# Copyright Notice

# W3

# Monitoring biodiversity

# W3 Lesson 1

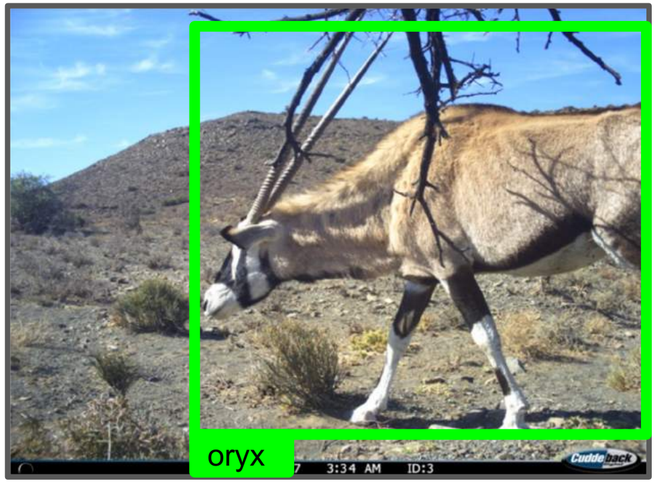
# Using AI for Biodiversity Monitoring

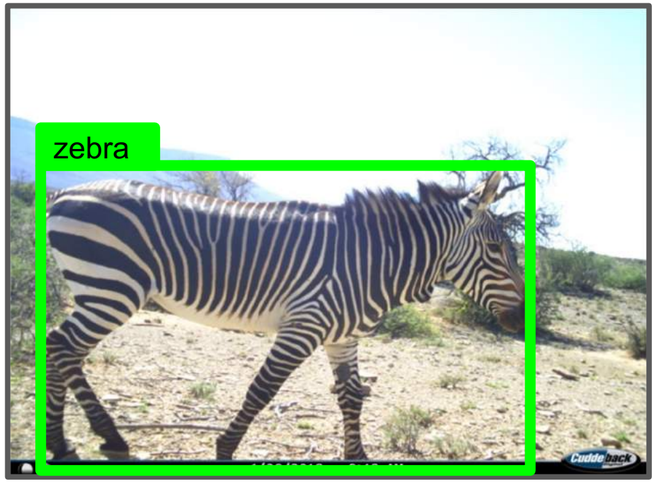
DeepLearning.AI

# AI and Climate Change

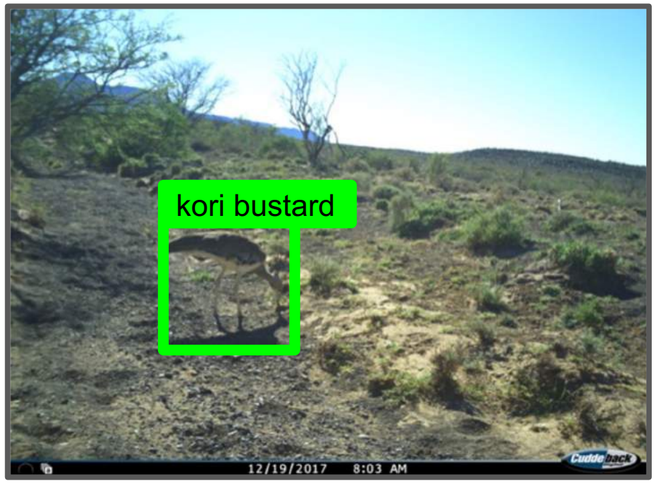
## Welcome to Week 3

# Monitoring biodiversity

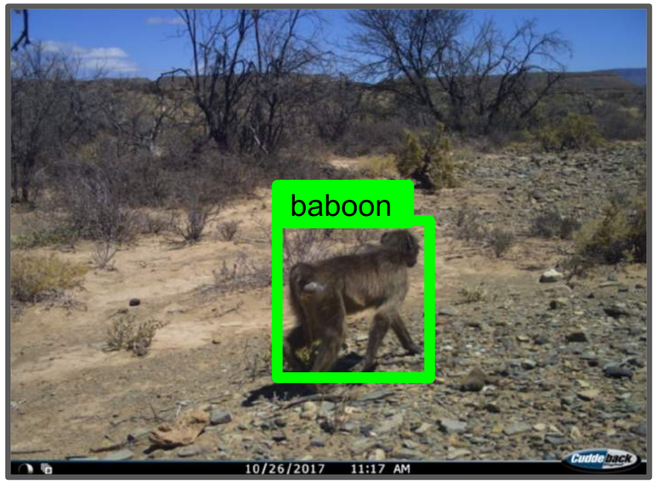








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21 1
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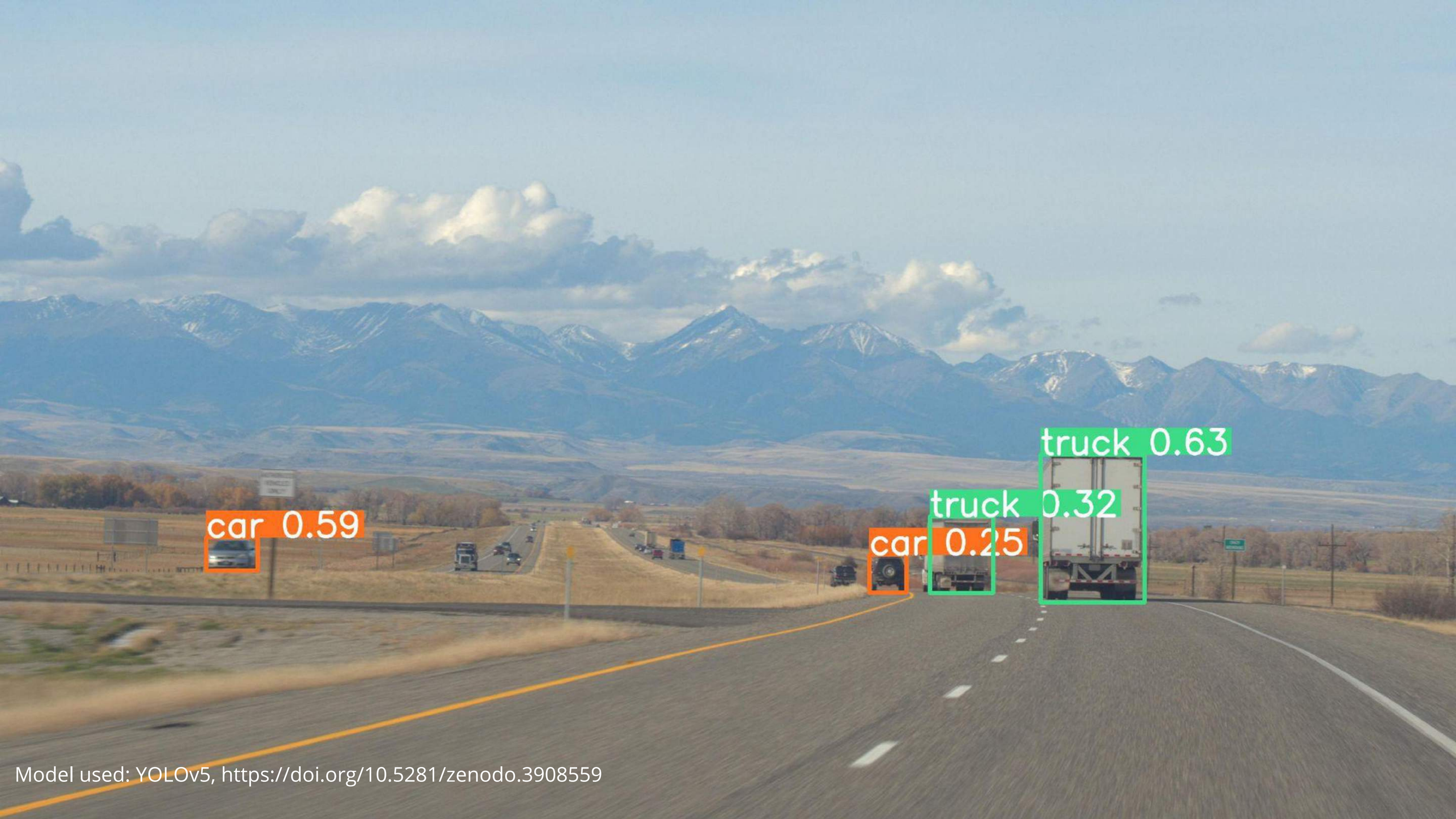
ID 3322544
ID




Model used: YOLOv5, https://doi.org/10.5281/zenodo.3908559

DeepLearning.AI

# AI and Climate Change

## Project Spotlight: Sara Beery – Why Monitor Biodiversity?

# Living Planet Report

nature

Published: 02 March 2011

## Has the Earth's sixth mass extinction already arrived?

Anthony D. Barnosky ✉, Nicholas Matzke, Susumu Tomiya, Guinevere O. U. Wogan, Brian Swartz, Tiago B. Quental, Charles Marshall, Jenny L. McGuire, Emily L. Lindsey, Kaitlin C. Maguire, Ben Mersey & Elizabeth A. Ferrer

*Nature* **471**, 51–57 (2011) | Cite this article



nature

NEWS | 06 May 2019 | Update 06 May 2019

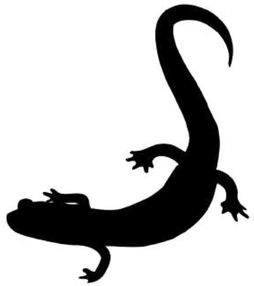
## Humans are driving one million species to extinction

**Landmark United Nations-backed report finds that agriculture is one of the biggest threats to Earth's ecosystems.**

Jeff Tollefson

# Sixth mass extinction

## Percentage of species threatened with extinction:



Amphibians

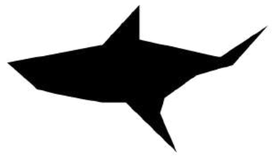
**40%**

Conifers

**34%**

Reef Corals

**33%**



Shark and Rays

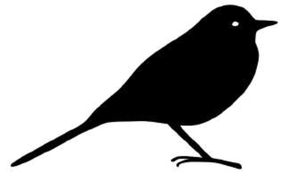
**31%**

Crustaceans

**27%**

Mammals

**25%**



Birds

**14%**

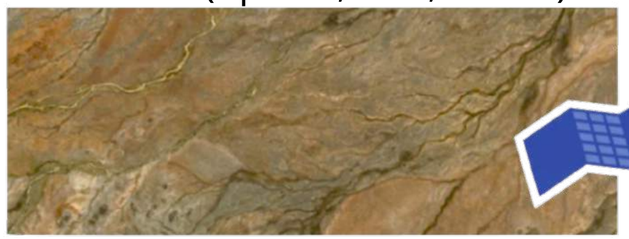
**68%** of animal population lost since 1970

