

# Ecology Unit – Lecture #2

Today:

- Finish terminology
- Effects of abiotic and biotic factors on distribution and abundance
  - intertidal Ecology
  - garter snake behavioural ecology
- Start Population Ecology (Part I):
  - Population size
  - Population density (if time)



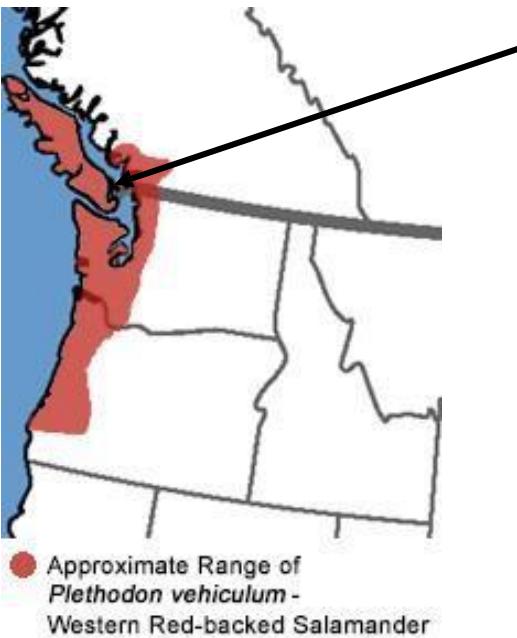
# Housekeeping

- Due this Sunday night – NO ASSIGNMENTS
- Group Project – by request, I am changing the due date for the group project to Sunday, April 2<sup>nd</sup> @ 11:59 pm.
  - Submitting peer evaluations of team members is optional, but highly recommended. I typically refer to peer evaluation feedback when writing letters of reference.
  - New: I posted several infographics from last term in the Group Project module.
- Midterm #2 returns – next week; trying for Tuesday, but may be Thursday. I will update you on Monday, if the return date will be Thursday.

# Abundance – varies with location

Abundance = Population size and /population density (number of individuals/unit area)

Population size/abundance can vary from location to location.



At Goldstream Provincial Park—  
estimated adult population size is  
>10,000 salamanders (1.8  
salamanders/meter square).

This salamander also inhabits nearby  
Pacific Spirit Park. But, in a study  
composed of 51 transects in nearby  
Pacific Spirit Park only 3 red backed  
salamanders were found.

Why the difference?

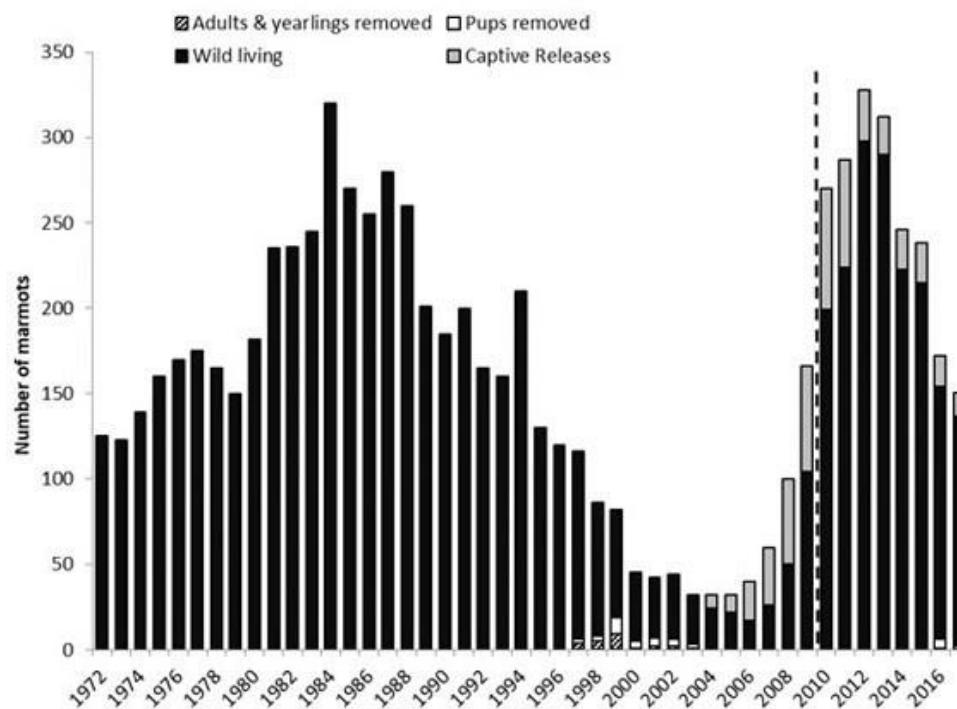


<https://californiaherps.com/noncal/northwest/nwsalamanders/images/pvehiculumtm05.jpg>

<https://a100.gov.bc.ca/pub/eswp/esr.do;jsessionid=75358177a5daba2e4c9f9c490ef404378418b454bc483c362afb5791403329cb.e3uMah8KbhmLe34PahiPc3yMbxr0n6jAmljGr5XDqQLvpAe?id=14097>

# Abundance – varies with time.

Estimated population size of the Vancouver Island Marmot (1972-2106). Canada's most endangered mammal.



Vancouver Island Marmot

Source: Dr. Andrew Bryant

# Abiotic factors (non-living factors)

## Temperature



<https://www.nationalgeographic.com/photography/photo-of-the-day/2012/2/squirrel-snowstorm/>

## Light Intensity



<https://www.flickr.com/photos/druclimb/15186192740>

## Water Availability



<https://www.washington.edu/news/2014/05/01/amphibians-in-a-vise-climate-change-robs-frogs-salamanders-of-refuge/>

# Biotic factors (living) – several examples

## Predation



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

## Competition



<https://biowithvalerie.wordpress.com/2012/08/04/>

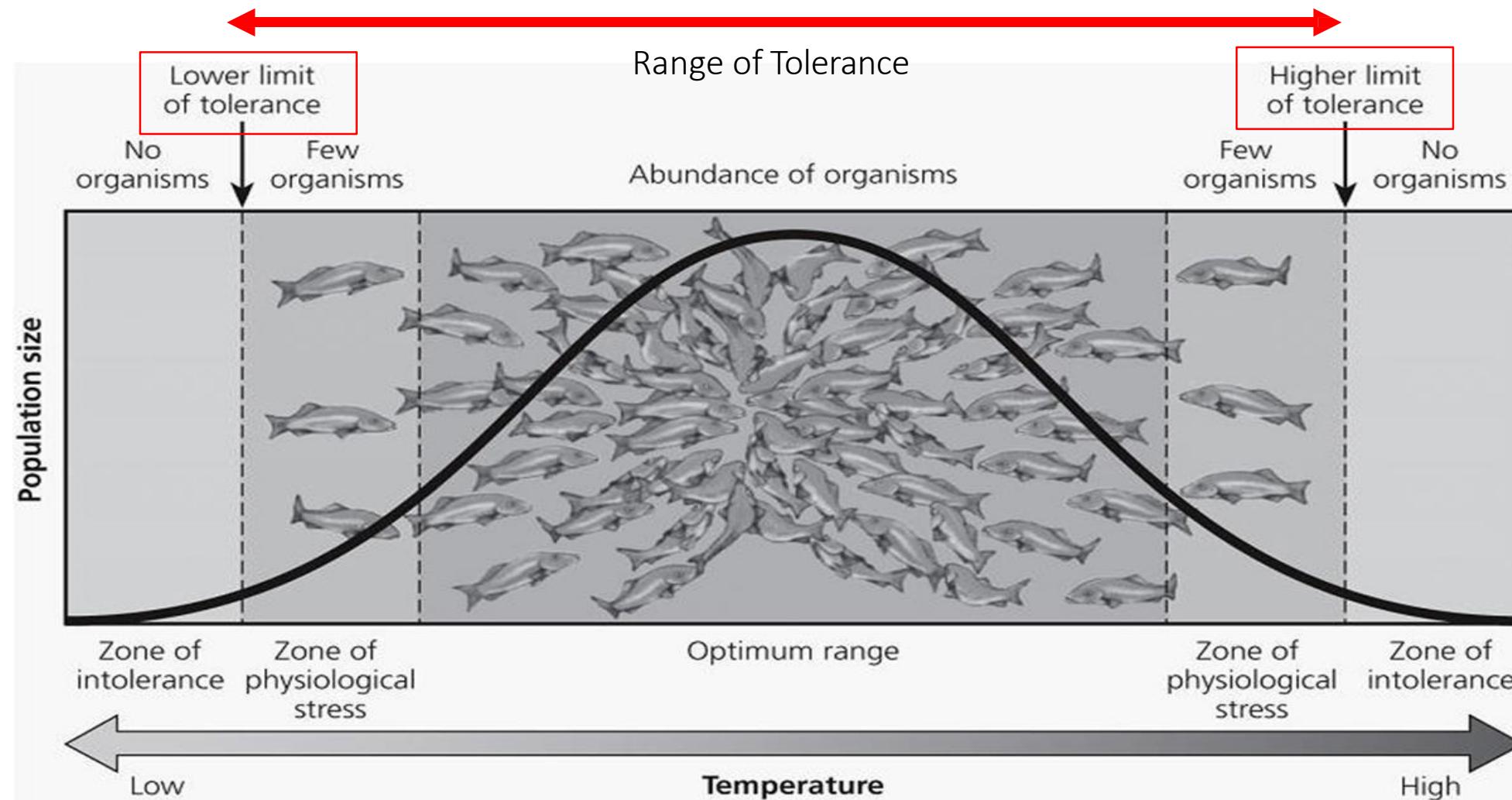
## Mutualism



<https://www.fsvaldovinos.com/mutualism-theory>

Biotic Interactions will be discussed in more detail next week in lecture on Community Ecology

Organisms can survive in an area over the long term, only if abiotic conditions are within the organism's range of tolerance.



The top of Mt. Everest = zone of intolerance for humans  
– we can only visit for a short time



<https://www.theguardian.com/world/2019/may/28/walking-over-bodies-mountaineers-describe-the-carnage-at-the-top-of-mount-everest>

# Example of an abiotic factor affecting abundance

In the summer of 2021, British Columbia experienced a heat wave than killed more than 100 people

Dr. Chris Harley (UBC) estimated that more than one billion sea creatures died in the Pacific Northwest

E&E NEWS

ENVIRONMENT

## Pacific Northwest Heat Wave Killed More Than One Billion Sea Creatures

The massive loss could destabilize local marine ecosystems

By Valerie Yurk, E&E News on July 15, 2021

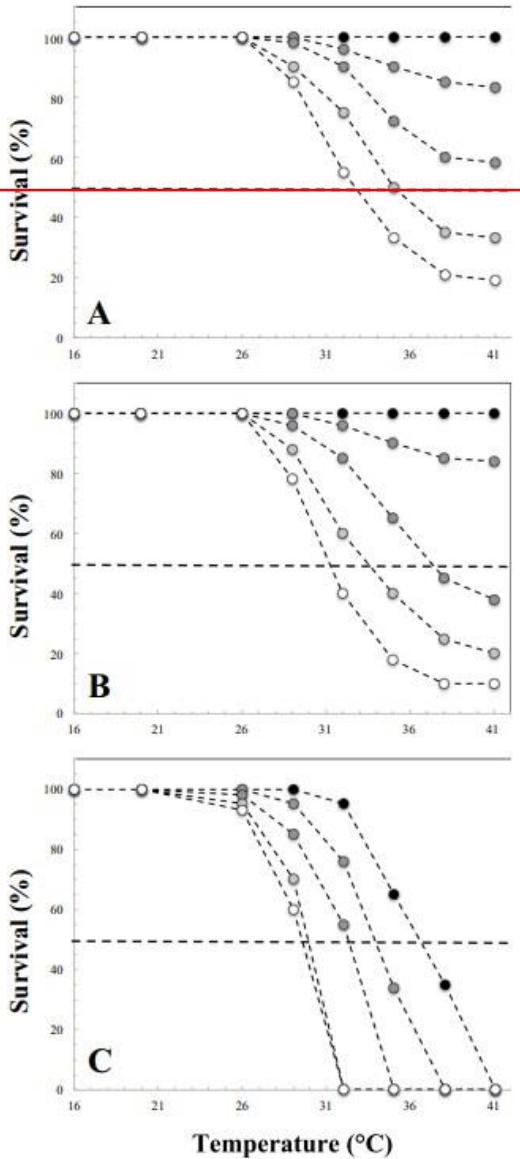


# Blue Mussels (*Mytilus edulis*)



“Estimated that on Galiano Island alone, 1,000,000 blue mussels died in an area the size of a tennis court.” (Dr. Chris Harley, UBC)

1.5 hours



3 hours

6 hours

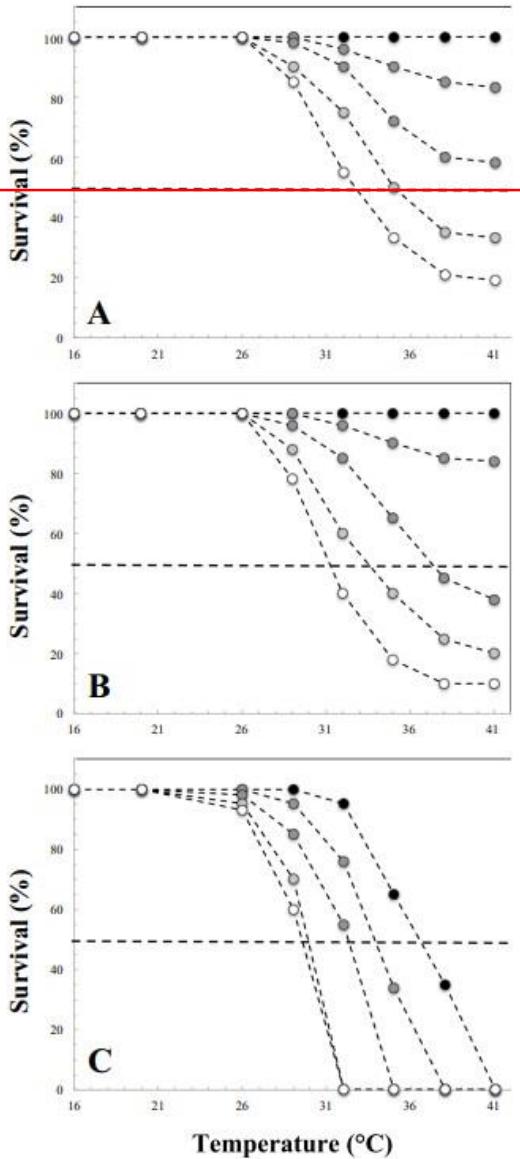
## iClicker Question

Can blue mussels tolerate being exposed to temperatures from 16-40°C for 1.5 hours?

