Today's lecture: Community Ecology: Competition & Predation (plus succession, if time)

A bald eagle tries to snatch a rabbit from a fox, but the furry predator doesn't give up easily. (Kevin Ebi/Audubon Photography Awards)

Remaining Assignments

- All remaining Canvas assignments (except two) are open until Friday, April 14th @ 11:59 pm. Please finish at your own pace.

- I will give you an idea when we have covered the content in class for each of these assignments.

- Two assignments without a final date yet (please stay tuned).
    1) Dr. Pam Kalas – Genetics Survey – Round II (1%). Pam will visit class on the 11th.
    2) Informal teaching feedback (Canvas) (1%) – I will likely make the deadline April 24th.

If you used chatgpt for Group Project

- Sentences that were written by the AI program = plagiarism.
- Please reword (into your own words) and add citations/reference to your infographic and resubmit.

New: Rory is joining us from home today. He will also have his office hours on Zoom.

iClicker Question

Traditionally, it was believed that Remoras (smaller fish) fed on scraps of food dropped by the Whale Shark, and also fed on parasites from the shark's skin and mouth.

What type of relationship do whale sharks and Remora have?

A. Amensal

B. Commensal

C. Mutualism

D. Predation

E. Competition

- Award winning photo by Evans Baudin/Scuba Diving
  https://www.diyphotography.net/whale-shark-with-50-remoras-in-her-mouth-wins-scuba-diving-magazines-2020-underwater-contest/

Answer

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iClicker Question

New research suggests that Remoras are primarily feeding on the feces of the whale shark. And, they attach to the whale shark using a “sucker” on their head; so, unlikely that they are eating parasites.

What type of relationship do whale sharks and Remora have?

A. Amensal

B. Commensal

C. Mutualism

D. Predation

E. Competition

- *National Geographic*

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What type of relationship do whale sharks and Remora have?

A. Amensal

B. Commensal (+ / 0)

C. Mutualism

D. Predation

E. Competition

- *National Geographic*

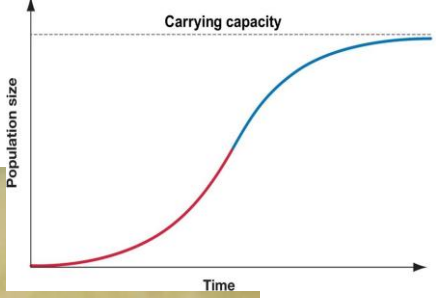
4: Competition (– ; –)

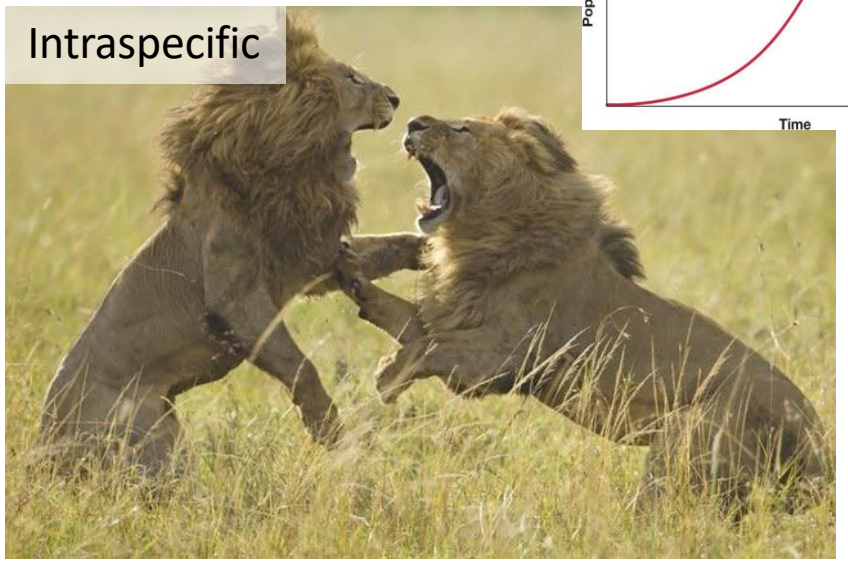
Competition: interaction where the fitness of both organisms potentially negatively affected

Two types of competition:

- Intraspecific competition
  - Between individuals of the <u>same</u> species
- **Interspecific competition**
  - Between individuals of <u>different</u> species

We will focus on interspecific competition for the community ecology unit.



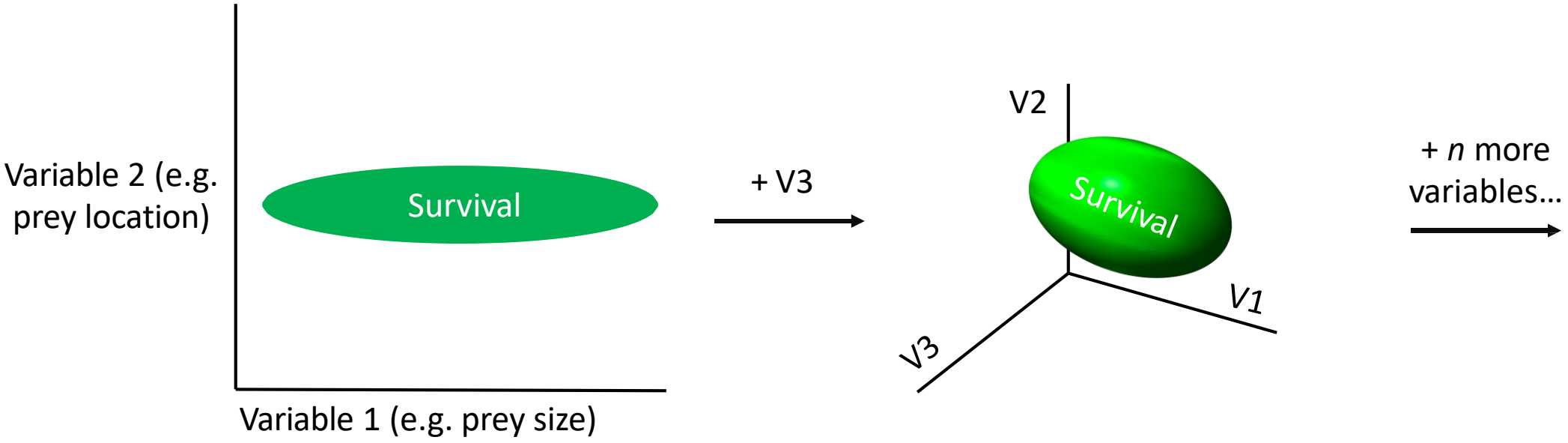


What is a niche?

Every species in a community has a niche (or ecological niche):

A specie's niche refers to the space, environmental conditions, and resources (e.g. food) that an organism uses to survive and reproduce. It also includes an organism's role in the community (e.g. producer, predator).

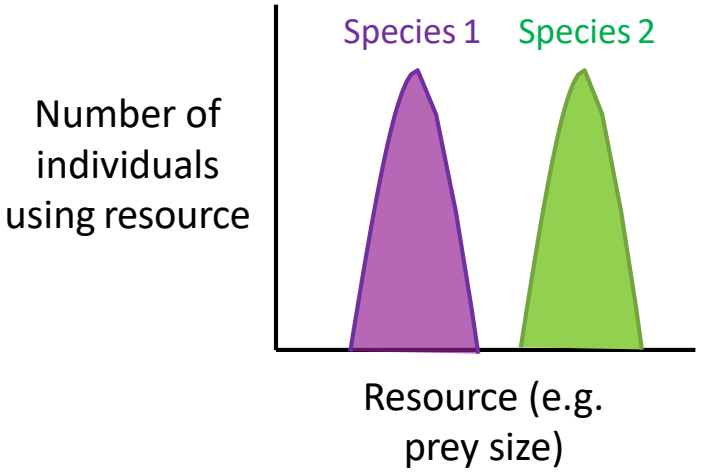
Niche space (NOT TESTABLE) = a multidimensional space encompassing suitable conditions for all factors which represent the conditions under which an individual, population, or species will persist.



Interspecific competition occurs when….

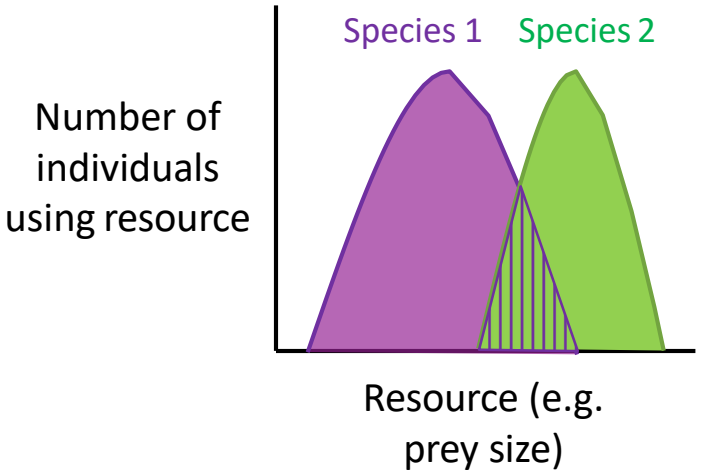
1. Species have overlapping niches (e.g. require the same prey size)
2. And, those resources are in limited supply (e.g. space, food)

No niche overlap:



- No competition

Partial niche overlap:

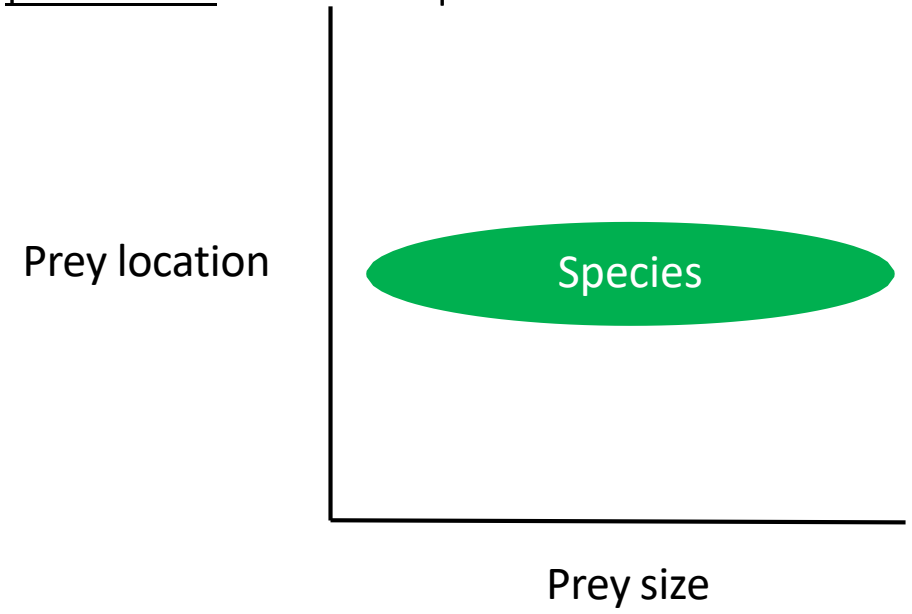


- Competition in area of overlap
- If species are competitively equal, both experience lower fitness in area of overlap

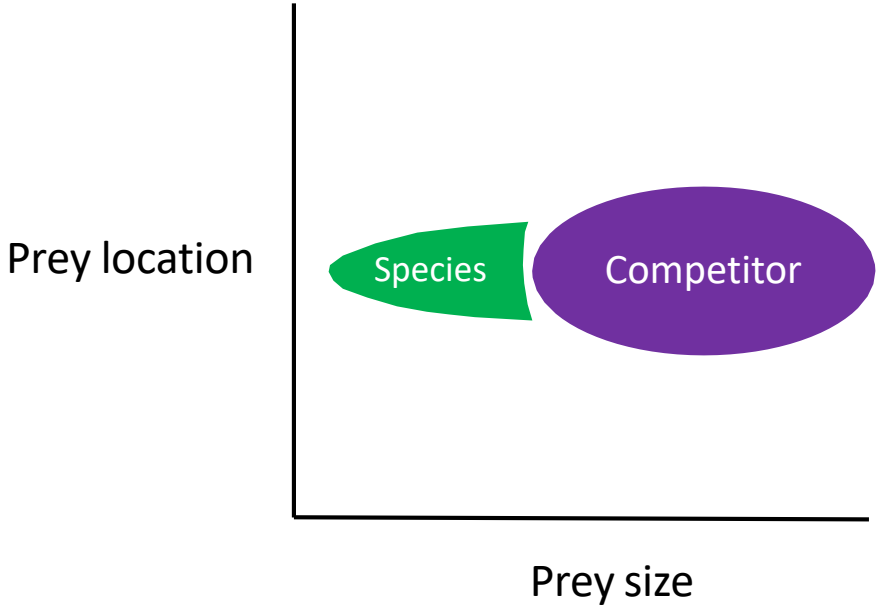
Fundamental vs realized niche - testable

Fundamental niche: the set of resources (biological and physical) that an organism is capable of using in the absence of competitors (and other biotic interactions).

Realized niche: the actual set of resources/environmental conditions an organism uses in the presence of a competitor.



Fundamental niche
(no competitor present)



Realized niche
(competitor present)

Interspecific competition has two possible ecological outcomes

1. **Stable coexistence (by niche partitioning)**

- Species are able to coexist (both remain in the site/habitat); both species give up part of their fundamental niche in order to coexist.
- They use the shared, limited resources but in different ways

2. **Competitive exclusion**

- One competing species is eliminated from part or all of the site/habitat (fundamental niche) by a superior competitor.

Coexistence is driven by selection for:

- Differential use of habitat/space
- Differential consumption of prey* species and/or prey* sizes (or food sources)
- Different temporal (timing of) activities (Rory will discuss in this guest lecture).

Spatial niche partitioning

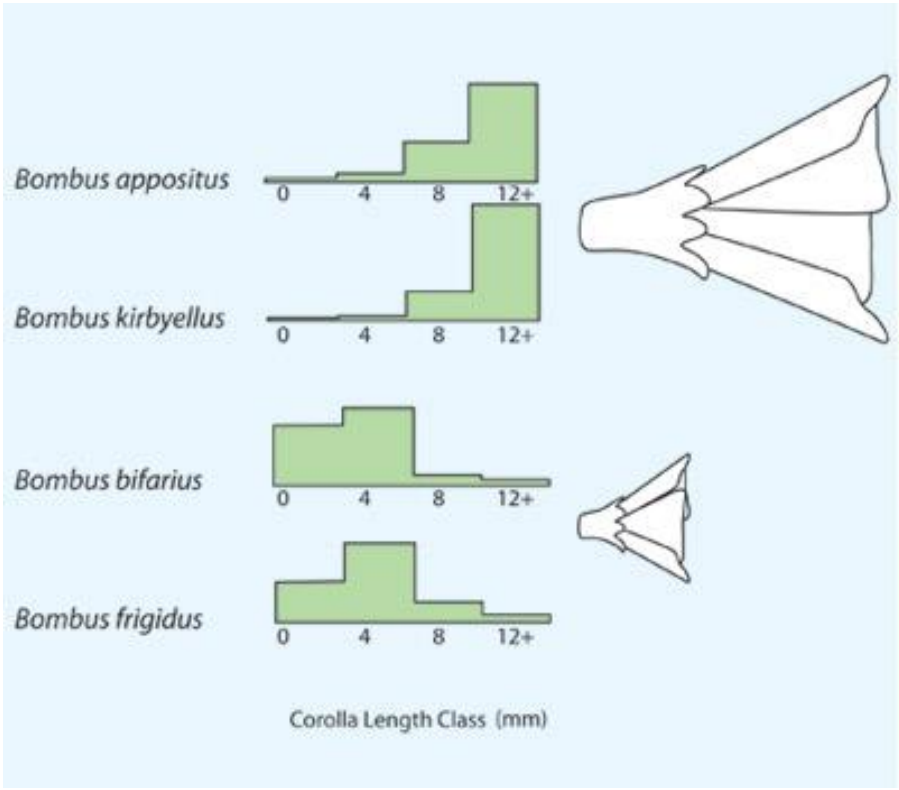
Five warbler species forage for insects.

But, they forage in different parts of the tree (and on different insects) (Robert McArthur),

This allows the warblers to coexist.