“What does ‘endangered species’ mean?. WWF, 2023

# Biodiversity monitoring sensors are diverse

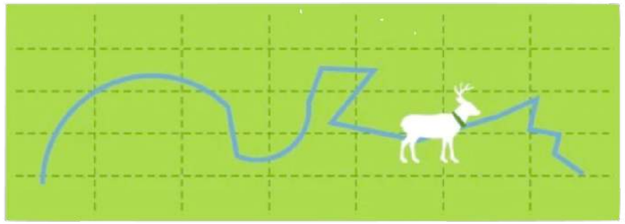
## Mobile Sensors

Satellite (optical, SAR, LiDAR)



UAV (RGB, thermal, LiDAR)

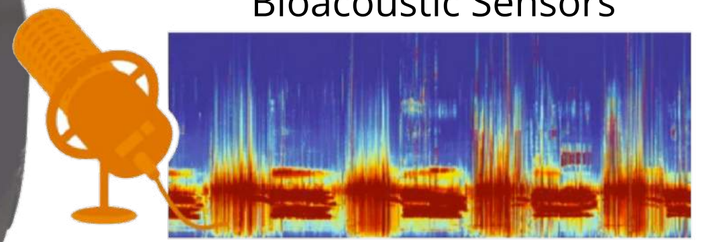
On-Animal Sensors



## Stationary Sensors

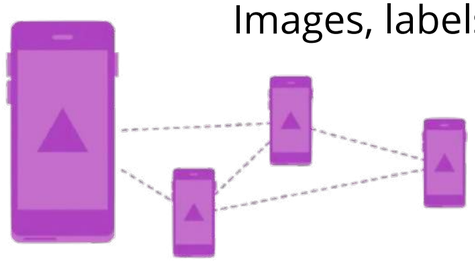
Camera Traps

Bioacoustic Sensors



## Community Scientists

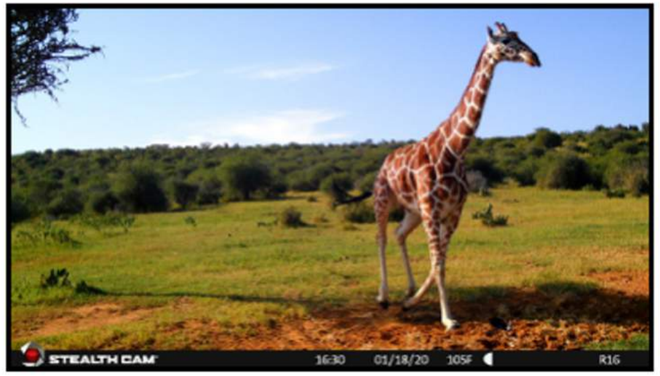
Images, labels, etc.



Seeing biodiversity: perspectives in machine learning for wildlife conservation - In Submission

# Manual data processing doesn't scale

## Camera Traps




**One project can collect >10M images/season**

## Community Scientists

**>64M Species observations in iNaturalist**

## Aerial Surveys

**One survey can generate >200TB of video**

# The MegaDetector

Conference Abstract

Biodiversity Information Science and Standards 3: e37222
https://doi.org/10.3897/biss.3.37222 (19 Jun 2019)

## Efficient Pipeline for Automating Species ID in new Camera Trap Projects

Sara Beery, Dan Morris, Siyu Yang, Marcel Simon, Arash Norouzzadeh, Neel Joshi


Beery, et al. (2019). Efficient Pipeline for Automating Species ID in new Camera Trap Projects. *Biodiversity information science and standards*

# The MegaDetector model speeds up processing 1000x+

Idaho Dept. of Fish and Game

WOLF
pop. mgmt

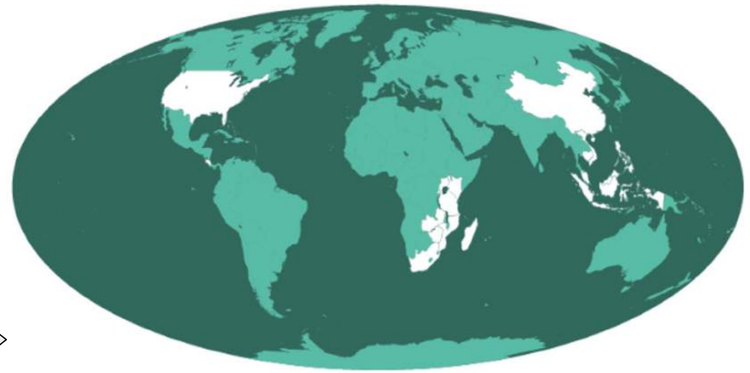
2,000
cameras

11M
images

Less than 15% of images require human review

The MegaDetector


Wildlife Protection Solutions



WILDLIFE CRIME PREVENTION

18 nations | 800 cameras | 900K images

Real-time alerts

Detects one real wildlife threat per week on average

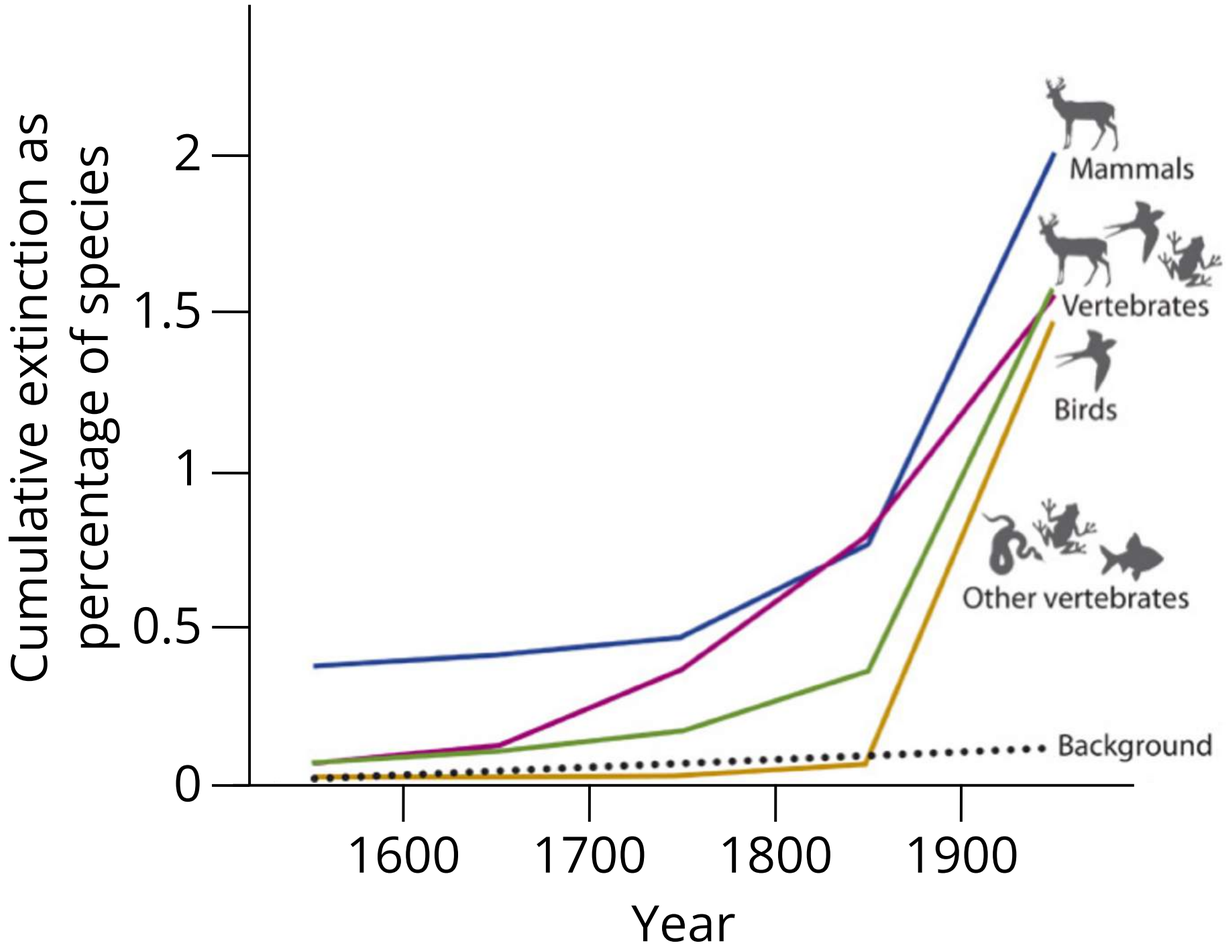
"Efficient Pipeline for Camera Trap Image Review." KDD 2019

DeepLearning.AI

# AI and Climate Change

## Climate Change & Biodiversity

# Rise in extinction rates

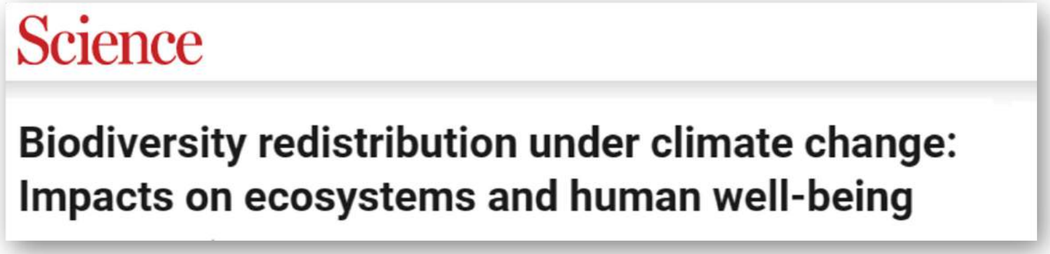


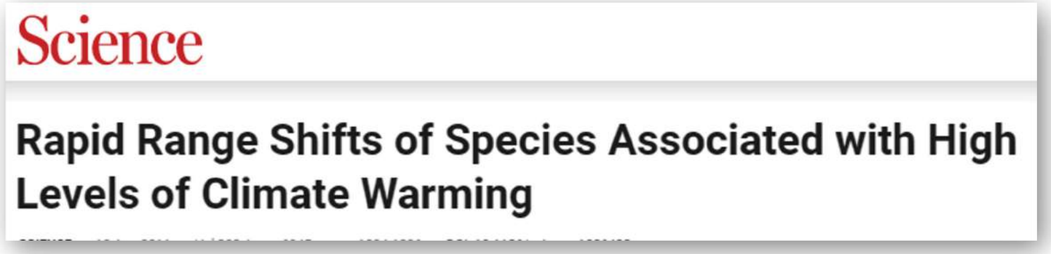

Reasons for extinction:

- Hunting and fishing
- Land development
- Environmental pollution
- Climate change

Ceballos et al. (2015). Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science Advances*

# Impacts of climate change



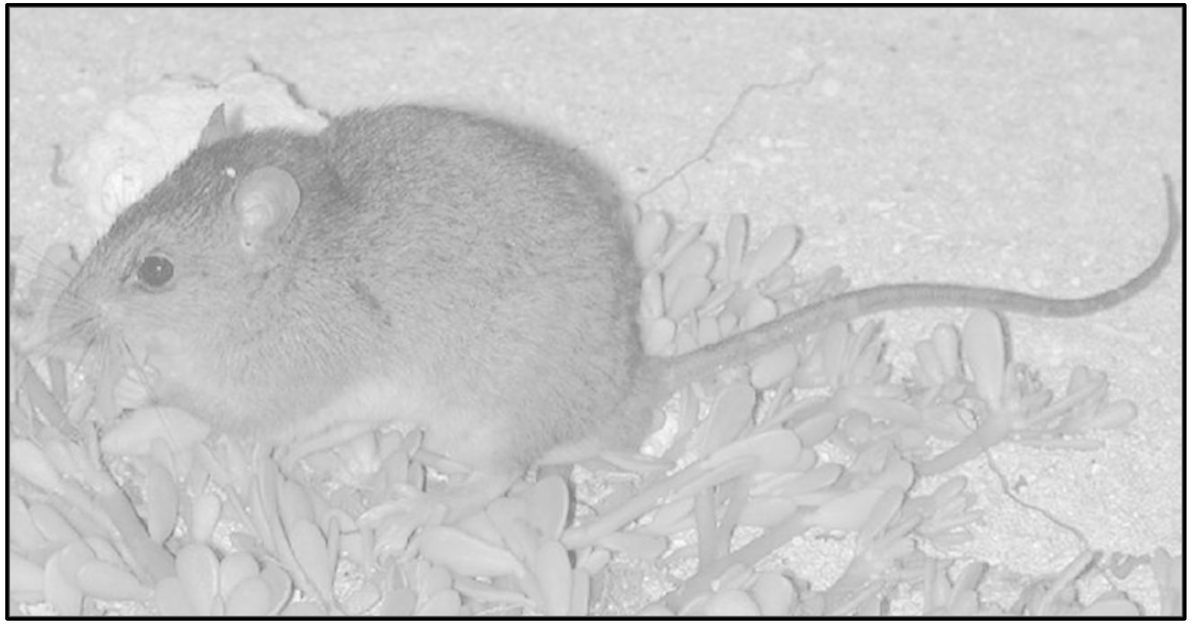





- Half of all species are on the move
- 17 km per decade on land
- 72 km per decade at sea

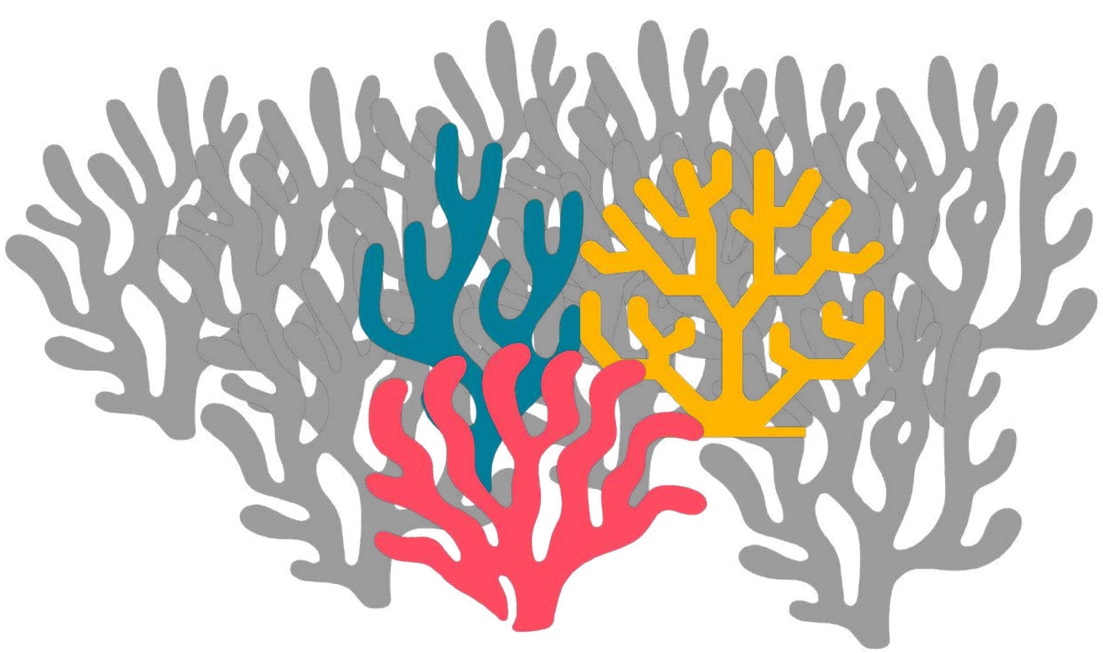
# Impacts of climate change

First mammal extinct due to climate change



# Coral reef depletion

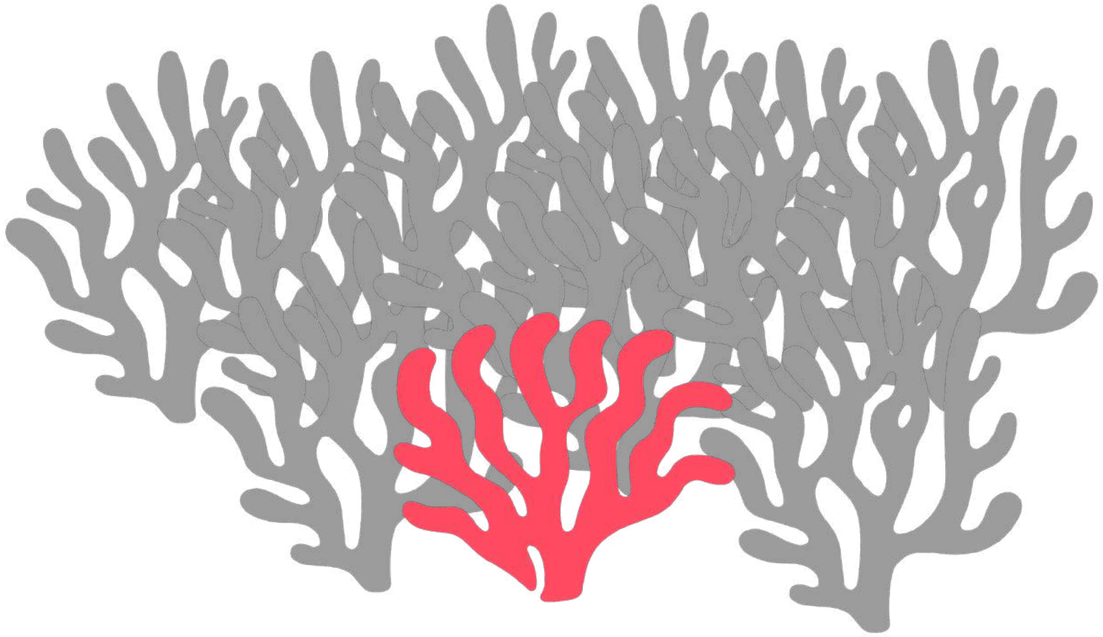
**+1.5 °C**



**70-90%**

of coral reefs will disappear

**+2.0 °C**



**99%**

of coral reefs will disappear

“How is climate change affecting biodiversity?” @United Nations Climate Change un.org/en/climatechange/

# Ocean wildlife extinction

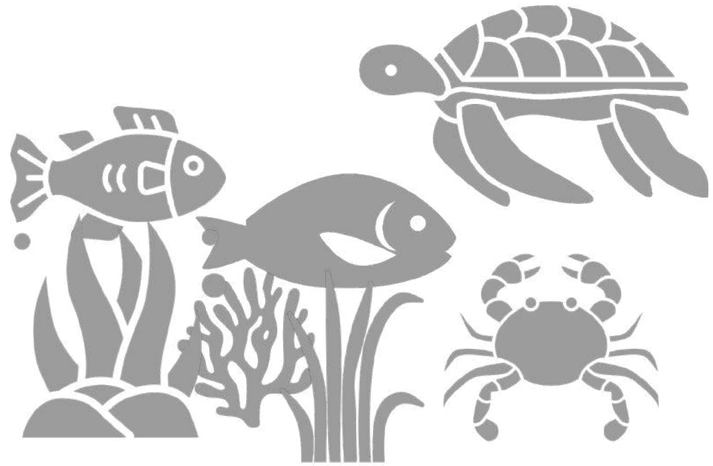
nature climate change

Article | Published: 22 August 2022

## A climate risk index for marine life

Daniel G. Boyce, Derek P. Tittensor, Cristina Garilao, Stephanie Henson, Kristin Kaschner, Kathleen Kesner-Reyes, Alex Pigot, Rodolfo B. Reyes Jr., Gabriel Reygondeau, Kathryn E. Schleit, Nancy L. Shackell, Patricia Sorongon-Yap & Boris Worm