- A. Yes
- B. No
- C. Not sure

**Figure 4.** Survival rates (%) of *M. edulis* as a function of experimental temperature for thermal exposure of 1.5 hour (A), 3 hours (B) and 6 hours (C), where each separate curve is a separate exposure event. Black dots: first exposure; dark grey dots: second exposure; intermediate grey dots: third exposure; light grey dots: fourth exposure; white dots: fifth exposure. The dashed horizontal line represents a 50% survival rate.

1.5 hours



3 hours

6 hours

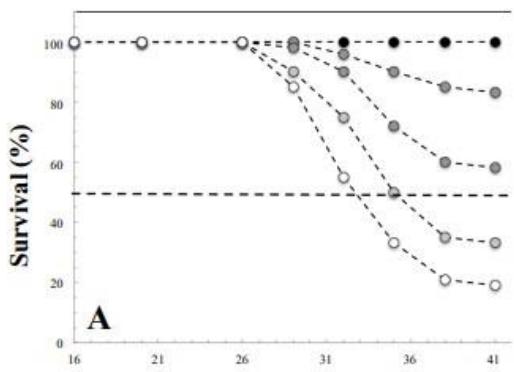
## Answer

Can blue mussels tolerate being exposed to temperatures from 16-40°C for 1.5 hours?

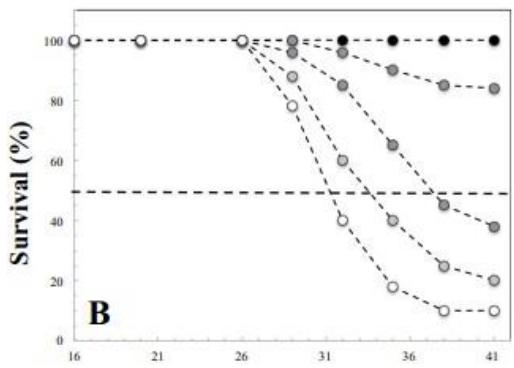
- A. Yes (although repeated exposure is suboptimal at temperatures above ~27°C)
- B. No
- C. Not sure

**Figure 4.** Survival rates (%) of *M. edulis* as a function of experimental temperature for thermal exposure of 1.5 hour (A), 3 hours (B) and 6 hours (C), where each separate curve is a separate exposure event. Black dots: first exposure; dark grey dots: second exposure; intermediate grey dots: third exposure; light grey dots: fourth exposure; white dots: fifth exposure. The dashed horizontal line represents a 50% survival rate.

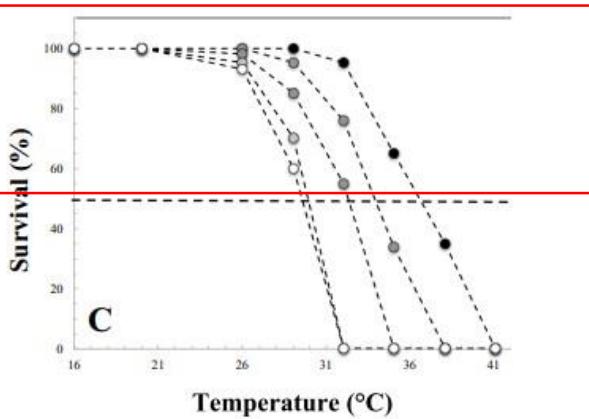
1.5 hours



3 hours



6 hours



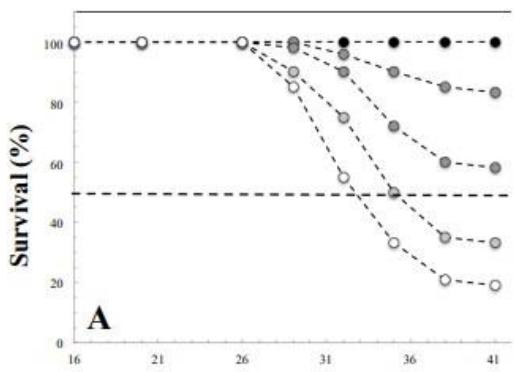
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## iClicker Question

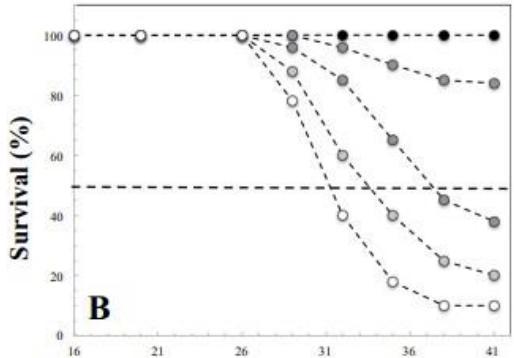
Can blue mussels tolerate being exposed to air temperatures above 40° for 6 hours more than once?

- A. Yes
- B. No
- C. Not sure

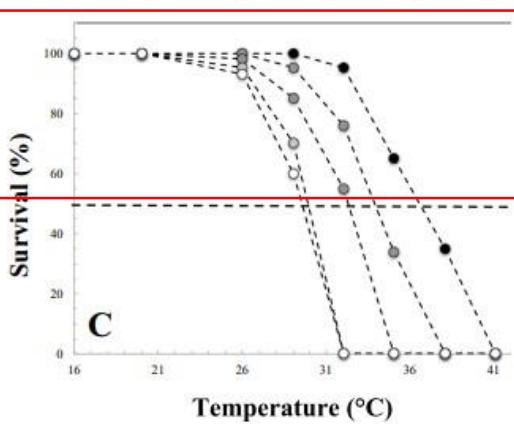
1.5 hours



3 hours



6 hours



**Figure 4.** Survival rates (%) of *M. edulis* as a function of experimental temperature for thermal exposure of 1.5 hour (A), 3 hours (B) and 6 hours (C), where each separate curve is a separate exposure event. Black dots: first exposure; dark grey dots: second exposure; intermediate grey dots: third exposure; light grey dots: fourth exposure; white dots: fifth exposure. The dashed horizontal line represents a 50% survival rate.

## Answer

Can blue mussels tolerate being exposed to air temperatures above 40°C for 6 hours more than once?

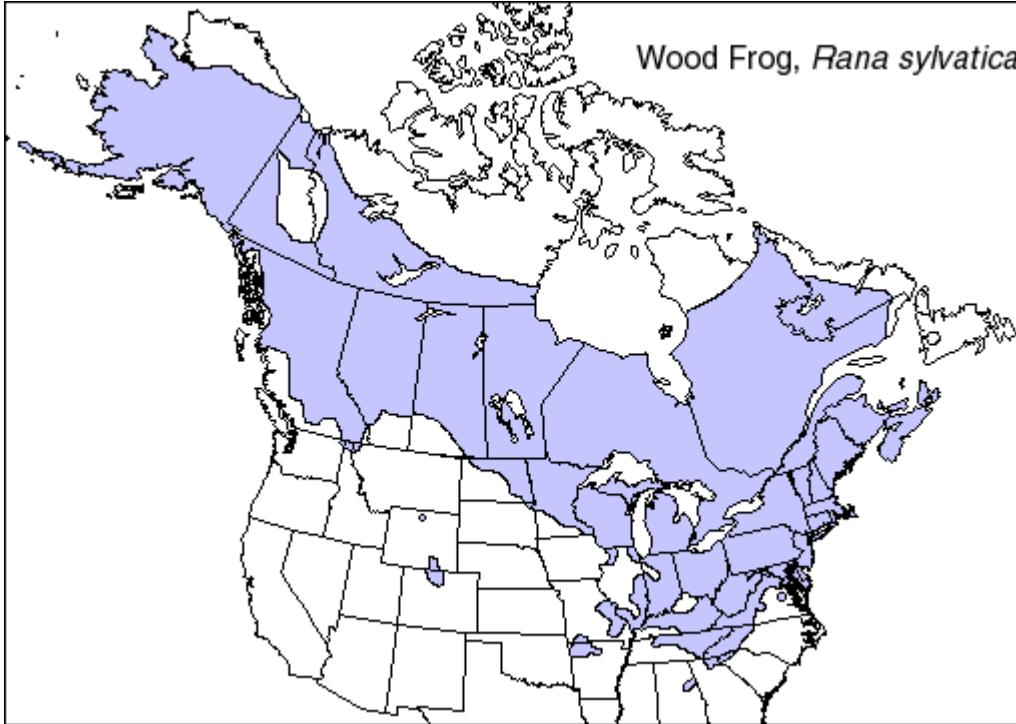
- A. Yes
- B. No - 6 hours of exposure to temperatures above 40°C is outside their range of tolerance (0% survival)
- C. Not sure

# To summarize up to this point:

- A species' distribution and abundance are determined largely by:
  - Dispersal ability
    - physical structures (e.g. oceans and mountains) and climate can act as barriers to dispersal.
  - Abiotic factors (non-living)
    - can organism survive the abiotic conditions (are conditions within the organism's range of tolerance)?
      - optimal conditions – most abundant (all else being equal)
      - stressful condition – less abundant
      - beyond range of tolerance – not present except for very short time periods
    - Biotic factors (living) – to be discussed in more detail – community ecology

# Species differ in their ranges of tolerance

- this is reflected in different patterns of distribution and abundance



[www.Wikipedia.org](http://www.Wikipedia.org)

<https://www.youtube.com/watch?v=pLPeehsXAr4&t=3s>



- Cannot tolerate the long cold winters at northern latitudes



# iClicker Question

Have you visited the intertidal zone?

- A. Yes, in the Vancouver area
- B. Yes, but not in the Vancouver area
- C. No
- D. What is an intertidal area
- E. My favourite letter

Worksheet #11 involves an intertidal organism; so, I want to go through a quick case study of how abiotic and biotic factors can affect distribution patterns.

# The intertidal zone

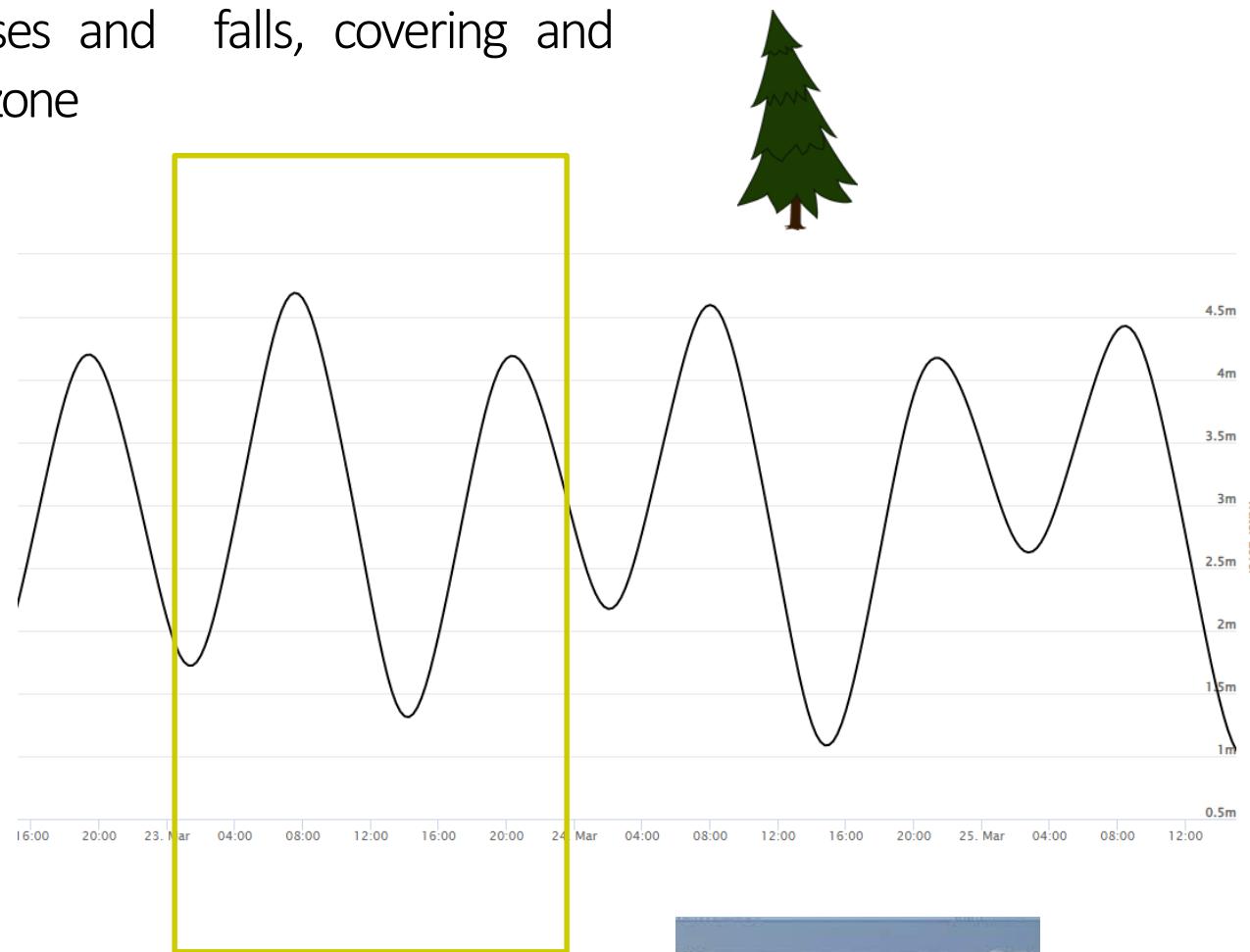
- Is the part of the marine environment that is uncovered and covered each day as the tide rises and falls.
- The animals and algae that live in the intertidal zone full time are marine organisms living at the edge of that ecosystem.