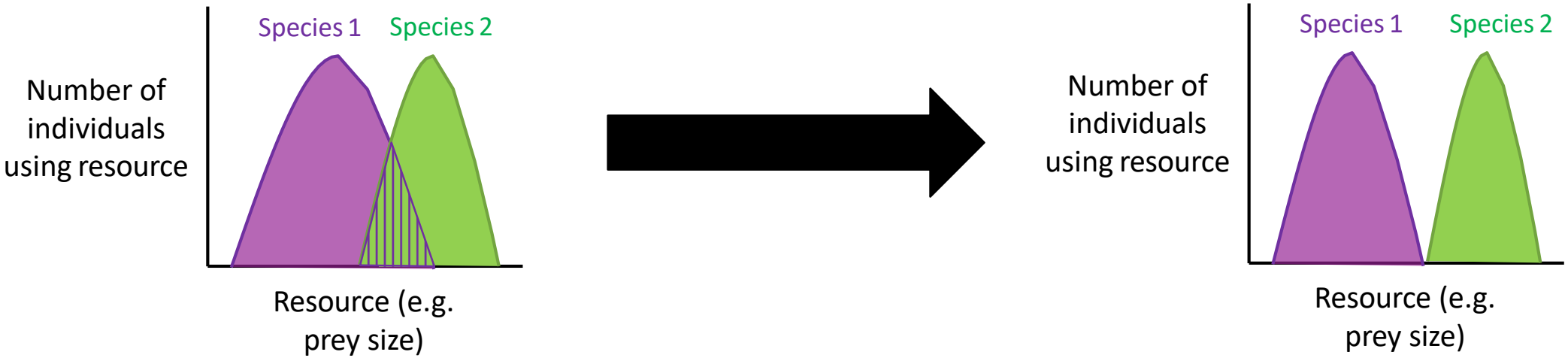
Differential consumption of food

Bumblebees compete for the same nectar from flowers.
But different bumblebee species in the same area prefer different flower sizes (correlated with the bee's feeding appendage size).

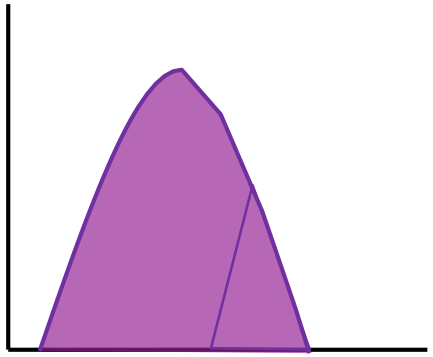


https://www.nature.com/scitable/knowledge/library/resource-partitioning-and-why-it-matters-17362658/

Outcome of niche partitioning



- Realized niche becomes smaller than fundamental niche for both species.
- If one competitor were removed, the other species could immediately capitalize on the full range of resources (change was not heritable)

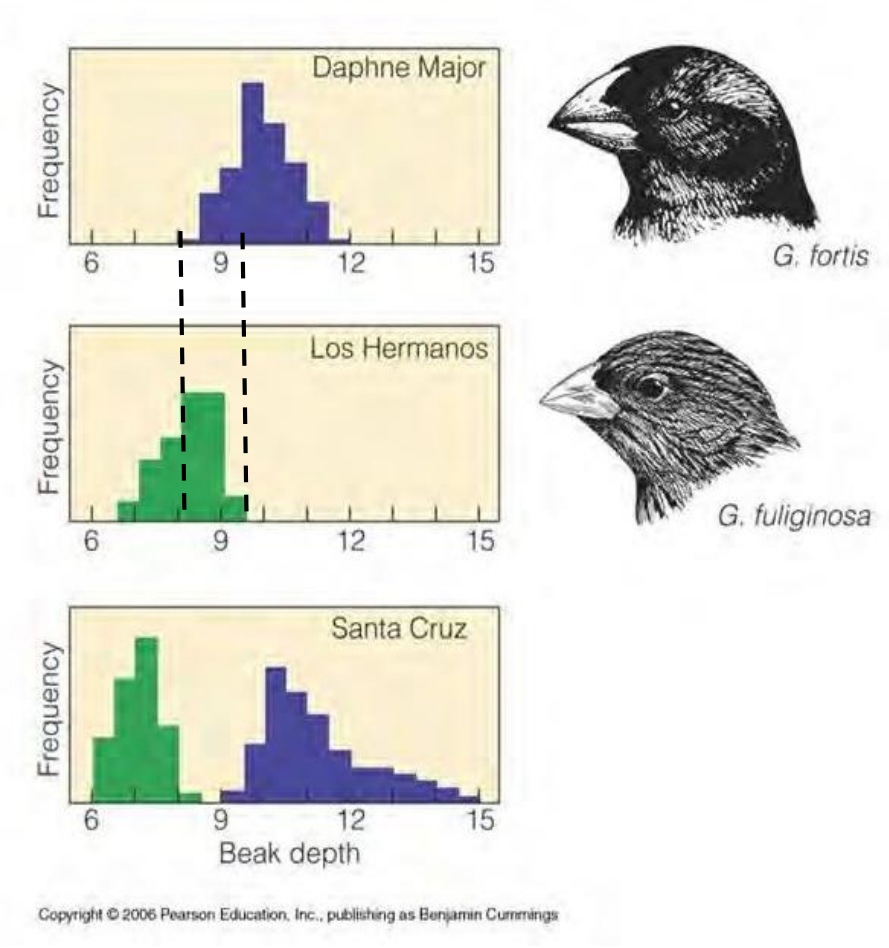


Niche partitioning over long periods of time…..

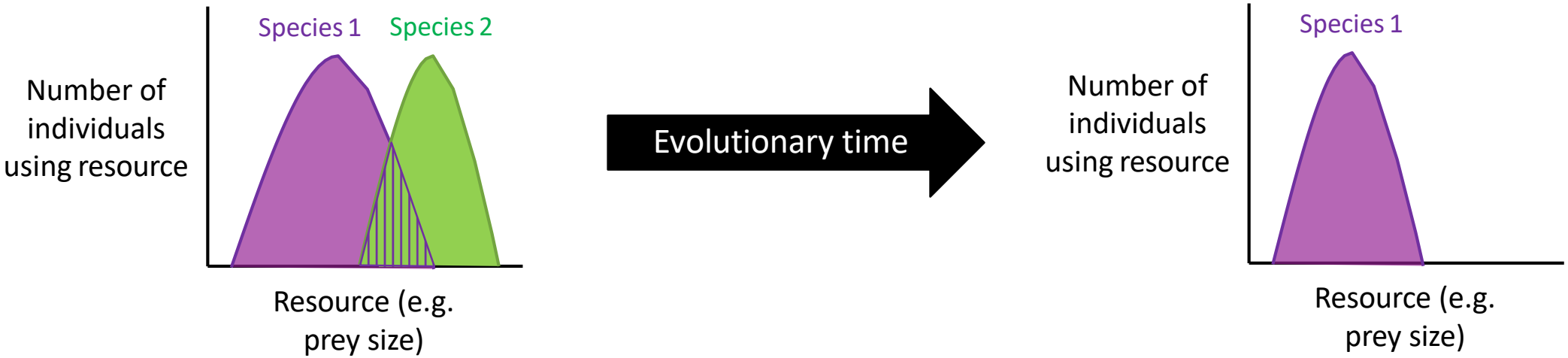
….can drive the evolution of heritable morphological differences (or character displacement)

Example: Galapagos finches have different beak sizes to specialize on seed types

- When they occur alone (Daphne Major & Los Hermanos), there is some overlap in beak sizes (~8 to 9.5 mm)
- When the two finches occur together (on Santa Cruz), beak sizes diverge to reduce competition for food.



If the fundamental niche has undergone an evolutionary change….



- If one competitor were removed, the remaining species could not immediately capitalize on the full range of resources
- For example, if species 2 (green) was removed, species 1 (purple)could not immediately expand its fundamental niche to historical levels (it would require a mutation).

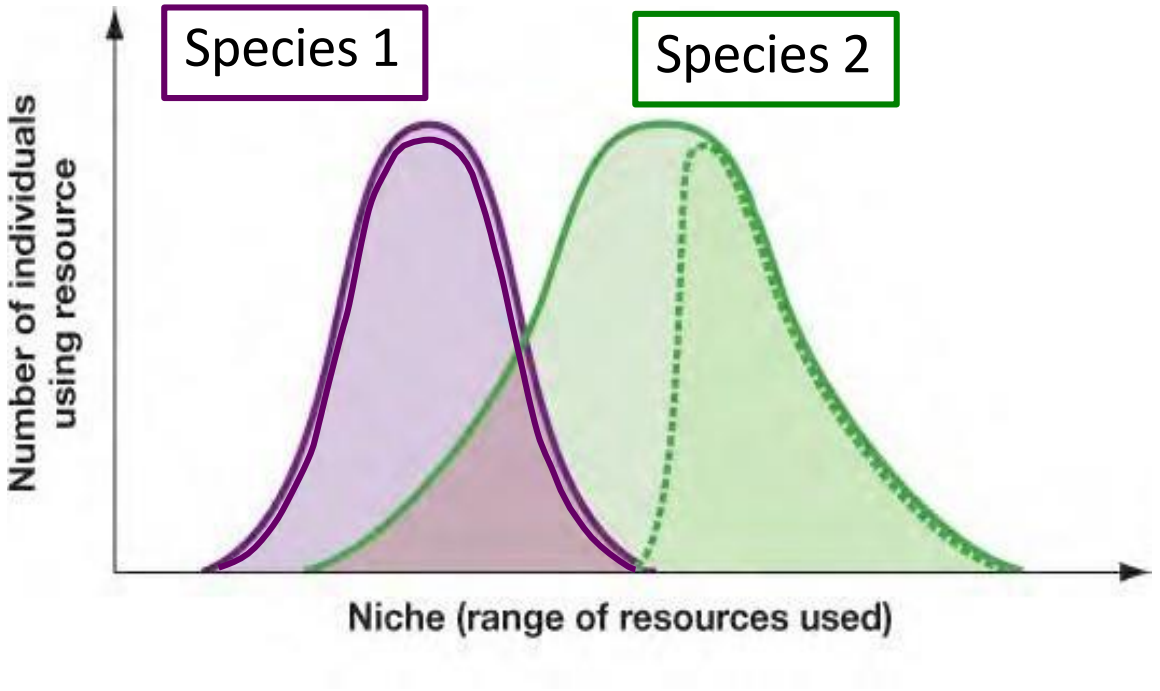
What happens if one competitor is superior?

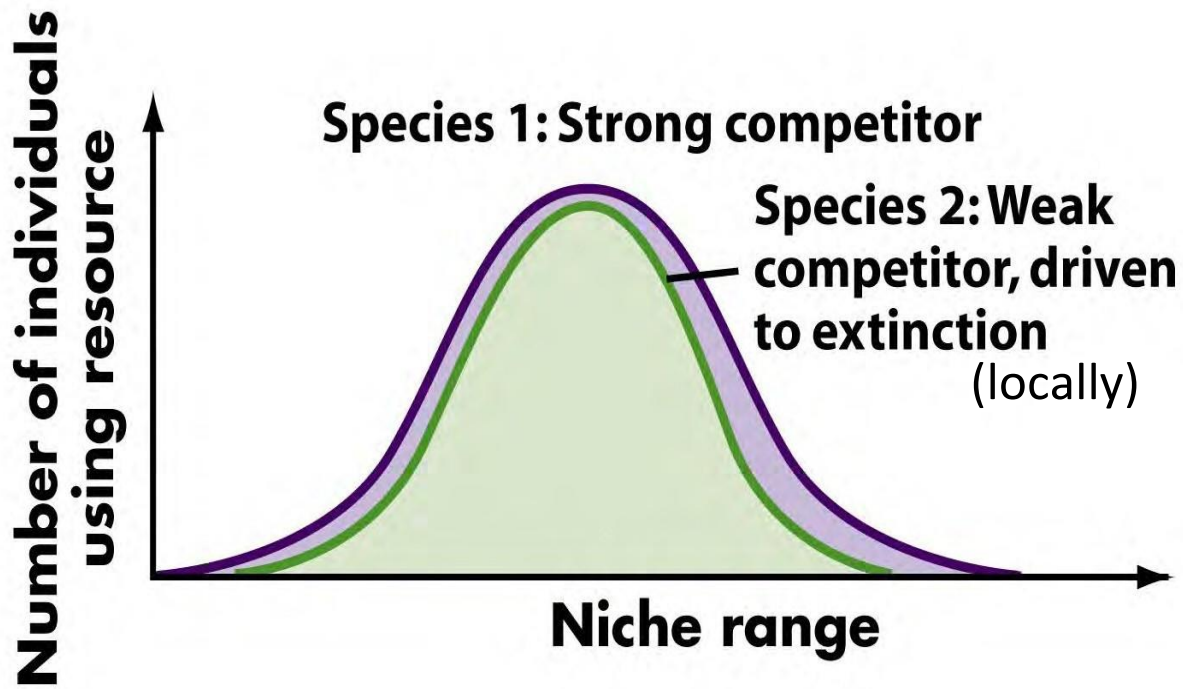
If niches only **partially overlap**:

- Both species can co-occur
- Outcome: Weaker competitor (#2) experiences reduction in its fundamental niche – competitively excluded from part of niche.
- Superior competitor (#1) experiences no reduction in fundamental niche

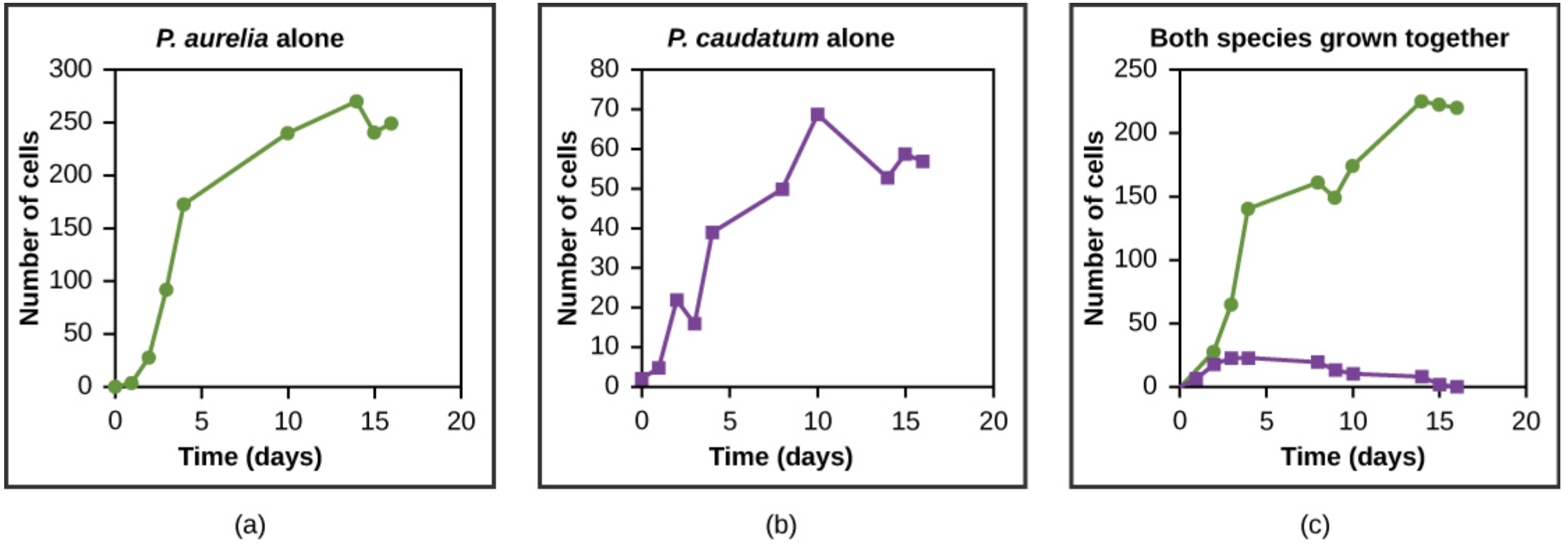
If niches **fully overlap**:

- Species cannot co-occur
- Outcome - Weaker competitor (#2) is competitively excluded from entire niche





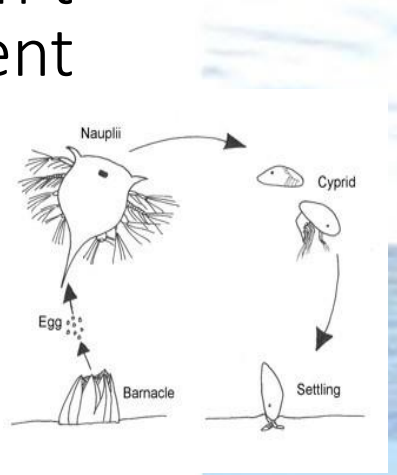
Competitive Exclusion



Source: Wikipedia commons

Competitive exclusion in barnacles

- Adult barnacles are sessile (they don't move). A hard surface for attachment is a limited resource.
- Larval barnacles float in the water column; and, are are moved by tides/currents.
- If they survive, at some point they will settle to the substratum. Very little choice in location.
- Lucky larvae will settle somewhere in an intertidal area.
- *Chthamalus* only occurs in the upper intertidal and *Semibalanus* only occurs in the lower intertidal.

