

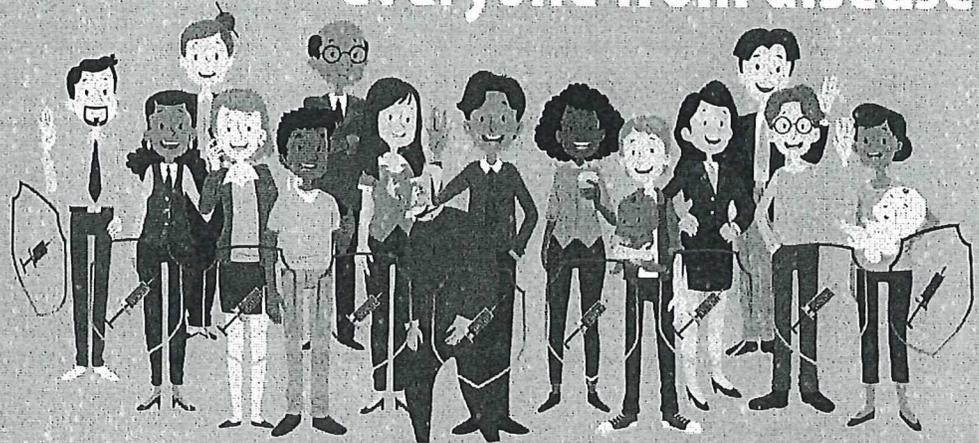
NAME: \_\_\_\_\_

CLASS: \_\_\_\_\_

SCIENCE

PRACTICE PACKET

# How can a community protect everyone from disease?



## Authors:

Corey M. Paak, Amanda L. Rolly,  
 Andrew S. Azman, Caroline O. Buckee

## Associate Editors:

Seda Dawson & Madeleine Corcoran

## Abstract

Did you know that you protect yourself and those around you by getting vaccinated? Diseases can't spread easily when enough people in a population get vaccinated. This effect is called *herd immunity*. *Cholera* is a big threat in countries that don't have safe water and toilets for everyone. These countries sometimes vaccinate large numbers of people (*mass vaccination*). This creates herd immunity and prevents disease outbreaks. But, it is hard to know how long herd immunity will last.

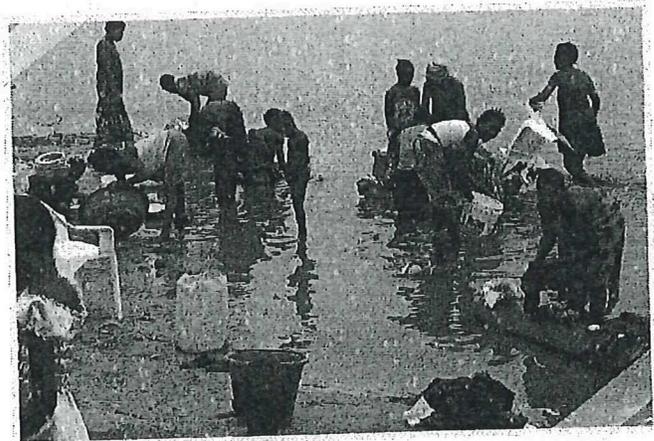
In one camp in South Sudan, people who had fled their homes during a war received mass vaccination. However, there was a cholera outbreak the following year. We

developed a *mathematical* model to find out what affects how long herd immunity lasts. We found that it lasts for a shorter time when (a) a lot of people move into and out of an area, and (b) the vaccine gets less effective for each person over time. Our results suggest that herd immunity lasts longer if authorities do two things: 1. vaccinate everyone; 2. always give vaccines to new arrivals to the camp and to those who were vaccinated a long time ago

## Introduction

Some people can be nervous about going to the doctor, but getting your vaccinations is important. Vaccines make you *immune* to many diseases. They are also important for the health of our community. How? *Infectious diseases* cannot spread easily when enough people are vaccinated against them. In this situation, vaccinated people protect unvaccinated (or *susceptible*) people. This form of group protection is called herd immunity. Thanks to mass vaccination and herd immunity some diseases have disappeared (e.g. smallpox) or are now very rare (e.g. polio).

However, other diseases like cholera continue to threaten millions of people worldwide. Cholera causes severe diarrhea and dehydration and can be fatal. The disease spreads where people don't have access to safe water and toilets. In such environments, the feces (poop) of an *infected* person can get into the drinking water (Fig. 1).



**Figure 1:**

The Congo River in Africa is the main source of water for drinking, cooking, and washing for many people. Conditions like this are perfect for the transmission of cholera and many other diseases.

Source: Oxfam East Africa on Wikimedia Commons

Oral (taken via the mouth) cholera vaccines can be used to help prevent cholera outbreaks in at-risk populations. One such population is *displaced people* in the Protection of Civilians Camp in Bentiu, South Sudan. Camp residents were vaccinated in 2014 and 2015. However, in 2016 a cholera outbreak occurred. How could this happen? We know that an individual person can expect the cholera vaccine to protect them for at least 3 years. What we don't know is how long a population can have herd immunity when lots of people are coming and going, and the vaccines wear off. We did research to find out more.

**Explainer:** Different vaccinations work in different ways and to different degrees. Some vaccines are given as shots, while others are swallowed as a liquid (oral vaccines). Oral vaccination is ideal for cholera because the bacteria that cause it live in the gut. Some vaccinations protect you from a disease for life (e.g., the measles vaccine), while others reduce the chances of getting sick from the disease for a period of time (e.g., the flu vaccine). Vaccines are given at different ages or repeatedly throughout a lifetime. The cholera vaccine can't be given until a baby is over one year old.

## Methods

We created a mathematical model (a computer simulation) to analyze the key factors affecting herd immunity. We considered:

**Declining vaccine efficacy:** A measure of how well the vaccine protects the person who receives it. We created stages where the vaccine wears out over time (Fig. 2).

**Vaccination Strategies:** We analyzed two strategies -

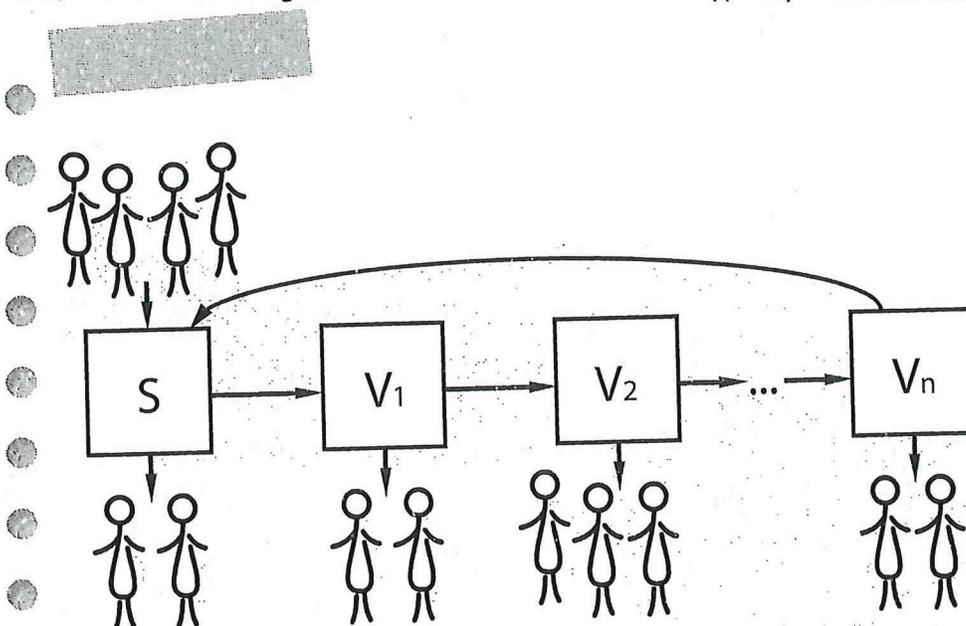
- Mass vaccination – most of the population is vaccinated on one particular day.
- Routine vaccination – a smaller part of the population is vaccinated whenever necessary. For example, the vaccine is given to those who are new to the camp, or those who have recently become old enough.