# Tidal pattern in Vancouver area last class

Twice each day, the tide rises and falls, covering and uncovering the intertidal zone

2023-03-23 (Thu)		
Time PDT	Height (m)	Height (ft)
01:23	1.7	5.6
07:33	4.7	15.4
14:11	1.3	4.3
20:21	4.2	13.7



<https://www.tides.gc.ca/en/stations/7735>



## Low tide at Stanley Park

When the tide is low, part or all of the intertidal zone is exposed to terrestrial conditions.

Intertidal organisms are marine organisms (not terrestrial); so, abiotic conditions are suboptimal and potentially lethal.



<https://www.yelp.ca/biz/girl-in-a-wetsuit-vancouver>

## High tide at Stanley Park

When the tide is high, most or all of the intertidal zone is exposed to marine conditions (optimal abiotic conditions).

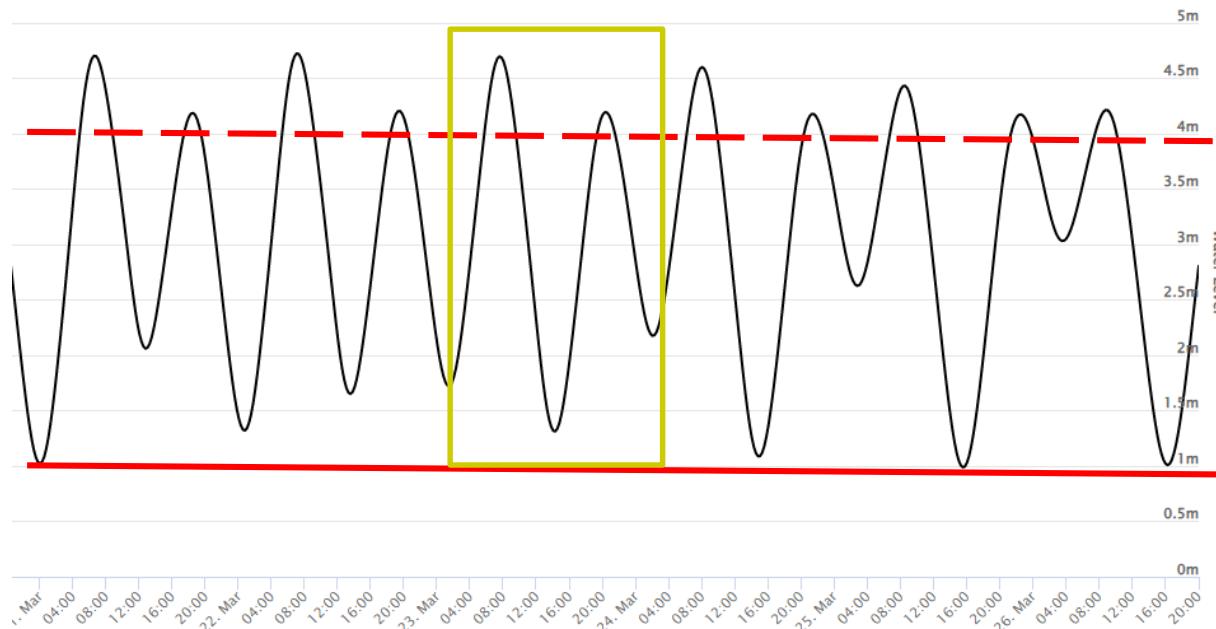


By Samantha Larabie - Imported from 500px (archived version) by the Archive Team. (detail page), CC BY 3.0, <https://commons.wikimedia.org/w/index.php?curid=73805320>

## iClicker Question - Time exposed to terrestrial conditions



The length of time that an intertidal organism is exposed to terrestrial conditions depends upon its location in the intertidal zone.



Organisms living higher in the intertidal zone (i.e. closer to the terrestrial environment) are exposed to the air for longer.

Today (23<sup>rd</sup>) an intertidal organism located at a tidal height of 1 m (solid red line) will be exposed to the air (and terrestrial conditions) for approximately how many hours?

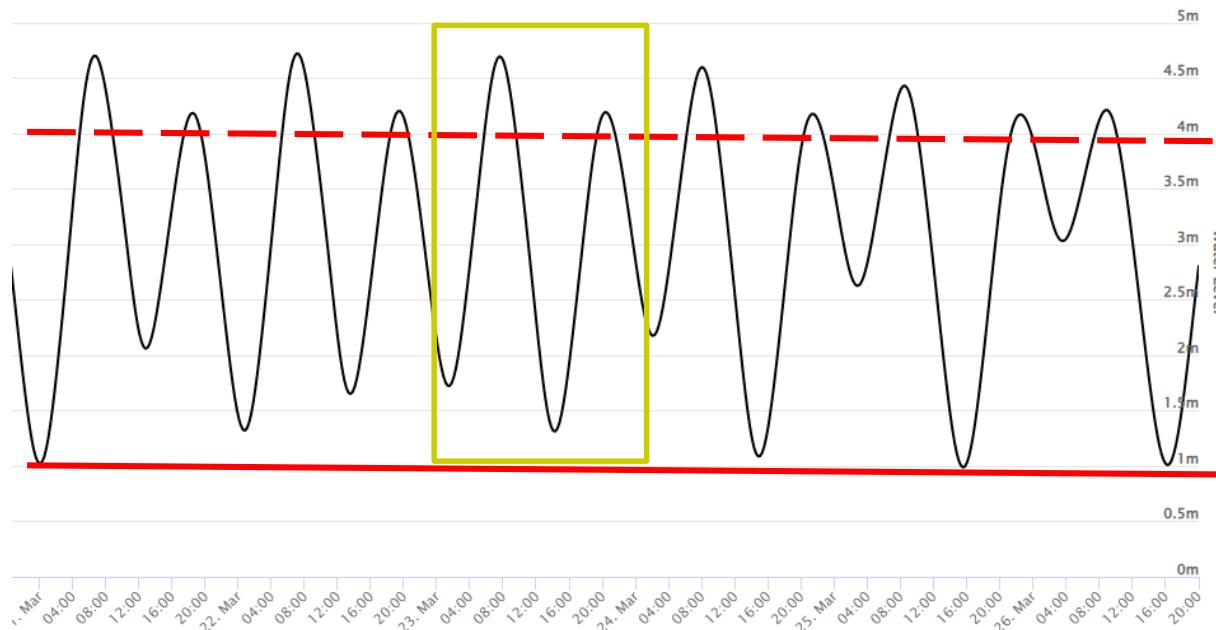
Event Date	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2023-03-20	1.5	2.2	3	3.8	4.4	4.7	4.5	4.2	3.7	3.2	2.7	2.5	2.6	3	3.4	3.8	4.1	4.1	3.7	3.1	2.4	1.8	1.2	
2023-03-21	1	1.3	1.8	2.6	3.4	4.1	4.6	4.7	4.4	3.9	3.3	2.7	2.2	2.1	2.3	2.8	3.4	3.8	4.2	4.1	3.8	3.2	2.5	1.9
2023-03-22	1.4	1.3	1.7	2.3	3.1	3.8	4.5	4.7	4.5	4.1	3.5	2.8	2.1	1.7	1.7	2.1	2.7	3.3	3.9	4.2	4.1	3.8	3.2	2.7
2023-03-23	2.1	1.8	1.8	2.2	2.9	3.5	4.2	4.6	4.6	4.3	3.7	3	2.3	1.6	1.3	1.5	2	2.6	3.3	3.9	4.2	4.1	3.8	3.3
2023-03-24	2.8	2.4	2.2	2.3	2.8	3.4	3.9	4.4	4.6	4.4	3.9	3.2	2.5	1.8	1.3	1.1	1.4	1.9	2.6	3.3	3.9	4.2	4.1	3.9
2023-03-25	3.5	3	2.7	2.6	2.8	3.2	3.7	4.1	4.4	4.4	4	3.4	2.8	2.1	1.5	1	1	1.4	2	2.7	3.4	3.9	4.1	4.1
2023-03-26	3.9	3.6	3.3	3.1	3.1	3.2	3.5	3.9	4.1	4.2	4	3.6	3	2.4	1.8	1.3	1	1.1	1.5	2.1	2.8	3.4	3.9	4.1

- A. 0 hours
- B. 2–5 hours
- C. 6–10 hours
- D. 10–15 hours
- E. >15 hours

# Answer



The length of time that an intertidal organism is exposed to terrestrial conditions depends upon its location in the intertidal zone.



Organisms living higher in the intertidal zone (i.e. closer to the terrestrial environment) are exposed to the air for longer.

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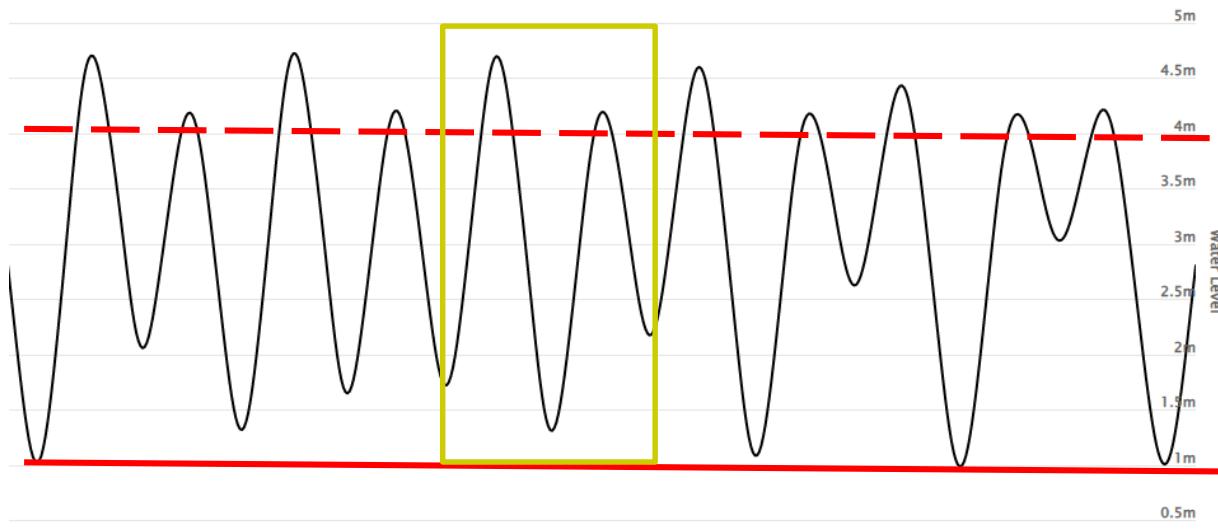
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2023-03-21	1	1.3	1.8	2.6	3.4	4.1	4.6	4.7	4.4	3.9	3.3	2.7	2.2	2.1	2.3	2.8	3.4	3.8	4.2	4.1	3.8	3.2	2.5	1.9
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- A. 0 hours
- B. 2–5 hours
- C. 6–10 hours
- D. 10–15 hours
- E. >15 hours

## iClicker Question - Time exposed to terrestrial conditions II



The length of time that an intertidal organism is exposed to terrestrial conditions depends upon its location in the intertidal zone.



Organisms living higher in the intertidal zone (i.e. closer to the terrestrial environment) are exposed for longer.

Today (23<sup>rd</sup>) an intertidal organism located at a tidal height of 4 m (dashed red line) will be exposed to the air (and terrestrial conditions) for approximately how many hours?

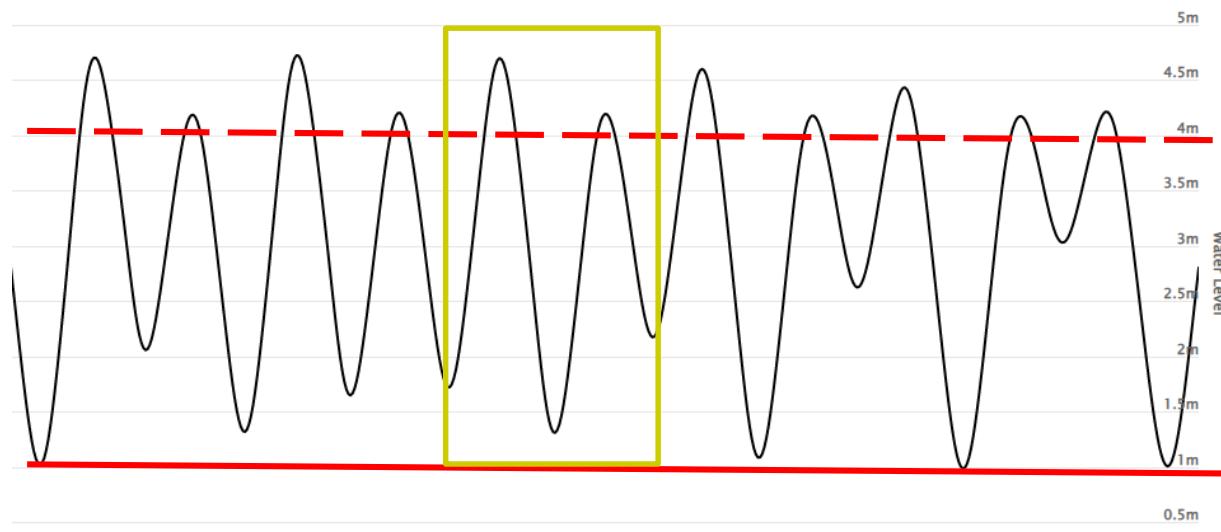
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- A. < 1 hour
- B. 2 – 5 hours
- C. 6 – 10 hours
- D. 10 – 15 hours
- E. > 15 hours

# Answer



The length of time that an intertidal organism is exposed to terrestrial conditions depends upon its location in the intertidal zone.



Organisms living higher in the intertidal zone (i.e. closer to the terrestrial environment) are exposed for longer.

Today (21<sup>st</sup>) an intertidal organism located at a tidal height of 4 m (dashed red line) will be exposed to the air (and terrestrial conditions) for approximately how many hours?

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- A. < 1 hour
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- D. 10 – 15 hours
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# Abiotic conditions in the intertidal zone

Intertidal organisms are primarily marine organisms living at the edge of this ecosystem.