*Nature Climate Change* **12**, 854–862 (2022) | Cite this article

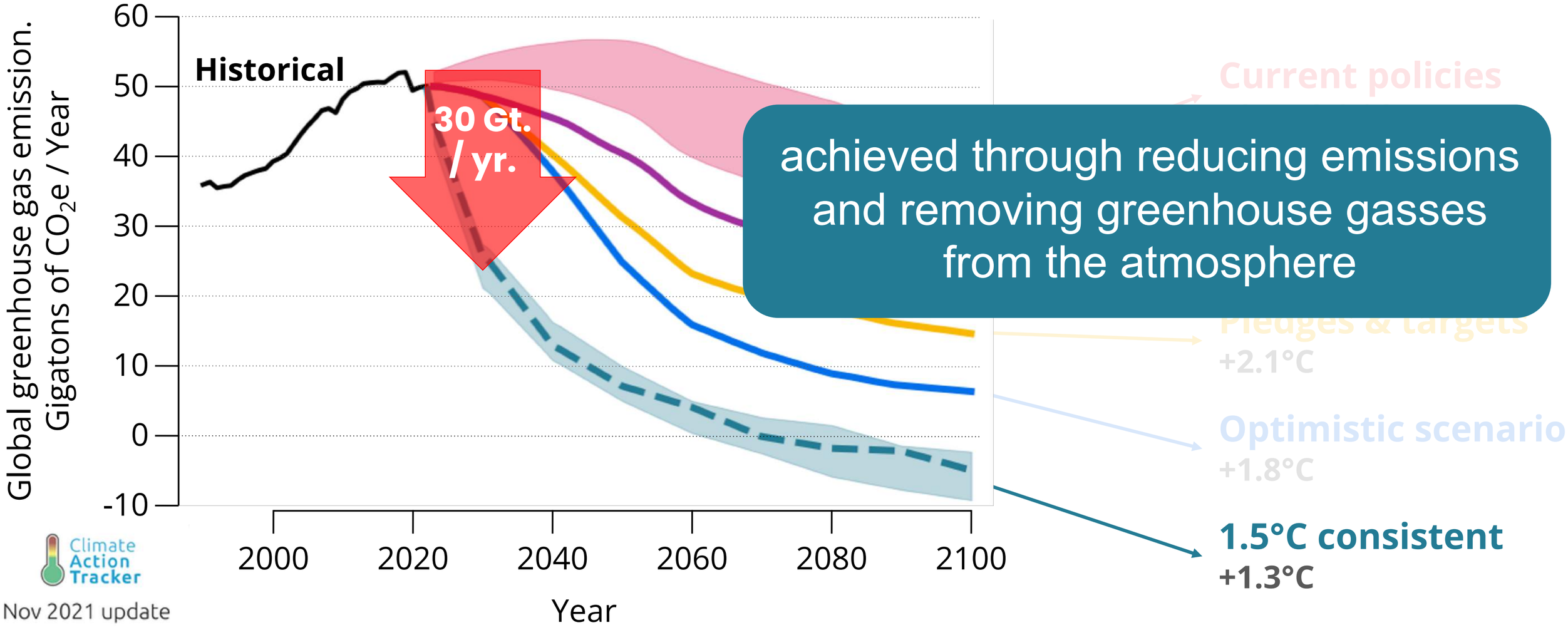


**90%**

of all ocean plants and animal species could be at risk of extinction by 2100

Boyce, D.G., Tittensor, D.P., Garilao, C. et al. (2022). A climate risk index for marine life. *Nat. Clim. Chang*

# 2100 warming projection



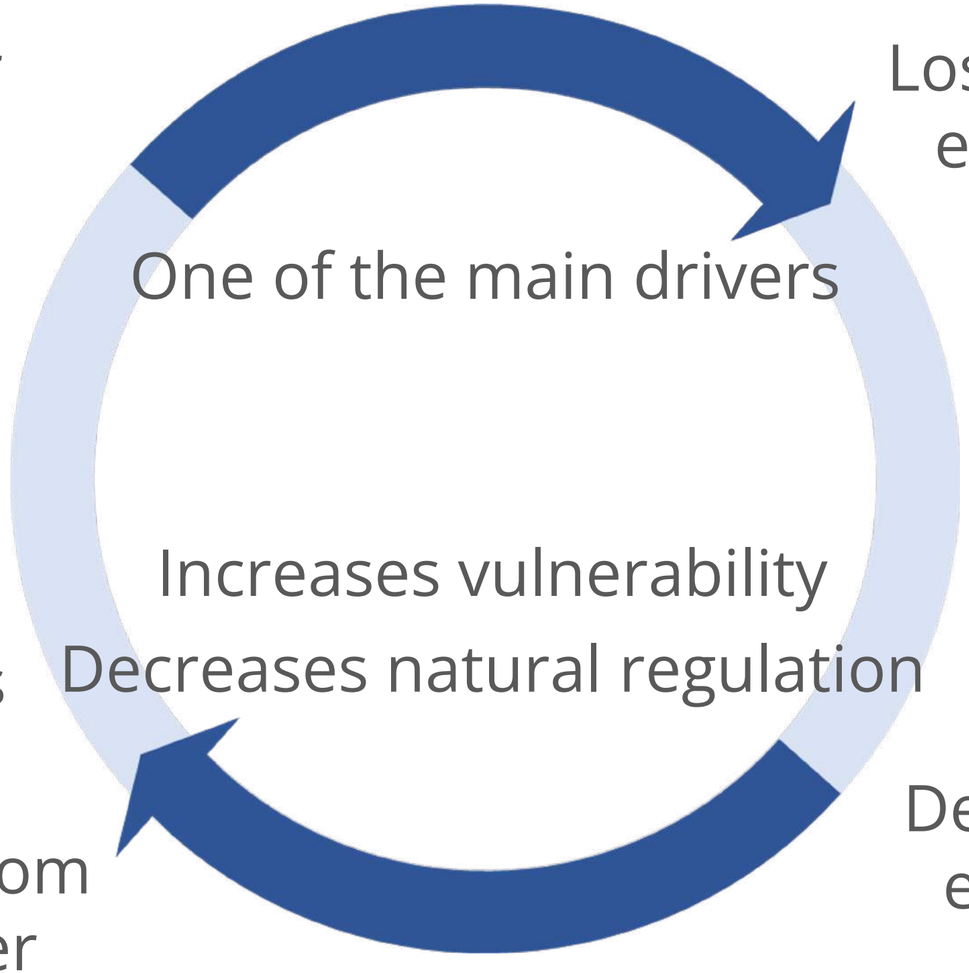

achieved through reducing emissions and removing greenhouse gasses from the atmosphere

# Greenhouse gas removal

- Halting deforestation (3 Gt/year)
- Actively managing and restoring forests (5 Gt/year)
- Nature-based solutions across all ecosystems (11.7 Gt/year)

Nature based solutions are actions to protect, sustainably manage, and restore natural or modified ecosystems that are natural sinks or reservoirs of carbon.

