



THE INVADED ARCTIC!

WHAT WILL YOU FIND IN THIS DOCUMENT?



The BASICS

- ✓ EVOLUTIONARY FACT: ONLY ROOM FOR ONE IN EACH NICHE. WHAT IS THE CONCERN?
- ✓ WHAT IS THE DIFFERENCE BETWEEN BEING EXOTIC AND BEING INVASIVE? HOW DO SPECIES BECOME INVASIVE?
- ✓ WHO ARE THE INVASIVE SPECIES? WHAT MAKES THEM "SUCCESSFUL"?
- ✓ RESEARCH METHODS
- ✓ WHAT IS SPECIAL WITH ARCTIC INVASIONS? CONSEQUENCES OF ARCTIC INVASIONS

FUN FACTS

- ✓ THE PARTY FACTOR
- ✓ THE FIRST EVER INVASIVE
- ✓ AND THE CHAMPION IS: THE EUROPEANS!
- ✓ IT WAS THE SCIENTISTS WHO DID IT
- ✓ ROBOTS TO THE RESCUE!



DEBATE!

- ✓ WANTED DEAD OR ALIVE
BY ALL MEANS?



IN-DEPTH

- ✓ INVASIONS FROM THE BELOW TO THE ABOVE



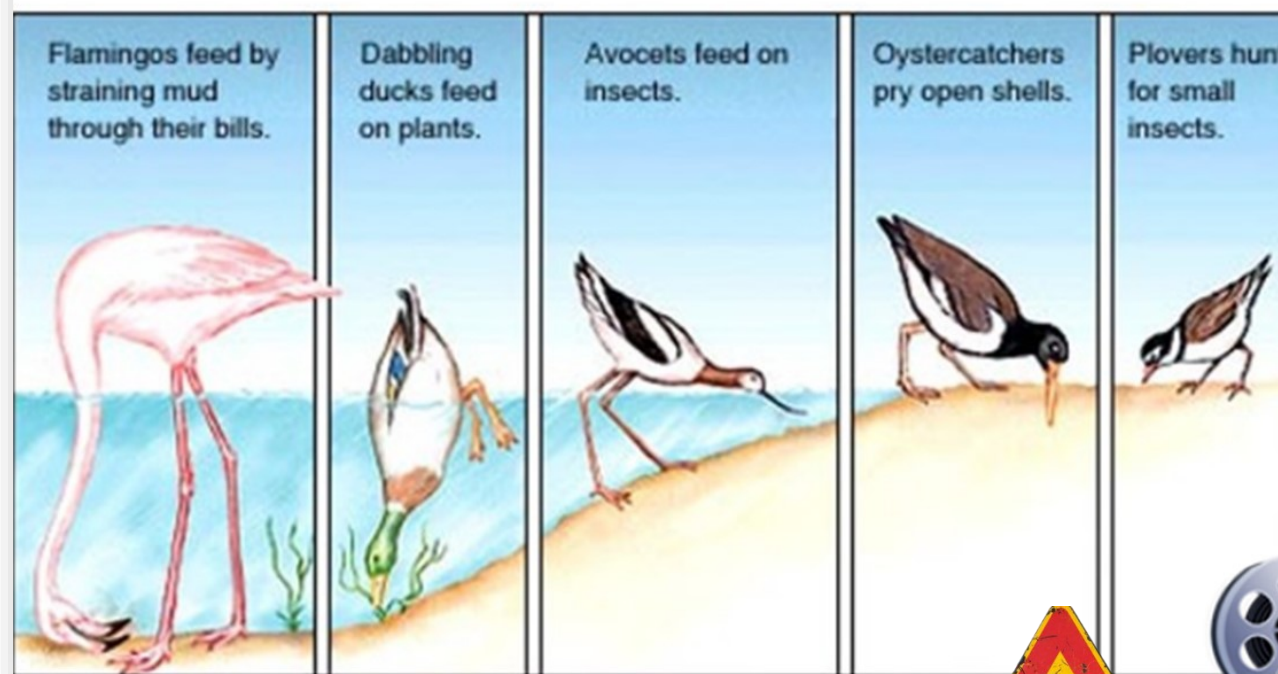


THE INVADED ARCTIC!

