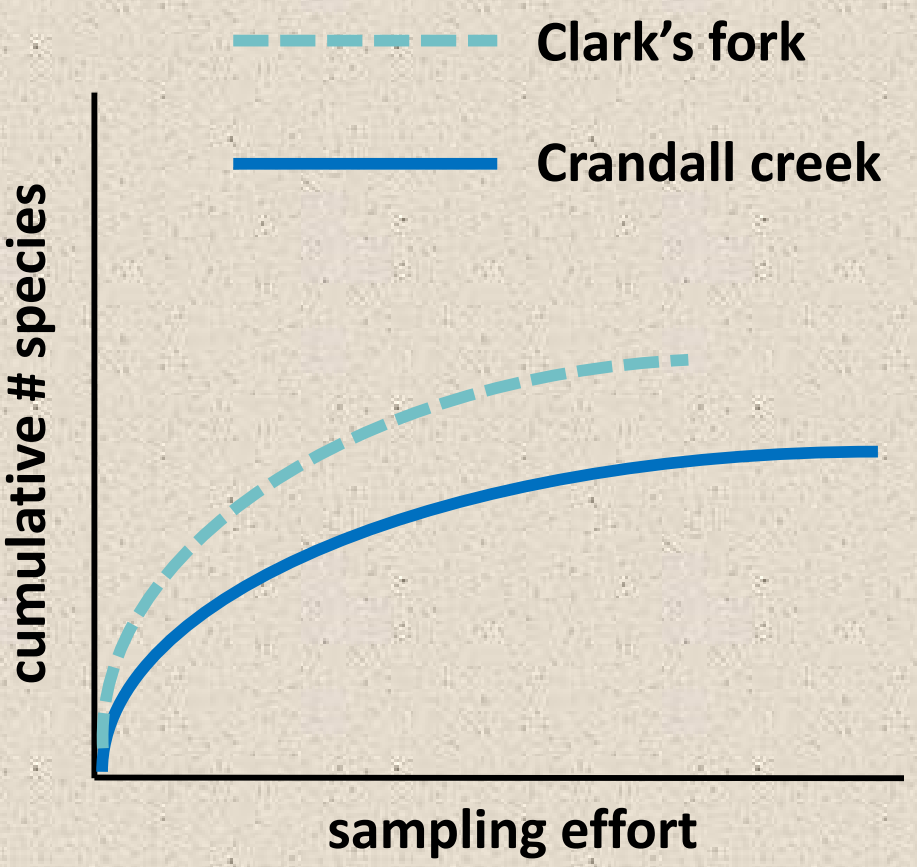




Discussion: what modification(s) would we like to add to the rarefaction curves below? Hint: remember that species rarefaction curves are "averages" of many species accumulation curves.

Besides wildlife and fisheries biology, can you think of other examples for which rarefaction could be used to estimate the # of something?





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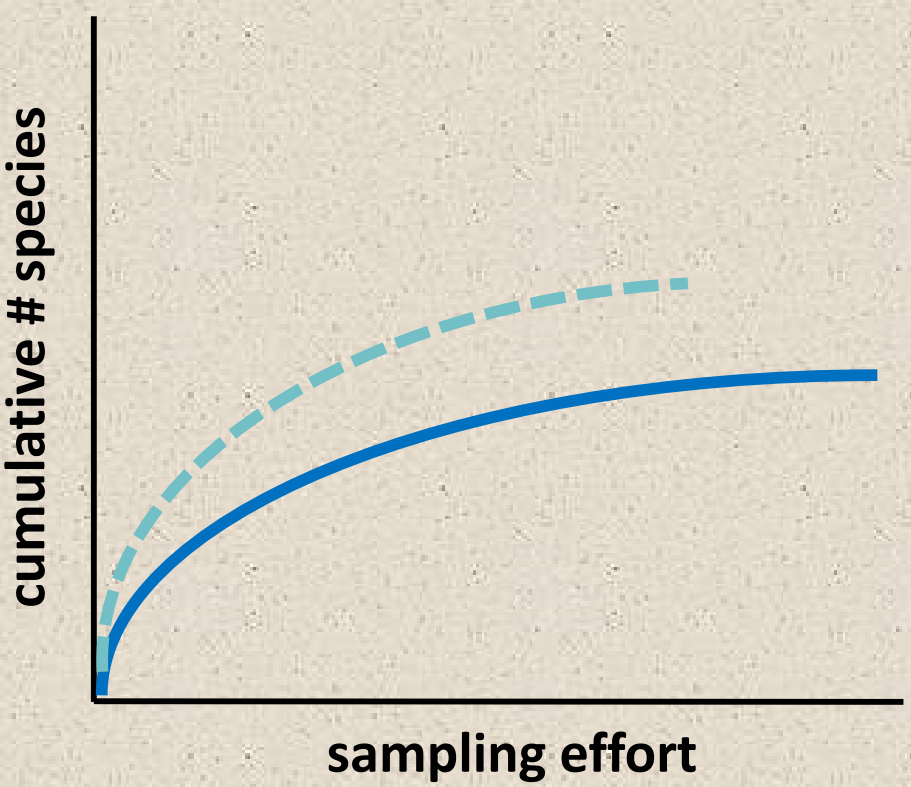
Clark's fork

Crandall creek



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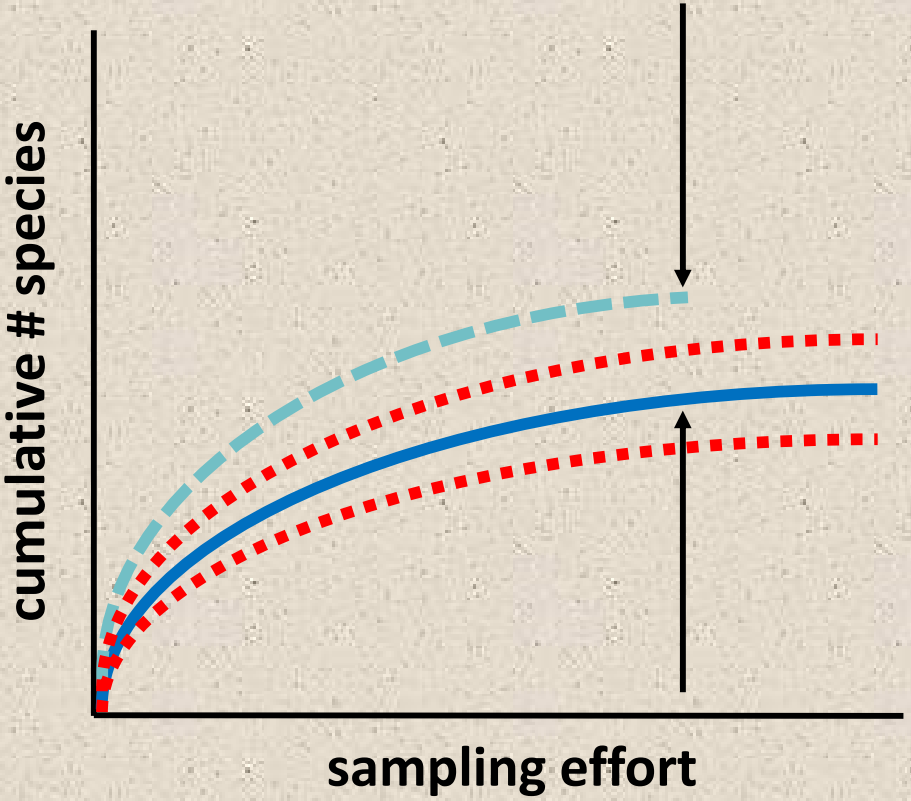
Crandall creek