**Migration rates:** This is how much the people are on the move. Migration rates capture the average number of years people live in a population. The camp residents in Bentiu, South Sudan moved every 4.8 years on average.

The **rate of births and deaths** in the camp.

We also included these concepts in our model:

- We considered all those who entered the camp as being susceptible to cholera.
- We chose at random whether those leaving the camp were vaccinated or susceptible.
- We estimated that one sick person in the camp would typically infect two susceptible people.

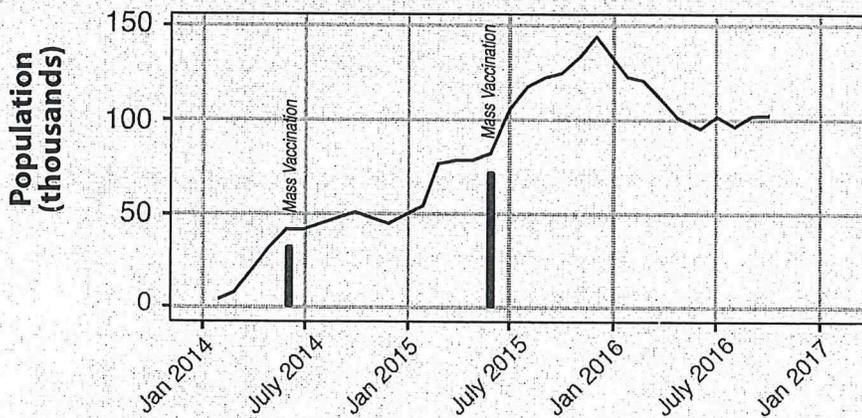


**Figure 2:**

Our simulation of declining vaccine efficacy. After vaccination, susceptible individuals (S) moved into the first stage of vaccine protection (V1). Every 30 days, they moved into the next stage where the vaccine efficacy is slightly lower. At the last stage (Vn) the vaccine doesn't provide protection any more, so these individuals become susceptible again (S). Throughout this process, new people enter into the camp (arrow pointing into S), and some of those who are vaccinated move out of the camp (arrows pointing out of the S and V stages).

## Results

- ① Mass vaccination can quickly protect an at-risk population through herd immunity. This effect weakens over time depending mostly on how long the vaccine effect lasts and how quickly members of a population move in and out.
- ② Two large mass vaccination campaigns in 2014 and 2015 protected the camp population as it grew from about 4,000 people to over 100,000 people (Fig. 3a).
- ③ By the end of 2016, however, less than half of the camp population had been recently vaccinated because of the high numbers of people moving in. This was not enough to maintain herd immunity. Our model suggests that the camp population was highly susceptible to cholera when it first broke out in October 2016 (Fig. 3b).
- ④ Herd immunity can be maintained for a longer period of time by combining two strategies. First, perform mass vaccination and then routinely vaccinate anyone who needs it. Using both strategies together was better than either strategy alone.

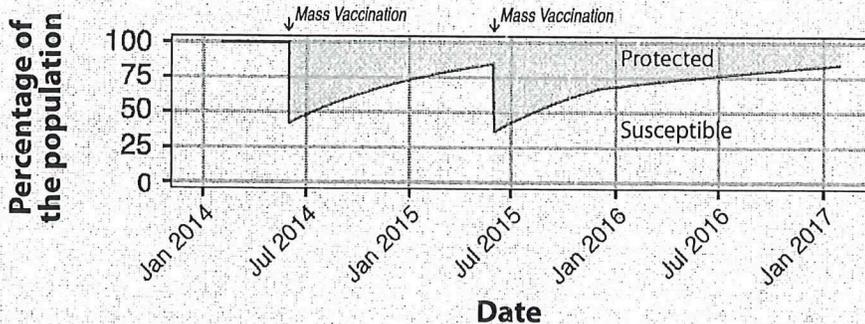


**Figure 3a:**

This line graph shows the population size of the camp in Bentiu between January 2014 to January 2017. Vertical lines mark the time when mass vaccinations took place.

### Question:

Analyze these two graphs. How does the protected population change after mass vaccination? What about as the camp population increased? What percentage of the camp was protected close to the end of 2016 when the outbreak happened?



**Figure 3b:**

This graph shows the part of the population that is protected from cholera (in the shaded region) versus the part that is susceptible to the disease.

## Discussion

What happened in the camp? Was it a vaccine failure? Our study shows that the protection provided by herd immunity can disappear if vaccines wear out over time and the population changes a lot. These factors explain why the camp was susceptible to an outbreak despite two recent mass vaccinations.

Our mathematical model reveals periods of time during which a population maintains herd immunity. Based on these results, we suggest a "mass and maintain" vaccination

strategy for the camp setting: The whole population gets vaccinated once. Routine vaccinations are then given to new arrivals and those who have become old enough to be vaccinated. This vaccination strategy could help protect vulnerable populations with high rates of migration.

Our model can help in the fight against infectious diseases. It explains the outbreaks. In turn, this can help us develop effective vaccination strategies and determine how to best supply vaccines.

## Conclusion

Vaccination is one of the greatest breakthroughs in modern medicine. It has saved countless lives and completely wiped out some diseases. Some other diseases are now so rare that it's easy to underestimate the importance of vaccinations.

But, if many people decide not to have their vaccinations, herd immunity will be broken and outbreaks can occur. How mindful are you about your health and others?

- Get all your recommended vaccinations. By getting vaccinated you are protecting the most vulnerable in your community as well as yourself.
- Educate others about the importance of immunization. We all depend on each other for herd immunity.
- Do your homework before traveling to other countries and get the required vaccination(s).

## Glossary of Key Terms

**Cholera** – a treatable yet potentially fatal disease caused by some strains of the bacteria *Vibrio cholerae*. The cholera bacteria infects the gut and causes severe diarrhea which in turn causes dehydration.

**Contamination** – polluting something. Whether it is food, air, water, when something is contaminated it is polluted, impure, or poisoned. Water that is contaminated by human waste is not safe to use or drink.

**Displaced people/person** – someone forced to leave their home region or country because of war, persecution or disaster; a refugee.

**Herd immunity** – As more and more people in a population are vaccinated, the chance that a disease can spread decreases and everyone gets extra protection thanks to those who have been vaccinated. When enough people are vaccinated, the chance for that disease to spread gets so low that we say this population has herd immunity.

**Immunity or being immune** – the ability of your body's defense system (immune system) to fight off disease. We gain immunity either by being exposed to the disease or by vaccination.

**Infected** – when a person is affected by a disease-causing germ.

**Infectious disease** – a disease that can pass from person to person.

**Mathematical (aka scientific) model** – a computer program which attempts to simulate a particular system and to predict how the system would behave in the real world.

**Outbreak** – the sudden increase in the occurrences of a disease in a particular time and place.

**Susceptible / Susceptibility** – being at risk of becoming sick with a disease. People with weak immune systems are susceptible to many diseases, as are people who have not been vaccinated against a disease.

**Vaccinations (also called immunizations)** – are typically made from very small amounts of weak or dead germs that can cause diseases — for example, viruses, bacteria, or toxins. Your immune system produces antibodies to fight against them. This prepares your body to fight the disease faster and more effectively when you come into contact with the actual germ or virus, so you don't get sick.