Abiotic conditions are more optimal for most intertidal organisms when they are exposed to marine conditions

- i.e. when they are submerged in water.

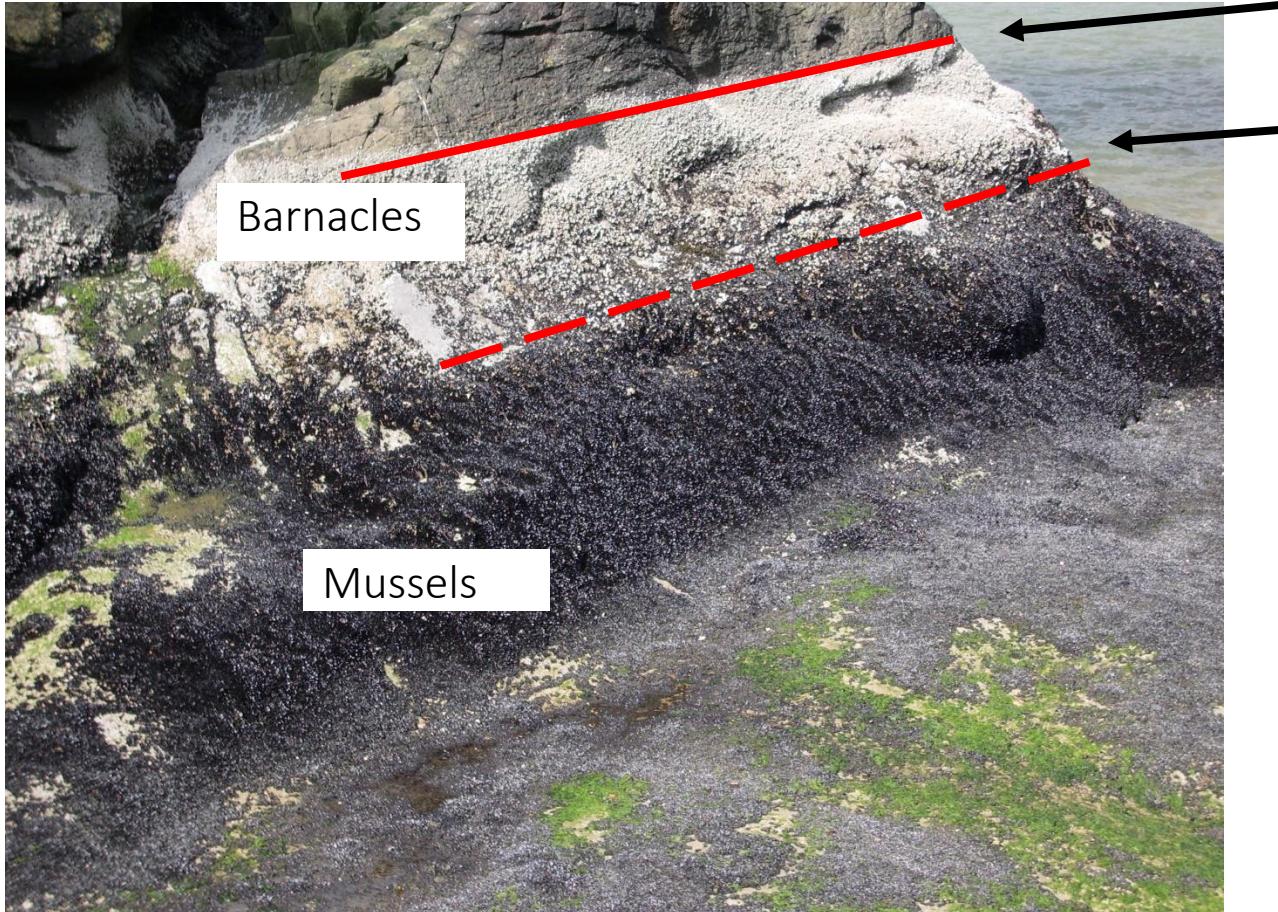
Abiotic conditions (e.g. temperatures, salinities, oxygen availability) are stressful (and potentially lethal) when intertidal organisms are exposed to the air.

Abiotic conditions tend to determine the upper limit of distribution of an intertidal organism.



Source: [https://www.wikiwand.com/en/Intertidal\\_ecology](https://www.wikiwand.com/en/Intertidal_ecology)

# Effects of abiotic factors on the distribution of intertidal organisms



The upper limit of distribution - barnacles  
The upper limit of distribution - mussels



barnacles



mussels

# iClicker Question – upper limit of distribution

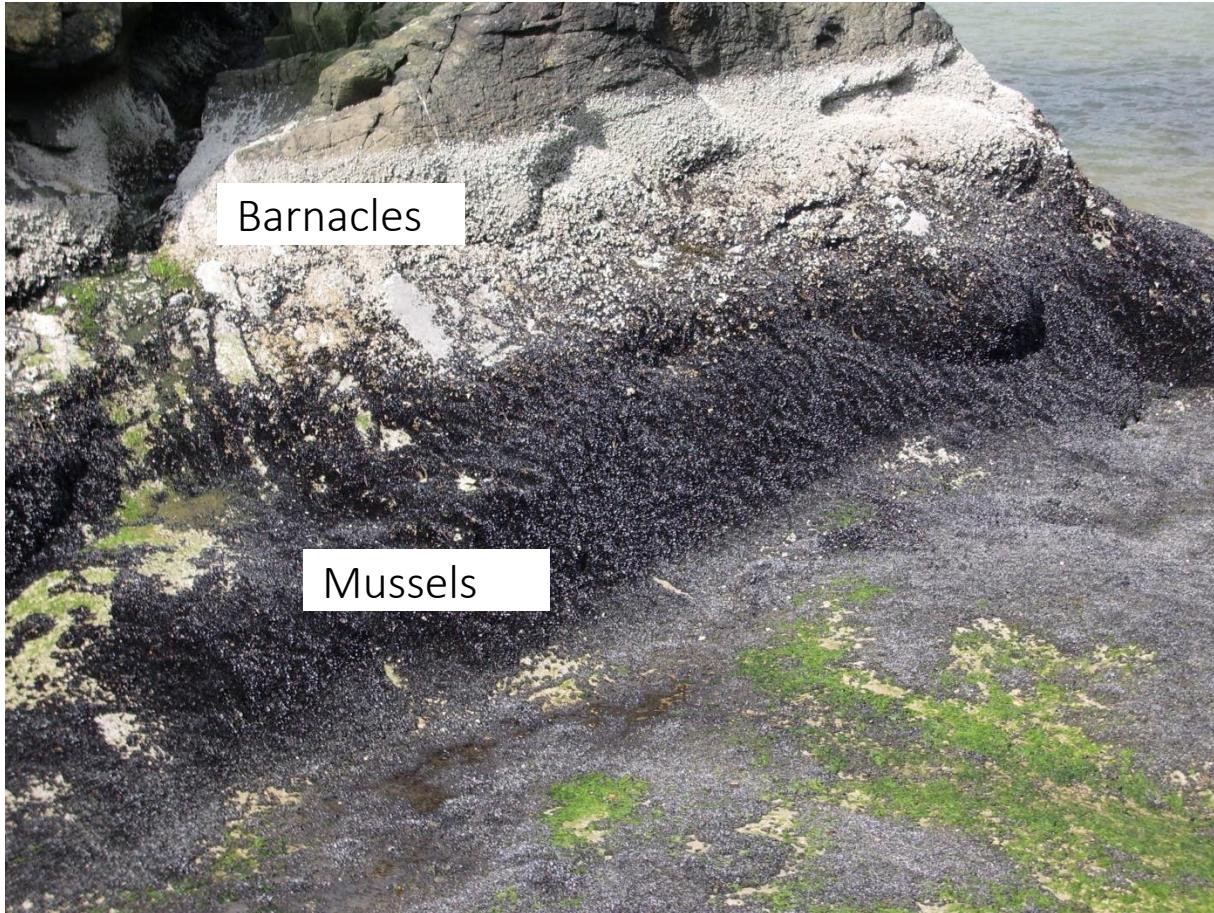


Barnacles and mussels\* are sessile animals, i.e. they cannot move. They both need oxygen. When the tide is low both species use the dissolved oxygen trapped within their shells for survival.

Which intertidal animal do you think has a greater range of tolerance for low dissolved oxygen conditions?

- A. Barnacles
- B. Mussels
- C. Not sure

# Answer



Which intertidal animal do you think has a greater range of tolerance for low dissolved oxygen conditions?

- A. Barnacles
- B. Mussels
- C. Not sure

## In the intertidal zone - biotic conditions tend to limit lower limit of distribution

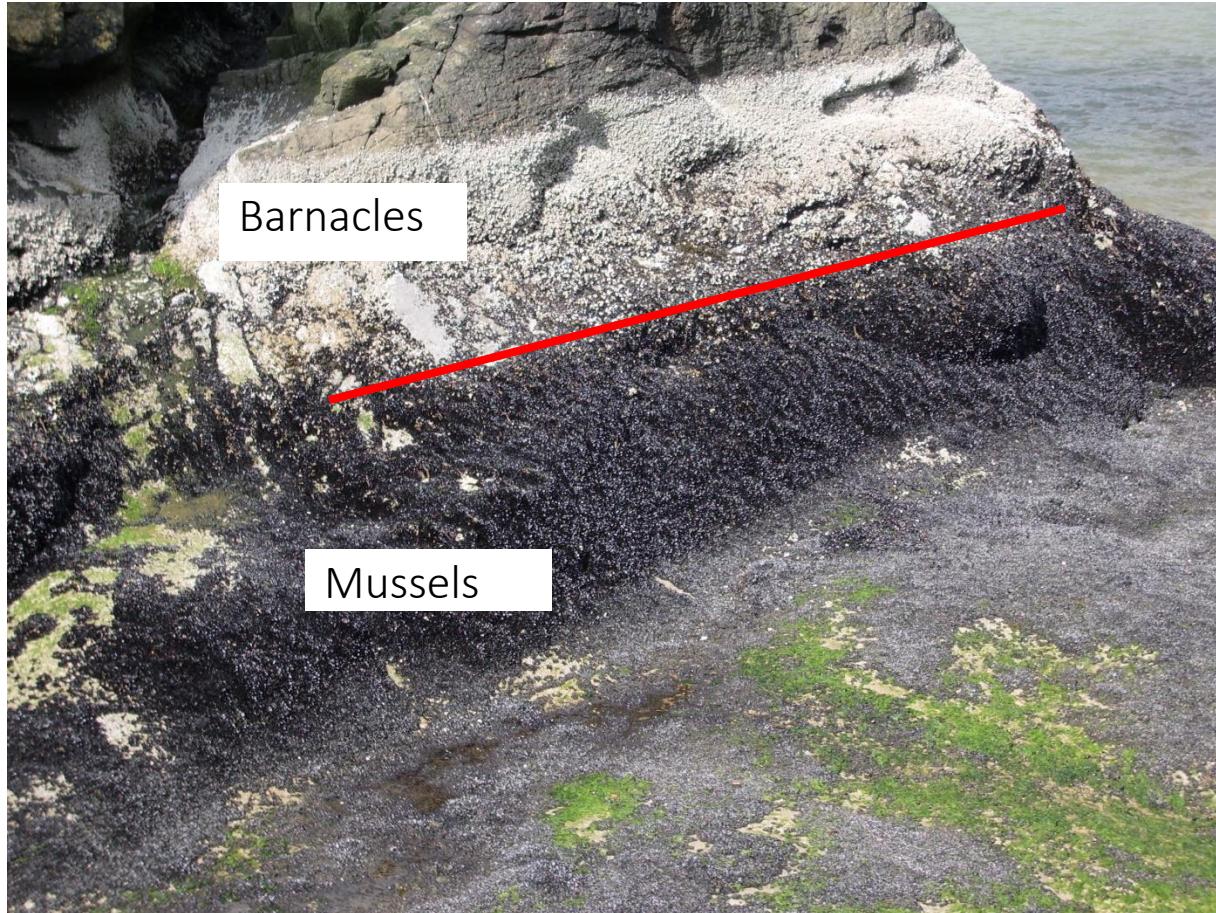
Predation intensity from marine predators is higher when intertidal organisms are submerged.

Competition for limited resources(e.g. for limited space) is more intense in locations where abiotic conditions are more optimal.