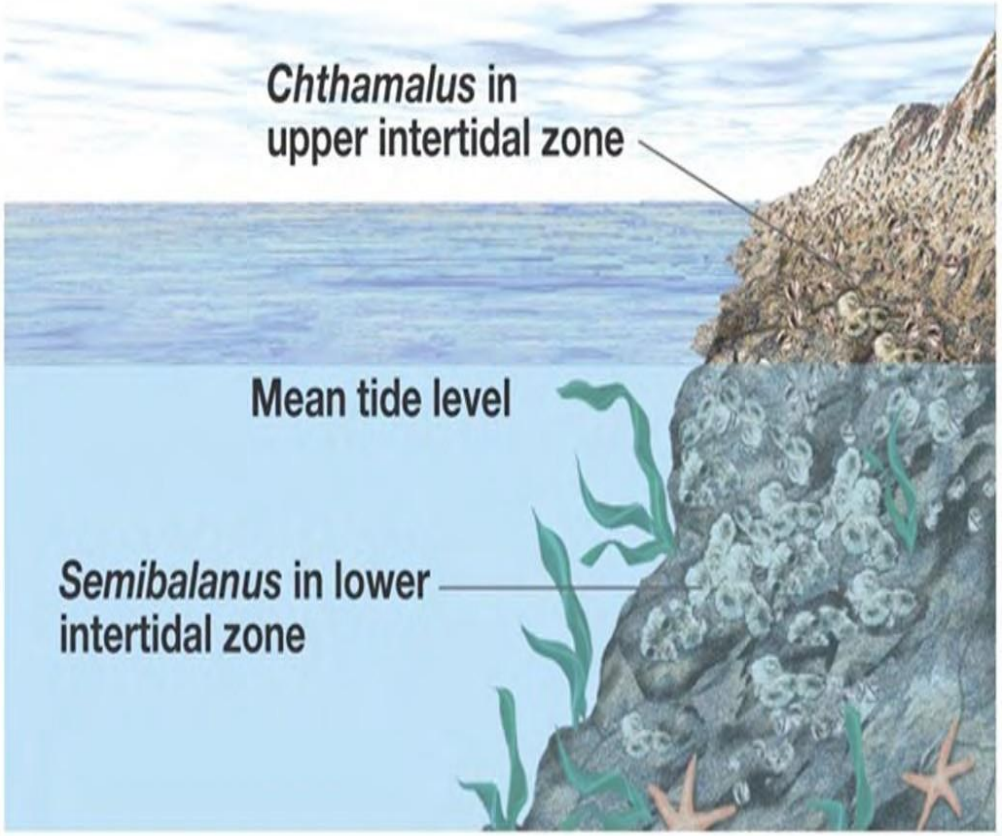


Dr. Joseph Connell's study (1961)

Dr. Connell studied the distribution of two barnacle species at his rocky intertidal study site in Scotland.

He found that:

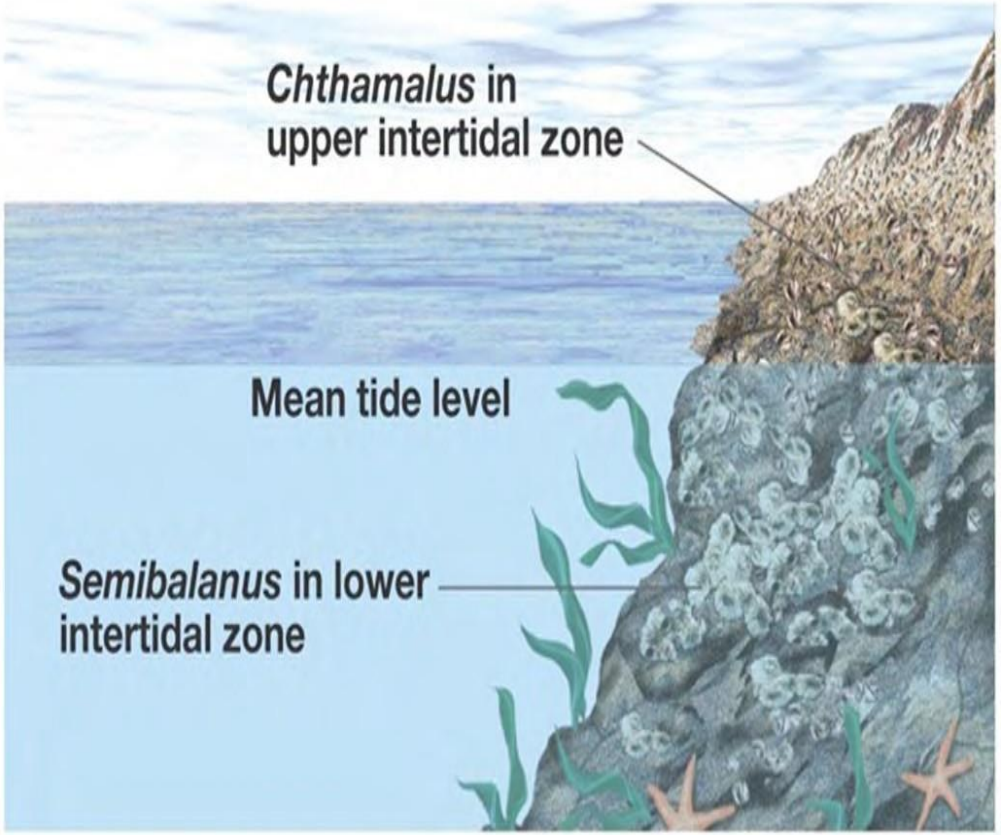
1. *Chthamalus* – a small barnacle – was almost exclusively found in the upper intertidal zone.
2. The much larger *Semibalanus* consistently occupied the lower intertidal zone.



Dr. Joseph Connell's study (1961)

Dr. Connell tested two hypotheses of why *Chthamalus* is only in the upper intertidal zone:

1. *Chthamalus* **are competitively excluded** from the lower intertidal by *Semibalanus*
2. *Chthamalus* **cannot tolerate the abiotic conditions** of the lower intertidal

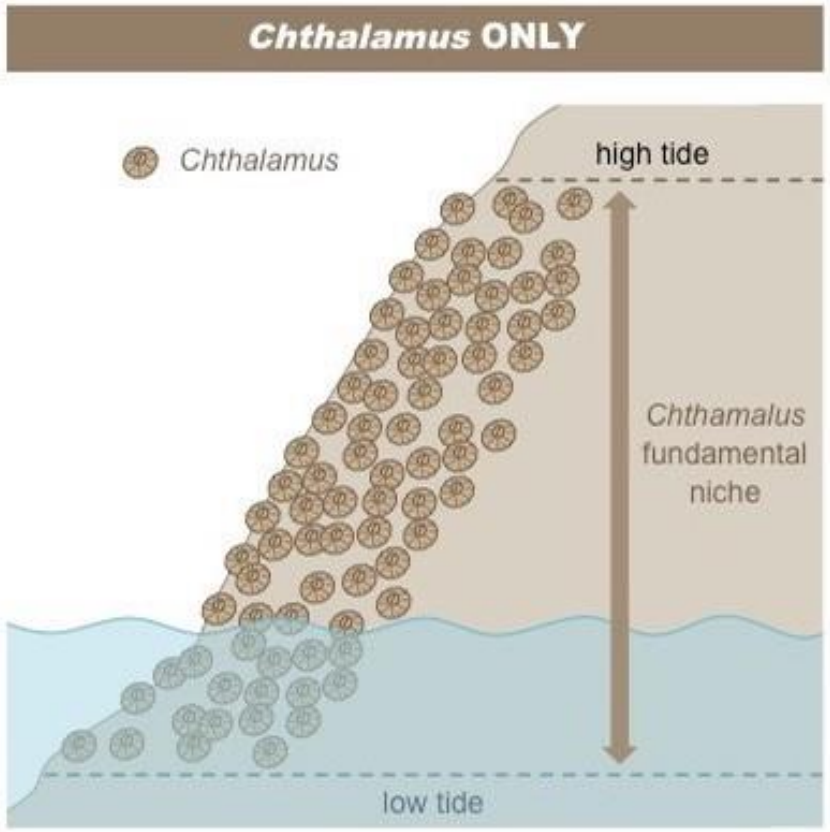


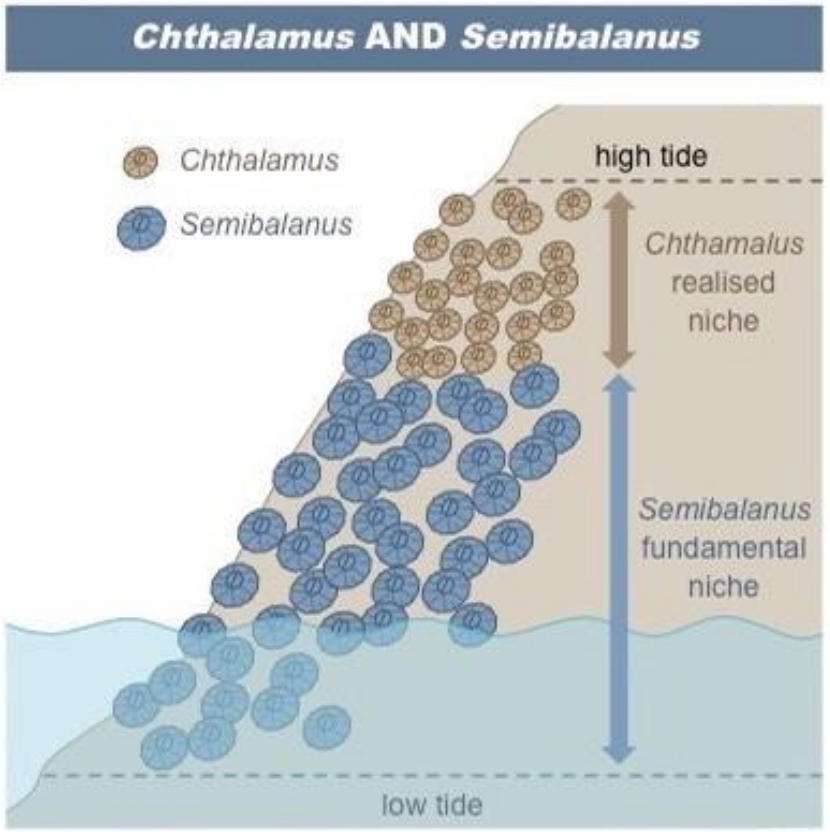
Part of his methodology:

- He moved rocks containing *Chthamalus* to the lower intertidal zone and monitored survival.

iClicker Question

Dr. Connell found that the *Chthamalus* could survive in the lower intertidal zone if *Semibalanus* was not present. However, in the presence of *Semibalanus*, the smaller *Chthamalus* was overgrown and/or displaced.

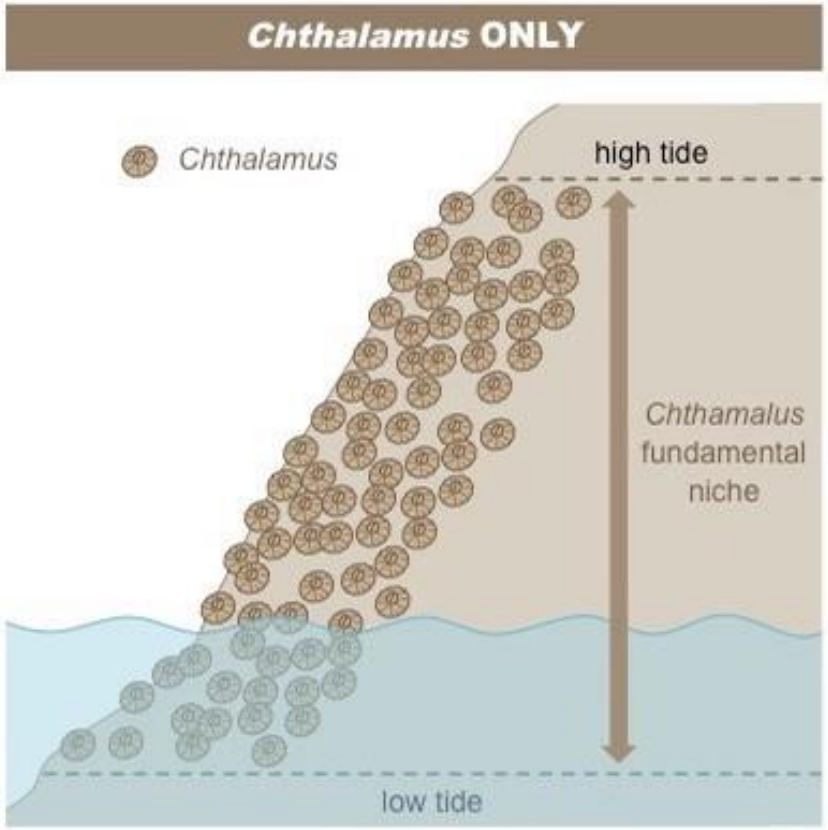


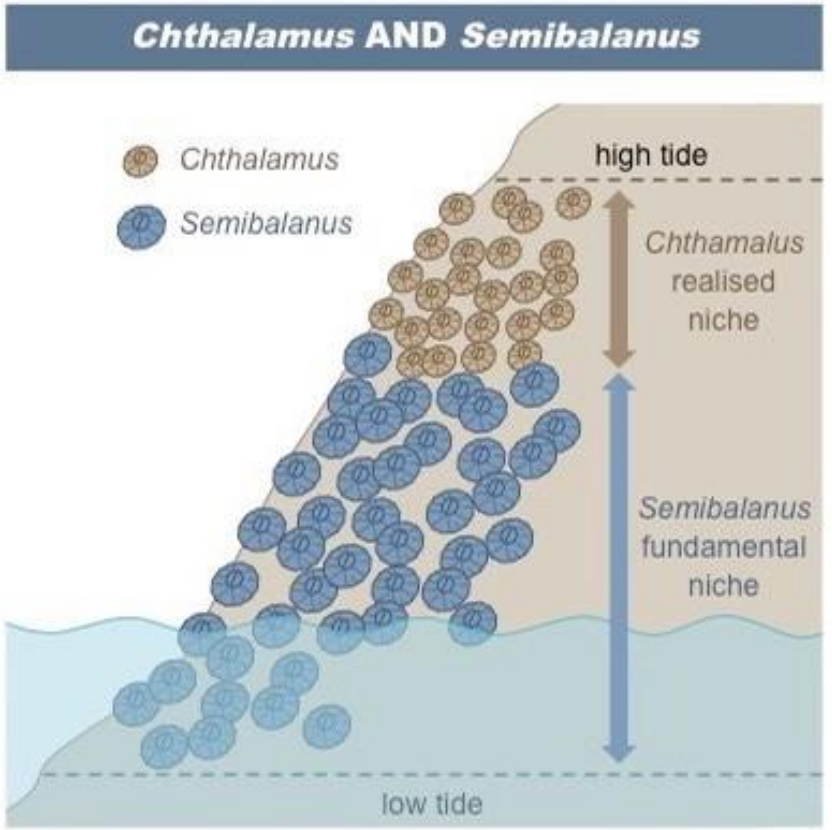


Is the lower intertidal zone part of *Chthalamus*'s **fundamental niche**?