# Climate change and biodiversity

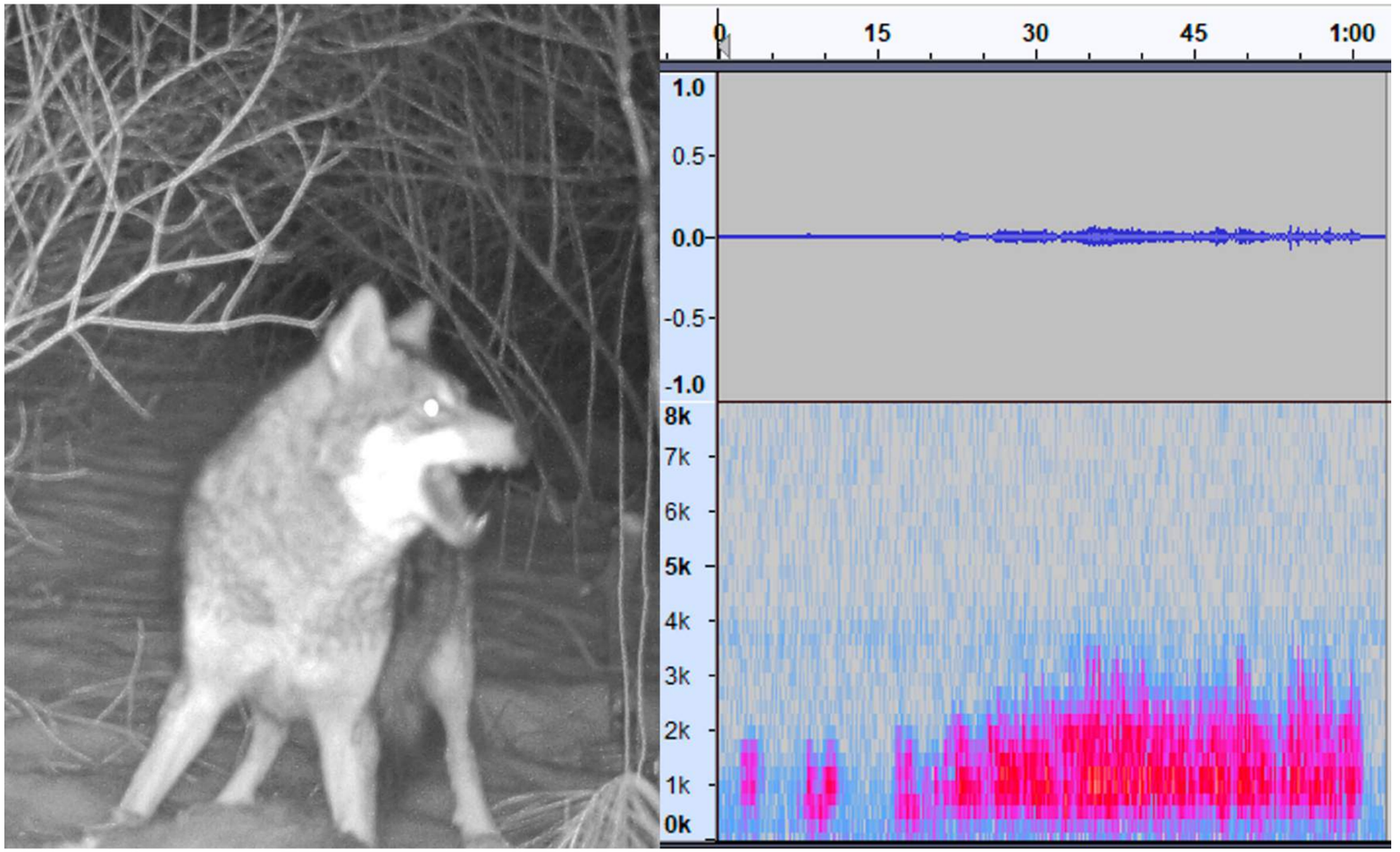


DeepLearning.AI

# AI and Climate Change

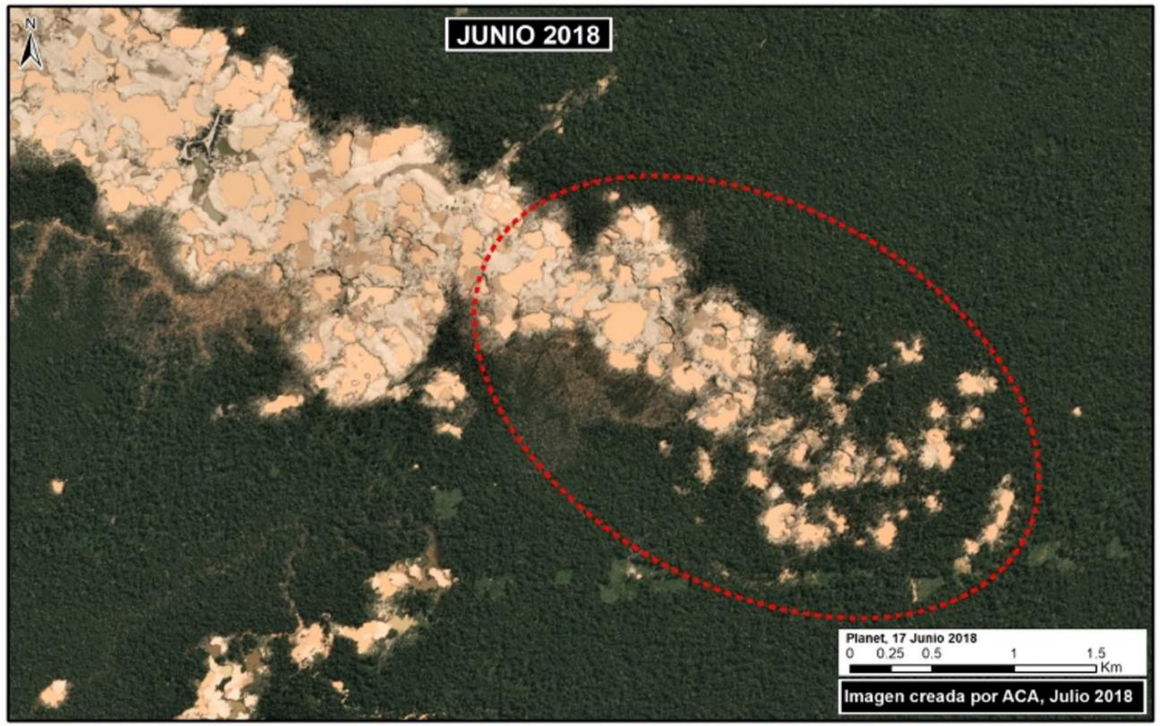
## Monitoring Biodiversity

# Camera Trap & Microphones




*Using an Acoustic Logger to Capture Wildlife Sounds. Winterberry Wildlife*

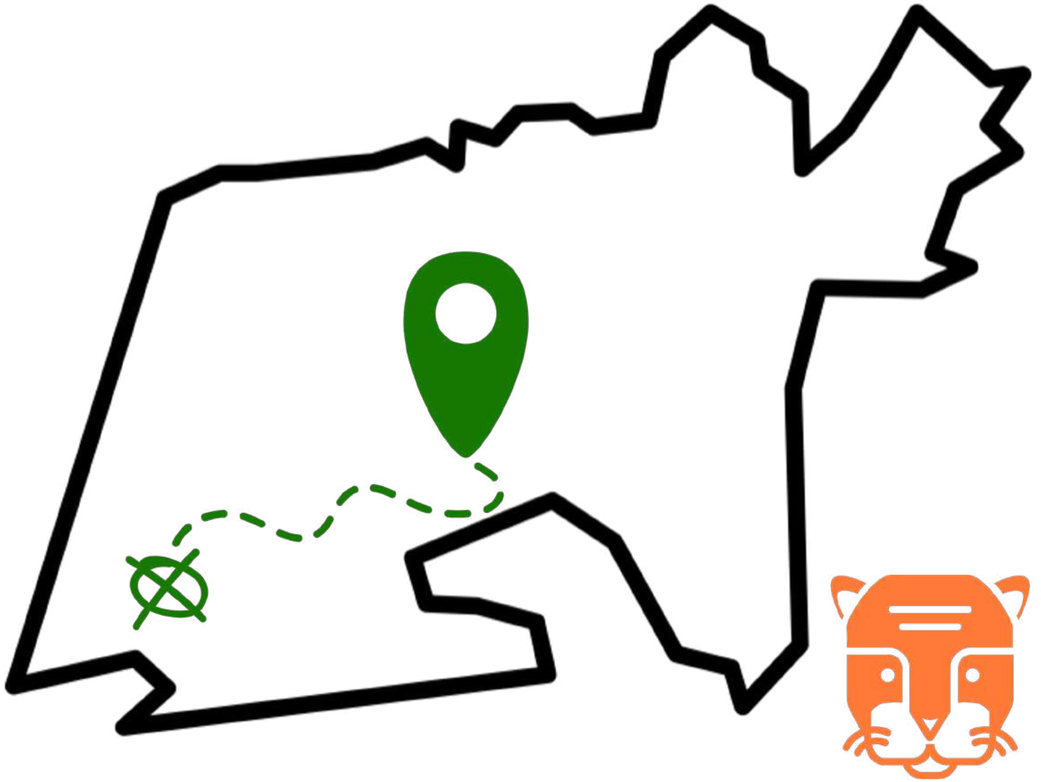
# Aerial Imagery




"Illegal gold mining in La Pampa and Tambopata National Reserve, Peru".
@Max Stoisser on Environmental Justice Atlas.