✓ ONLY ROOM FOR ONE IN EACH NICHE

Ecological niche = all creatures need certain elements to live, such as food, air, light, temperature, conspecifics to mate with, shelter from weather, stones to crack open their food, wind to blow away insects, and so on. In ecology, a niche is any combination of these factors that makes a livable space for one species. Any one species has its own niche, but at the same time is part of different niches for many other species.

An organism's **habitat** is its “address” while its **niche** is its “occupation”



Niche competition = happens if more than one species tries to occupy the same niche. It typically occurs when exotic species invade new areas. Because only one species can occupy a niche over time***, the most competitive species will "win" the niche, while the other one will have to adapt to occupying another niche (or become extinct!).

*** Why? If more than one species *could* occupy a niche, evolution by **natural selection** would over time make them into the same species.

WHY THE CONCERN? Invasive species disrupt the established niche system of the ecosystem. This is a serious threat to sustainability of ecosystem functioning, which includes human well-being as everything we do depends on functional ecosystems in one way or another.



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✓ WHAT IS THE DIFFERENCE BETWEEN BEING EXOTIC AND BEING INVASIVE?

Native (or indigenous) species = a native species is one that came to an area without the help of human transport. For a species to be truly native, its ancestors must also have been native to the area they lived in. If a species is introduced by humans in for example Poland and then moves on its own feet into Germany where it has never been native, the species will not become native in Germany.

Can become

Do not become*

Exotic (or introduced) species = an exotic species is a species that arrives in a new area where it did not live before, by the means of human transport. The transport can be deliberately or accidentally done by humans. For a species to be truly exotic, it has not been native in this new area at any time in history.

Rarely become

Can become

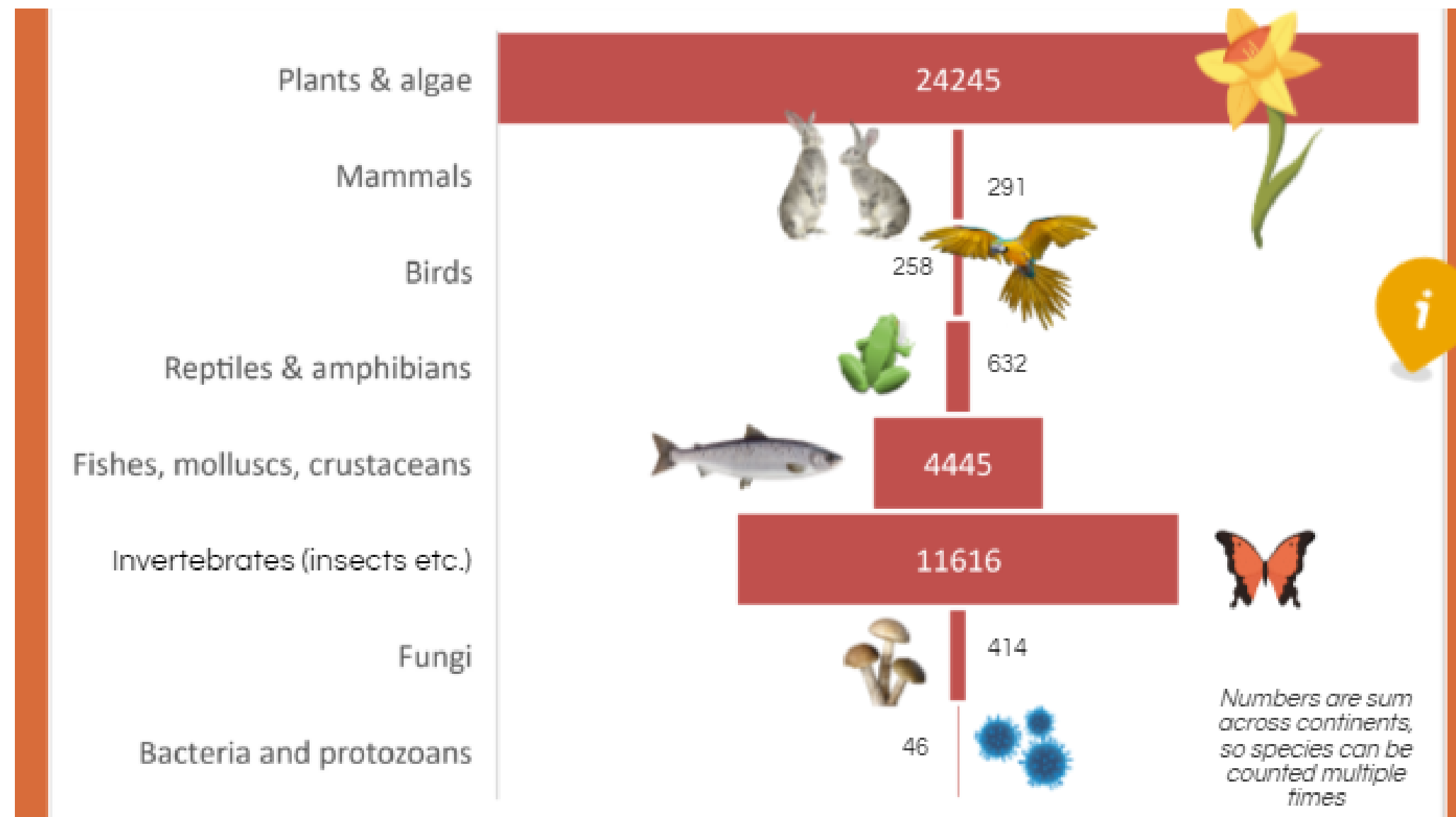
Invasive species = if an exotic species becomes very numerous in the new area, we start to talk about the species being invasive. Even native species can become invasive, but this is very rare in nature. If it occurs almost always humans have made extreme changes to the environment.