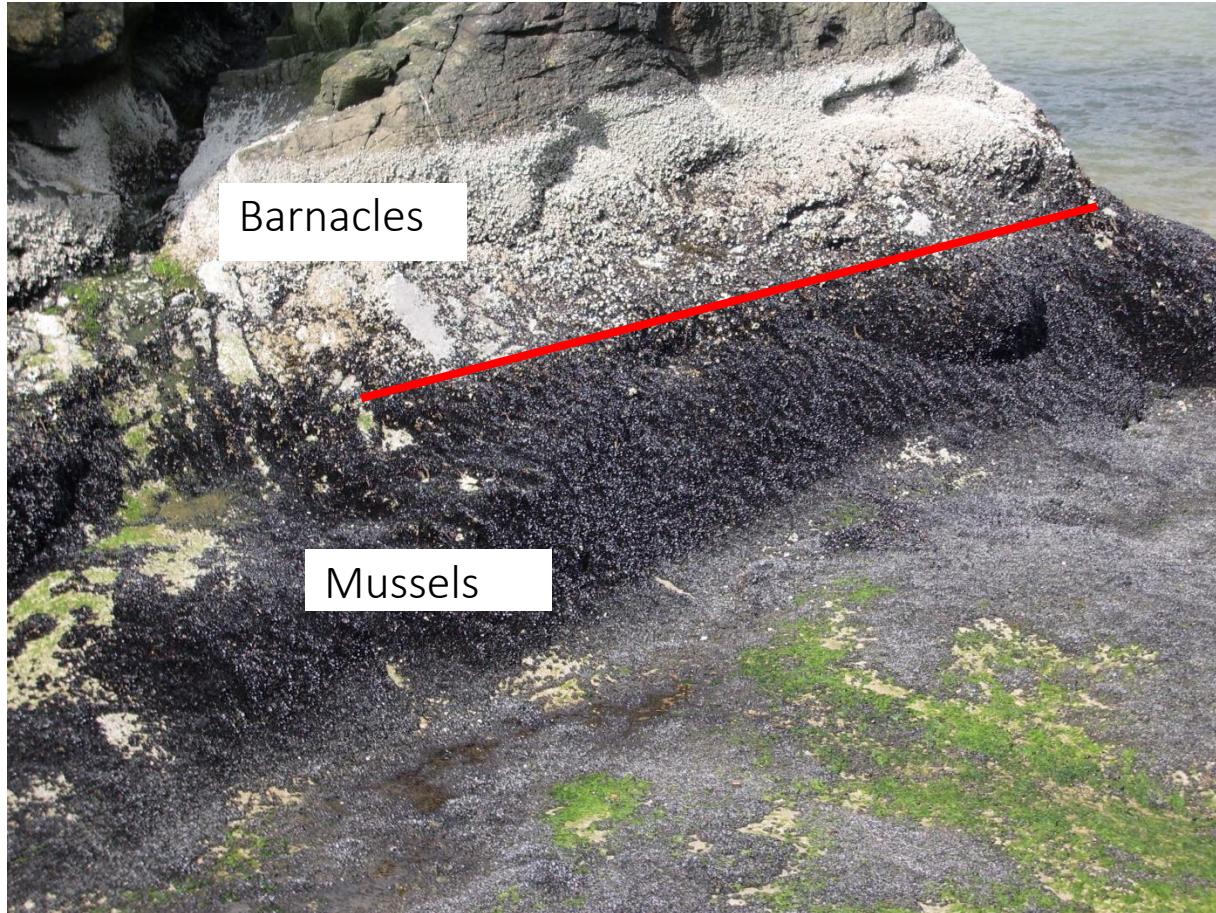
Source: <https://www.news.ucsb.edu/2016/016475/california-s-ecological-abundance>

# iClicker Question – biotic factor -barnacles



- What biotic factor could be determining the lower limit of distribution of the barnacles (solid red line)?
  - A. Competition
  - B. Predation
  - C. Not sure

# iClicker Question



- What biotic factor could be determining the lower limit of distribution of the barnacles?

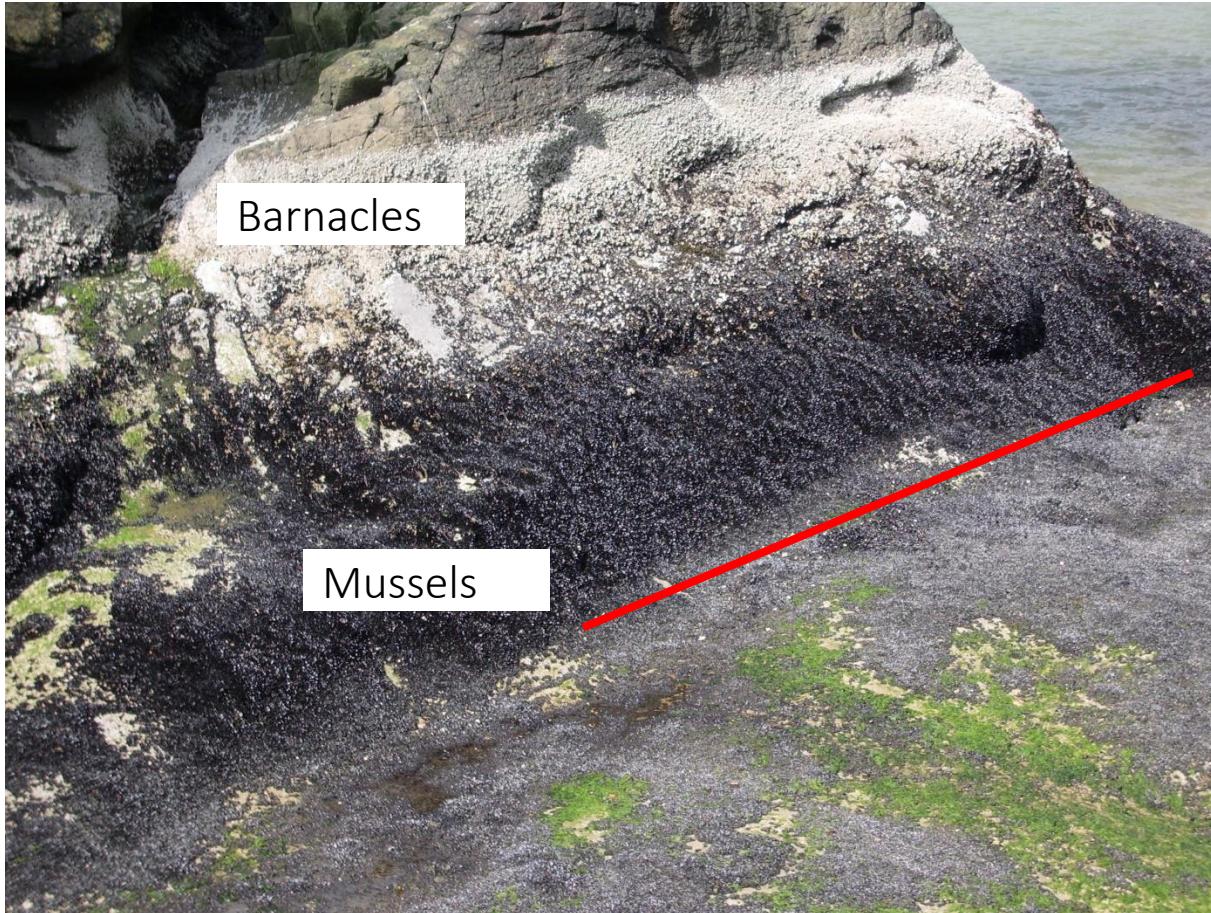
- A. Competition (for space)
- B. Predation
- C. Not sure



Mussels are superior competitors for space to attach to compared to barnacles. They can just grow on top of the barnacles

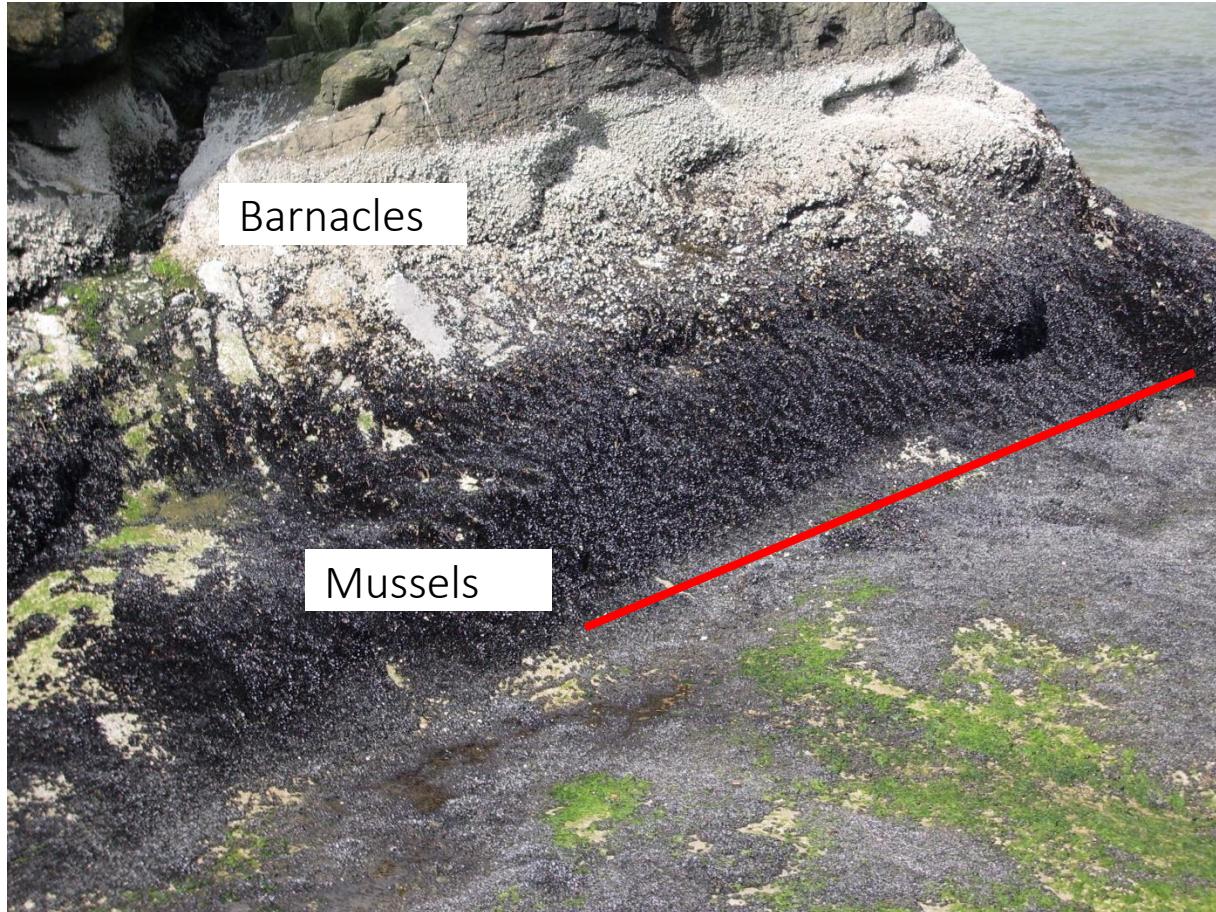
(return to this point in two weeks – community ecology unit)

# iClicker Question – biotic factor – blue mussels



- What biotic factor could be determining the lower limit of distribution of the mussels (solid red line)?
  - A. Competition
  - B. Predation
  - C. Food availability
  - D. Not sure

# Answer



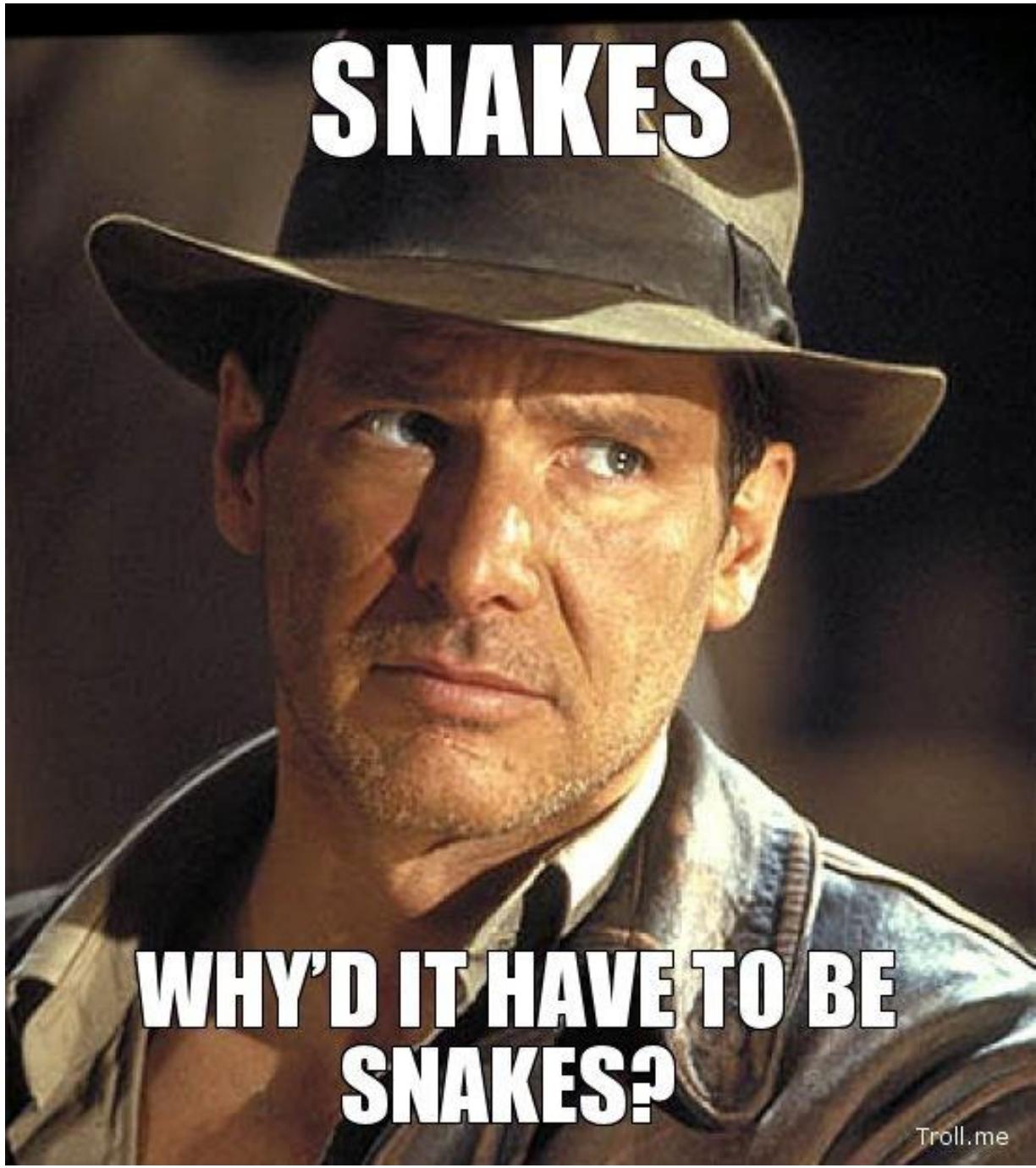
- What biotic factor could be determining the lower limit of distribution of the mussels?
- A. Competition
- B. Predation (e.g. by seastars)
- C. Food Availability
- D. Not sure