A. Yes
B. No
C. Inconclusive

Answer





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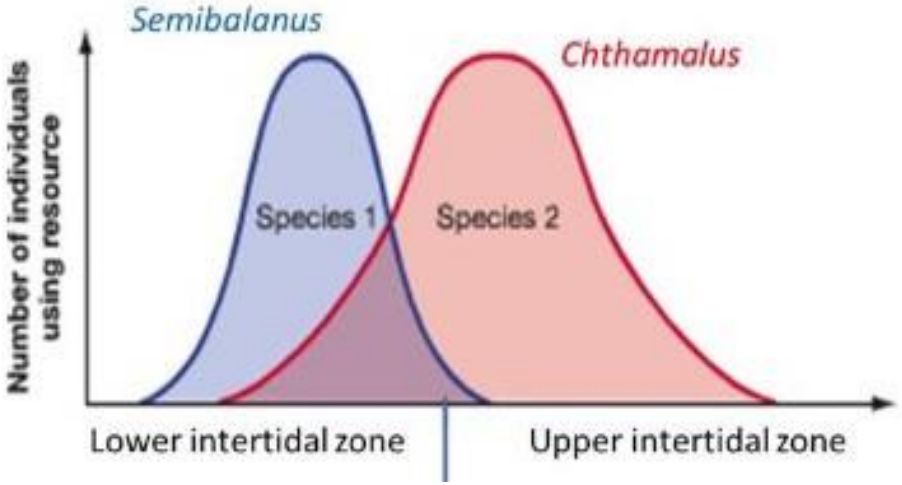
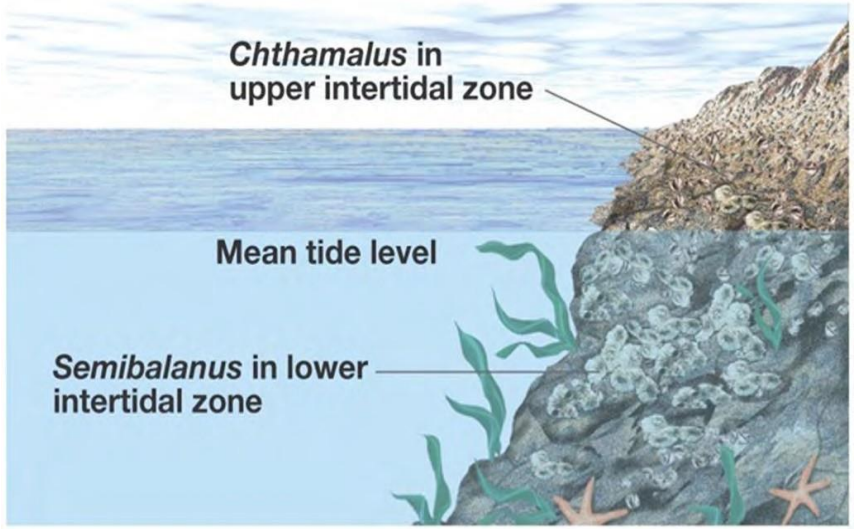
C. Inconclusive

Competitive exclusion in barnacles

Connell found better support for the hypothesis that *Chthamalus* is competitively excluded from the lower intertidal by *Semibalanus*

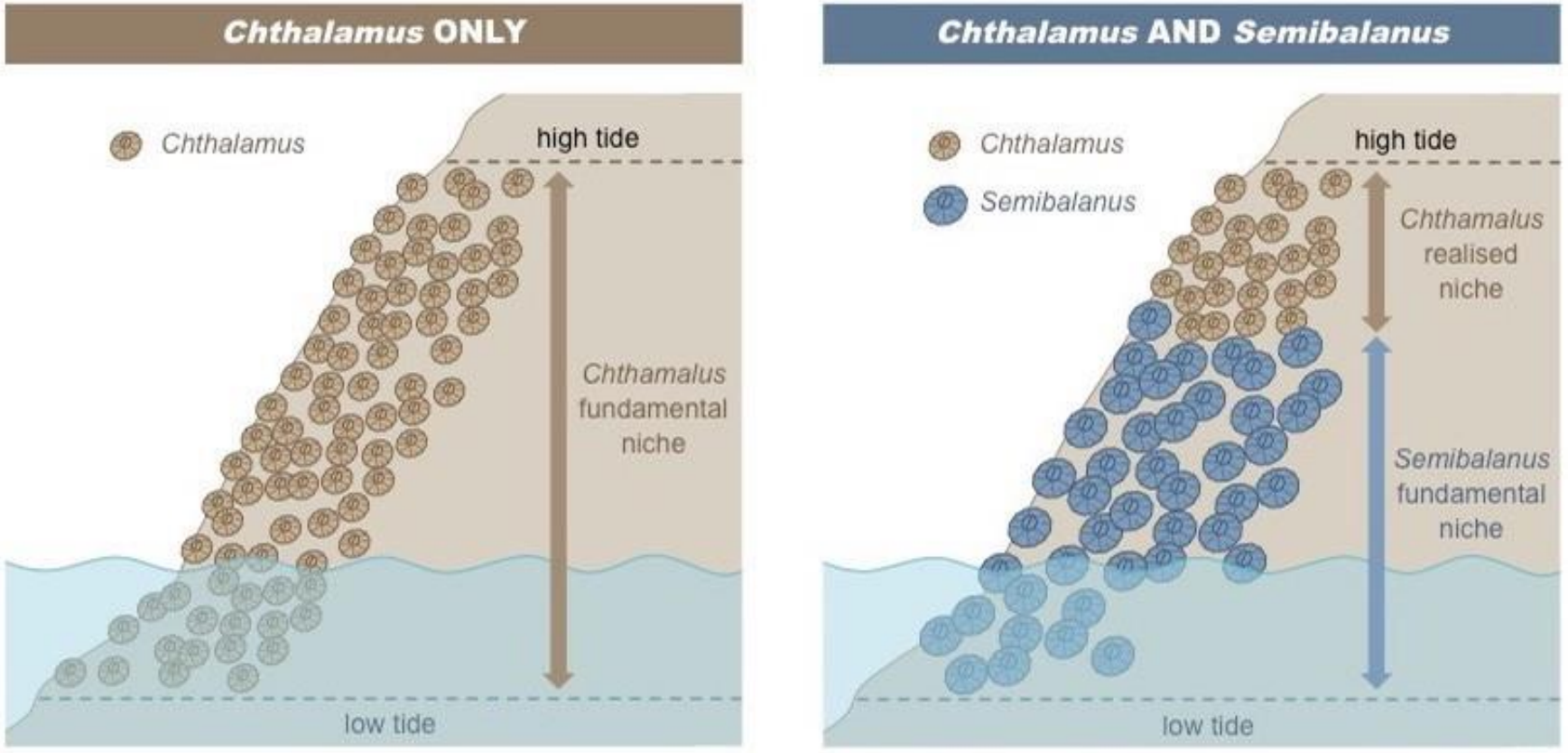
- *Chthamalus* can occur in the lower intertidal, but only if *Semibalanus* is not present
- Suggests that **realized niche** of *Chthamalus* is restricted to upper intertidal





Question

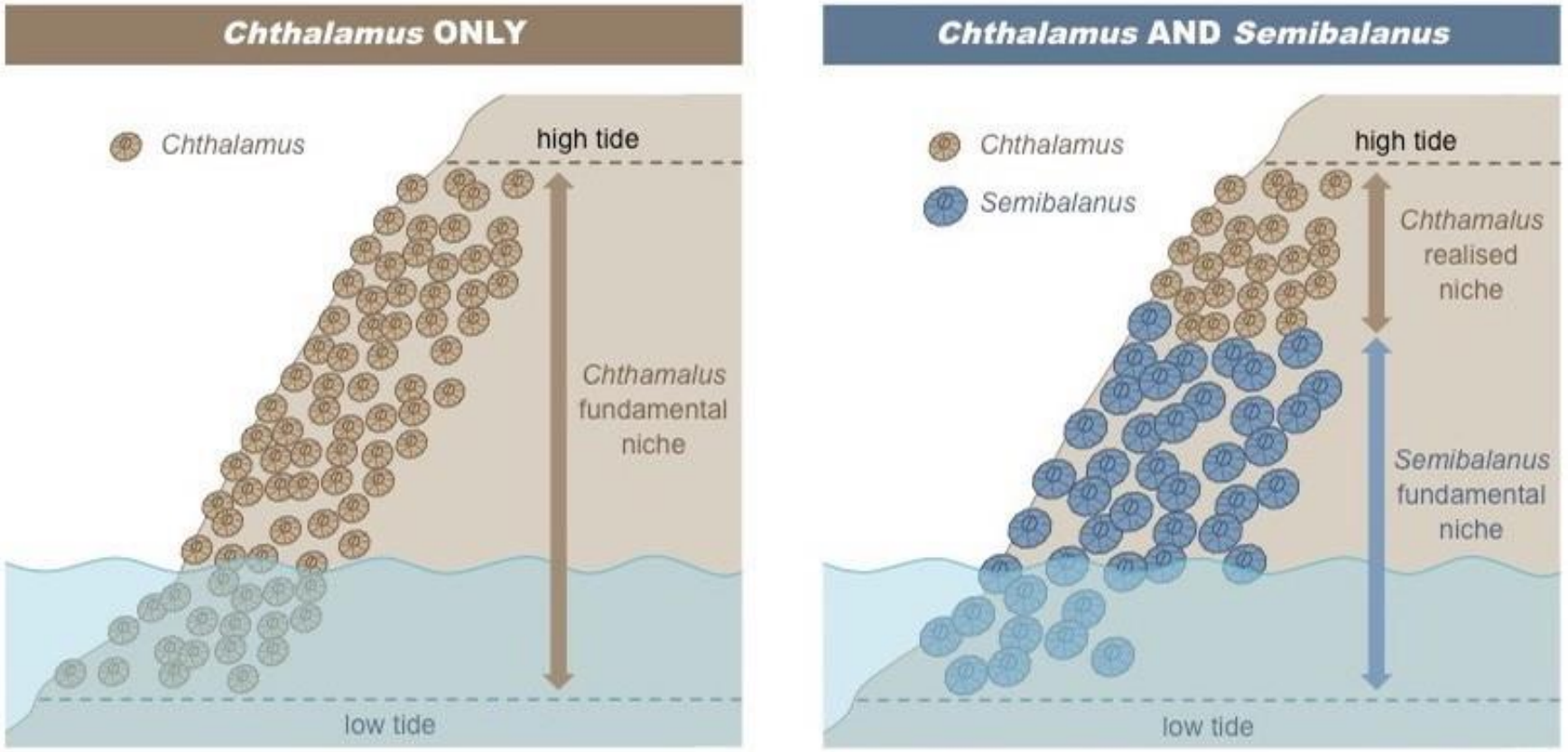
Connell found that *Semibalanus* was unable to survive in the upper intertidal zone. They could not tolerate the long exposure to air during low tide.



Is the upper intertidal part of *Semibalanus'* **fundamental niche**?

A. Yes
B. No
C. Inconclusive

Answer



Is the upper intertidal part of *Semibalanus'* **fundamental niche**?

A. Yes

B. No

C. Inconclusive

At least one abiotic condition in the high intertidal zone is outside the *Semibalanus'* range of tolerance

Question (not iClicker) – related to worksheet #11

What series of events would need to occur for a *Semibalanus* population to become established in the high intertidal zone?

Please discuss this question for one minute.

Points to incorporate into answer

- *A mutation would need to occur that would allow the Semibalanus to tolerate the abiotic conditions (e.g. temperature in the high zone).*
- *Mutation would need to occur in a germ line cell (or gamete)*
- *Individual with mutation would need to survive long enough to reproduce*
- *Larvae with mutation would need to be transported to the intertidal zone; specifically the high intertidal zone*
- *For the new allele to increase in frequency, natural selection would need to select for that allele (how could that happen).*
- *[Alternatively, genetic drift would need to increase the frequency of the allele]?*

You can now complete Worksheet #11 – Species Interactions: Barnacles

Take home points - competition

- Competition occurs when an essential resource (e.g. food, space, mates) is in limited supply.

- Two ecological outcomes of competition:

1. **Niche partitioning** – the fundamental niche of both competitors is reduced.

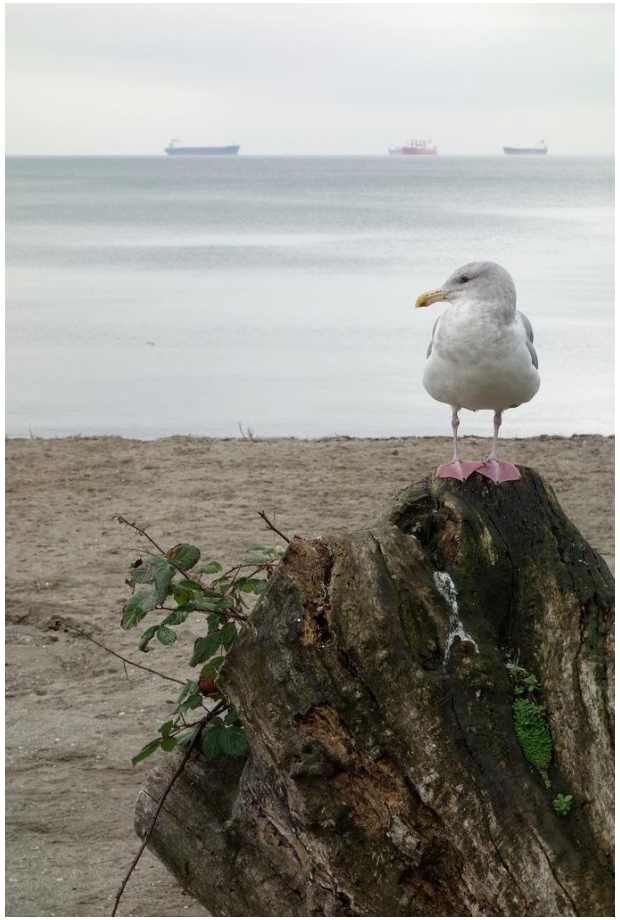
- - negative fitness consequences for both species, as neither species can access/use the full range of resources that it is capable of using.
- - so selective pressure to use shared resources in different ways (space, time).

Evolutionary outcome of niche partitioning: character displacement (e.g. differences in beak size) to minimize competition and the negative fitness effects.

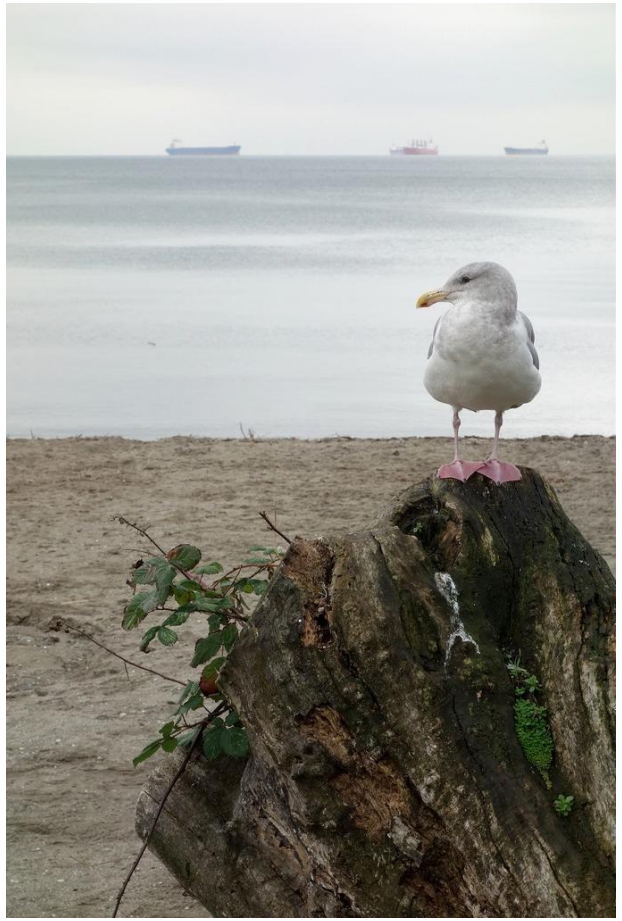
2. **Competitive Exclusion** – fundamental niche of the weaker competitor is reduced; or the

- The weaker competitor is eliminated from the area.
- Negative fitness consequences for the weaker competitor at least.

I came across this bird while walking near English Bay.
What type of bird is it?



So, it is not a bay gull……☺



4-minute break

https://www.flickr.com/photos/free-images-flickr/27272059009

5. Consumption (+ / -)

Consumption occurs when one organism eats or absorbs nutrients from another.