**Vaccine efficacy** – a measure of how well the vaccine protects the person who gets it. For example, in our study, we ran some simulations for the perfect vaccine which protected forever, and also some which waned over time.

# Check your understanding



**1** Herd immunity is crucial to protect those who cannot get vaccinated, such as infants, pregnant women, and the elderly. What is herd immunity? How does it work?

-----  
-----

**2** Cholera is very rare in developed (wealthy) countries but kills thousands of people in developing (poorer) countries every year. Why does cholera continue to be a threat in those areas?

-----  
-----

**3** People in the camp had been vaccinated two times in the previous two years. Why did a cholera outbreak occur in the camp?

-----  
-----

**4** Scientists suggest a "mass and maintain" vaccination strategy to prevent outbreaks. Explain this vaccination strategy.

-----  
-----

**5** Why are vaccinations against infectious diseases still important, even in countries where infectious diseases are less common? What happens if some people decide not to get vaccinated?

-----  
-----

## REFERENCES

Peak CM, Reilly AL, Azman AS, Buckee CO (2018) Prolonging herd immunity to cholera via vaccination: Accounting for human mobility and waning vaccine effects. PLoS Negl Trop Dis 12(2):e0006257.  
<https://doi.org/10.1371/journal.pntd.0006257>

Vaccine Knowledge Project  
<http://vk.ovg.ox.ac.uk/herd-immunity>

5 GIFs that show why herd immunity is so important  
<https://www.buzzfeed.com/carolynkylstra/vaccines-and-herd-immunity>

Cholera - World Health Organization  
<https://www.who.int/news-room/fact-sheets/detail/cholera>

# Can science and business work together to save the ocean?



## Authors:

Henrik Österblom, Jean-Baptiste Jouffray, Carl Folke, and Johari Rockström

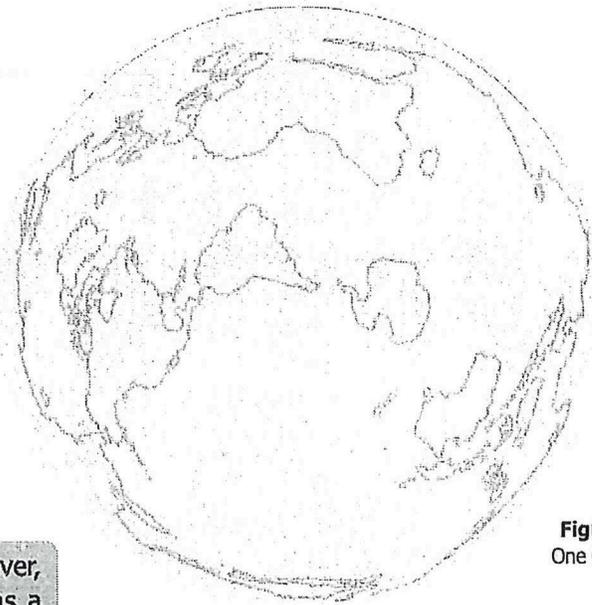
## Associate Editors:

Madeleine Corcoran and Rachel Watson

## Abstract

Do you like to eat fish? Our ocean provides the growing human population with valuable food. Seafood - like fish and shellfish - is an important business for some companies. A healthy ocean is essential if we are to keep eating seafood - and if companies are to keep making money from marine ecosystems. However, our ocean is in danger. *Overfishing* and unsustainable fish farming (known as *aquaculture*) pose threats to the long-term health of the ocean and the creatures in it. We wanted to explore how scientists and big companies could work together to benefit ocean life and the seafood trade. We shared our scientific knowledge with powerful companies and they then acted to protect the ocean. This approach allowed us to challenge the threats facing our ocean on an international level. We think that our science-business partnership could be a useful example of how to protect the environment where businesses operate.

Previously at SJK, we have referred to several oceans. However, there has been a recent push towards recognizing the ocean as a singular entity: the one ocean that unites us all (Figure 1). UNESCO's Intergovernmental Oceanographic Commission has embraced it with their "One Planet, One Ocean" tagline.



**Figure 1:**  
One Ocean.

## Introduction

Do you enjoy eating shellfish like shrimp or mussels? Have you tried sushi? Food from the sea is an essential and popular part of our diets. But do you know how it gets onto your plate?

Seafood is either caught in the ocean or farmed (aquaculture) in parts of the ocean (Figure 2). As with all of our interactions

with the natural world, if we don't do things in a responsible way, the environment will suffer - and that means seafood stocks could run out. Worse, our whole planet could be under threat if we don't look after our ocean. The ocean, and the creatures that live in it, support all of life.

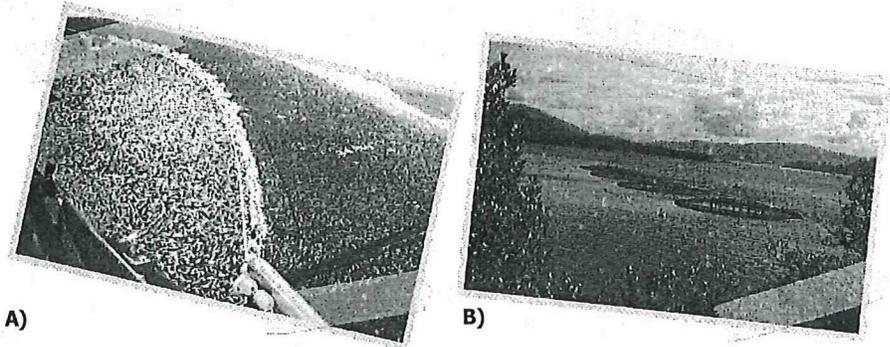
*Please see  
Figure 2 on Page 2*

**Figure 2:**

- A) Salmon fish farm in Norway
- B) 400 tons of Jack Mackerel being caught in Chile.

Source:

- A) Brataffe on Wikimedia Commons
- B) C. Ortiz Rojas on Wikimedia Commons



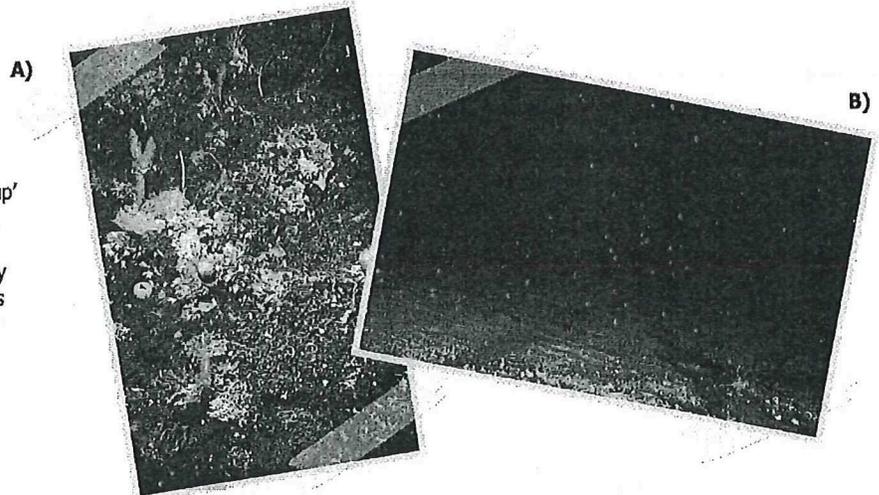
Transnational corporations (big companies often working across many countries) have made it their business to catch and farm the seafood we eat. But if the seafood runs out, so will their profits. In the short term, they may want to farm and catch as much seafood as possible, but in the long term this will use up stocks (Figure 3).