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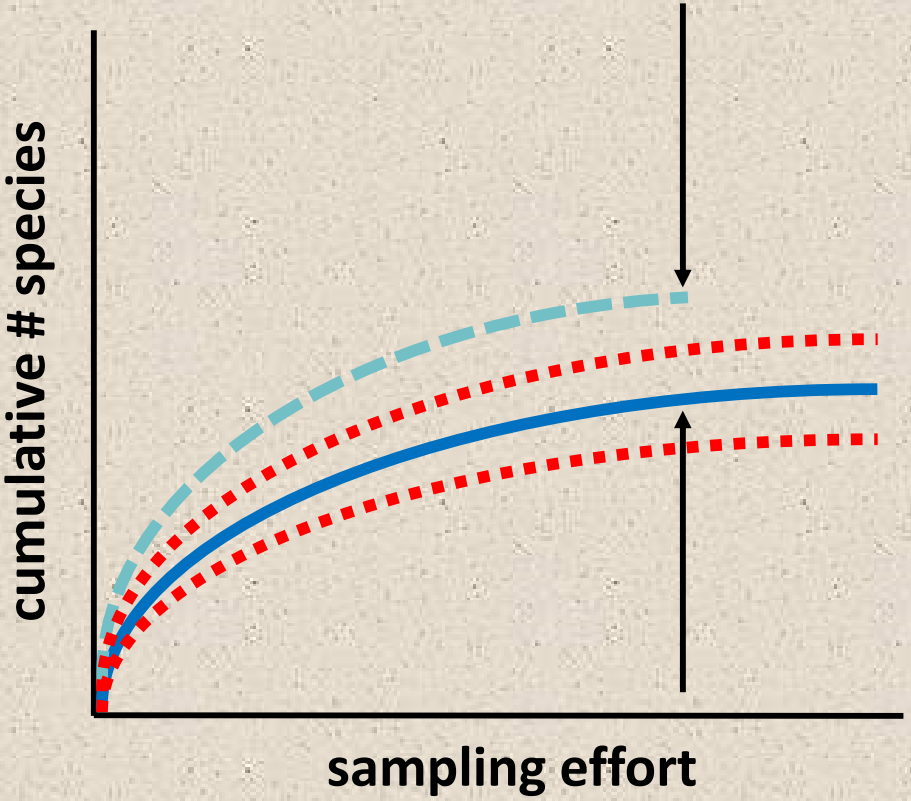
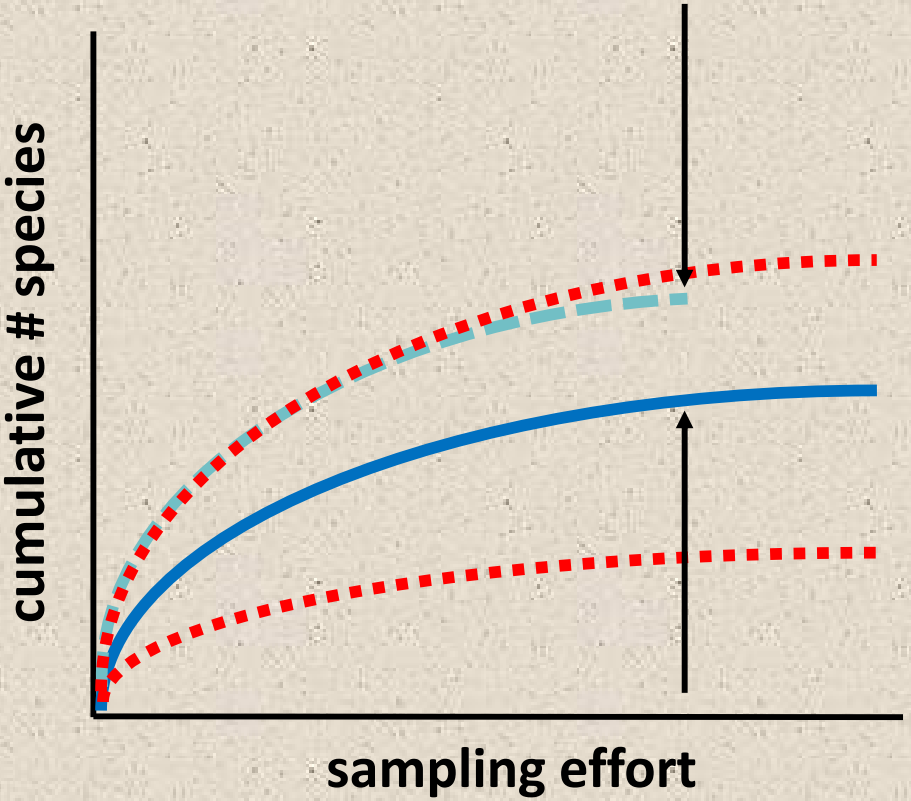
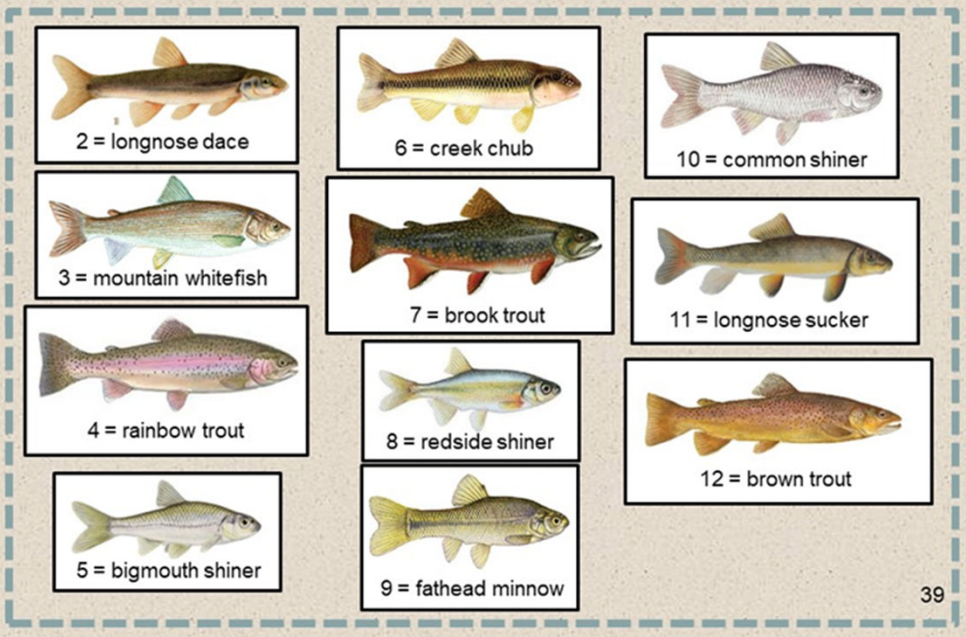
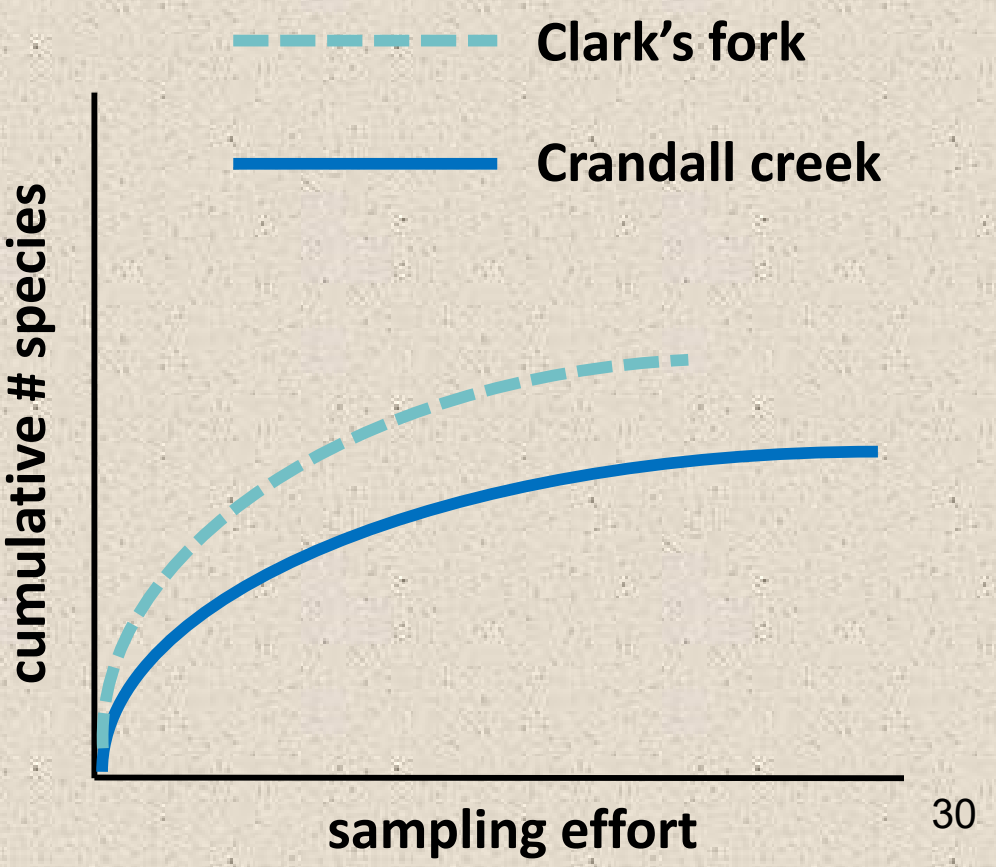