Positive effect on the consumer's fitness (+)

Negative effect on the victim's fitness (-)

3 different types of consumption:

- Predation
- Parasitism
- Herbivory

5.1 Predation (+/-)

- One organism kills and consumes another organism

https://hakaimagazine.com/news/salish-sea-killer-whales-have-a-surprising-new-way-of-hunting/

5.2 Parasitism (+/-)

One organism lives on/in another and steals its <u>nutrients/resources</u>

- Parasite usually does not kill host

https://aaronrhodesc.wordpress.com/herbivory-2012-072/

www.Wikipedia.org

http://phenomena.nationalgeographic.com/2013/02/28/tongue-eating-fish-parasites-never-cease-to-amaze/

https://imgur.com/gallery/mMR4X8v

5.3 Herbivory

One organism consumes all or part of a plant

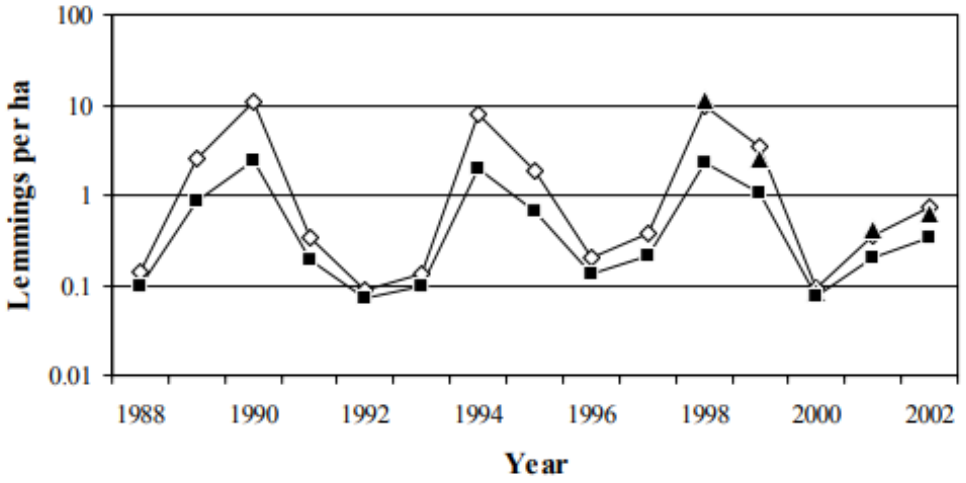
http://calgaryherald.com/news/local-news/canadian-pacific-parks-report-investigates-grizzly-deaths
www.Wikipedia.org

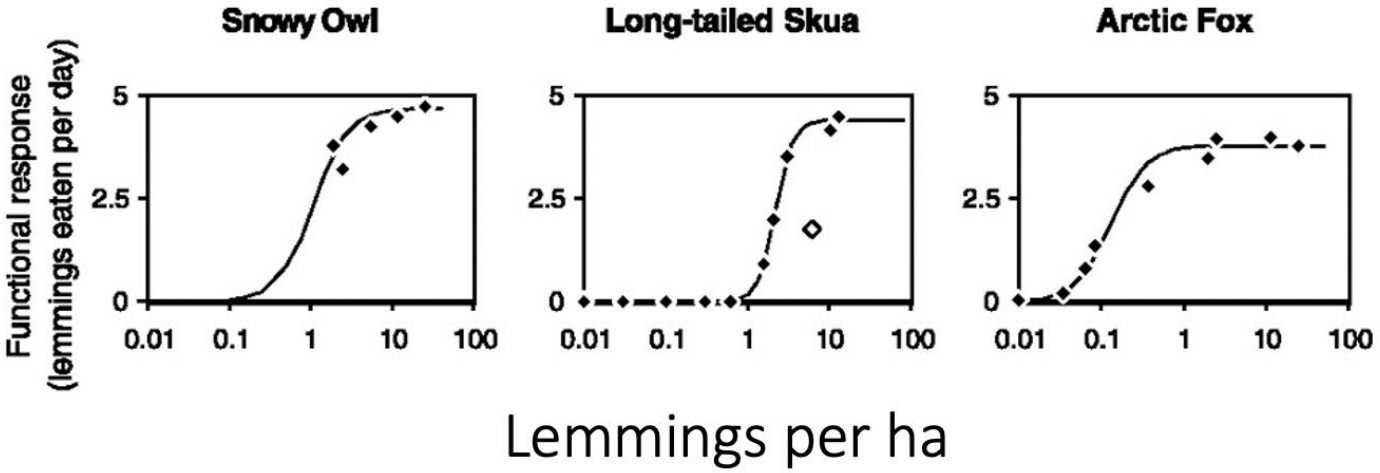
www.Wikipedia.org

https://www.flickr.com/photos/briangratwicke/8500354707

Predator Effects: Predators can affect the abundance of their prey

Example from lecture #3 – predation by birds and foxes reduces the population density of lemmings



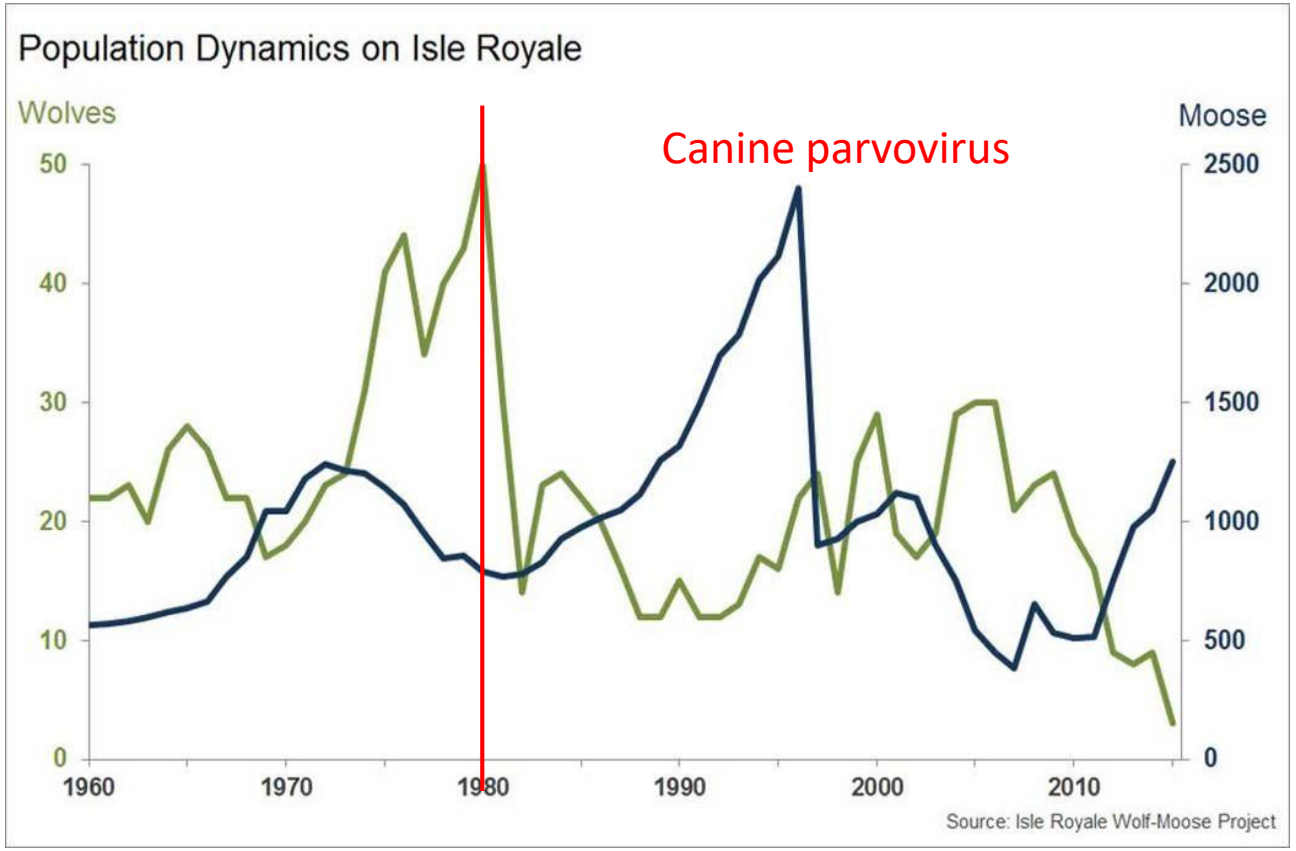


www.perc.org/articles/isle-royales-wolf-dilemma

Predator effects on abundance – Isle Royale

Example: as the wolf population increases (light green line), the moose population decreases (blue line) – around mid 1970's

And when the wolf population size declined due to a virus introduced by a pet dog, the population size of the moose, the moose population increased (1990's)



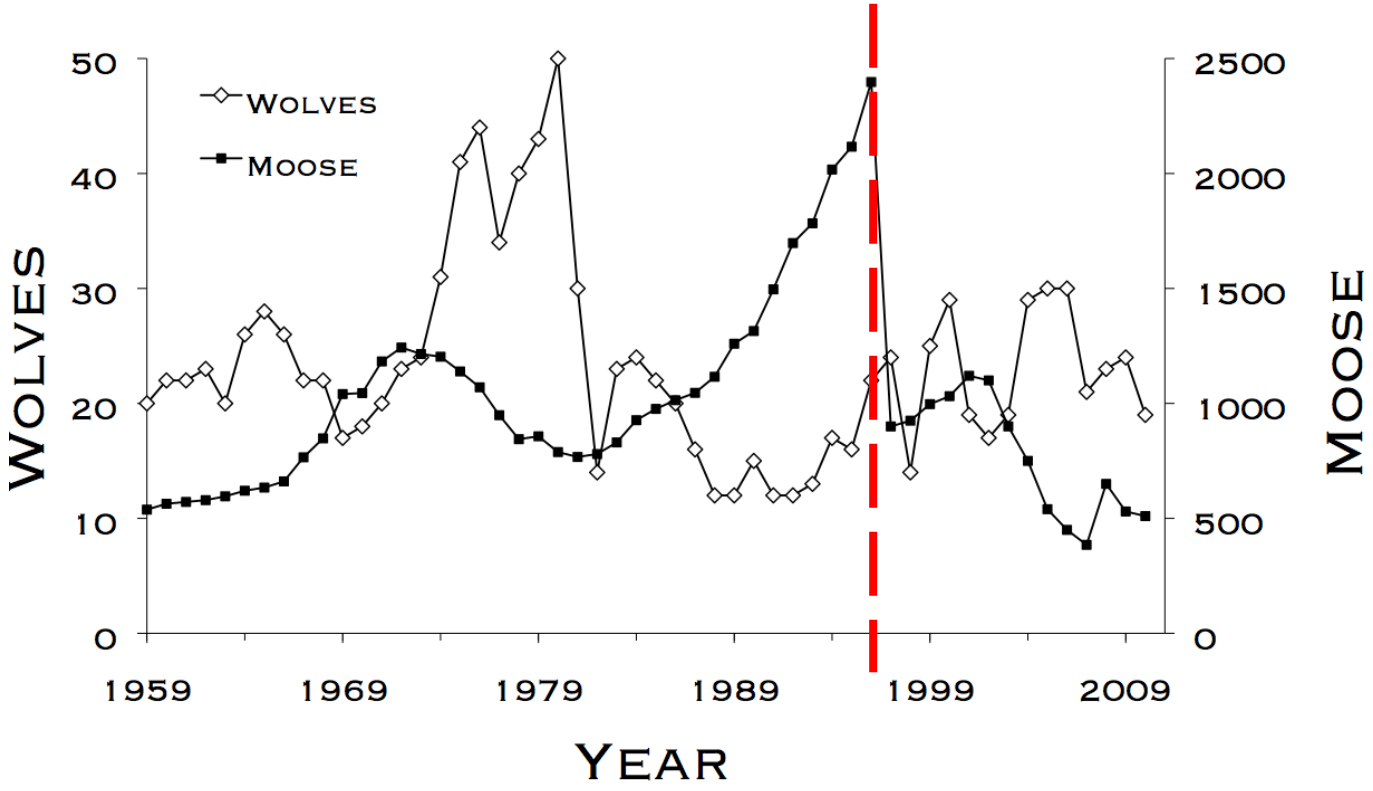
www.perc.org/articles/isle-royales-wolf-dilemma

iClicker Question

During the winter of 1996, a lack of food, an outbreak of ticks and a severe winter resulted in the moose population size decreasing to only ~500 individuals.

Is food availability an example of an abiotic or biotic factor? And, is food availability an example of a density-dependent or density independent factor?

A. Abiotic, density independent
B. Abiotic, density dependent
C. Biotic, density independent
D. Biotic, density dependent
E. Not sure



Source: https://isleroyalewolf.org/data/data/home.html

Answer

During the winter of 1996, a lack of food, an outbreak of ticks and a severe winter resulted in the moose population size decreasing to only ~500 individuals.

Is food availability an example of an abiotic or biotic factor? And, is food availability an example of a density-dependent or density independent limiting factor?

A. Abiotic, density independent
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C. Biotic, density independent
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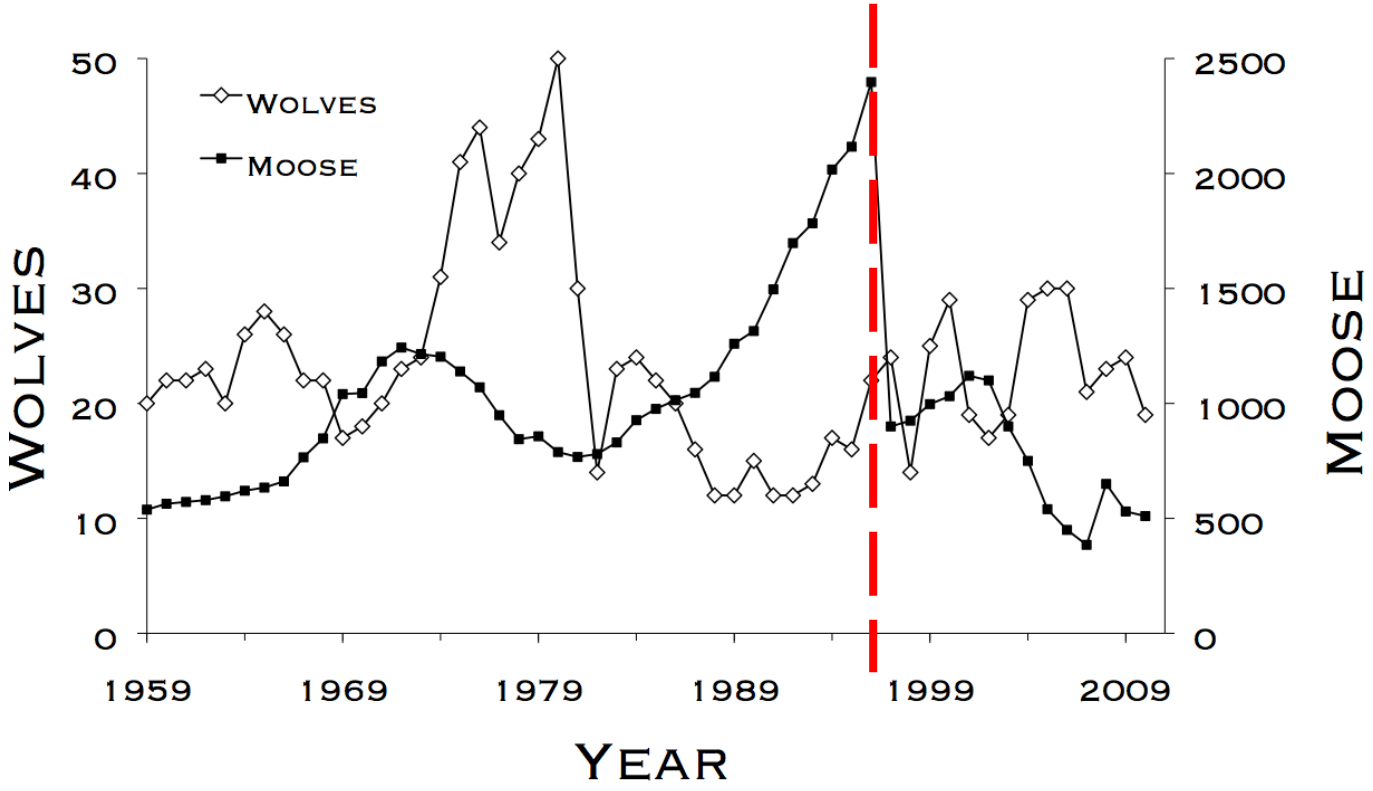
E. Not sure