* A species brought into an area by humans, and therefore exotic, can later come to the area on its own feet (or wings etc.), by natural dispersal. Then it becomes also native.



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✓ WHO ARE THE INVASIVE SPECIES? WHAT MAKES THEM “SUCCESSFUL”?



Remember that some species groups are easier to detect than others! Plants are much easier to detect than, for example, bacteria or zooplankton in the deep oceans.

You can use this for in-class discussion: what does this mean for your interpretation of the graph?

Graph shows number of SPECIES identified as invasive. Reference for the numbers:
 Seebens, H., Blackburn, T., Dyer, E. et al. No saturation in the accumulation of alien species worldwide. *Nat Commun* 8, 14435 (2017). <https://doi.org/10.1038/ncomms14435>



THE INVADED ARCTIC!

WHAT MAKES
INVASIVE SPECIES
"SUCCESSFUL"?

Invasive species will of course not take over the planet. This is not science fiction.

BUT INVASIVE SPECIES CONQUER MORE AND MORE AREAS!



Because humans travel a lot more, and ship more goods across the world



And because of climate change

What does it mean to be a fast breeder?
the species is quickly reaching puberty, getting several offspring in each pregnancy and is not spending much effort on child care



The ecosystem is largely disturbed by human activity



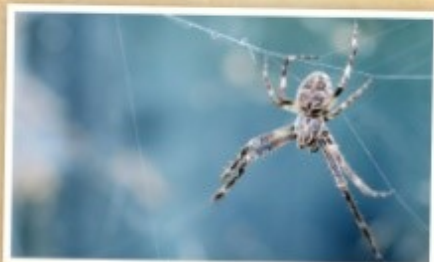
The species is small and easily transported by humans



The species is tolerant to varying living conditions



The species has no natural enemies in the new area



The species is able to eat lots of different food



The species is a fast breeder





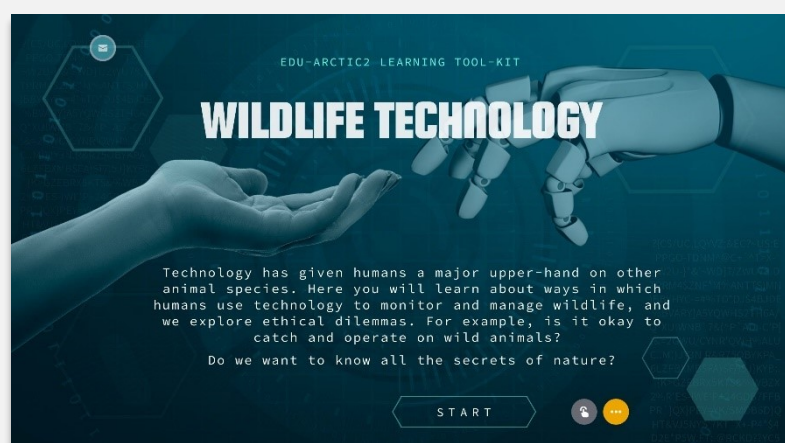
INTERACT EDUCATIONAL TOOL-KIT - BACKGROUND MATERIAL FOR TEACHER

THE INVADDED ARCTIC!