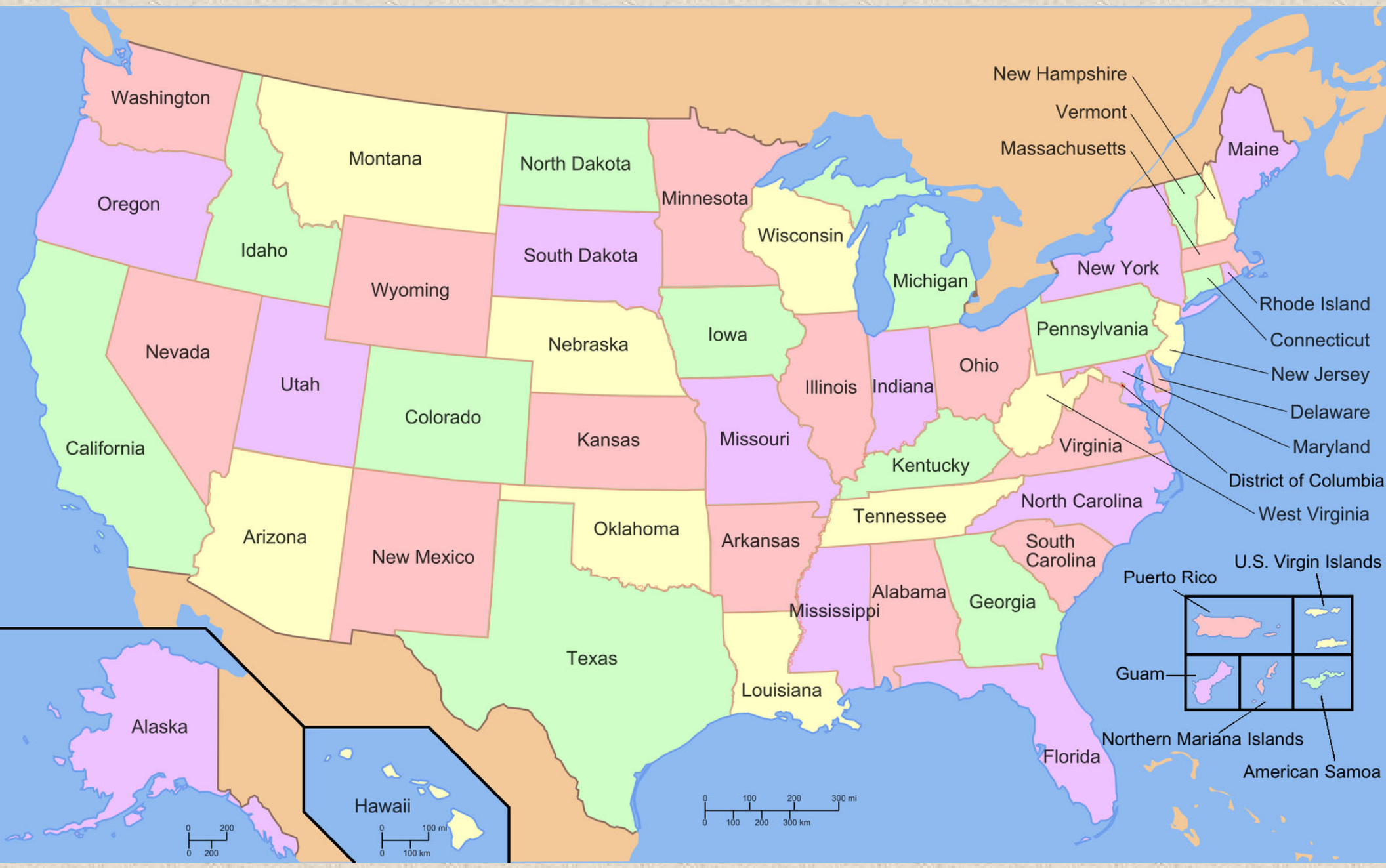


Discussion: what modification(s) would we like to add to the rarefaction curves below?