As scientists, we know a lot about how to interact with the ocean in a sustainable way. It would be helpful if we could engage with these powerful corporations to help them behave in a way that is good for our ocean but also good for their business. This is what we worked on figuring out: how can science and business work together for the good of all? And what might be the drawbacks of such a partnership?

**Figure 3:**

Some fishing practices are especially damaging to the environment. Bottom trawling, for example, where a boat drags a large weighted net along the ocean floor to 'scoop up' its catch, can damage the aquatic life there, leaving a blank landscape behind. See the deep sea ocean floor **A)** before trawling and **B)** afterwards. Trawlers can also unintentionally catch (and kill) a lot of other creatures - sea turtles, dolphins and other fish for example.

Source: CSIRO Marine Research on Wikimedia Commons.



## Methods

### Step 1: Who rules the waves?:

Over a period of two years we collected and analyzed data about seafood companies. We wanted to find which of them are "keystone actors," meaning the companies that catch or farm the biggest and most important fish stocks. Any actions they take have a huge effect on the whole ocean *ecosystem* and the whole ocean business system.

We identified 13 companies that account for 11-16% of all wild catches. A handful of them controlled up to 40% of the largest and most valuable fish stocks. They also dominate in aquaculture, farming the most valuable stocks, such as salmon and shrimp.

### Step 2: Working together:

We needed to get the attention of the CEOs (Chief Executive Officer, basically the boss) of these companies. We knew face-to-face meetings would be best, so we approached the CEOs and talked to them about what we could offer as scientists. We made it clear that we wanted to support their business plans in the long term.

These meetings led to a conference that brought together scientists and CEOs. The business people discussed the challenges facing their industry and we scientists were able to provide advice about how they could meet these environmental challenges and do best for themselves and the ocean.

## Results

Our approach was effective and led to the companies creating and signing the 'Seafood Business for Ocean Stewardship' (SeaBOS) agreement. Their commitment to looking after the ocean was even better than we had hoped! In fact, the companies arranged and attended a second and third conference to review and solidify their commitment to SeaBOS.

SeaBOS aims to tackle some of these problems:

- Stopping illegal fishing
- Ending *forced labour* of seafood workers
- Reducing the use of *antibiotics* in seafood production (antibiotics have a damaging effect on marine life)
- Addressing how the industry can limit and adapt to climate change.

## Discussion

The big companies' commitment to facing the ocean challenges is promising, but there is still much to be done. We don't yet know if they will be able to succeed. Other 'green clubs' set up by businesses have sometimes failed to deliver long-lasting or deep change.

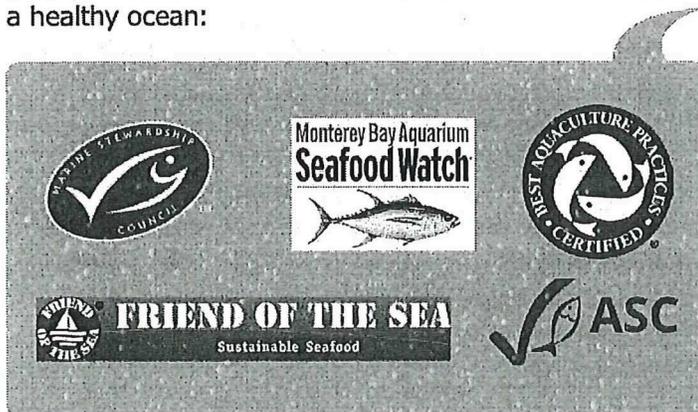
Our case study shows that when a group of scientific experts approach big business in an open-minded and supportive manner, we can work with companies to reduce their impact on the planet. It was essential that we did not just lecture the companies, we also listened to their concerns and worked with them to bring our two agendas together - healthy business and healthy ecosystems.

Scientists are used to working with governments to create environmental policy, and governments have a massive role to play. But working with business has its advantages, as they can adapt quickly and work across large areas of the world. However, scientists and business do not often talk to each other, and there are risks of misinterpretation and that the expectations are not met. If businesses connect to science and become better at cooperating, they are better able to tackle environmental issues and create positive visions for the future. After all, our ocean is interconnected - our response to the problems must be interconnected as well!

## Conclusion

We think that our science-business partnership is a good example of a largely untapped potential: the power of business and science to prevent damage to the environment together. But there are also things you can do to support a healthy ocean:

- Only buy wild-caught seafood that is eco-certified as sustainable, for instance by the Marine Stewardship Council, or Friend of the Sea, or Monterey Bay Aquarium Seafood Watch.
- Only buy farmed fish that is certified 'farmed responsibly,' for example by the Aquaculture Stewardship Council or Best Aquaculture Practices.
- Keep up to date on which species of fish are sustainable by checking the Marine Conservation Society's 'Good Fish Guide.'
- Reduce your use of plastics, especially throw-away items like plastic cutlery and straws that often end up in the ocean.



## Glossary of Key Terms

**Antibiotics** – a medicine that targets bacteria. In fish farms, antibiotics are routinely added to the water to stop fish getting sick in unsanitary conditions. This is dangerous because it can lead to the development of bacteria that are resistant to the antibiotics and are hard to kill.

**Aquaculture** – the farming of fish and other aquatic life, e.g. shrimp. Farms may be set up in parts of the ocean or in other bodies of water.

**Ecosystem** – a community of interacting organisms (plants, animals, microbes) and their environment. Each part of the ecosystem is connected to the other parts. An example of a marine ecosystem are coral reefs - large structures of coral growths which support a huge variety of species.

**Forced labour** – a situation where a worker is made to work either through violence, by being forced into debt to the employer, or being intimidated with threats of deportation or exposure to the authorities (in the case of undocumented migrants).

**Overfishing** – a situation when more fish are removed from the population than can reproduce in time to keep the stocks stable. The population therefore declines and even collapses. The Atlantic bluefin tuna is an example of a species under threat from overfishing.

**Sustainable / Sustainability** – in general, if something is sustainable, it is able to be maintained at a certain level or rate. When it comes to the environment, sustainability means avoiding using up natural resources in order to maintain healthy life on earth. Sustainable fish, for example, is fish that hasn't been fished or farmed in a way that damages the ocean, and isn't from a species that is under threat.

**Stewardship** – the role of supervising or taking care of something. For example, seafood companies can take on the role of caring for the parts of the ocean in which they operate.

## Check your understanding

- 1 How does the seafood business potentially harm the ocean?
- 2 What are some advantages of science and business working together to address how industry impacts the ocean?
- 3 What do you think some of the difficulties of working with big business are, from a scientist's perspective?
- 4 What are some of the issues that the seafood corporations hoped to address in their ocean stewardship agreement (SeaBOS)?
- 5 Can you think of any other contexts in which science and business could work together to limit industrial impacts on the environment?
- 6 What can you do to help protect our ocean?

## REFERENCES

Österblom, H.; Jouffray, J.B.; Folke, C. and Rockström, J. *Emergence of a global science-business initiative for ocean stewardship*, Proceedings of the National Academy of Sciences of the United States of America, August 22, 2017, vol. 114, no. 34, pp. 9038–9043.

Keystone Dialogues: The SeaBOS Initiative

<http://keystonedialogues.earth>

UNESCO Intergovernmental Oceanographic Commission: One Planet, One Ocean

<http://unesdoc.unesco.org/images/0024/002476/247687e.pdf>

BBC Blue Planet: Can eating seafood ever be sustainable?