✓ RESEARCH METHODS

Ever advancing technology

Central to combatting the already released invasive species are the same methods that are used to monitor native species in the wild. If some of your students are especially interested in wildlife technology, let them explore our interactive tool-kit:



<https://view.genial.ly/60d7577f00ac720dd823edf1>

Genetic methods to the rescue!

Methods that use DNA can be utilized to streamline the process of finding new invasive species because we can use environment DNA (eDNA) from soil or river water to find them. With genetic methods we can find a lot of species at the same time, including invasive species. This is the reason why genetic methods are now more frequently used in invasive species discovery.

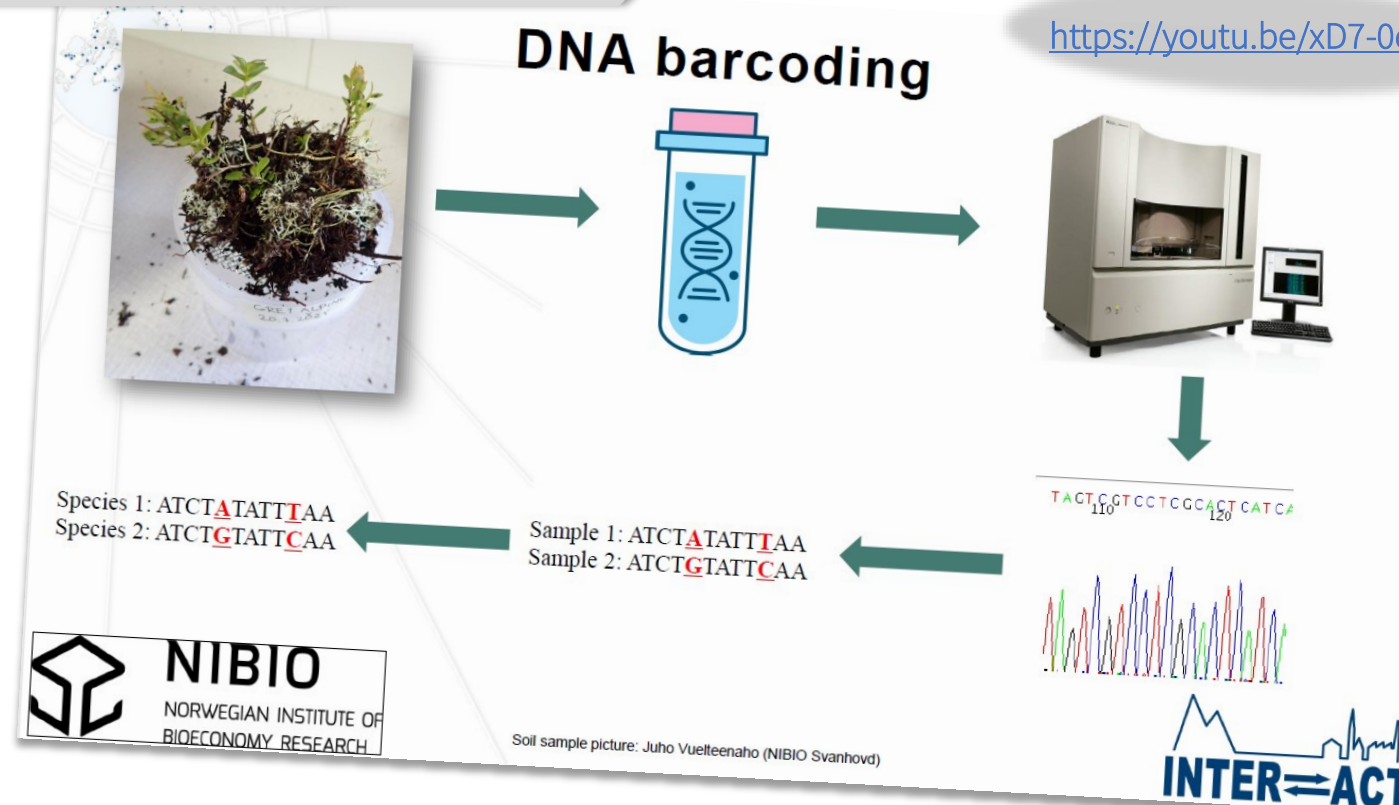
It is hard to find invasive species!