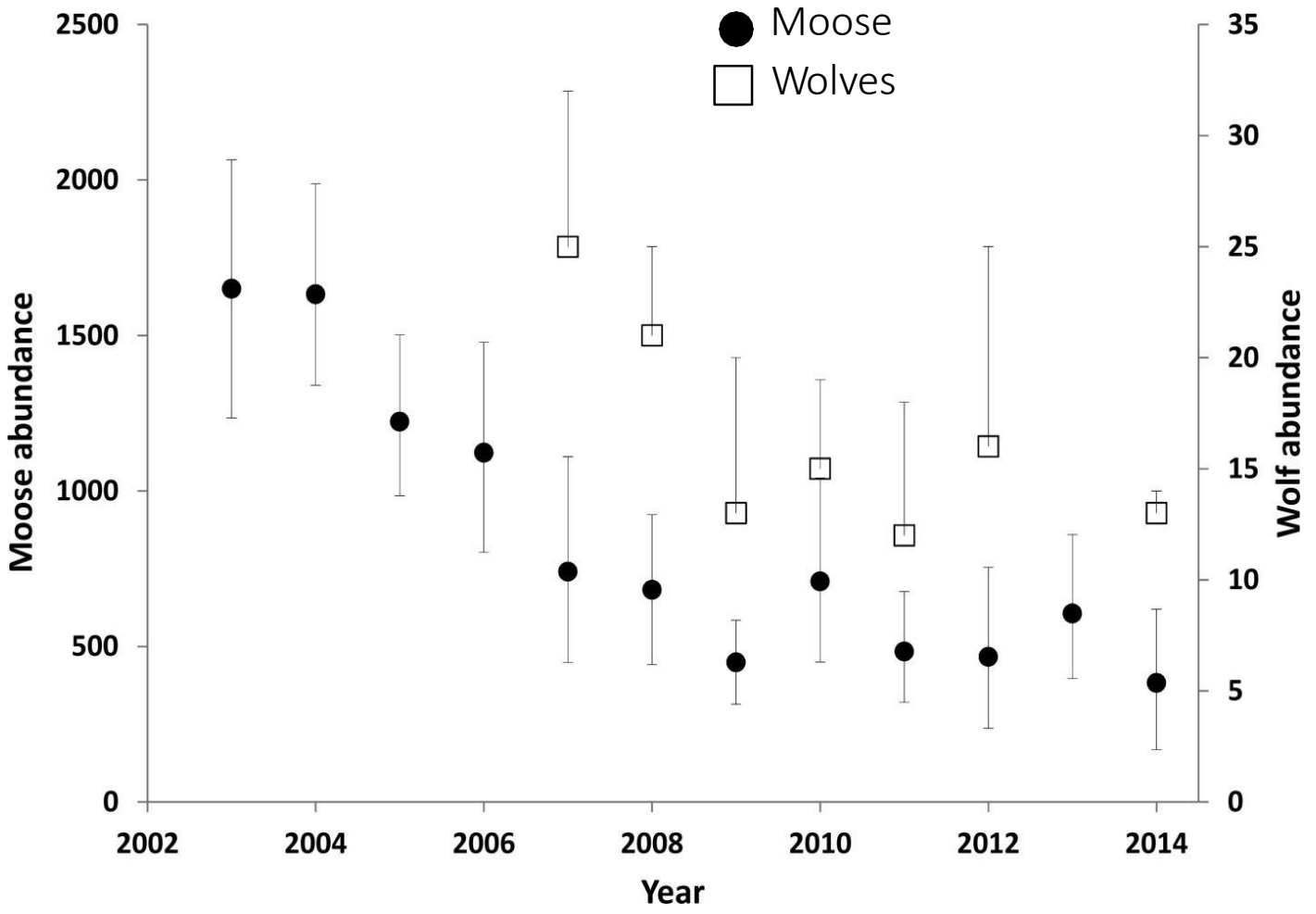


Source: https://isleroyalewolf.org/data/data/home.html

Prey Abundance can also affect predator abundance - iClicker Question

When the # of moose hunting permits in B.C. increased (2002), moose declined by 70% (black circles)

- Wolves dispersed elsewhere and/or died due to lack of food (open squares)



Is the decrease in the wolf population due to a decrease in prey availability an example of a

A. Density independent factor?

B Density dependent factor?

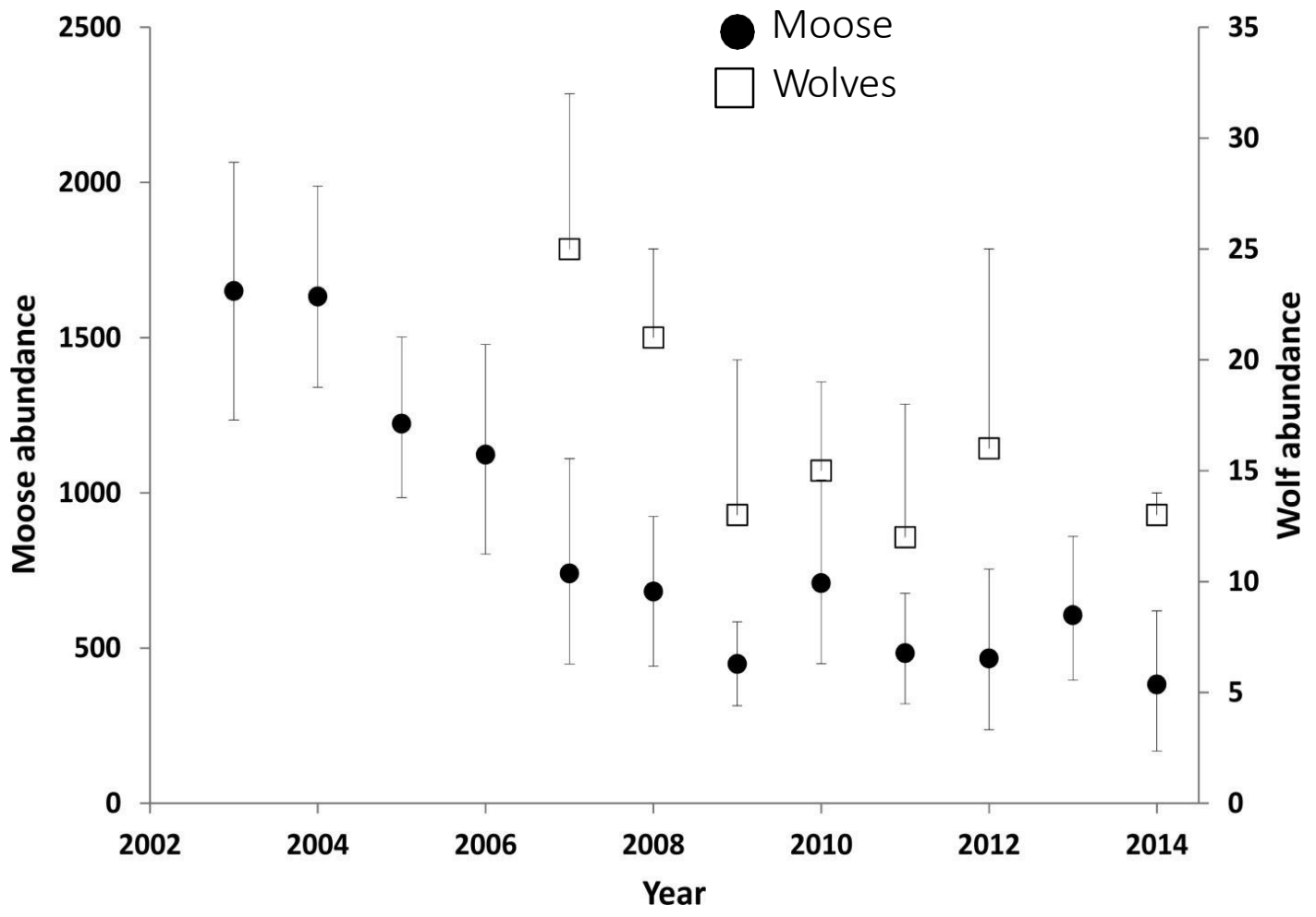
C. Not sure

Serrouya et al. 2017. https://peerj.com/articles/3736/

Answer

Example: when the # of moose hunting permits in B.C. increased, moose declined by 70% (black circles)

- Wolves dispersed elsewhere and/or died due to lack of food (open squares)



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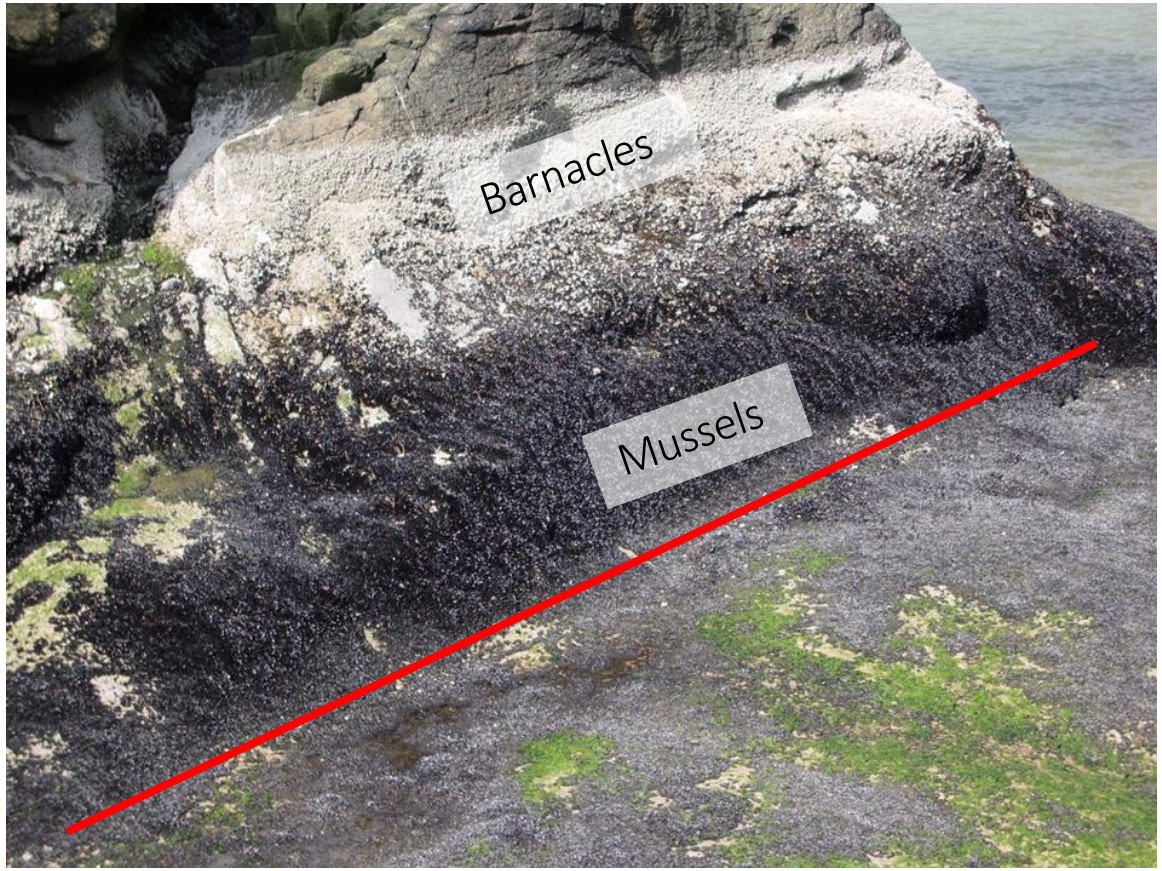
Predator effects of distribution

In Ecology Lecture #2, we discussed how the lower limit of mussels (prey)in the intertidal zone might be determined by predation by sea stars (predators)



Predators effects on distribution

Dr. Robert Paine tested whether predation by a sea star (*Pisaster*) determines the lower limit of mussels

- 1963-1968: Dr. Paine physically removed *Pisaster* from experimental sites
- 1969-1973: *Pisaster* allowed to naturally return
- Dr. Paine monitored the lower limit of the mussel's distribution

Oecologia (Berl.) 15, 93—120 (1974)

Intertidal Community Structure

Experimental Studies on the Relationship between a Dominant Competitor and Its Principal Predator

R. T. Paine

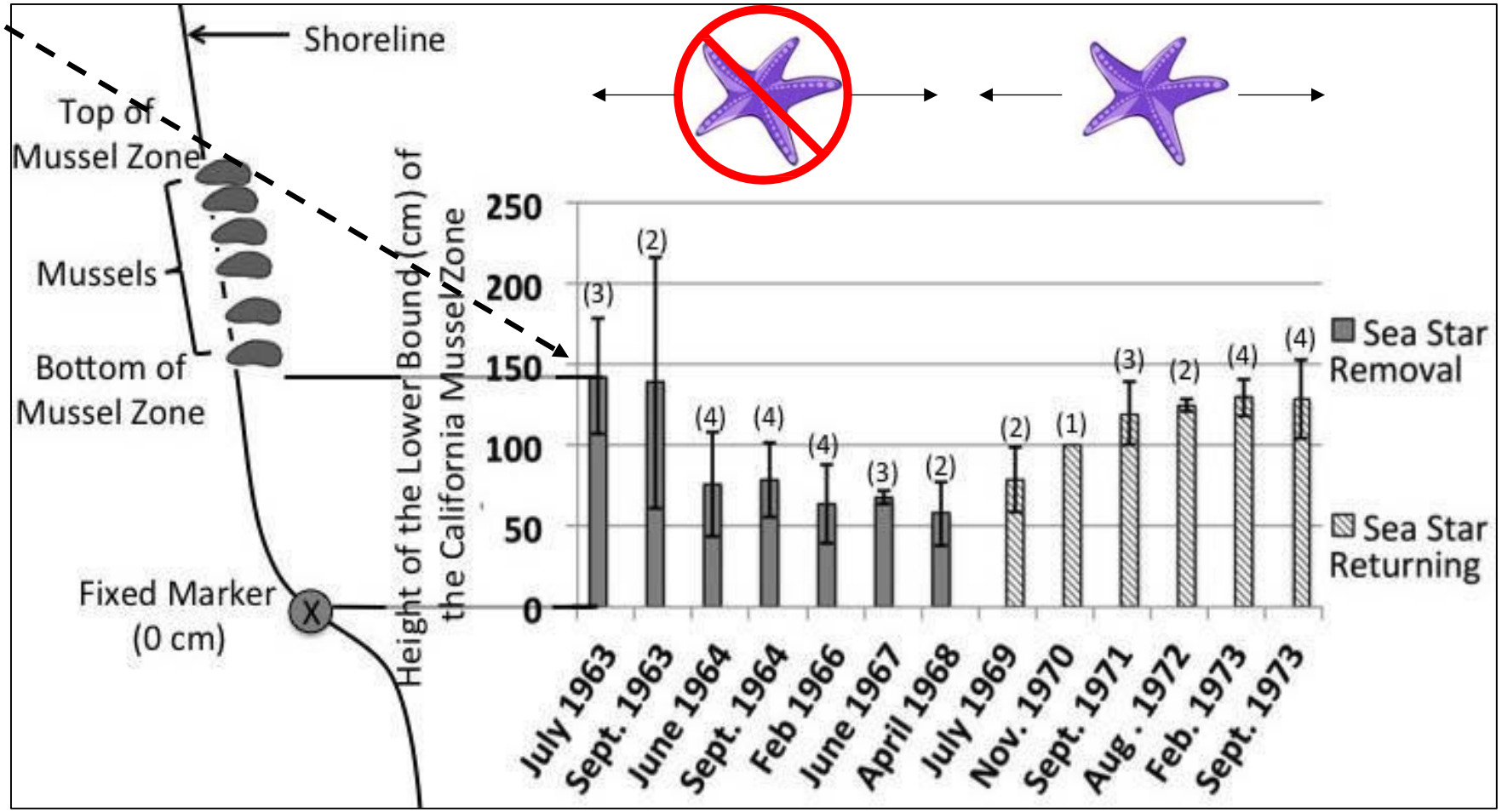
Department of Zoology, University of Washington, Seattle, Washington 98195

Received November 15, 1973

Pisaster preying on mussels

Effects of sea star predation on distribution of mussels.

https://oregonmarinereserves.com/2020/07/29/intertidal-data/



Predators can positively affect biodiversity of the community

- Paine also found that removing *Pisaster* (predator) resulted in the elimination of at least 25 other intertidal species.
  - Mussels are competitively dominant.
  - In the absence of *Pisaster*, mussels can outcompete most other sessile species.
  - *Pisaster* indirectly promotes biodiversity by removing the dominant species (mussels)!
  - Predators in other ecosystems have similar effects on biodiversity (e.g. wolves in Yellowstone).