<https://ourblueplanet.bbcearth.com/blog/?article=can-eating-seafood-be-sustainable>

# How does rock climbing impact birds?



**Authors:**

Nora Covy, Lauryn Benedict, William H. Keeley

**Associate Editors:**

Seda Dawson and Madeleine Corcoran

## Abstract

Do you enjoy exploring the great outdoors? Hiking and camping are great ways to connect with nature. Lately, another outdoor activity, rock climbing, has become very popular. As a result, the number of people using cliffs has increased rapidly. Cliff *ecosystems* are home to many living things, including birds. Since climbing is a fairly new activity, we don't know its impact on cliff ecosystems. Here, we studied how climbers affect birds that nest on cliffs in *The Flatirons* area in Colorado. We selected cliffs that face

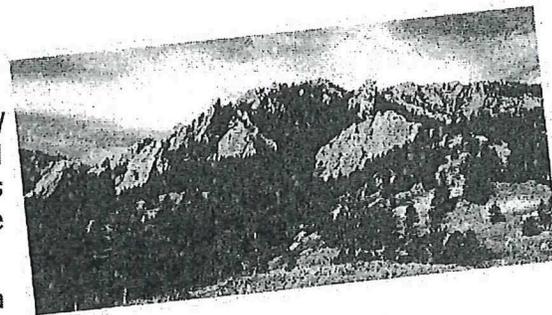
different directions (north, east, west, and south). Half of the cliffs are visited by lots of climbers and half by very few or no climbers. We compared the number and *species* of birds on these different cliffs. We found that east-facing cliffs have the greatest number and *diversity* of birds. Our results show that north-facing cliffs are the best option for new climbing routes when it comes to protecting wildlife. Our solution may help the area to handle the growing number of climbers while protecting cliff ecosystems.

## Introduction

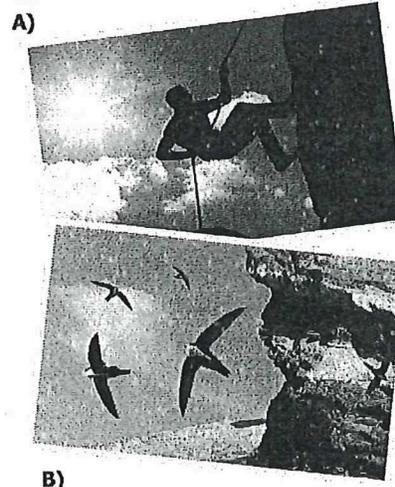
Are you afraid of heights? Rock climbing is a *recreational* activity in which athletes climb up, down, and across natural rock formations. Despite the heights, climbers enjoy this peaceful experience in nature. Lately, more and more people are visiting climbing destinations around the world.

In North America, The Front Range in Colorado is a rock climbing hotspot. Part of this range, known as 'The Flatirons' is popular with climbers thanks to its unusual rock formations (Fig. 1). To accommodate climbers' desires, the City of Boulder Open Space and Mountain Parks (OSMP) department is looking for ways to open new climbing routes while still protecting the environment.

But how does climbing impact the cliff environment? You might think that climbing cannot harm a rock. However, cliffs provide *habitat* and protection for lots of different living things. Some living things found in cliff habitats are special. They have unique features that help them to survive there, and they are difficult to find in other places. Certain types of birds are special in this way. They make nests and *forage* for food on the cliffs in The Flatirons area (Fig. 2).



**Figure 1:**  
Part of  
The Flatirons in  
Boulder, Colorado



**Figure 2:**  
Rock climbing has many physical and mental benefits: it builds muscle, improves endurance, boosts brain function, reduces stress, and helps us build a relationship with nature. But wildlife, such as these white-throated swifts, are the real owners of the cliffs. The Flatirons are nesting and foraging areas for many perching bird species.

Source:  
A) Freepik  
B) Richard Crossley on  
Wikimedia Commons

Previous studies have shown that climbers disturb *nesting* birds of prey such as *raptors*. However, we don't yet know how climbing impacts all the different birds living together on a cliff (known as a *community*). This is because climbing

is a newly popular activity and because cliff environments are difficult for scientists to reach. We wanted to close this knowledge gap. We wanted to look at how climbing affects whole bird communities on cliffs, not just raptor species.

## Methods

Using data collected by the City of Boulder, we selected 16 areas in the Flatirons with lots of climbing and 16 areas with not much climbing (Fig. 3). We considered that "not much climbing" = less than 100 climbers per year; and "lots of climbing" = more than 500 climbers per year.

We looked at climbing sites facing different directions - north, south, east, and west (called '*cliff aspect*').

**Bird Observations:** Sitting 20 meters (or about the length of two school buses) away from the cliff's base, we quietly watched and listened for birds on a 30-meter wide section of the cliff, plus the air space above the cliff. We wrote down how many birds we saw, what species and where the birds were. We also recorded whether there were climbers at the site (and how many). Each observation was 1-hour long and we conducted 5-6 observations at each of our 32 study sites. This took a lot of patience!

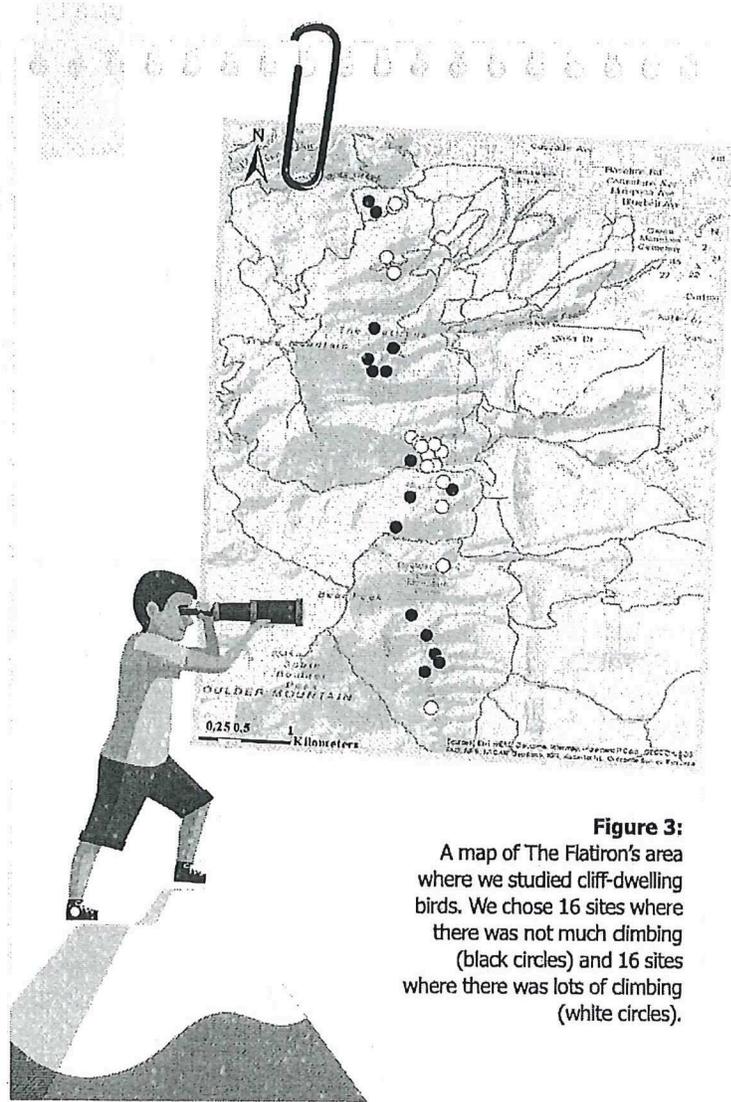
**Mathematical Analyses:** Using a mathematical model we calculated which things had the biggest influence on *avian* diversity (the number of different bird species on a cliff). We also calculated which things affected *avian abundance* (the number of birds on a cliff). We considered things like whether climbers were present, cliff height, cliff aspect, and how close the cliff is to parking lots.