We are often unaware that new invasive species spread to other regions because we would have to search for them over large geographical areas and continuously over time and a lot of species, for example, in soil are quite small.

Watch our
webinar to
learn more

YouTube

<https://youtu.be/xD7-0clKIB0>





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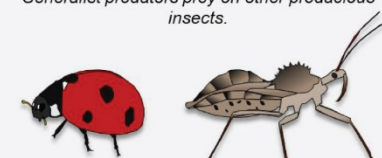
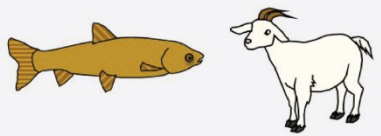
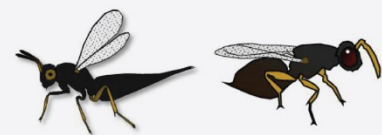
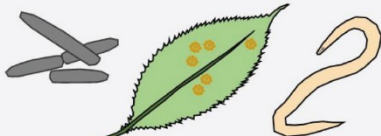

✓ WHAT IS SPECIAL WITH ARCTIC INVASIONS?

The Arctic ecosystems are particularly vulnerable if invaded by exotic species. This is because of the harsh polar environment. All the native species live at extremes. Even a small change in their environment can shift the odds from living to dying, such as having to compete for food with a new species or being chased by a new predator.

The Arctic is also particularly affected by the warming climate¹, and increased tourism². Nowhere on Earth are temperatures rising faster than in the polar areas. The landscape of ice turns into ocean. So, there is dramatic alterations going on in the ecosystems.

✓ (MIS-) MANAGEMENT OF INVASIVE SPECIES

An old management tool is to introduce other species to control for the invasive species (biocontrol). However, this has one big disadvantage: sometimes these introduced species become invasive themselves!

	Nonnative, invasive plants	Nonnative, invasive insects
Types of Antagonists	Phytophagous Arthropods <i>Phytophagous arthropods include insects and other arthropods that feed on plant material (i.e., leaves, roots, stem, seeds, flowers). They are sometimes effective biological control agents for plants.</i> 	Predators <i>Predatory insects, such as lady beetles, kill and feed on other insects, such as herbivorous aphids. Generalist predators prey on other predacious insects.</i> 
	Herbivorous Vertebrates <i>Herbivorous vertebrates are animals that consume plants, often whole, rather than individual parts of the plants. They can be effective biological control agents for plants in small patches.</i> 	Parasitoids and Hyperparasitoids <i>Parasites, or parasitoids, are organisms that live and feed in or on a host. Hyperparasitoids parasitize and sometimes kill other parasitoids.</i> 
	Pathogens <i>Bacteria, fungi, nematodes, and viruses are microorganisms that can infect and help reduce populations of nonnative plants.</i> 	Pathogens <i>Bacteria, fungi, nematodes, protozoa, and viruses are microorganisms that can provide control for populations of nonnative insects.</i> 

Schulz et al. 2019 Successful Invasions and Failed Biocontrol...BioScience, Volume 69: 711–724, <https://doi.org/10.1093/biosci/biz075>

¹ If you want to teach about climate change in the north, check out our interactive tool-kit: <https://view.genial.ly/60d5553a00ac720dd823d904>