Example #2 - Wolves in Yellowstone National Park

https://www.yellowstonepark.com/things-to-do/wolf-reintroduction-changes-ecosystem

Yellowstone National Park

- Wolves become ecologically extinct in Yellowstone in the 1920's – human persecution.
- Reintroduced in 1995 (Canadian wolves)

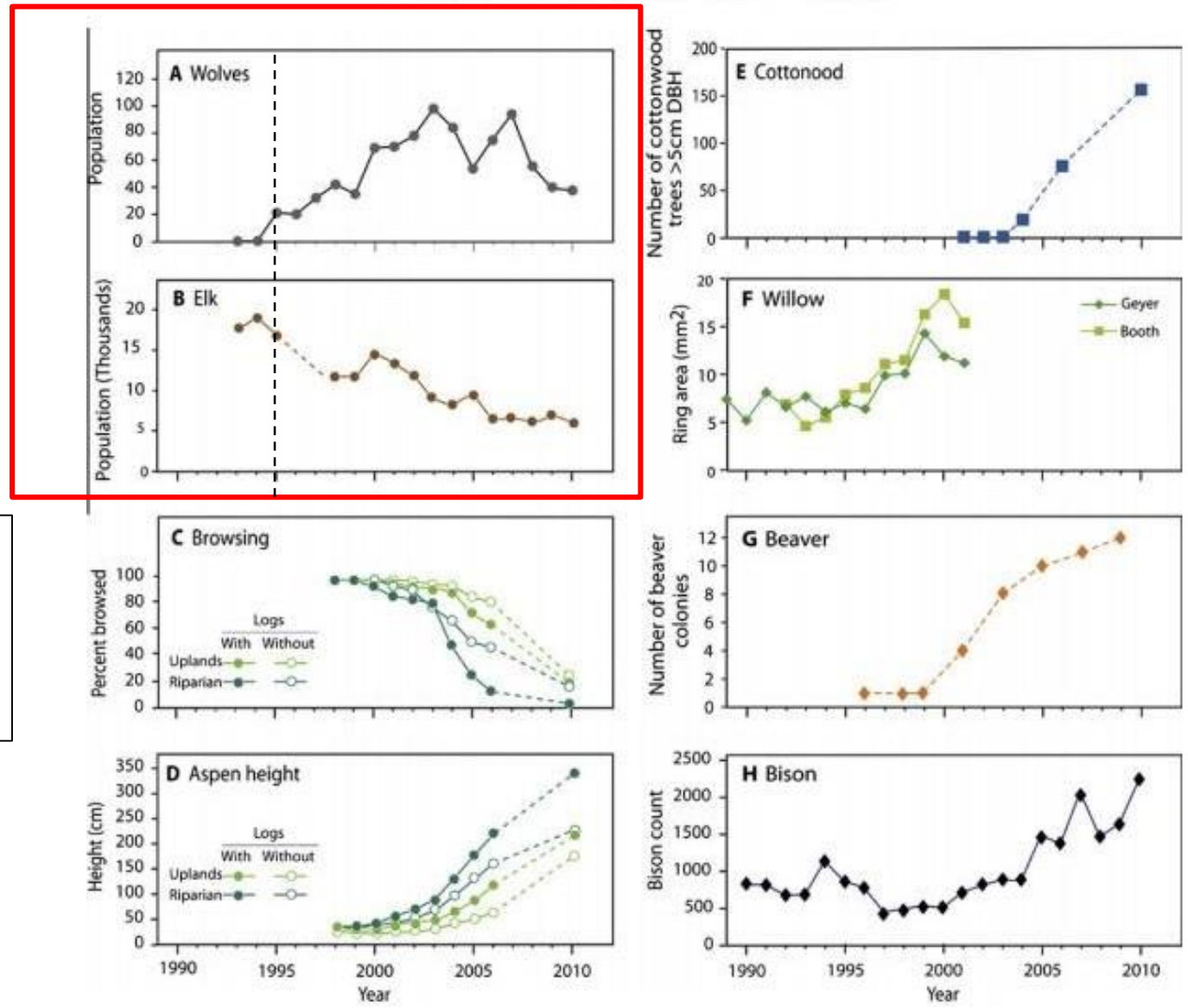
https://www.sciencealert.com/how-31-wolves-transformed-yellowstone-in-ways-nobody-could-ever-have-predicted-national-park-wolf-reintroduction-trophic-cascade

What happened to the population size of the wolves after their reintroduction in 1995?

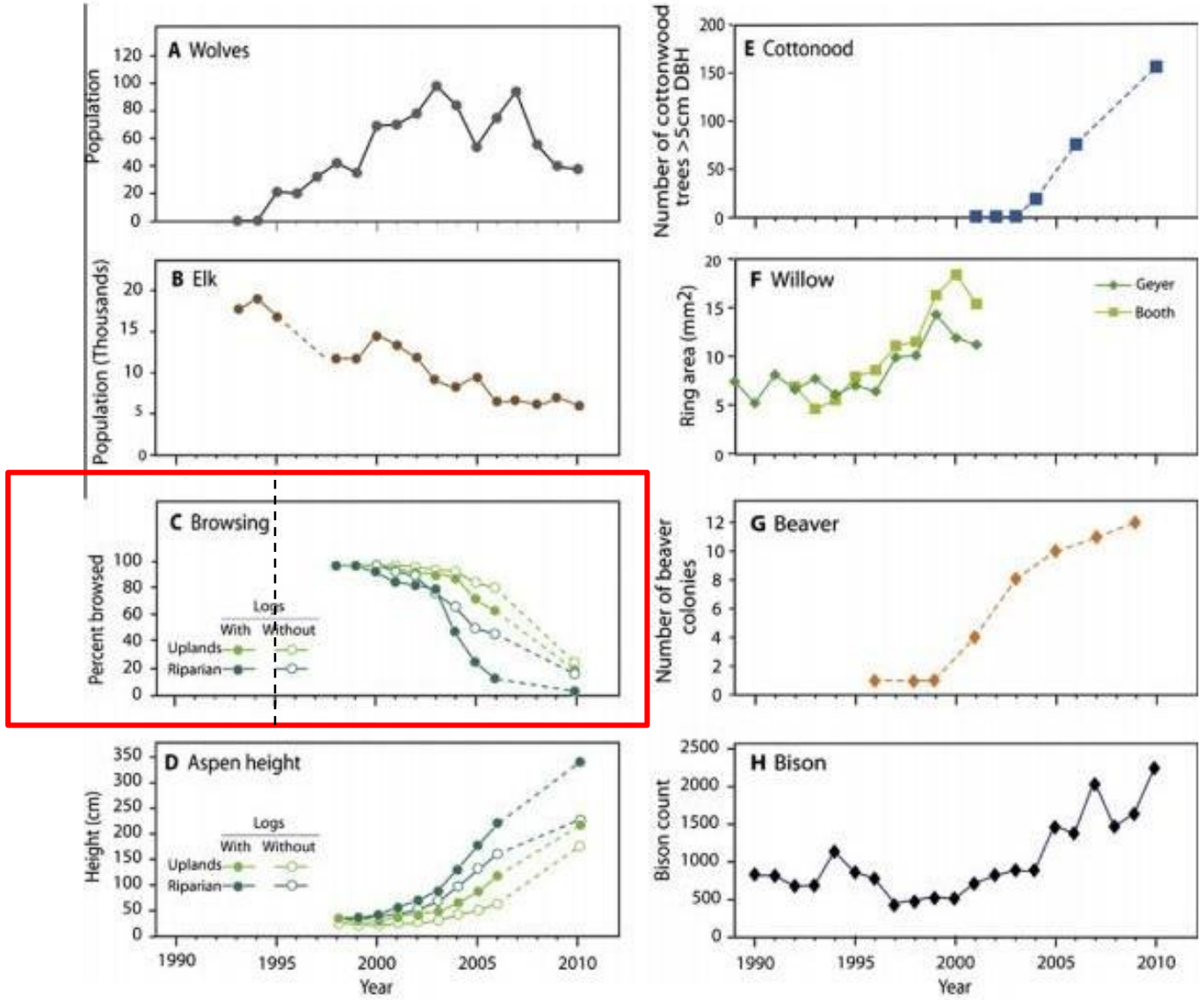
What happened to the population size of their main prey (Elk)?

What is not shown in the figure is that after the reintroduction of the wolves, the elk spent more time in coniferous forests (so distribution affected)

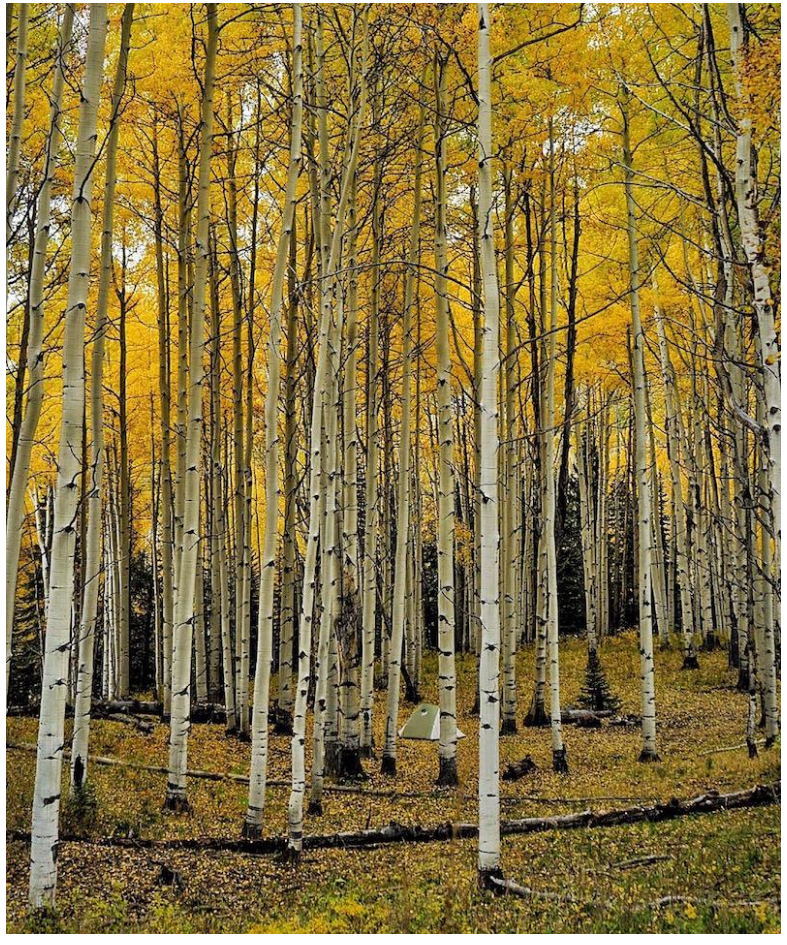
wikipedia

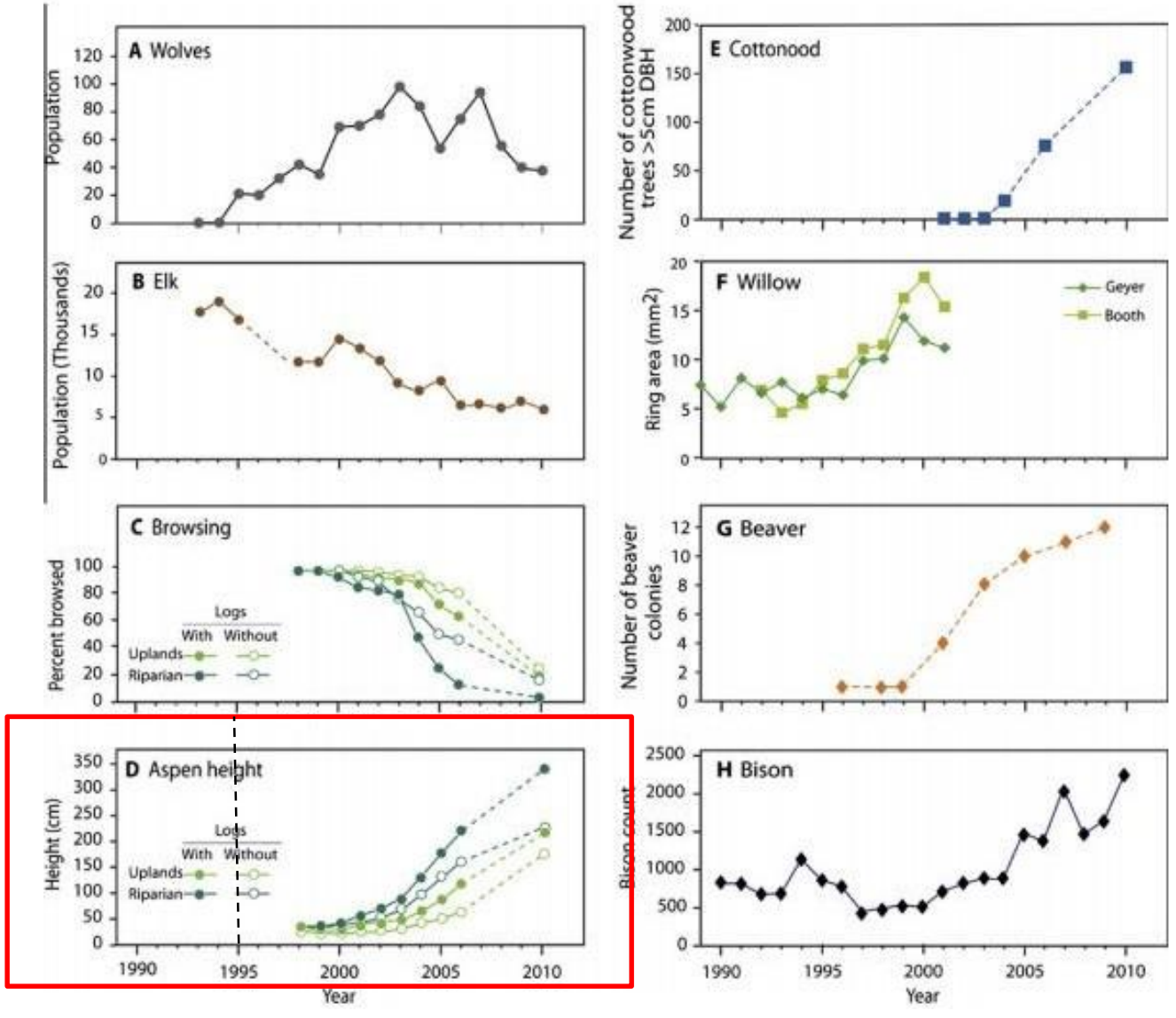


What effect did the wolves have on the browsing of the elk over time?
Browsing = feeding on leaves, twigs, etc.



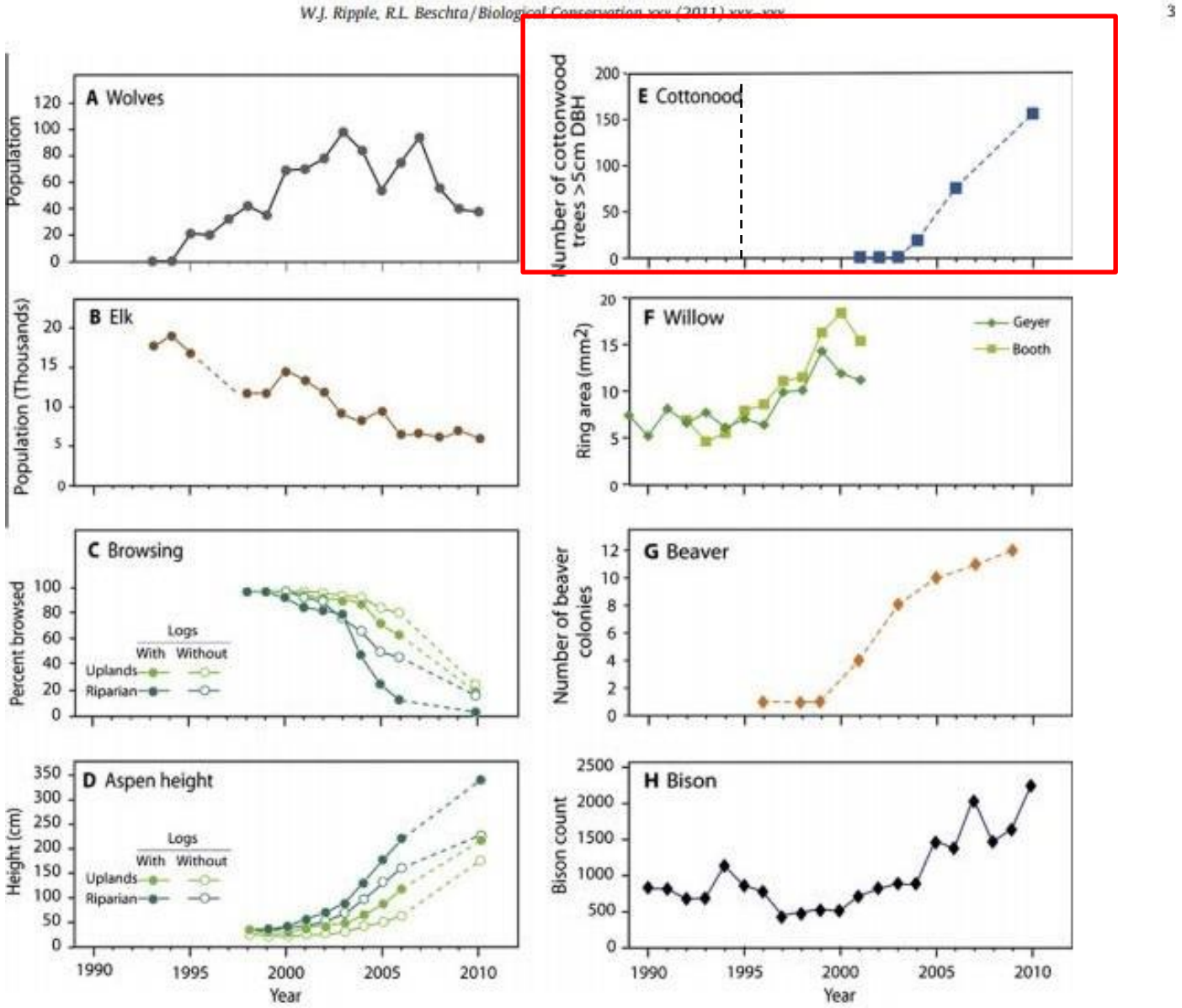
What happened to the height (D) of the aspen trees?