Besides wildlife and fisheries biology, can you think of other examples for which rarefaction could be used to estimate the # of "something" through sampling?



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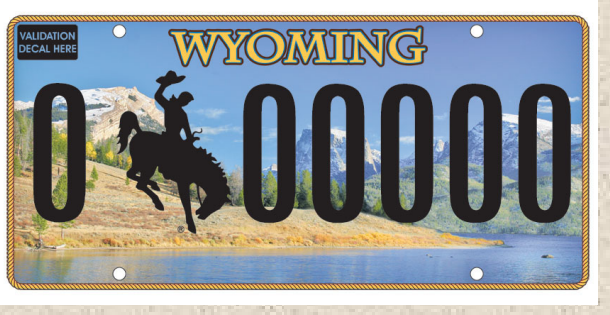
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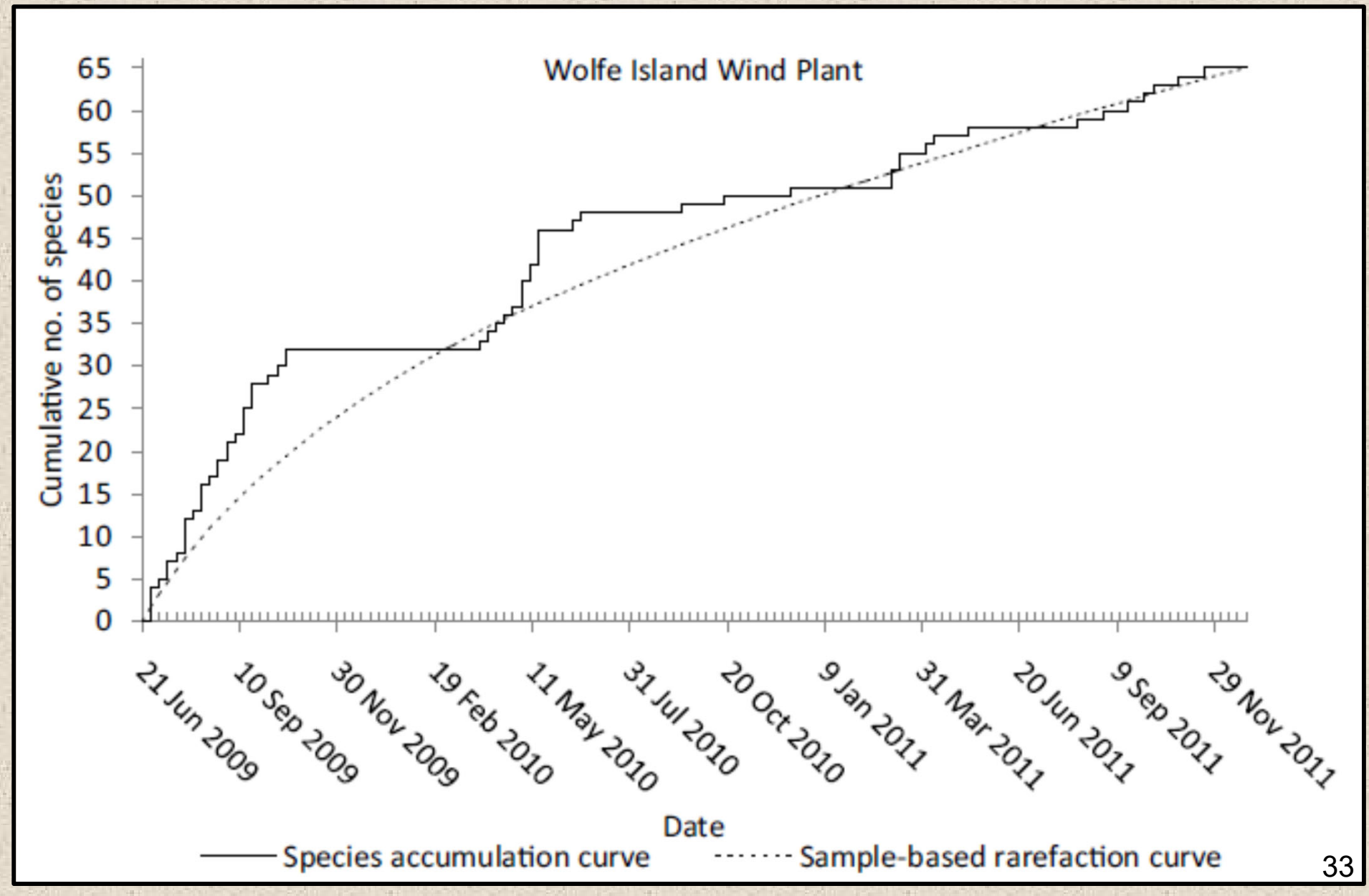
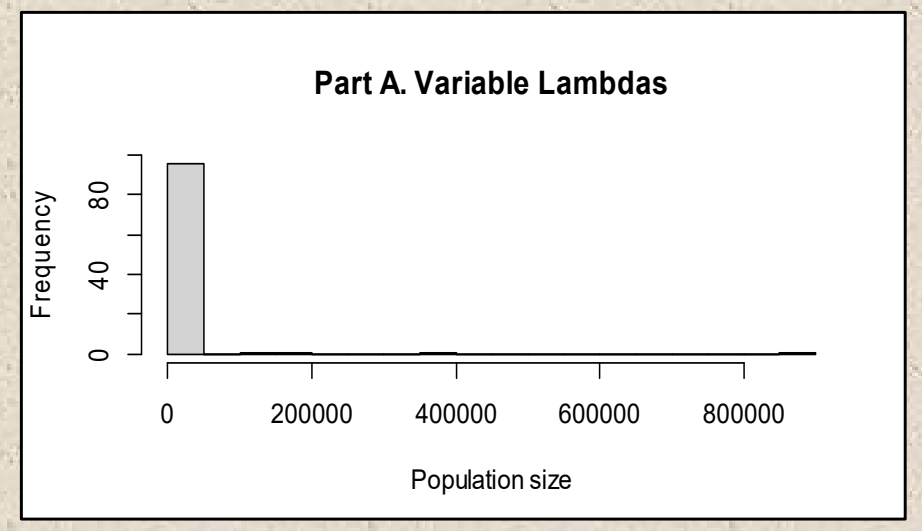
Northern Mariana Islands
American Samoa
Alaska
Hawaii