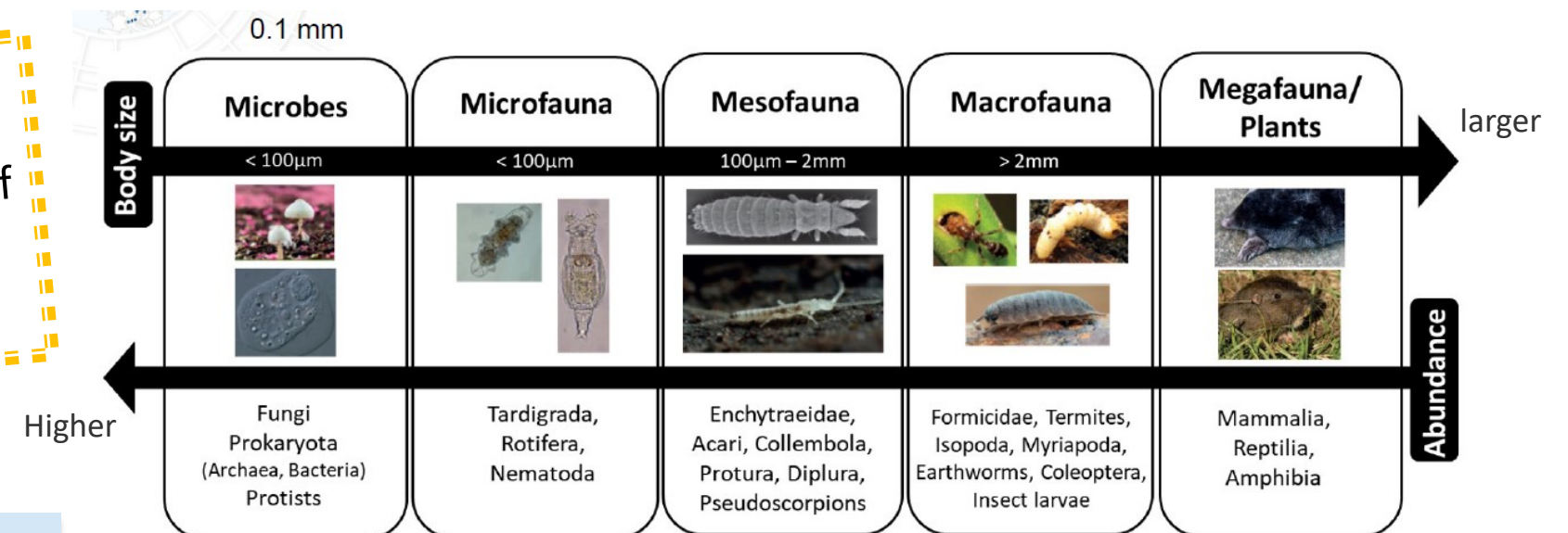
² For example, [PAME and the British Antarctic Survey \(BAS\)](#) show a 35% increase in the number of passenger vessels in the Arctic from 2013 to 2019.



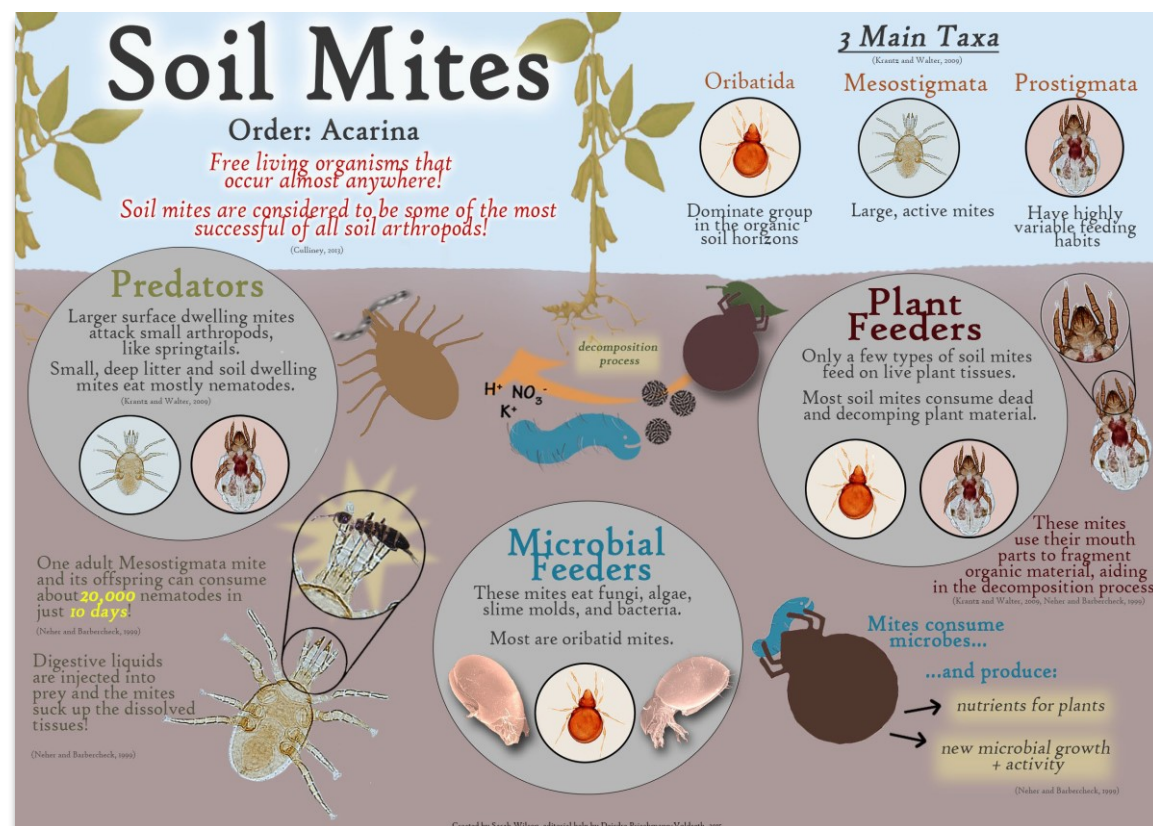
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The link between life below ground and species that invade the above ground (or below water for that matter) might not be obvious to you. Here's an explanation of that link!