# On-animal sensors

*Tigress with radio collar in Tadoba Andhari National Park, India. PR Ganapathy*



# Bioacoustic monitoring

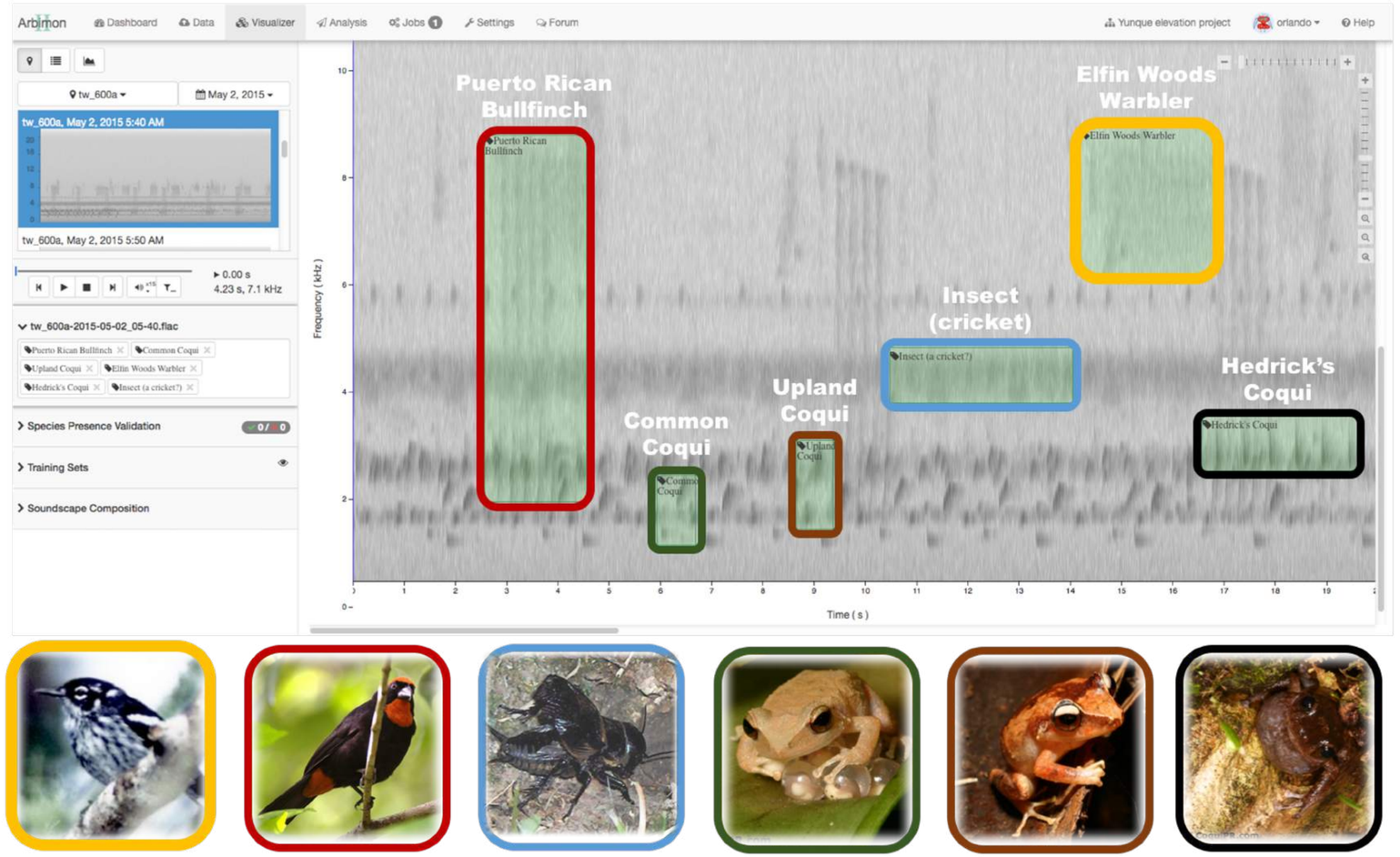
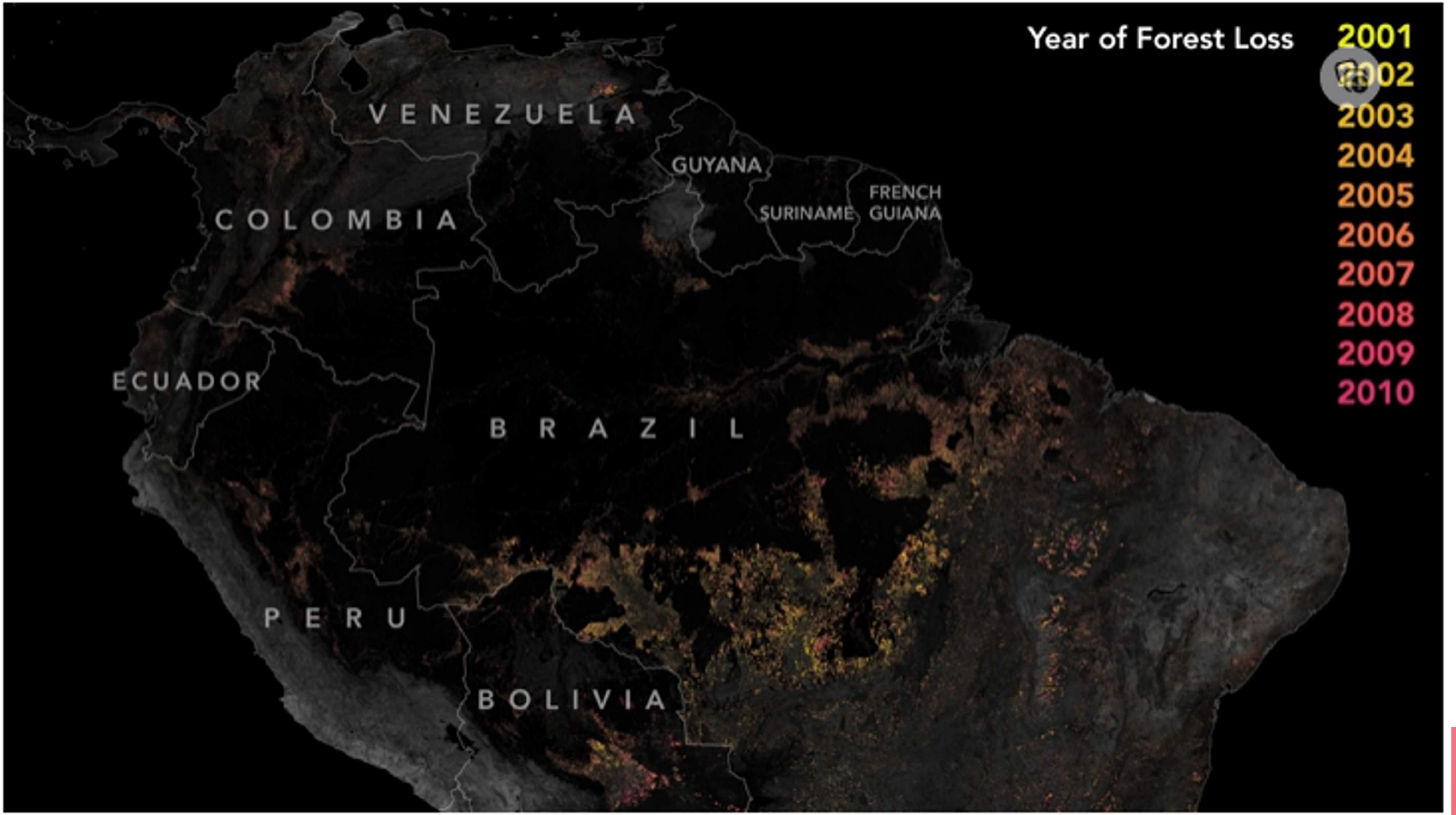
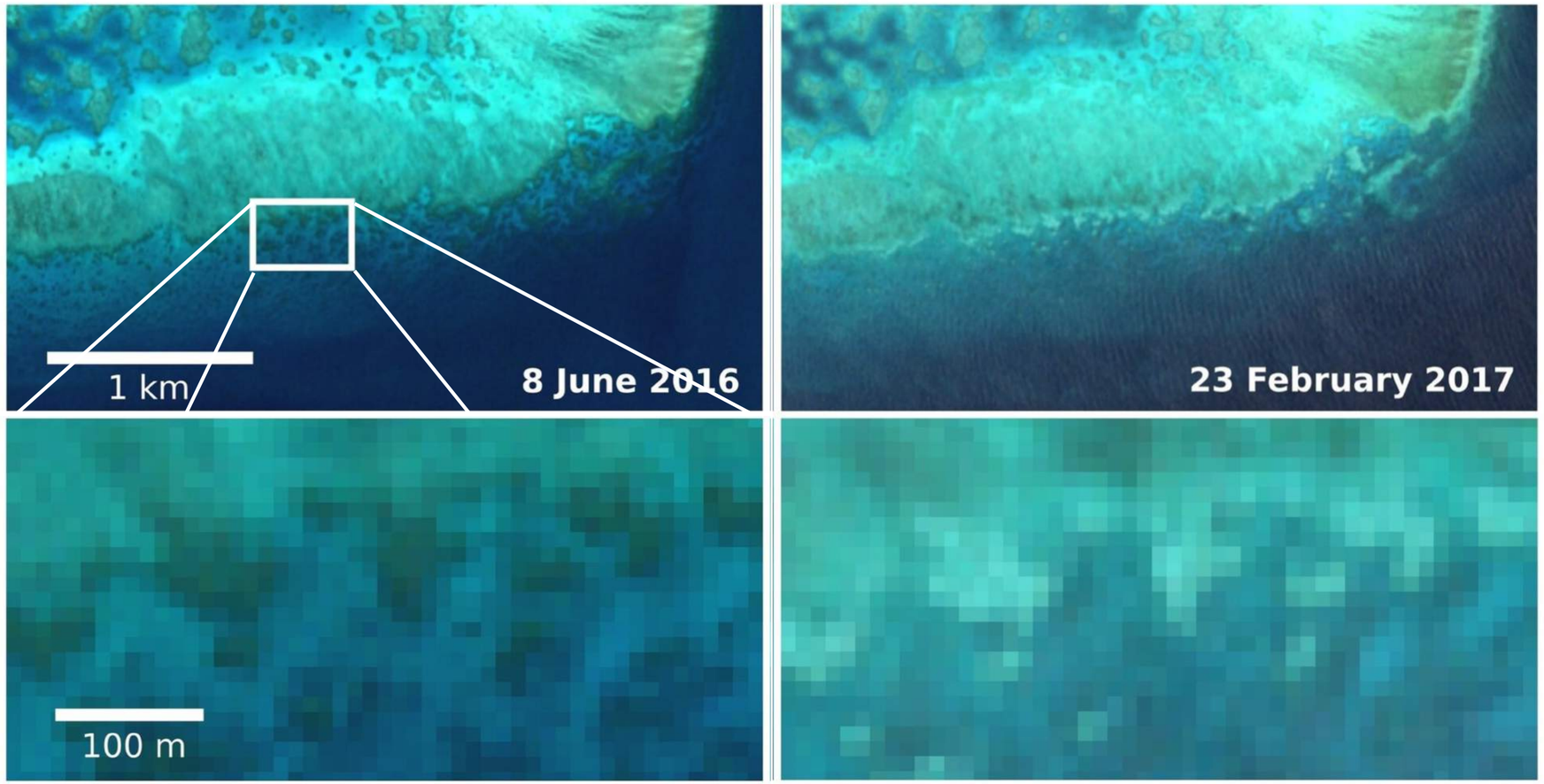



Image courtesy of Marconi Campos/ ARBIMON

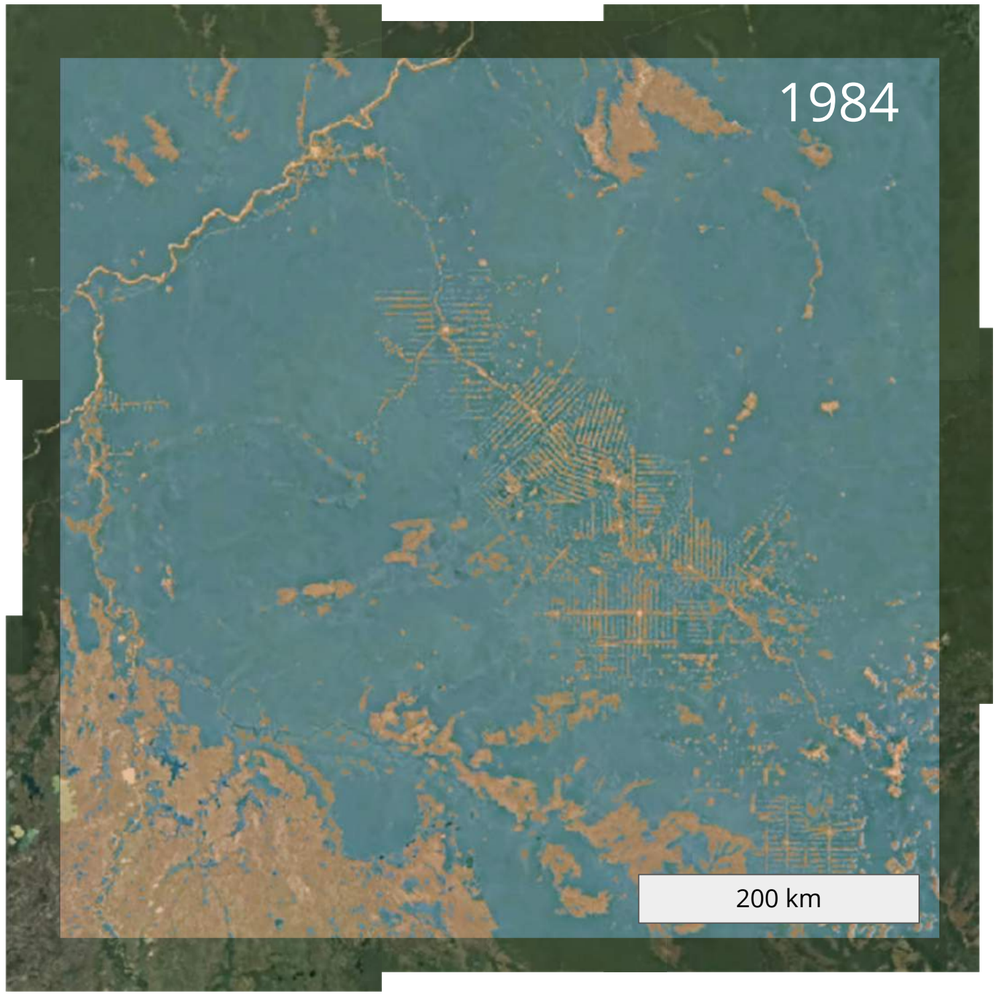

Year of Forest Loss
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
VENEZUELA
GUYANA
SURINAME
FRENCH GUIANA
COLOMBIA
ECUADOR
BRAZIL
PERU
BOLIVIA