Accumulation curves: what they are, why they're used

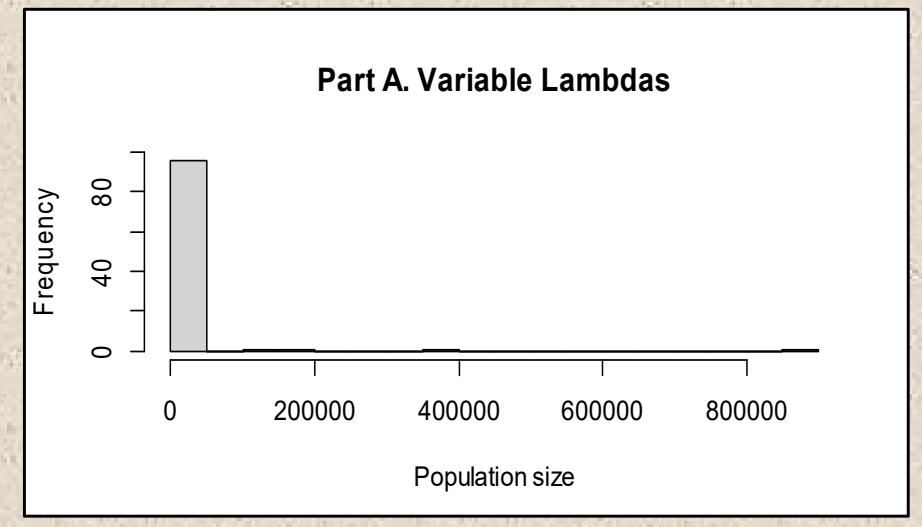


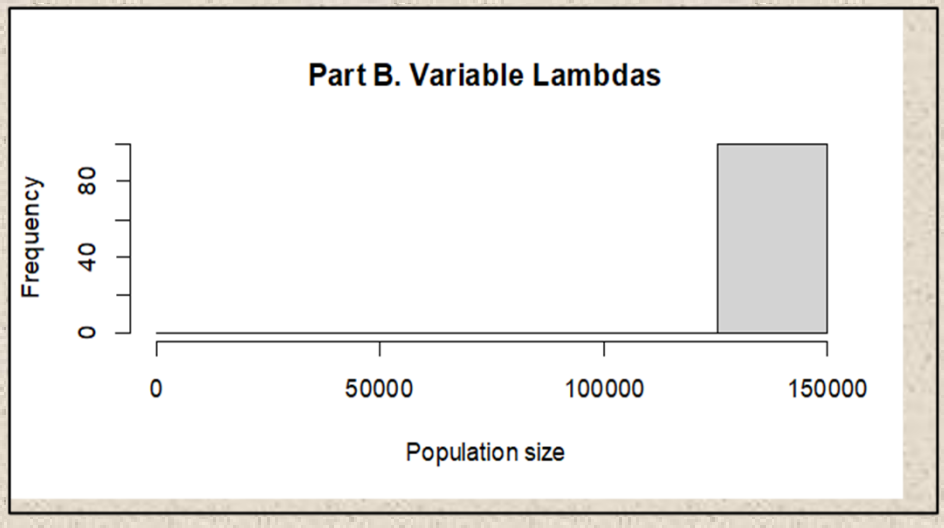
Beston et al. 2015.

1a) Follow the code with the given vector of five lambda values to create a PVA. Copy and paste the histogram of population sizes of Wyoming toads onto your .doc. From the histogram you generate, visually estimate the % of populations that will go extinct after 100 years (the length of the simulations). Hint: what is the population size of an extinct population?

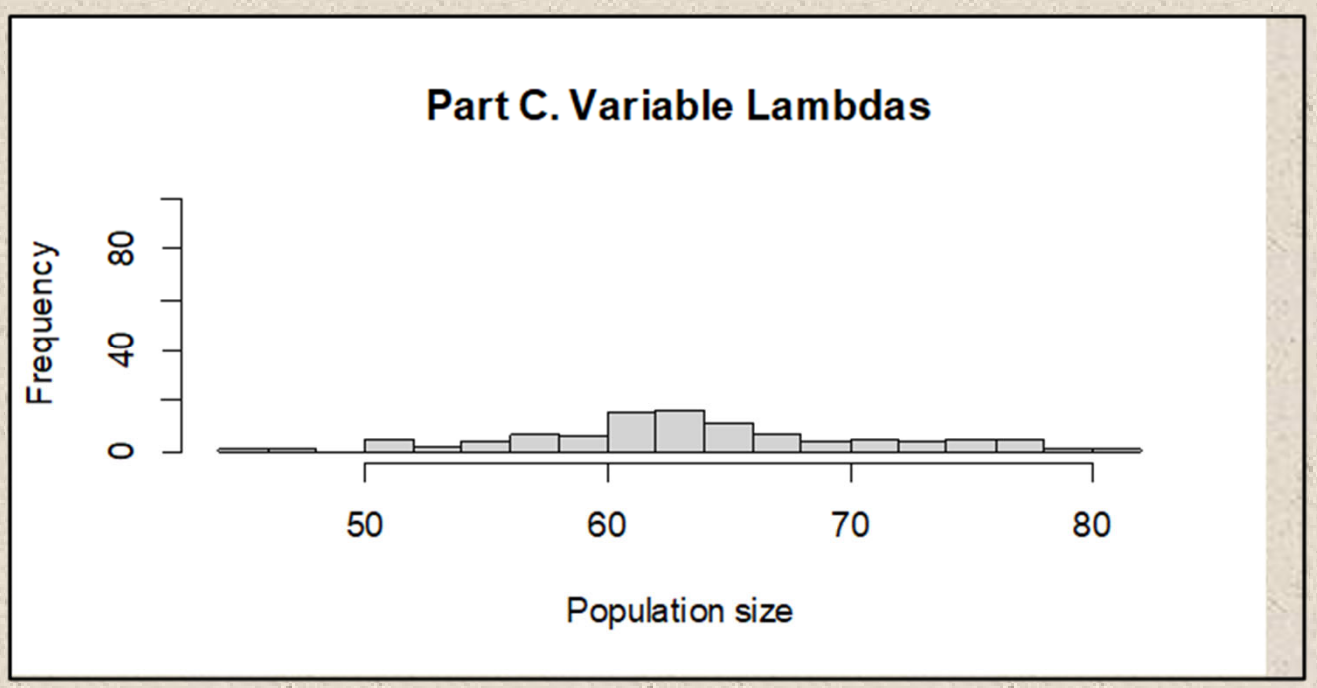


1b) take the arithmetic mean (i.e., the average) of the five lambda values. Now, create a new vector of 5 identical lambda values (r) values that include this mean in each vector element. Using this new lambda vector, run through the population simulation code a second time to predict the population size of Wyoming Toads in 100 years. Then, like in part “a”, create another histogram and paste it here in the .doc. In words, describe how the results of the simulation differ from the original results. Why is this occurring?