First of all, soil biota makes up 25% of global biodiversity! It likely also makes up the most of invasive species. We just don't know because the soil biota is not seen unless you dig for it.



Source of figure: Tibbett et al. (2020). Identifying potential threats to soil biodiversity. *Peer Journal* 8, e9271.



Secondly, soil biota links all ecological processes from death to birth which means that any invasive species below ground can make huge differences on anything from roots to treetops to birds in the sky.

We therefore largely dedicated the students' worksheet that accompanies this tool-kit to the magnificent world beneath our feet! There you will find links to lots more resources to go in-depth of this topic with your students.



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Europeans have contributed the most to invasive species across the globe. Europe is the continent with the most recorded invasive species (6 253 species as of 2017), and Europeans colonized Australia and North America, bringing with them the culture of releasing exotic species. Australia and North America today stand 2nd and 3rd place on the podium.

Invasive species have concerned people for centuries:

The first records of invasive species dates back as far as year 1500!



Behind many invasive species there is indeed a “party” factor! People have deliberately imported species for all sorts of reasons, including those just for luxury. The species can smell good, look good, be a delicacy to eat or simply be cool to have (like exotic pets or collectors’ items of insects).

It was **SCIENTISTS** that released the invasive red king crab in the Barents Sea! Yup, sometimes scientists do wrong too...

Jørgensen, L. L., Manushin, I., Sundet, J. H., & Birkely, S. R. (2005). The intentional introduction of the marine red king crab *Paralithodes camtschaticus* into the Southern Barents Sea. ICES Cooperative Research Report, 277, 18.

An **invasive** escape room!



In case you cannot click on the image, here is the web address:
<https://view.genial.ly/5ff5b373c217200ce77c9fb1>

Reference for the numbers in these fun facts:
Seebens, H., Blackburn, T., Dyer, E. et al. No saturation in the accumulation of alien species worldwide. *Nat Commun* 8, 14435 (2017).
<https://doi.org/10.1038/ncomms14435>

THE INVADED ARCTIC!

Here are some ideas for in-class discussions. Invasive species can be debated in ethical sense, practical sense, and philosophical sense.

**ARE ALL MEANS TO ERADICATE AN INVASIVE SPECIES ACCEPTABLE?
WHICH ARE OR WHICH ARE NOT?
WHY?**



Photo showing Lykke, a dead young dog who was accidentally caught and killed in a trap set out to kill invasive rodents in Finnmark, northern Norway 2021.



Collecting invasive pink salmon using nets to catch the fish. Then various methods can be used to kill the fish. Which methods would be acceptable to your students?



Collecting lupins by hand

Only some examples to start the debate!