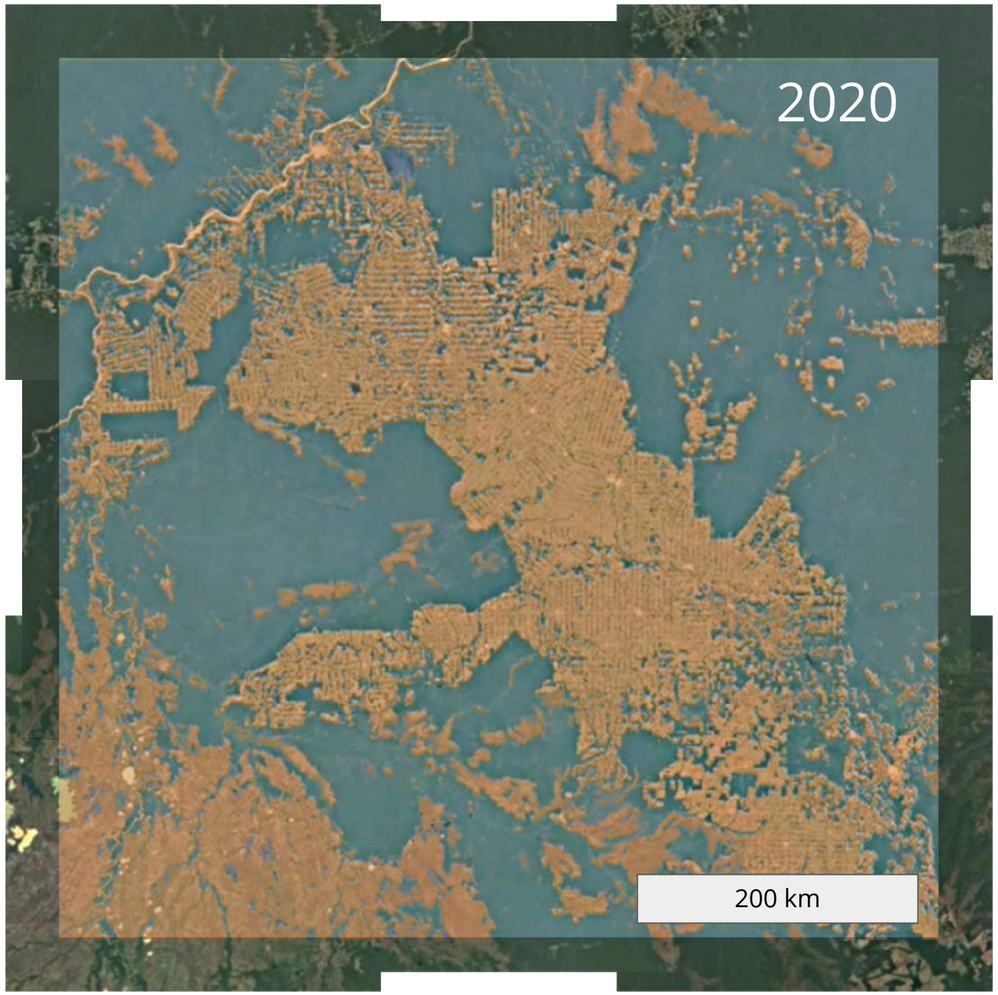
# Satellite data: Sen2Coral project




“Sentinel-2 captures coral bleaching of Great Barrier Reef” @ESA, The European Space Agency esa.int/Applications/Observing_the_Earth