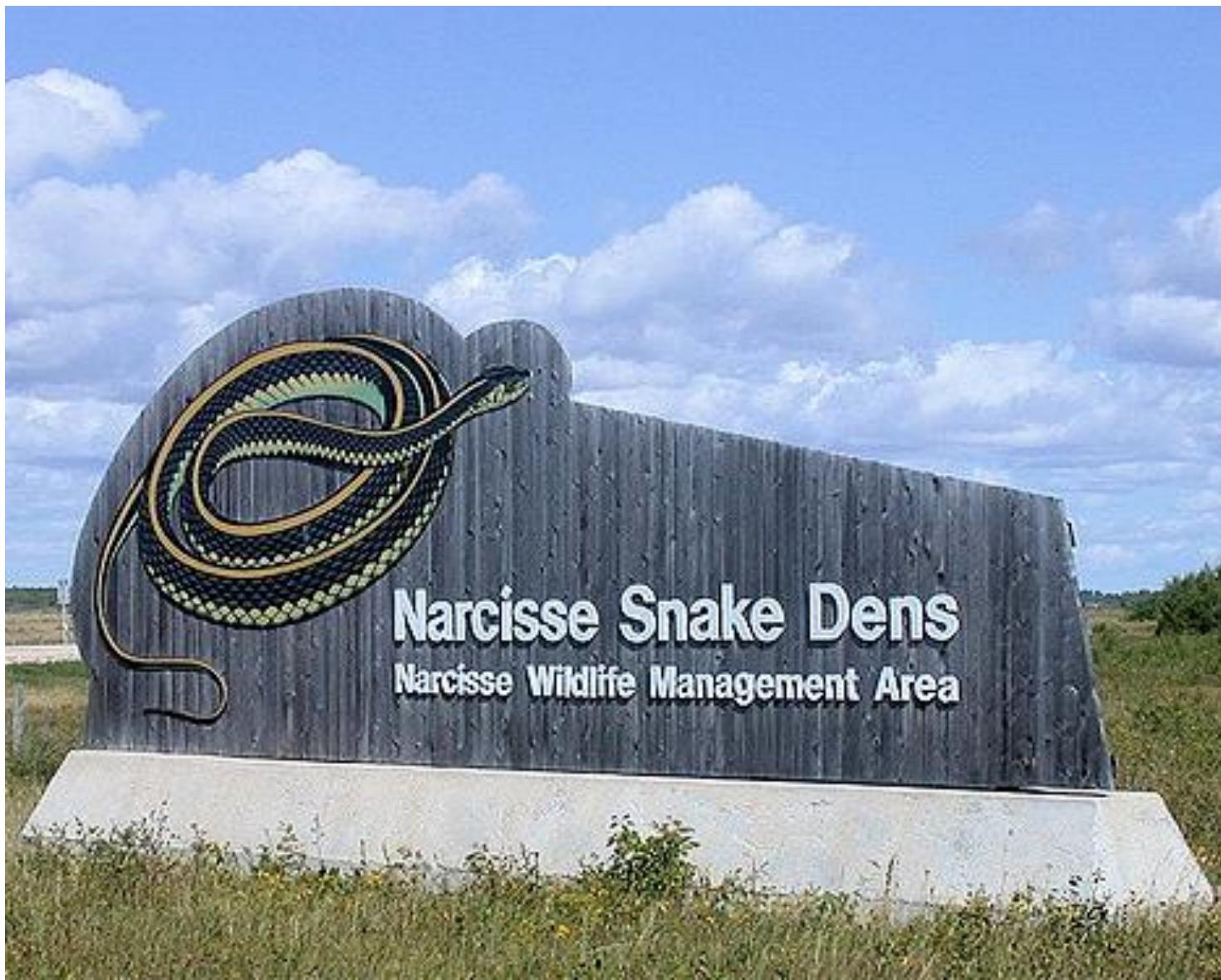


# 4-minute break, then snakes



Lance isn't a common  
name these days, but  
in medieval times,  
people were named Lance a lot.









By Oregon State University - <https://www.flickr.com/photos/oregonstateuniversity/6848773253/>, CC BY-SA 2.0,  
<https://commons.wikimedia.org/w/index.php?curid=47806139>

# Effects of abiotic factors on patterns of distribution and abundance - Narcisse snake dens



neilfisher.com

<https://neilfisher.com/blog/snakes-of-fort-livingstone>

Snakes:

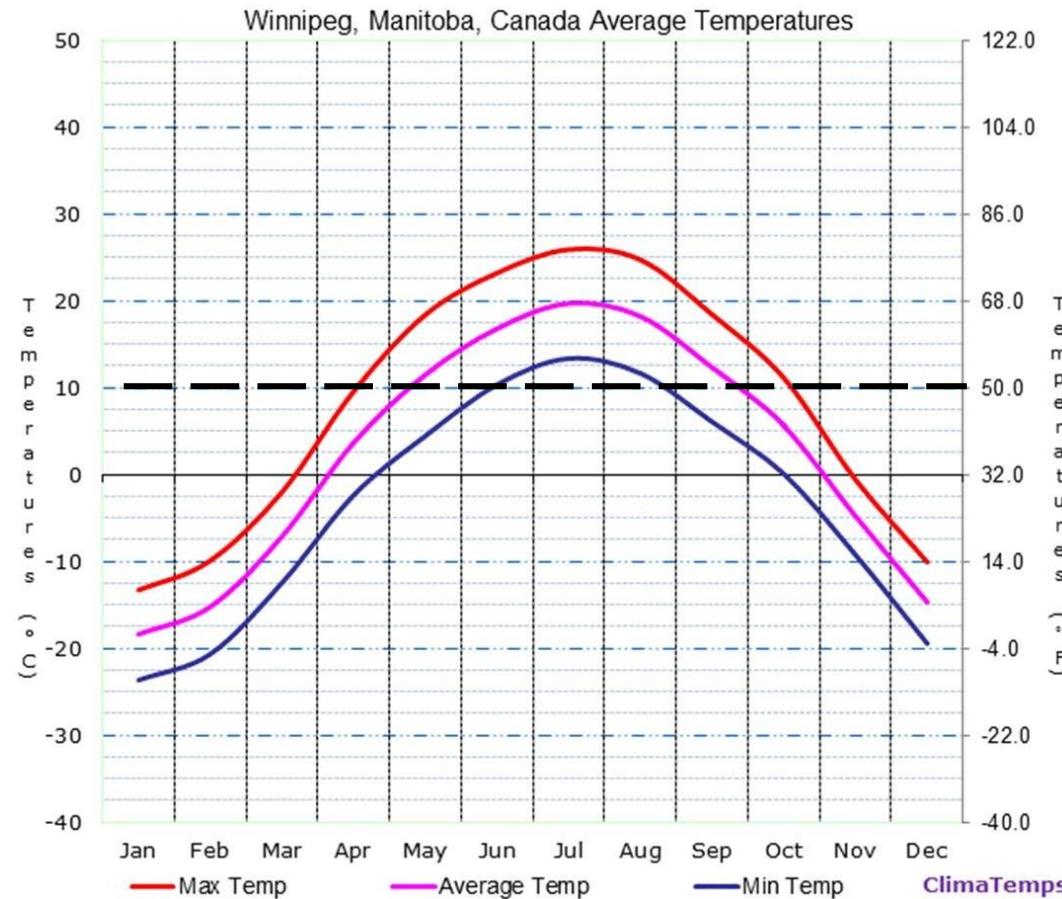
Den communally, often in large numbers (Narcisse dens ~60,000 snakes)

Move long distances from den to summer foraging site (> 18 km)

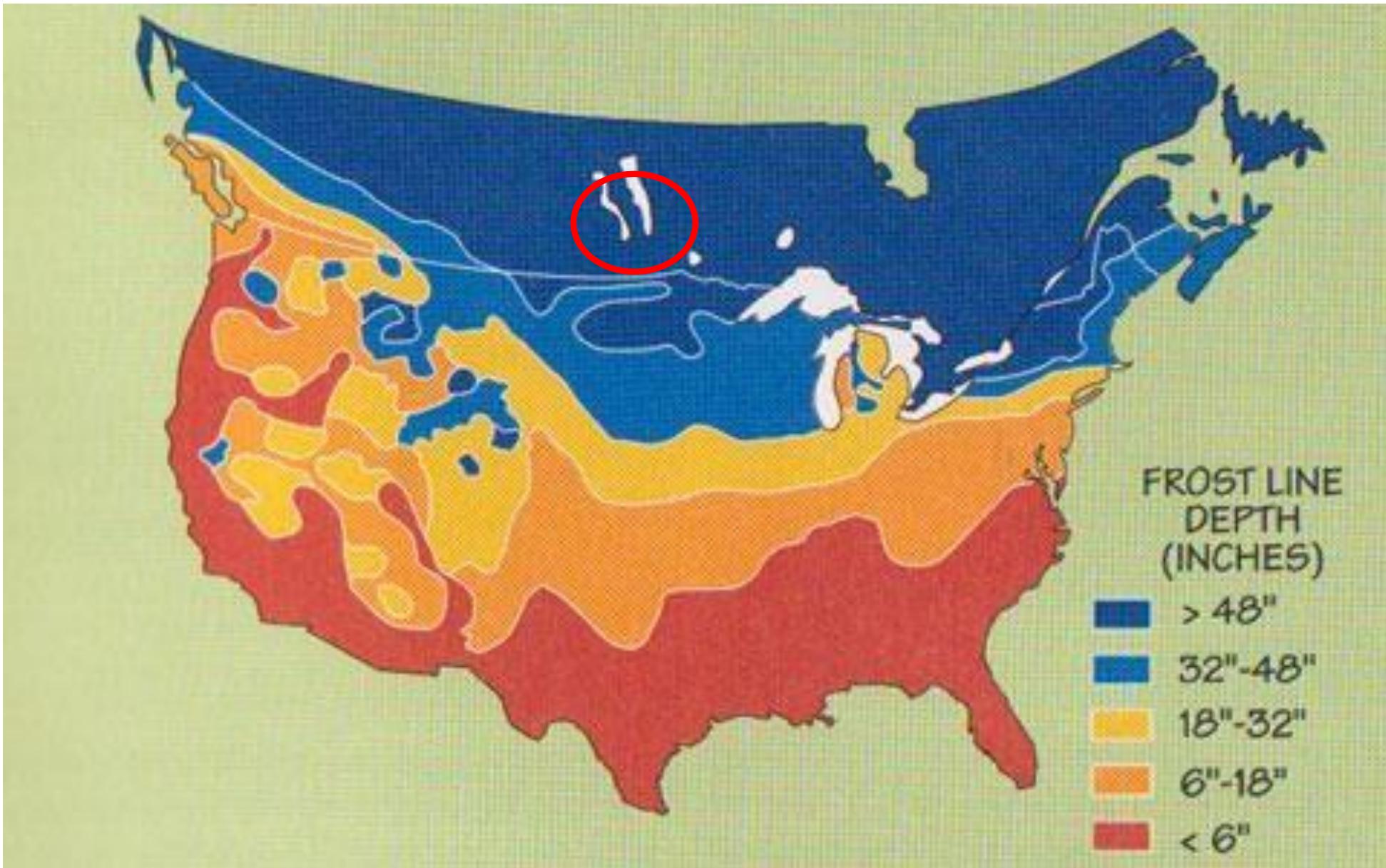
Show high den site fidelity (>97%)

Hypothesis: Pattern reflects low den site availability

# Hypothesis: Patterns reflects low den site availability



- Snakes are ectotherms
- Body temperature must be above 10°C to digest food (dashed line -----)
- Air temp. are below 10°C for 7 months per year
- And below freezing for ~6 months per year.



Frost-line reaches depths greater than one meter below the ground.