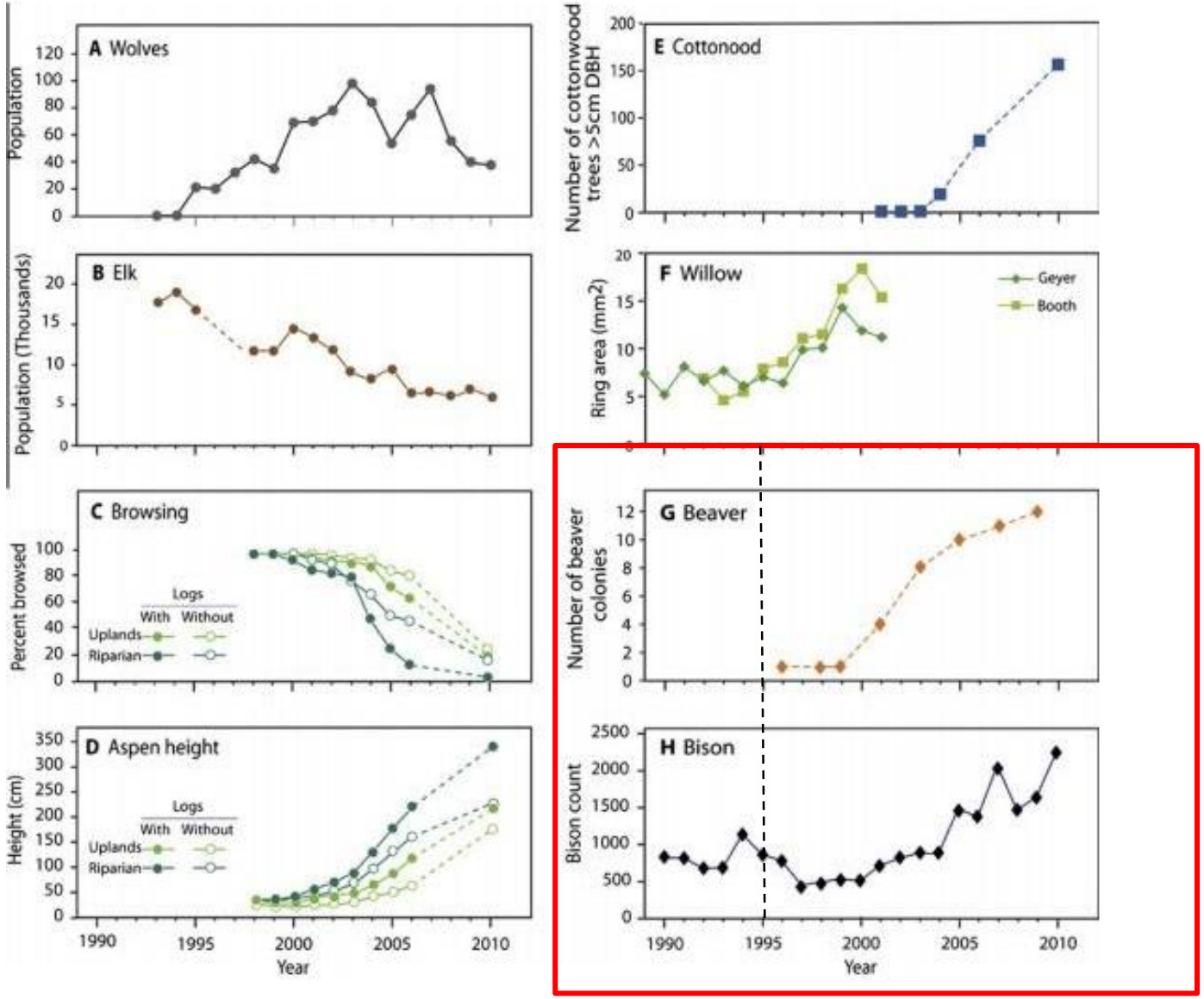
What happened to the abundance of cottonwood trees (E) that the elk would have fed upon

https://www.swcoloradowildflowers.com/Tree%20Enlarged%20Photo%20Pages/populus%20angustifolia.htm



What happened to the abundance of beaver (G) and bison (H) over this same time period?

https://www.nps.gov/yell/learn/nature/beaver.htm



- Several species in Yellowstone (such as bears & crows) rely upon late-winter carrion* to survive and reproduce (*elk carcasses)

- Historically, some elk would die during the winter because it was difficult to reach food buried beneath deep snow.

- But winters getting shorter and snow pack getting more shallow; consequently fewer elk dying in winter; less carrion available for bears, crows, etc.

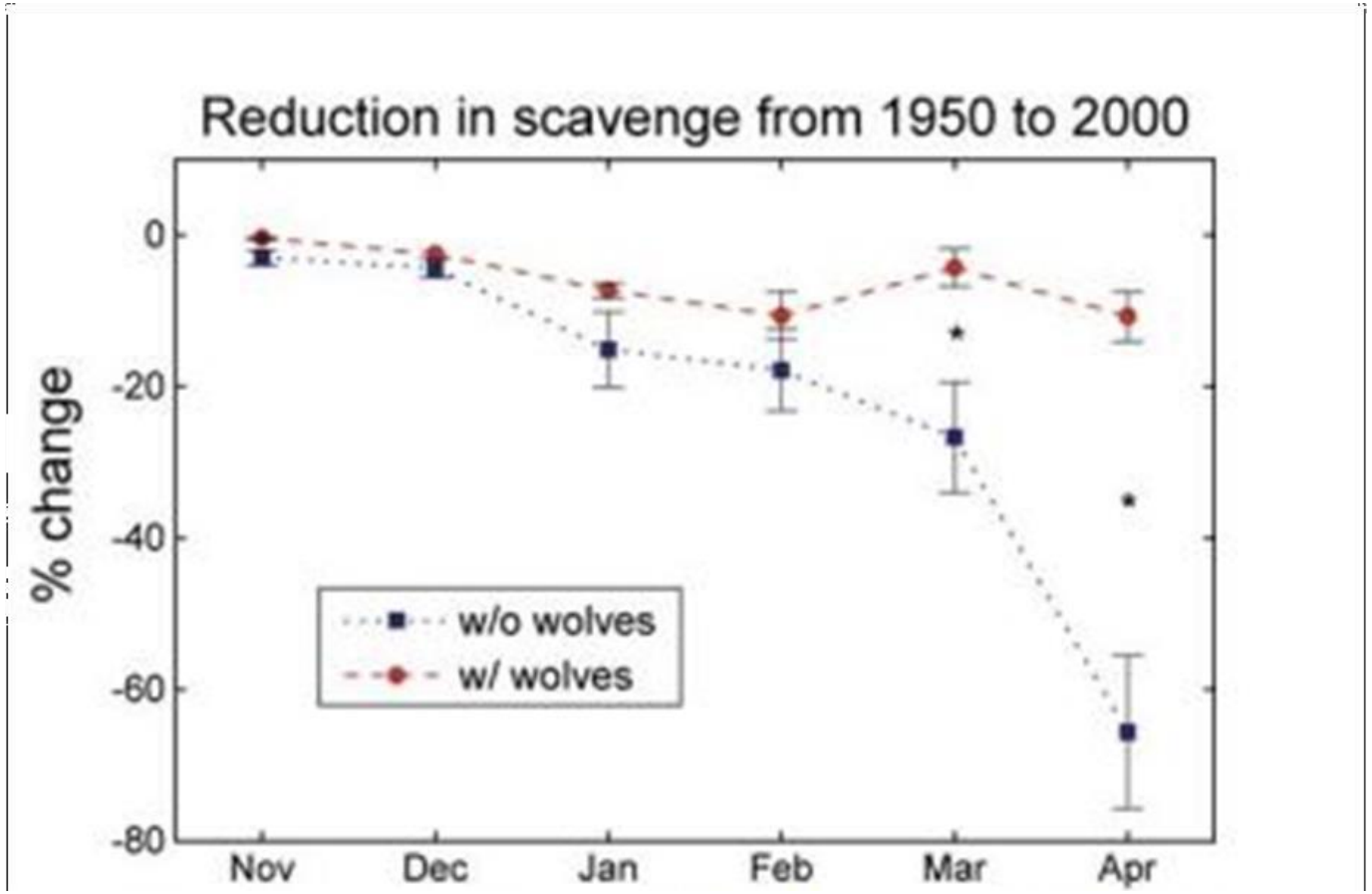
http://www.hcn.org/issues/46.21/have-returning-wolves-really-saved-yellowstone

http://www.myharriman.com/harriman-winter-black-bear/

Dr. Wilmer's Research, Berkeley

Effect of wolves on carrion availability for scavengers

What affect do wolves have on the availability of food (carrion) for scavengers in late Spring (March and April?)



https://www.youtube.com/watch?v=ysa5OBhXz-Q

Example #3 - Predators have a positive effect on biodiversity/community structure

In the 18th and 19th century, sea otters were almost hunted to extinction.

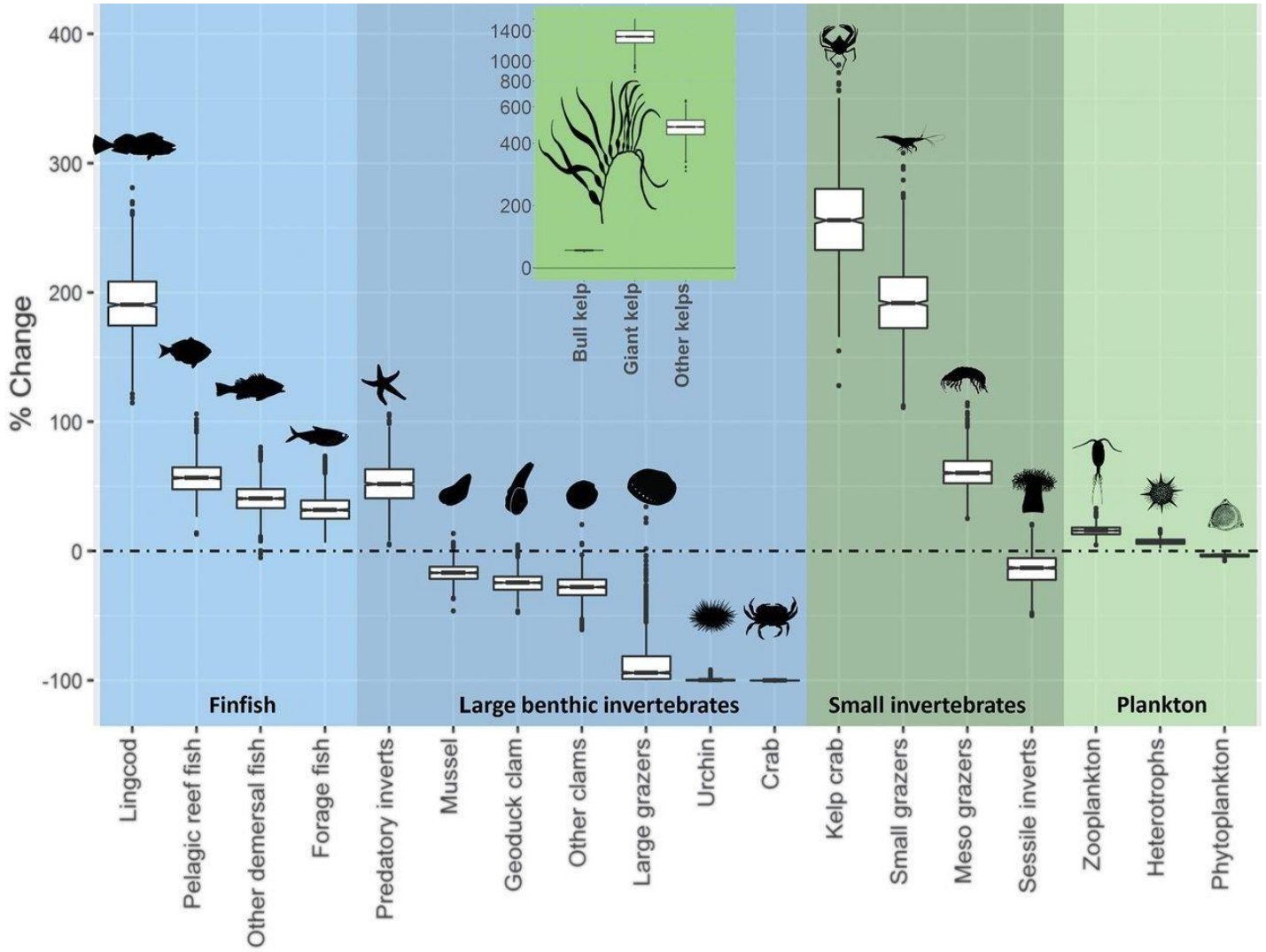
Sea otters prey on marine invertebrates, including sea urchins, which feed on kelp (big brown macroalgae).

Kelp forests are incredibly important habitat for fishes (such as salmon and rockfish). Kelp are also play an important role in uptaking carbon.

In the absence of sea otters, the sea urchins turned the kelp forests into barrens.

In 1911, sea otters were protected.
In the 1970's, 89 sea otters were introduced to coastal BC

% change in community biomass – linked to the reintroduction of sea otters



Information comes from a Science paper (2020). Authors: UBC researchers

REPORT

Cascading social-ecological costs and benefits triggered by a recovering keystone predator

Edward J. Gregr[1,2,*], Villy Christensen[3], Linda Nichol[4], Rebecca G. Martone[1,5], Russell W. Markel[1,5], Jane C. Watson[6], Christopher D. G. Harley[3,7,8], Evgeny A. Pakhomov[3,8,9], Jonathan B. Shurin[10], Kai M. A. Chan[1]

[1]Institute for Resources Environment, and Sustainability, University of British Columbia, 2202 Main Mall, Vancouver, BC V6T 1Z4, Canada.

Science
Vol 368, Issue 6496
12 June 2020

Authors concluded that the benefits of a healthy kelp forest ecosystem (tourism, carbon capture, fin fisheries) outweigh the costs (decline in geoduck, sea urchin and clam fisheries).

Activity of otters brings $50 million into the province each year.

Take home points - predation

Fitness effects of interaction: + for predator, - for prey

Predators can affect the distribution and abundance of their prey.

Predators can have a positive effect on biodiversity (# species in an area and their relative abundance)

Learning goals - community ecology up to this point

Be able to:

- Name the interaction that is occurring between two different species if provided with a scenario.
- Describe the outcome of these interactions in terms of fitness impacts
  - Positive (+): increases fitness
  - Negative (–): decreases fitness
  - Neutral (0): no effect on fitness
  - Link to relative reproductive success
- Make prediction about the **outcome** of competitive interactions, e.g. in terms of fitness effects, and species distribution and abundance (niche partitioning, competitive exclusion) based on niche overlap.
- Identify and explain the difference between fundamental vs. realized niches
- Explain how predators can affect the distribution and abundance of their prey and other species in the community

Next class: Ecological Succession

https://news.uchicago.edu/explainer/what-is-ecological-succession

If time, we will also start Ecosystem Ecology: How energy flows through an ecosystem.

It will depend upon whether Rory is able to give his lecture or not.