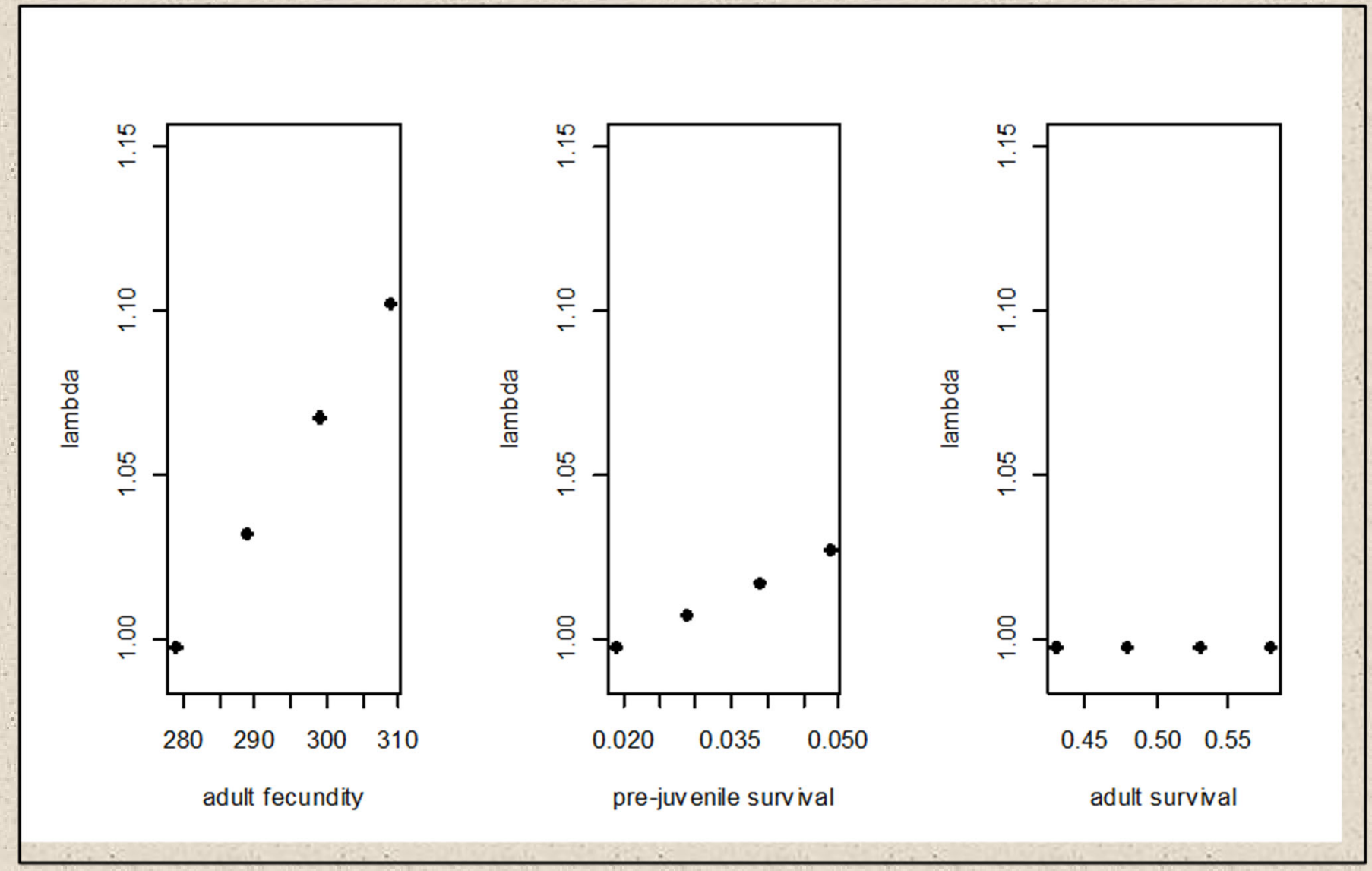




1c) Create a third vector of lambda values of 1.00, 1.02, 0.99, 1.01, and 1.02. Re-run the simulation again with this new vector and create a third histogram to include in your .doc. In words, describe how the results of the simulation differ from the results in part a. and b. Why is this occurring?