## Results

### How does cliff aspect affect bird communities?

- Avian diversity was highest on east-facing cliffs, and lowest on west-facing cliffs (Fig. 4). This means that there were more different kinds of birds on east-facing cliffs.
- Avian abundance was also highest on east-facing cliffs. So not only were there more types of birds on these cliffs, there were more birds of each type.

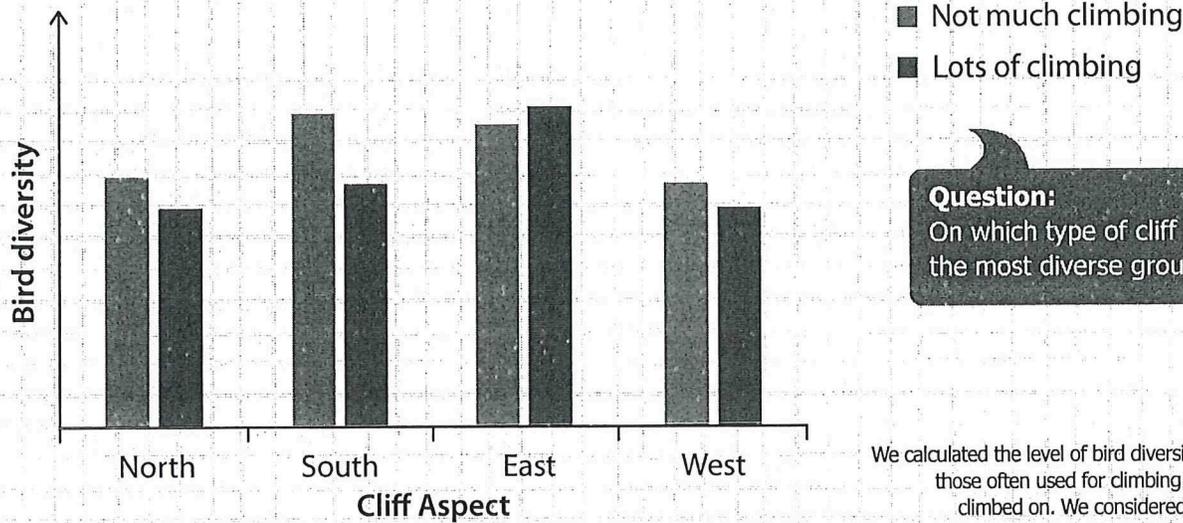
Please see  
Figure 4 Page 3



**Figure 3:**  
A map of The Flatirons area where we studied cliff-dwelling birds. We chose 16 sites where there was not much climbing (black circles) and 16 sites where there was lots of climbing (white circles).

### Do climbers affect bird communities?

- Avian diversity was higher when there were no climbers on a cliff. This might mean that climbers scare away some species of birds.
- Avian diversity and abundance on east-facing cliffs were highest on the cliffs that were used for a lot of climbing (although, not while the climbers were present). This suggests birds and climbers like the same kind of east-facing cliffs!



**Question:**

On which type of cliff can you find the most diverse group of birds?

**Figure 4:**

We calculated the level of bird diversity on different cliffs: those often used for climbing and those not often climbed on. We considered this comparison for cliffs facing in each direction (cliff aspect).

## Discussion

Our results show that rock climbing doesn't impact the number of birds on a cliff, but it does reduce the diversity of birds on each cliff. However, which way the cliff is facing also has a major influence on diversity and how many birds use the cliff. East-facing cliffs had the highest avian species diversity while west-facing cliffs had the lowest. On some cliffs that were used a lot for climbing bird abundance was very high. This shows that some bird species put up with human activity quite well.

Based on our results, we suggest opening new routes on north-facing cliffs for climbers. This is because there are

fewer bird species on north-facing cliffs and so human activity will not disturb as many of them.

Our study helps us understand cliff communities and how living things respond to rock climbing in the Flatirons. But we need to keep in mind that each climbing area has its own unique conditions. We need to study the combined impacts of natural and human factors for every location.

Those tasked with managing and looking after our cliffs need to protect nature while accommodating visitors. Science-based information can help them make the best decisions to do this.

## Conclusion

Exploring the great outdoors is a wonderful way to connect with nature. However, as visitor numbers increase, they can harm the environment. To minimize your own impact, you can follow these simple rules:

### Climbing

- Climb in designated areas
- Stay off the cliffs when there is a 'raptor closure' - closing the cliffs allows raptor species to raise their chicks without being disturbed

- Check for nesting birds before climbing in an area and report these to wildlife managers

### Any activity in nature

- Leave what you find and leave no trace behind.
- Respect wildlife. Observe animals from a distance, don't follow or feed them.
- Dispose of your waste responsibly.

## Glossary of Key Terms

**Abundance** – the number of individual animals (like birds) in a given area.

**Avian** – bird or something about birds.

**Cliff aspect** – the compass direction that a cliff's slope faces - either north, south, east or west.

**Community** – In the biological world, a community is a group of two or more different species that live together in the same area.

**Diversity** – the measure of how balanced the numbers of different species are to one another within a given area. For example, a cliff face would have high bird diversity if it had equal numbers of lots of different bird species. It would be less diverse if there were lots more (e.g. 90%) of one bird species than the others.

**Ecosystem** – A community of plants, animals, and other living things that interact with each other, and the environment around them.

**The Flatirons** – rock formations in the western United States, near Boulder, Colorado.

**Forage** – A wide search over an area to find food undertaken by animals or humans. For example, some birds forage for berries to eat.

**Habitat** – the natural home or environment of an animal, plant, or other living thing.

**Mathematical model** – values and concepts are put into a series of calculations in order to represent a process or situation in the real world. In our study, certain factors affecting birds on the cliffs were given values so we could assess potential impacts on birds in different locations.

**Nesting** – the activity that birds undertake when they build nests in which to lay their eggs and hatch and raise their young.

**Raptors** – these are birds of prey that hunt other animals for their food. They have strong, sharp talons (claws) for grabbing their prey and very good eyesight. Birds in the raptor family include eagles, hawks, and owls.

**Recreational** – activity for enjoyment when one is not working.

**Species** – a group of living things that can breed with each other. One species of bird is the Canyon Wren, while another species is the Violet-green Swallow. Both types nest in cliff environments (and we observed them in The Flatirons), but they cannot breed with each other, only within their own group.

## Check your understanding

- 1 Scientists wanted to know the impacts of rock climbing on The Flatirons' bird communities. Why?
- 2 What are the main factors that affect (a) avian diversity and (b) avian abundance?
- 3 Based on the results, what would be the best way to accommodate more climbers in The Flatirons? Why?
- 4 To protect wildlife and wildlife habitat, what are the rules we must follow while exploring the great outdoors?

## REFERENCES

Covy N, Benedict L, Keeley WH (2019) "Rock climbing activity and physical habitat attributes impact avian community diversity in cliff environments", PLoS ONE 14(1): e0209557.