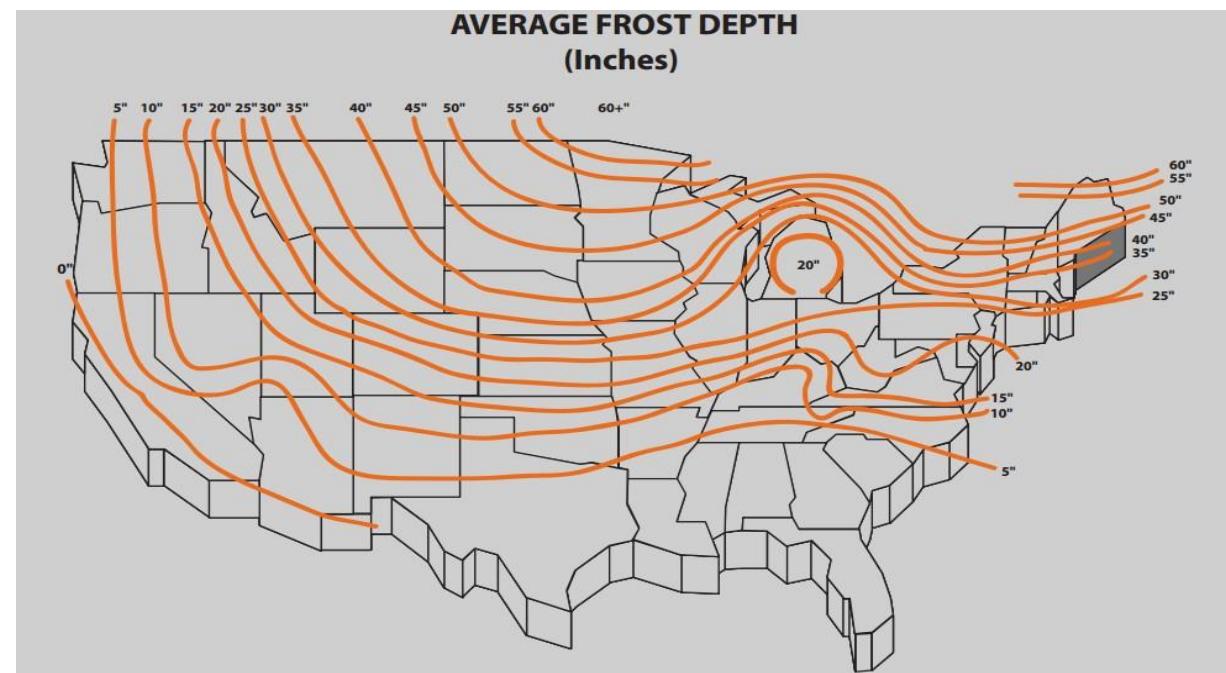
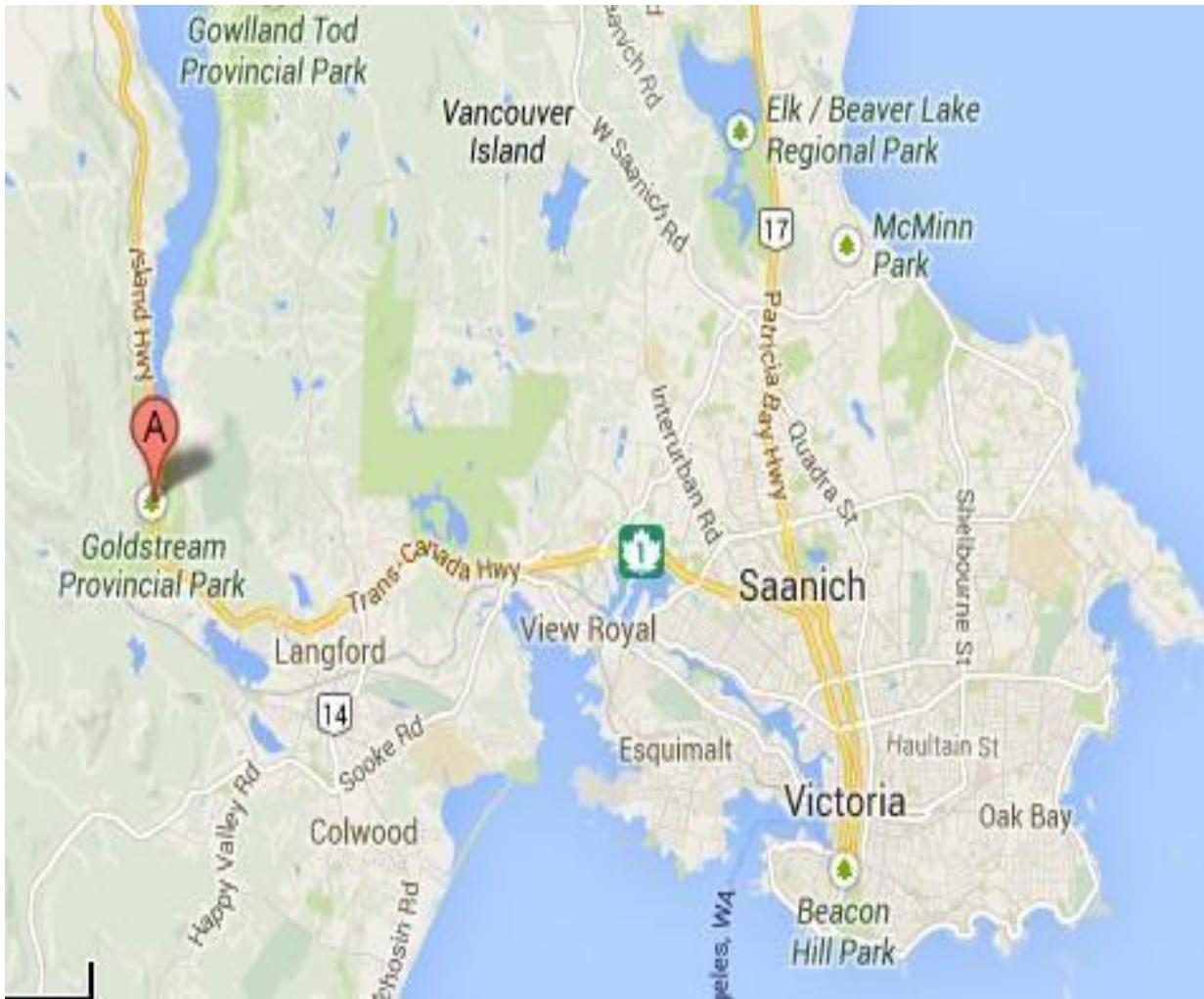
Suitable den sites likely rare.

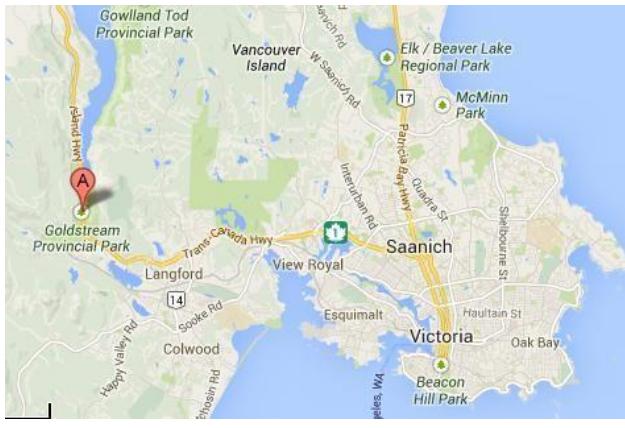
Difficult hypothesis to test: Impossible to identify/count number of suitable den sites in an area

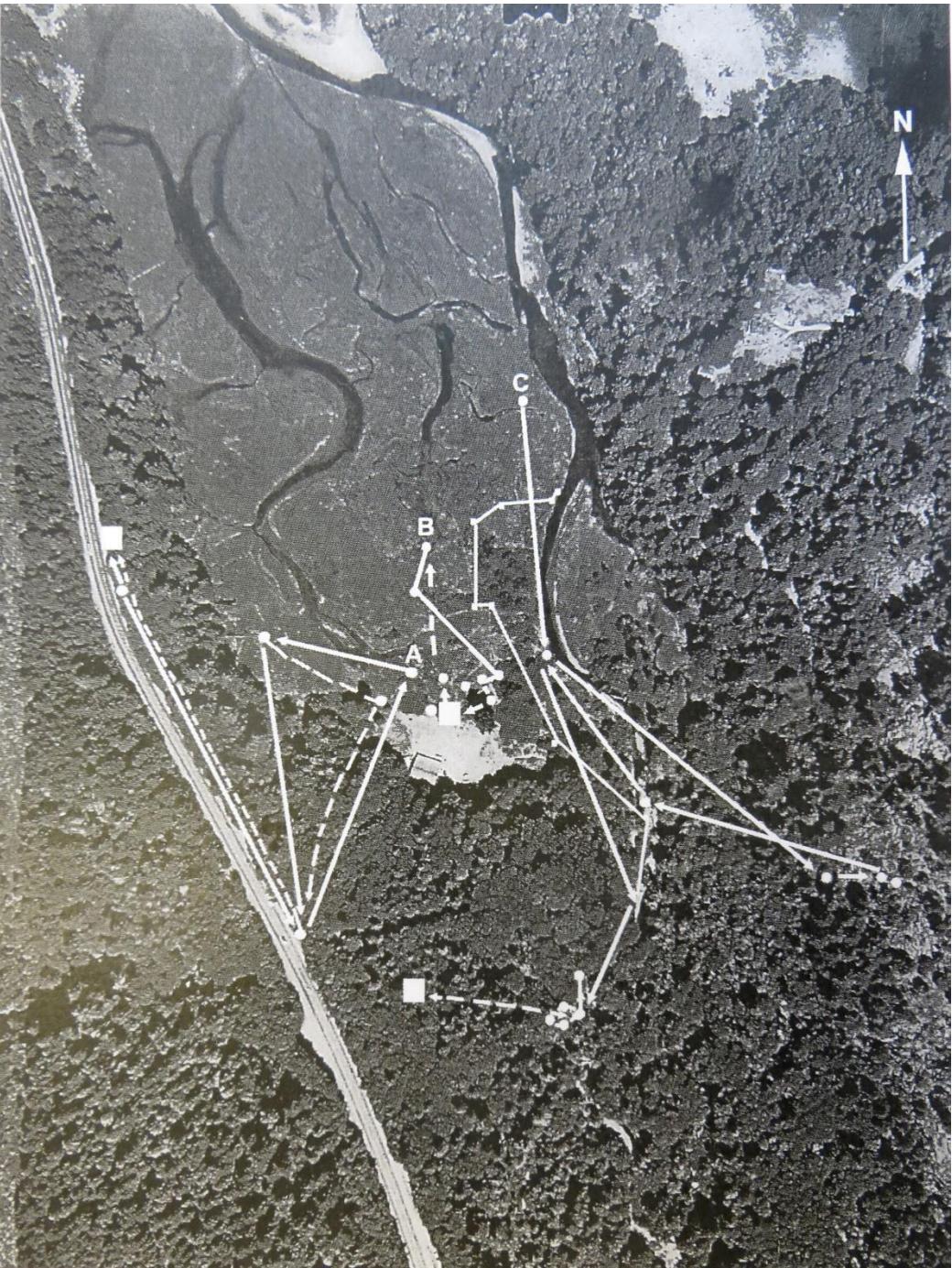
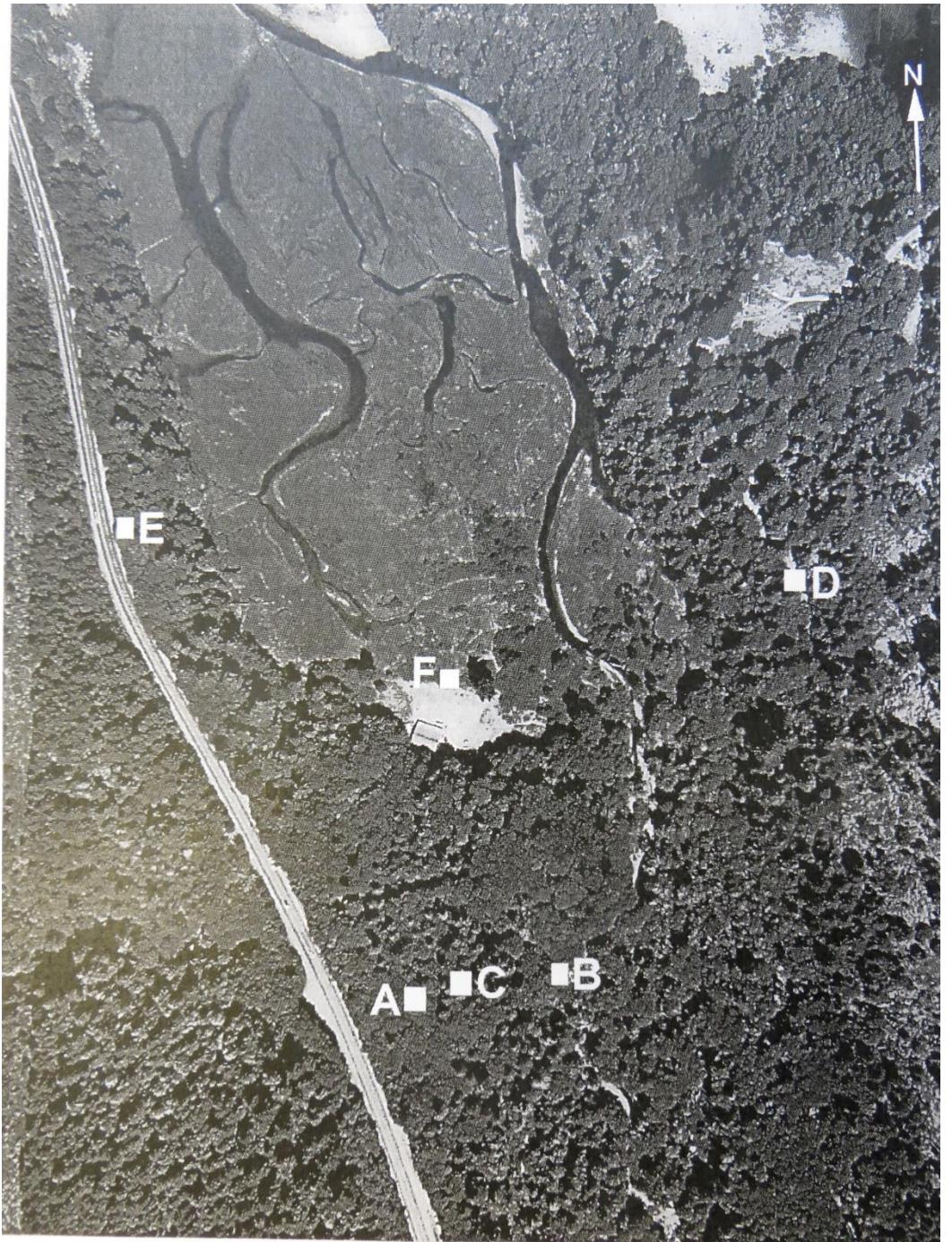


# But, if the den site availability hypothesis is true

- In locations with warmer winter climates
  - Frost line does not extend as deep into the ground
  - More den sites should be available (all else being equal)
  - Different patterns of behaviour should be observed
    - Smaller den size numbers
    - Shorter migrations
    - Less den site fidelity





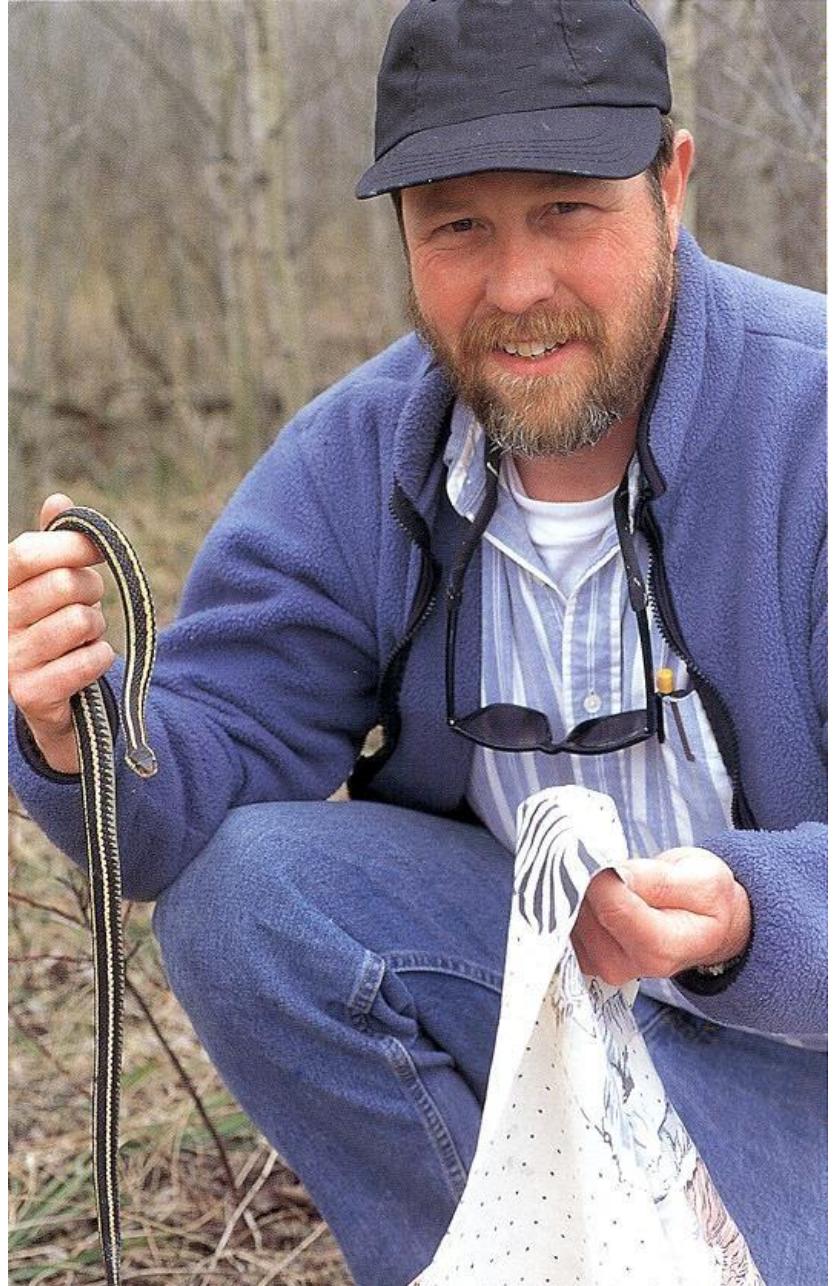


# Autecology – snake movement patterns

My data lends support to the hypothesis that den site availability (an abiotic factor) affects the distribution, abundance and behaviour of snakes.