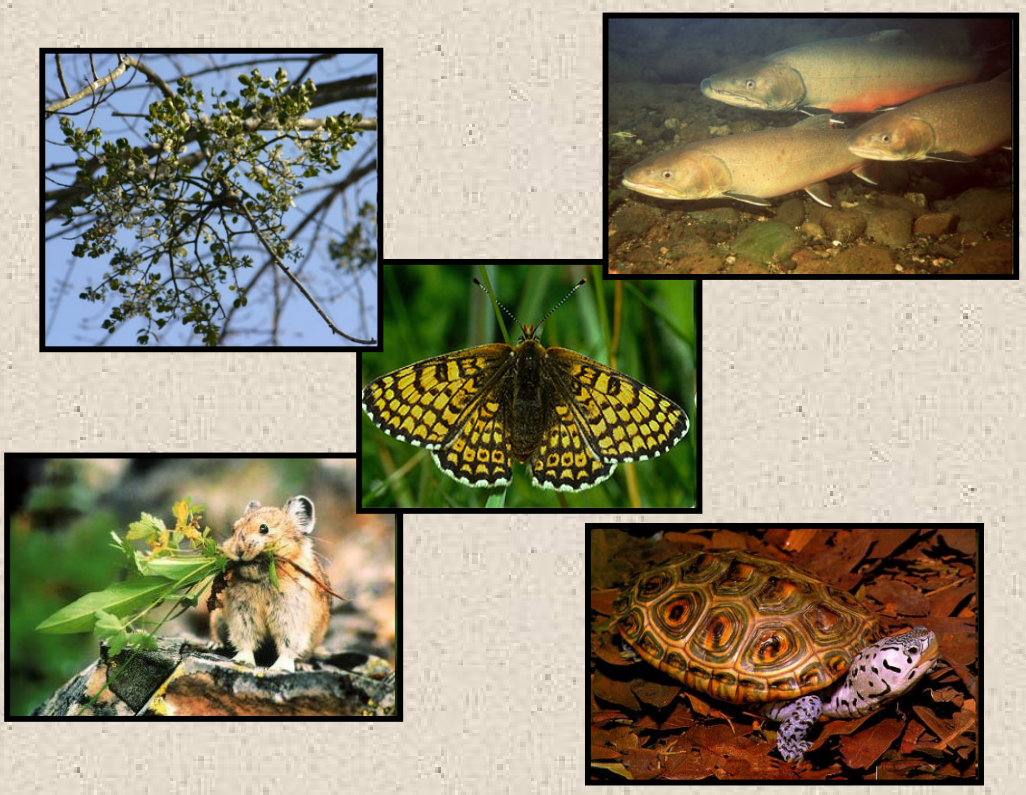


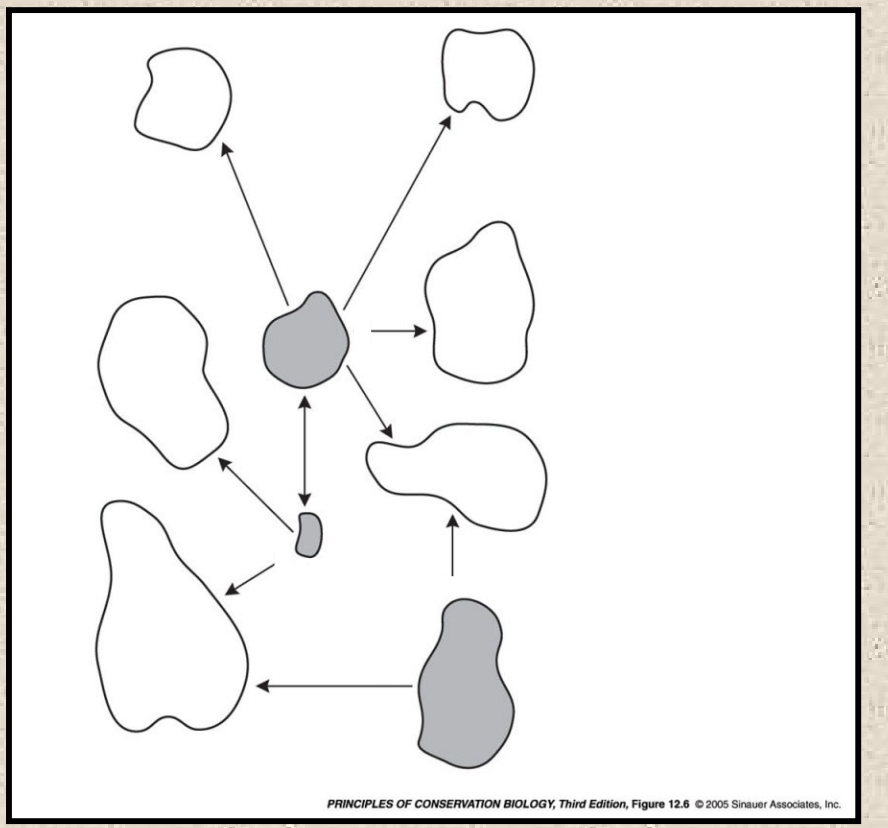
2c) Finally, create three plots, one for each vital rate adjusted. Which vital rate has the most influence on population growth (lambda)? Why would this occur?



Incorporating landscape complexity into population ecology

- **<u>metapopulation</u> = a series of populations linked by occasional dispersal and embedded in an inhospitable <u>matrix</u>**



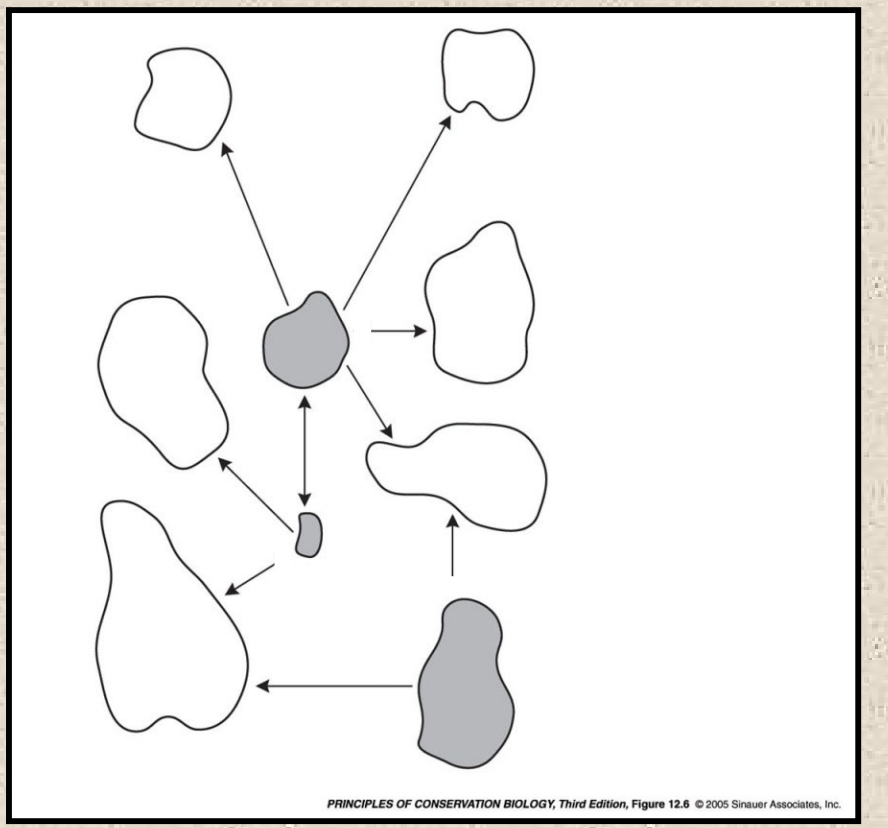


Incorporating landscape complexity into population ecology

- **source-sink dynamic = spatial linkage of populations such that high-quality habitats (sources) provide excess individuals that disperse and maintain low-quality habitats (sinks).**