<https://doi.org/10.1371/journal.pone.0209557>

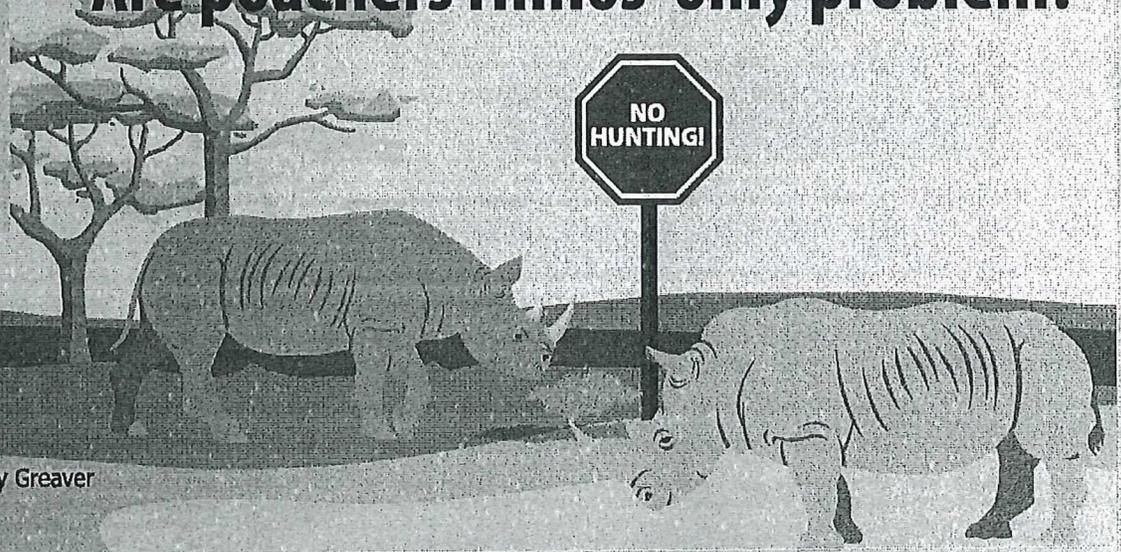
Leave No Trace Center for Outdoor Ethics, Seven Principles

<https://lnt.org/learn/7-principles>

The Beginner's Guide to Rock Climbing

<https://www.outsideonline.com/2062326/beginners-guide-rock-climbing>

# Are poachers rhinos' only problem?



## Authors:

Sam Ferreira, Nikki le Roex, Cathy Greaver

## Associate Editors:

Gogi Kalka and Tanya Dimitrova

## Abstract

Rhinos don't have it easy these days. Usually, they roam large areas in Africa and Eurasia. Now they occur almost only in protected areas due to *poaching* (forbidden hunting) and destruction of their *habitats*. We had a close look at Kruger National Park in South Africa where many rhinos live. We found they face two problems: illegal hunters and droughts.

Two rhino species live in Kruger Park - white and black rhino. One curious finding is that each of them suffers from the drought in a different way - due to the different food they eat. So keeping the poachers away is not enough to conserve the rhinos. We also have to understand the effect of the climate.

## Introduction

Two rhino species live in Africa: the white rhino and the smaller black rhino. Poachers hit both rhino *populations* so hard that they came to the brink of extinction.

Rhinos are killed for their horns because many people (mistakenly) think that they have healing powers and are ready to pay a lot of money for them. (Yet, a pill made of rhino horn has the same effect as a pill made of ground toenails.)

As a result, there are about 20,000 white rhinos and only about 5000 black rhinos left in Africa, despite all the people working to protect them. (Related article in *Science Journal for Kids*: **Can we save rhinos from extinction?**)

Most white rhinos live in Kruger National Park in South Africa (Figure 2). This is a protected area the size of the country Slovenia. You might have heard about this wildlife paradise - it is a popular safari destination. You can also see zebras, elephants, giraffes, and lions there.

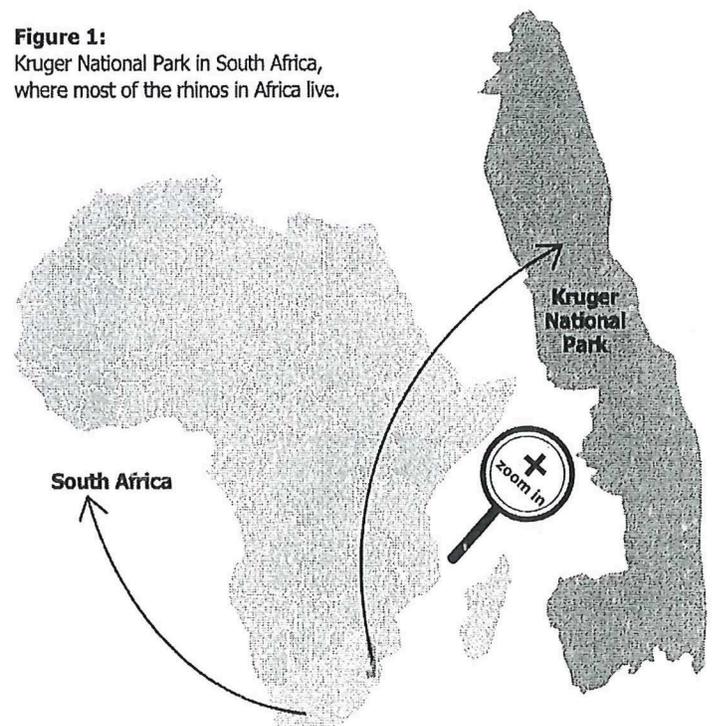
Yet, even in Kruger Park, neither black nor white rhinos live in total safety. In the five years from 2011 to 2015, poachers killed almost 3000 rhinos there. So the number of white and black rhinos has not increased much in recent years.

We wanted to know if illegal hunters are the only problem rhinos are facing. Do other factors also influence their survival? For instance, Kruger Park experienced a drought in

2015/16. Could that have also kept rhino numbers low? We looked at some climate data to find out.

### Figure 1:

Kruger National Park in South Africa, where most of the rhinos in Africa live.



## Methods

Our study focused on the southern part of Kruger where most rhinos live (Fig. 2). Here, the rainy season usually starts in October and ends in April. But in 2015/16 there was a drought. The region received about half of the average rainfall for normal years (293 mm of rain per year vs. 575 mm on average).

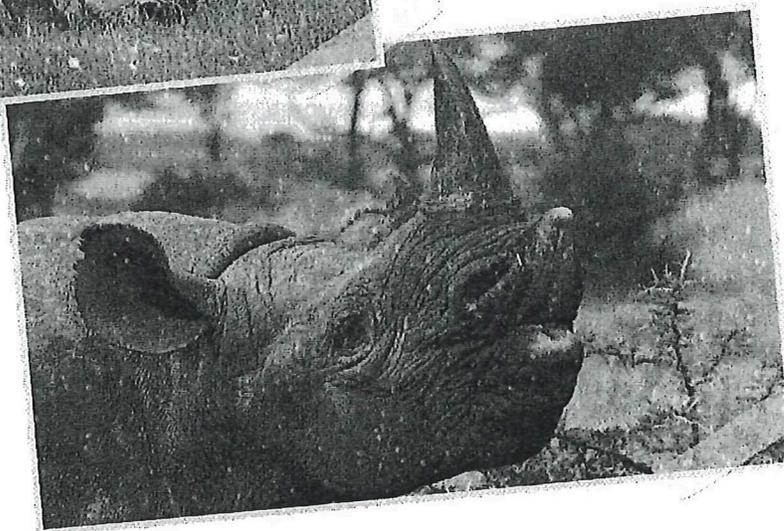
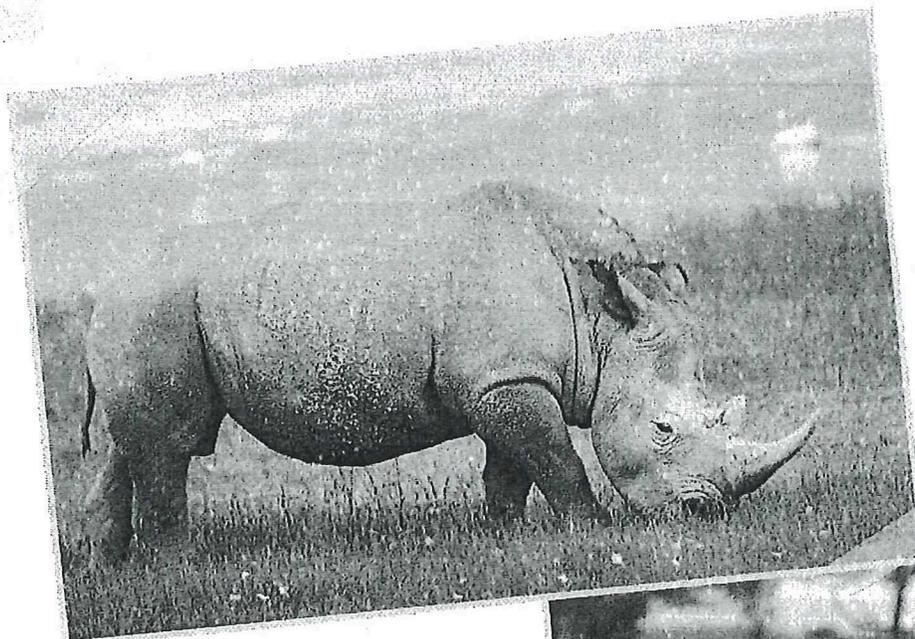
We compared the number of births and deaths (both natural and hunted) for white and black rhinos. We wanted data from before, during and after the drought to see if it affected them.