Where den sites are abundant:

- Snakes hibernate alone or in small numbers
- Hibernate very close to their summer foraging site
- Den site fidelity? Unanswered – thanks transmitter failure ☹.



Dr. Robert Mason, Oregon State University



Dr. Rick Shine, University of Sydney

Why do you think male garter snakes would emit a female hormone?

- Hypotheses?



<https://www.youtube.com/watch?v=nROAjbtew8M>

# Questions?



<http://www.iflscience.com/plants-and-animals/this-year-s-comedy-wildlife-photography-awards-are-looking-hilarious-already/>

# Learning Objectives

- I will not ask you a question about the Narcisse snakes on the final exam.
- But, be able to explain how abiotic (or biotic) factors could affect the distribution, abundance and/or behaviour of an organism.

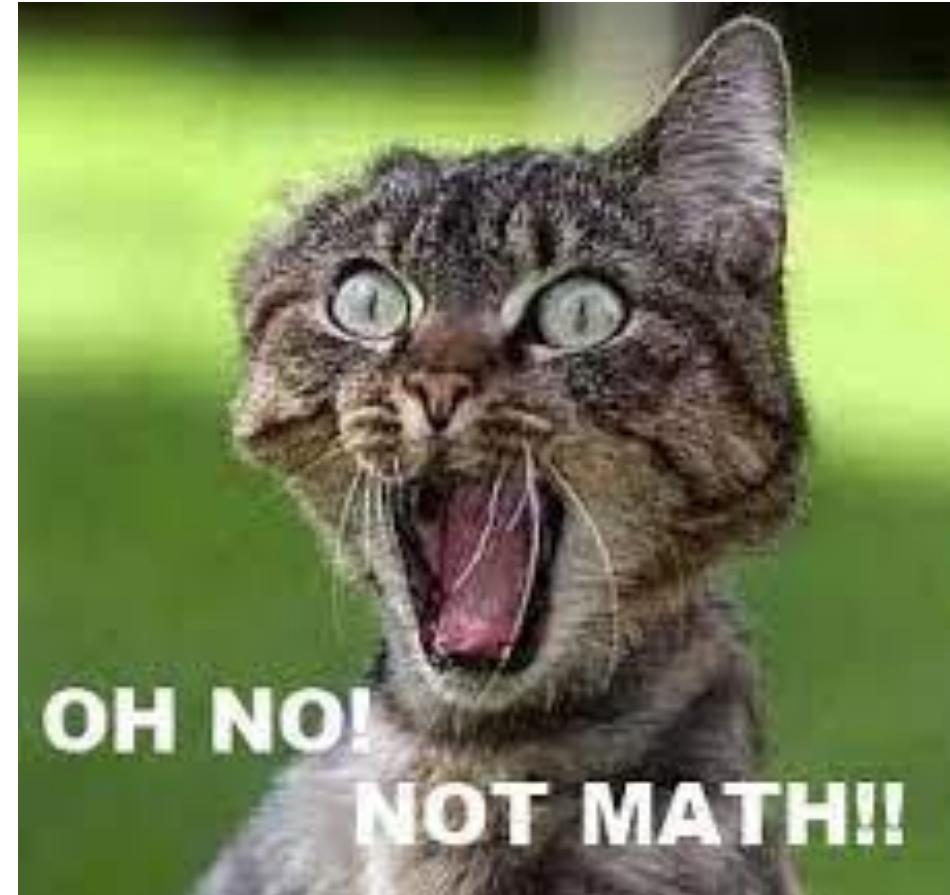
# Remainder of today' – Population Ecology I -



# Population ecology involves some math

We will be doing some basic arithmetic.

No calculus – phew!



# Definition of a population

A population is a group of individuals of the same species that live in the same area at the same time.



<https://bc.ctvnews.ca/why-do-crows-attack-expert-weighs-in-on-avian-dilemma-1.3047059>

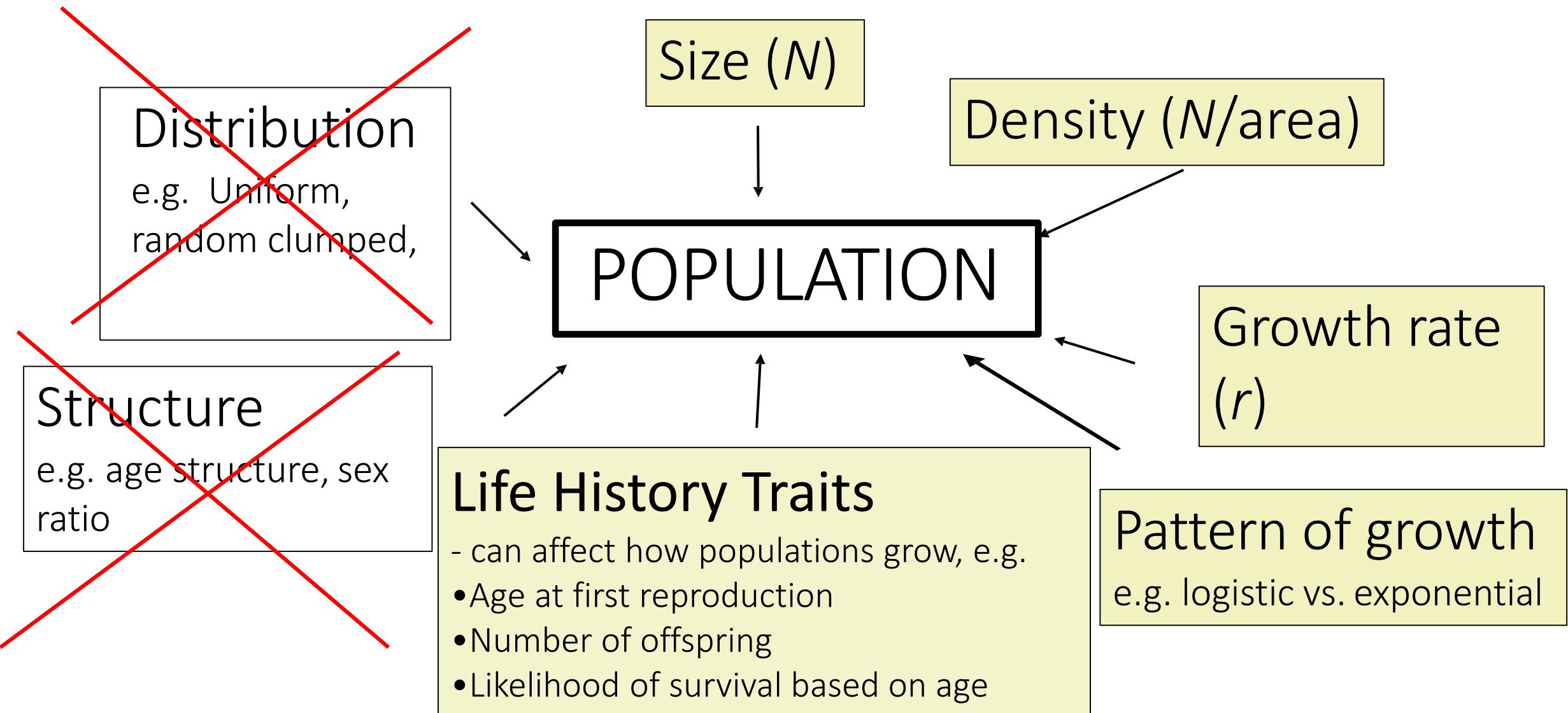
Note: the defined area can be small or large, e.g. population of crows at UBC or the population of crows in the Greater Vancouver area.

# Population Ecology

- Population ecologists primarily ask questions about how population size changes with time and location.
  - Is the population increasing or decreasing and why?
  - What factors affect population size?



# Topics we will cover over the next 2 classes

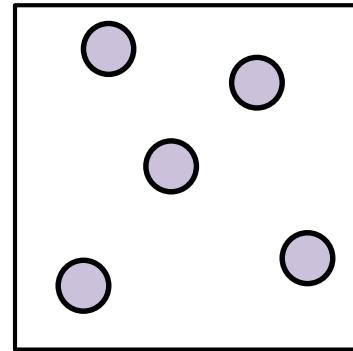


# Population size and population density (abundance)

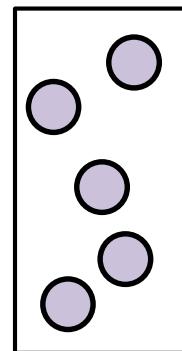
Population **size**: total number of individuals in a population

Population **density**: number of individuals per unit area (or volume)

**Population A**



**Population B**



iClicker Question - Does the population density differ between population A and population B?

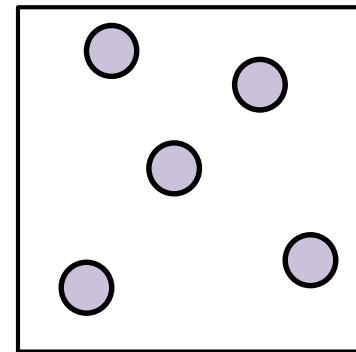
- A. Yes – population A has a greater density
- B. Yes – population B has a greater density
- C. No – population densities are the same ( $n=5$ )
- D. Not sure

# Population size and population density (abundance)

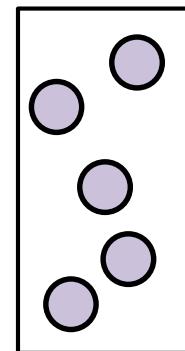
Population **size**: total number of individuals in a population

Population **density**: number of individuals per unit area (or volume)

**Population A**



**Population B**



iClicker Question - Does the population density differ between population A and population B?

- A. Yes – population A has a greater density
- B. Yes – population B has a greater density
- C. No – population densities are the same ( $n=5$ )
- D. Not sure
  - Do not differ in population size ( $N=5$ )
  - Differ in population density
    - Population A = 5 individuals/unit area
    - Population B = 5 individuals/0.5 unit area

iClicker Question coming up.... Northern spotted owl  
*(Strix occidentalis caurina)*

Biologists estimate that there is only ~1 breeding pairs left in BC.  
That forest is slated for logging ☹.



# Main reason for population decline – habitat loss

- Habitat (old growth forest) is being cut down



<http://www.utahpopulation.org/overpopulation-overconsumption-in-pictures/british-columbia-clear-cut-forest/>

# iClicker Question

IF the population size of spotted owls decreased by 80% and the available habitat decreased by 60%, what happened to the density of the owl population?

- A. Density increased
- B. Density decreased
- C. Density remained the same.



[https://commons.wikimedia.org/wiki/File:Female\\_Spotted\\_Owl\\_\(14412489519\).jpg](https://commons.wikimedia.org/wiki/File:Female_Spotted_Owl_(14412489519).jpg)

# Answer

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[https://commons.wikimedia.org/wiki/File:Female\\_Spotted\\_Owl\\_\(14412489519\).jpg](https://commons.wikimedia.org/wiki/File:Female_Spotted_Owl_(14412489519).jpg)

# iClicker Question

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# Answer

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# Poll Question

In Pacific Spirit Park, the density of banana slugs was once estimated to be 500 slugs per  $10,000\text{m}^2$ . However, recent urban development has reduced the available slug habitat in the park. The density of banana slugs is now estimated to be 250 slugs per  $6,000\text{m}^2$ .

What happened to the density of the banana slug population?

- A. Density Increased
- B. Density Decreased
- C. No change in density
- D. Not sure



Source: Wikipedia

# Poll Question

In Pacific Spirit Park, the density of banana slugs was once estimated to be 500 slugs per  $10,000\text{m}^2$ . However, recent urban development has reduced the available slug habitat in the park. The density of banana slugs is now estimated to be 250 slugs per  $6,000\text{m}^2$ .

What happened to the density of the banana slug population?

- A. Density Increased
- B. **Density Decreased**
- C. No change in density
- D. Not sure

Pre-urban development

$0.05 \text{ slugs/m}^2$

Post-urban development

$0.04 \text{ slugs/m}^2$

Or population decreased by  
50%, habitat by 40%



Source: Wikipedia

# Next Tuesday

## Population Ecology – Part II

- Estimating population size using the Lincoln-Peterson Index
- Assumptions of the Lincoln-Peterson Index
- Estimating population size at future times
- Per capita growth rate
- Patterns of Growth
- Life History Traits (if time)