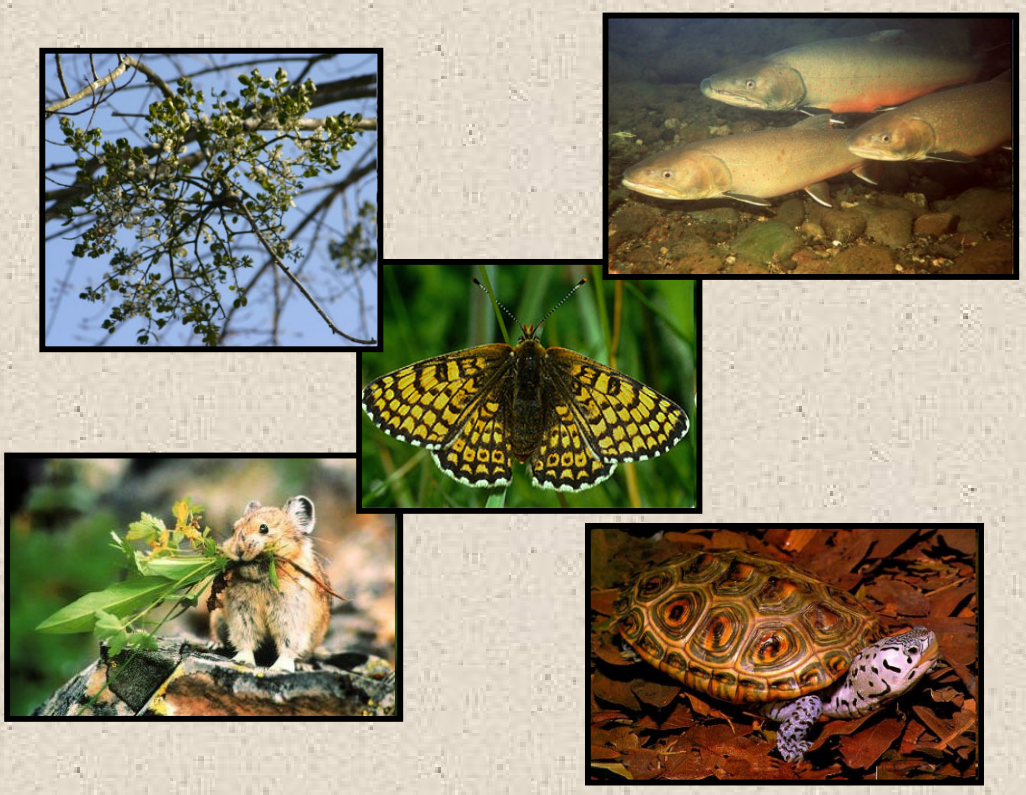
= $\lambda \geq 1$

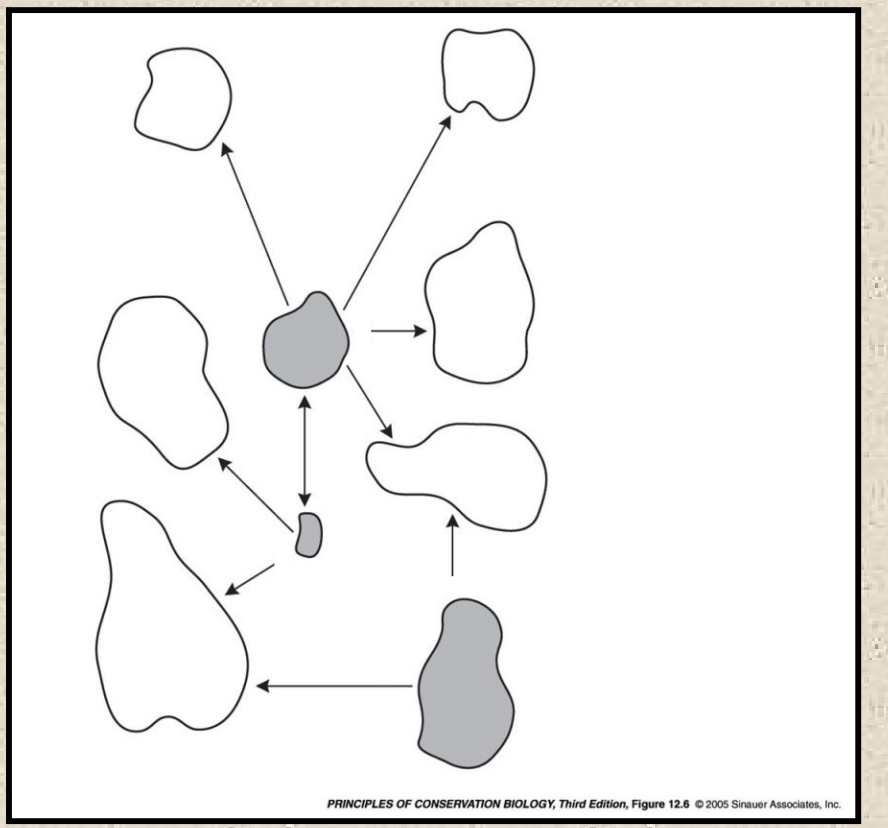
= $\lambda < 1$

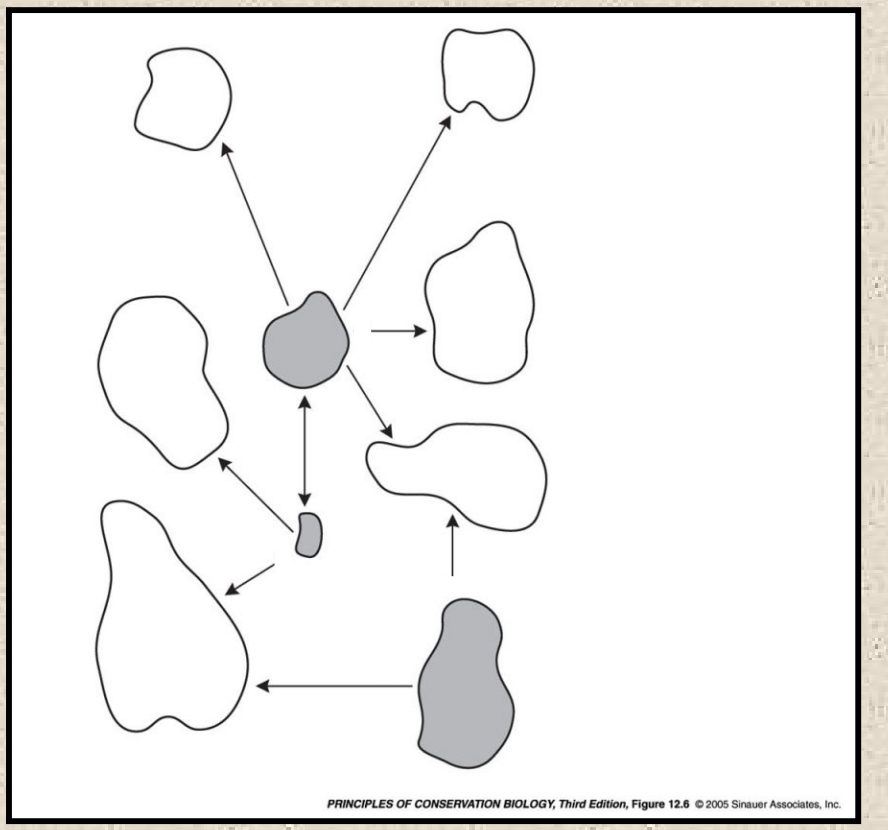


Incorporating landscape complexity into population ecology

- <u>connectivity (first definition, or "functional connectivity")</u> = the degree to which the landscape facilitates movement among discrete habitat patches





Discussion: The species below are among those that tend not to show metapopulation structure; that is, they do not occupy well-delineated habitat patches.

Why not? What does this say about the definition of connectivity?