To make sure the data were representative, we divided our

study area into 3x3 km squares. Then we randomly picked 489 of them where we conducted counts from helicopters. We counted all living and dead rhinos and noted the sex and age of the animals (judging from the animals' size).

We also determined how a rhino died: if its horn was still present we concluded it was a natural death. If the horn was cut off, the rhino was poached.

Finally, we calculated each rhino's birth year by counting backwards from the age we estimated it to be when we saw it.



**Figure 2:** African (white) and black rhinos have been hunted so much that they only live in protected areas.  
Credit: savetherhino.org

## Results

Interestingly, we found different results for the two rhino species: the population of black rhinos was growing, while the population of white rhinos was declining.

But why? Our 4-year comparison gave us some insights.

First the good news: in the last two years of our study, poachers killed fewer rhinos (both black and white) compared to before. Also, fewer black rhinos died of natural

causes. At the same time, their birth rate went up. So the black rhino population increased overall (Figure 3, right).

Things were different for the white rhinos though: more died of natural causes after the drought of 2015/16, and fewer white rhino babies were born. The death rate stayed more or less the same, so in the end, fewer babies meant fewer white rhinos (Fig. 3, left).

How many white and black rhinos were left in the park by the end of our study? Which species has a better chance of survival in the long run?

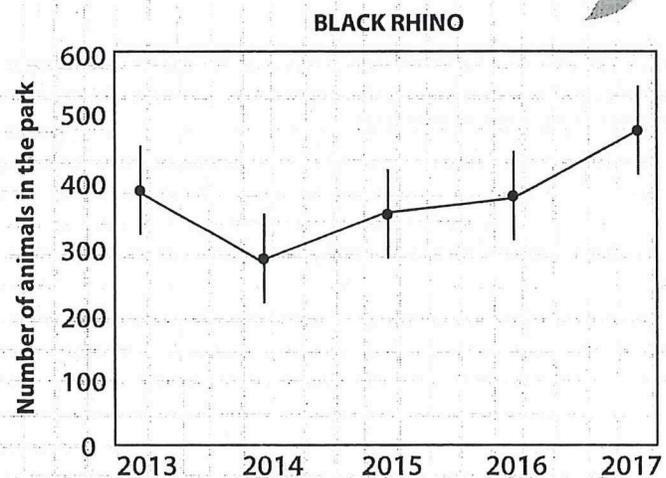
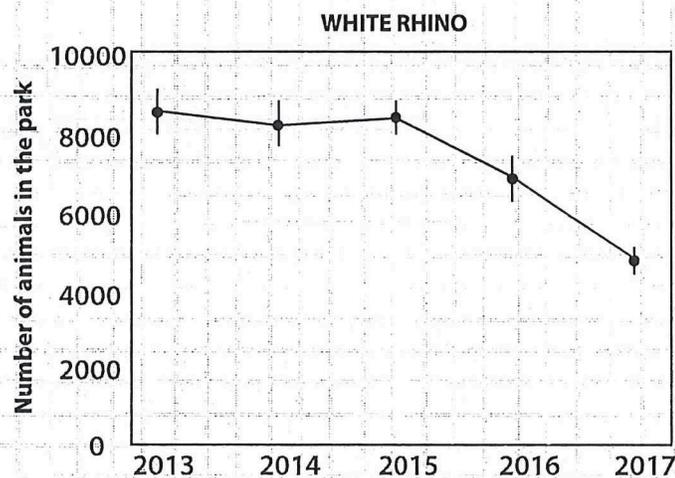


Figure 3: Population trends in white and black rhino in Kruger National Park from 2013–2017.

## Discussion

We're excited to see that over the course of our study, fewer rhinos were illegally killed by poachers. We have to keep protecting them, but some of the conservation efforts are certainly working.

But our study also shows that poaching is not the only threat white rhinos face. Climatic events like the drought in 2015/2016 in Kruger, can be really hard on the animals. The white rhinos had fewer babies and many animals died due to natural causes. We did not see the same effect on black rhinos. They did OK despite the drought. How can we explain this?

The white rhino is a *grazer*, which means they eat grass or plants that grow low to the ground. When there is less rain, less grass grows, and white rhinos have less food.

Black rhinos, on the other hand, are *browsers*. They mostly eat leaves from bushes or trees. Those plants are less affected immediately after droughts, so we think that the black rhinos were not short of food. Still, a longer-lasting drought could impact them too.

## Conclusion

Our study showed that on top of poaching, drought can make life harder for some endangered animals. People should continue to work hard to protect them. Continue to educate yourself about rhinos, their biology and habitat.

Never buy any wildlife products that are illegal and caused the animal to die in their production (like rhino horns, animal skins and teeth).

## Glossary of Key Terms

**Browser** – an animal that feeds off leaves or other parts of bushes or trees, like the black rhino in our study.

**Grazer** – an animal that eats grass and vegetation low to the ground, like the white rhino.

**Habitat** – a natural environment of an animal or plant (or other living organisms). It provides food and shelter.

**Poaching** – the illegal killing of animals.

**Population** – a group of animals from the same species that live in a certain area.

**Population trend** – describes changes in the size of a population over a period of time.

**Random sampling** – sometimes we cannot count every single animal out there so we must take a sample in which each animal has an equal chance of being counted.

**Representative sampling** – taking samples that are “typical”, so that we don’t accidentally get an estimate which is too high or too low. For example, a representative sample of rhinos should have a similar proportion of adult and baby rhinos as the full population.

## Check your understanding

- 1 Why can't you find rhinos in the wild anymore?
- 2 What did our numbers show about poaching of white and black rhinos in Kruger Park?
- 3 How were white rhinos impacted by the drought that occurred in 2015/16 in Kruger Park?
- 4 What impact did the drought have on black rhinos? How can you explain the different effect on the white rhinos?
- 5 What did our results show about overall population trends of white and black rhinos in Kruger Park?
- 6 What can you do to help protect rhinos and other wild animals?

## REFERENCES

Ferreira SM, le Roex N, Greaver C (2019) *Species-specific drought impacts on black and white rhinoceroses*. PLoS ONE. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0209678>

WWF: Rhino factsheet

<https://www.worldwildlife.org/species/rhino>

Science Journal for Kids: Can we save rhinos from extinction?

<https://www.sciencejournalforkids.org/search-articles/can-we-save-rhinos-from-extinction>