# Satellite data



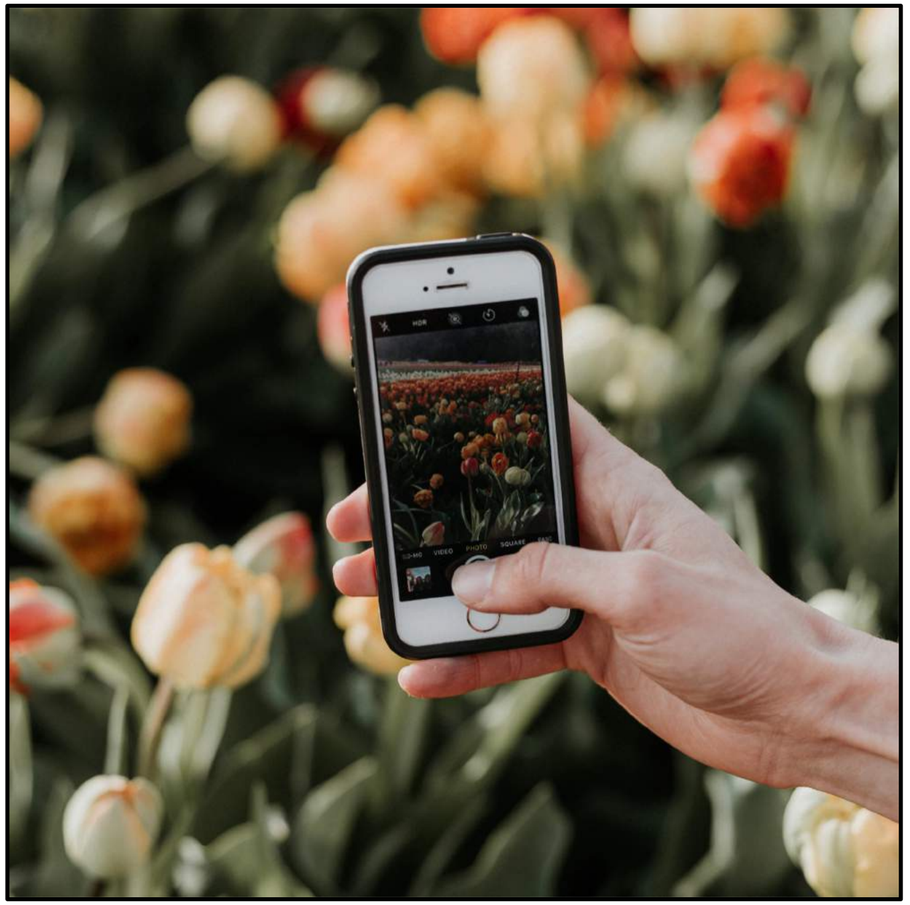



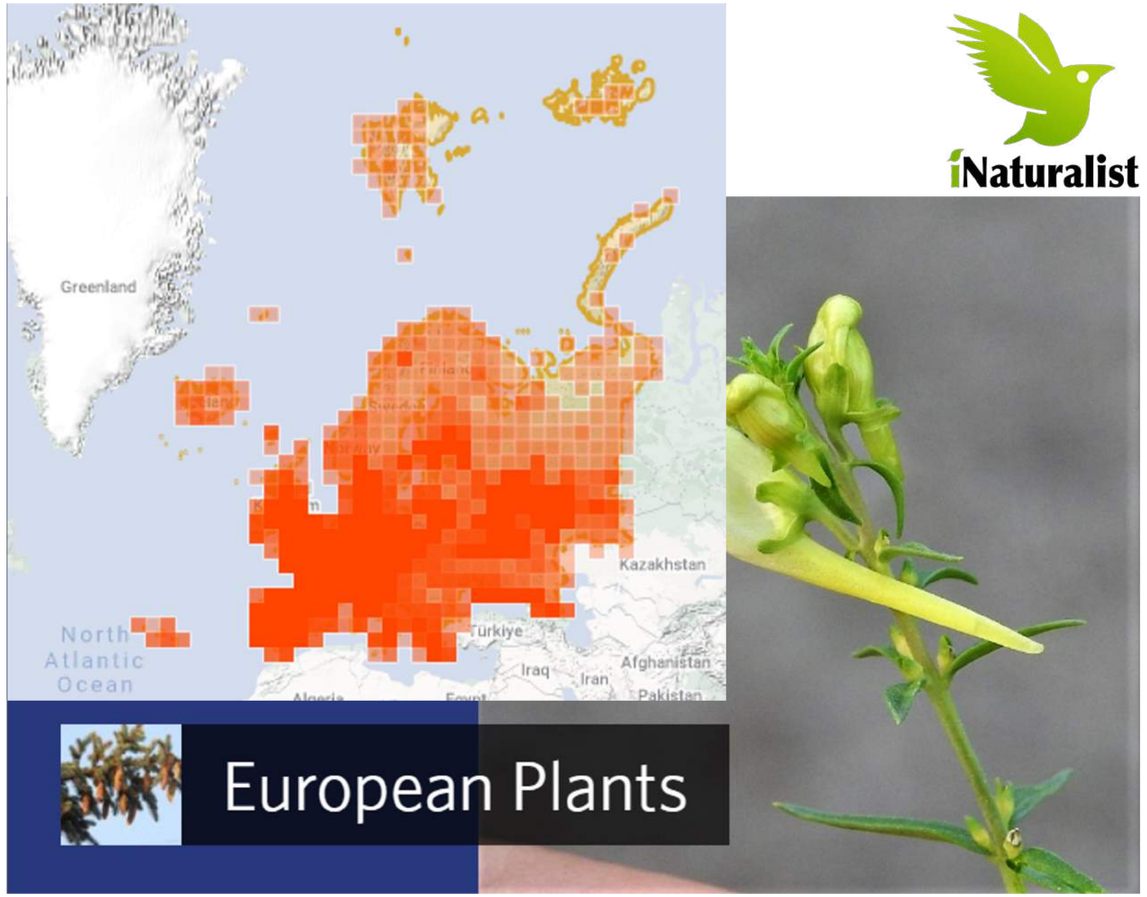

Forest

Other

Rondônia, Brazil - https://earthengine.google.com/timelapse/

# Citizen science data

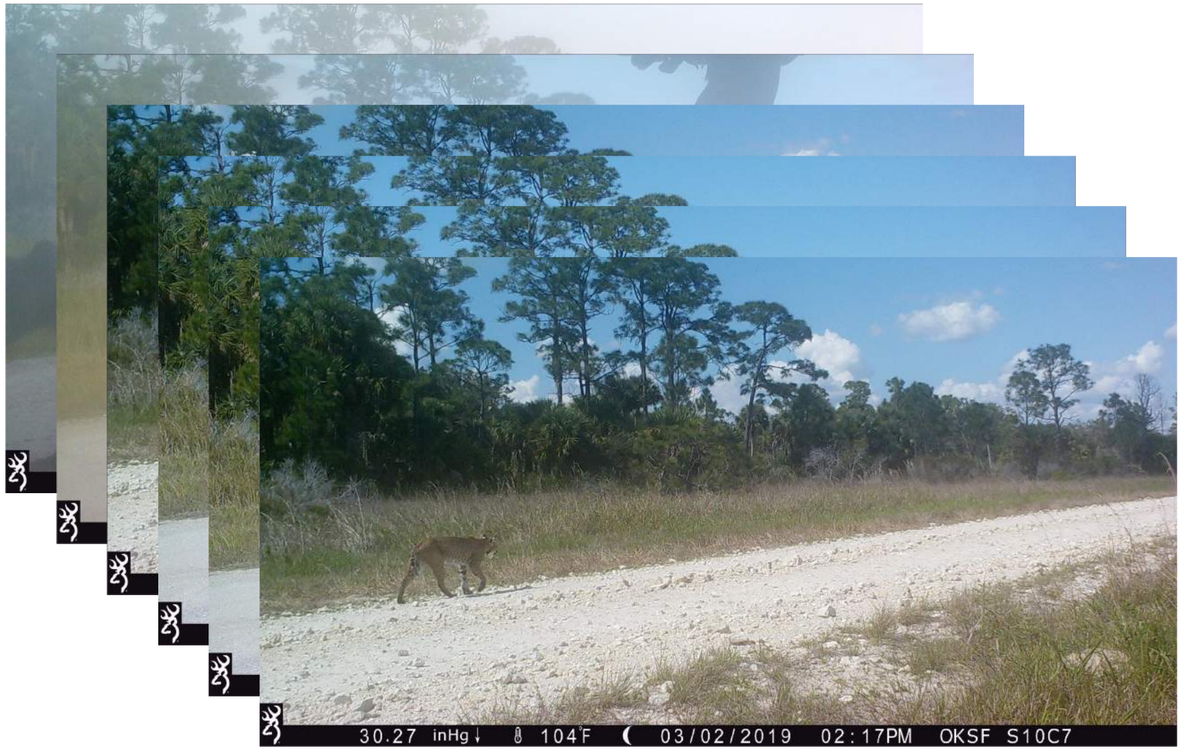





“iNaturalist” @ inaturalist.org

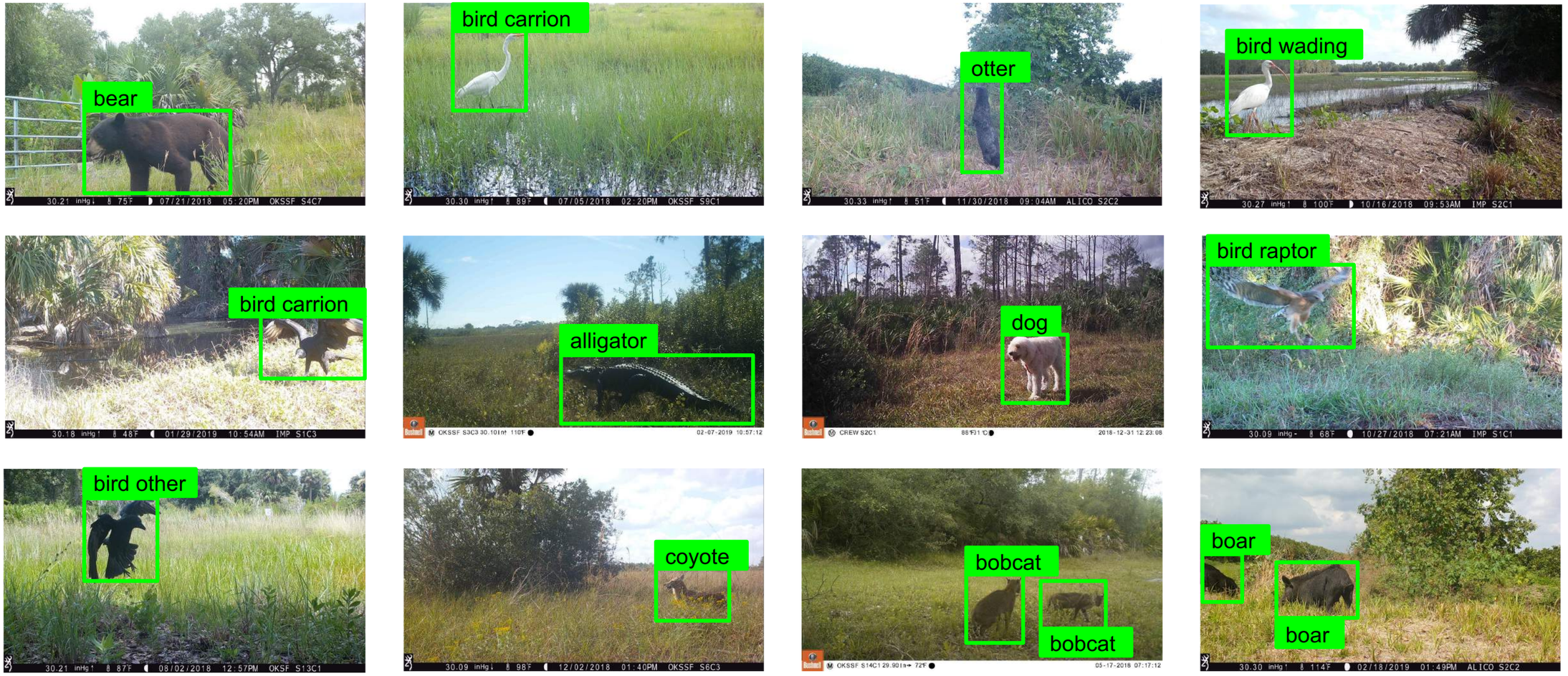
# Camera trap data

**Camera trap**



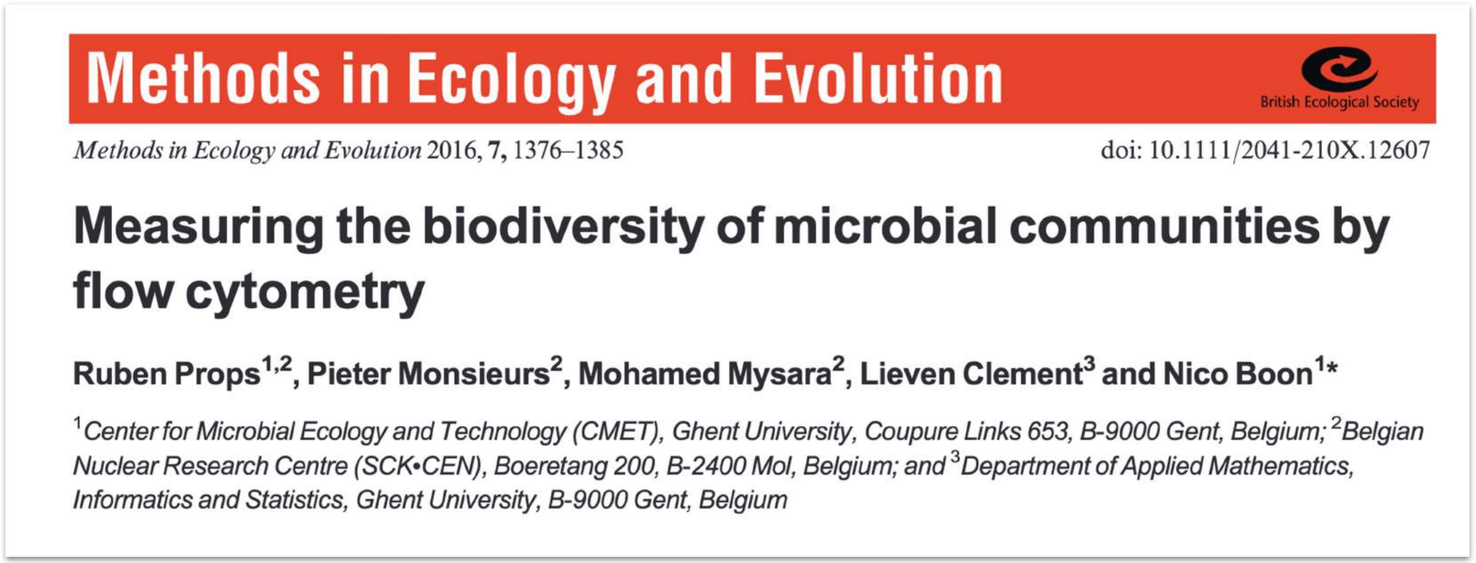

“Florida Wildlife Camera Trap Dataset” @University of Central Florida, Center for Research in Computer Vision crcv.ucf.edu/research/

# Camera trap data




"Florida Wildlife Camera Trap Dataset" @University of Central Florida, Center for Research in Computer Vision crcv.ucf.edu/research/

# Quantifying biodiversity for small creatures



Methods in Ecology and Evolution

British Ecological Society

*Methods in Ecology and Evolution* 2016, **7**, 1376–1385 doi: 10.1111/2041-210X.12607

## Measuring the biodiversity of microbial communities by flow cytometry

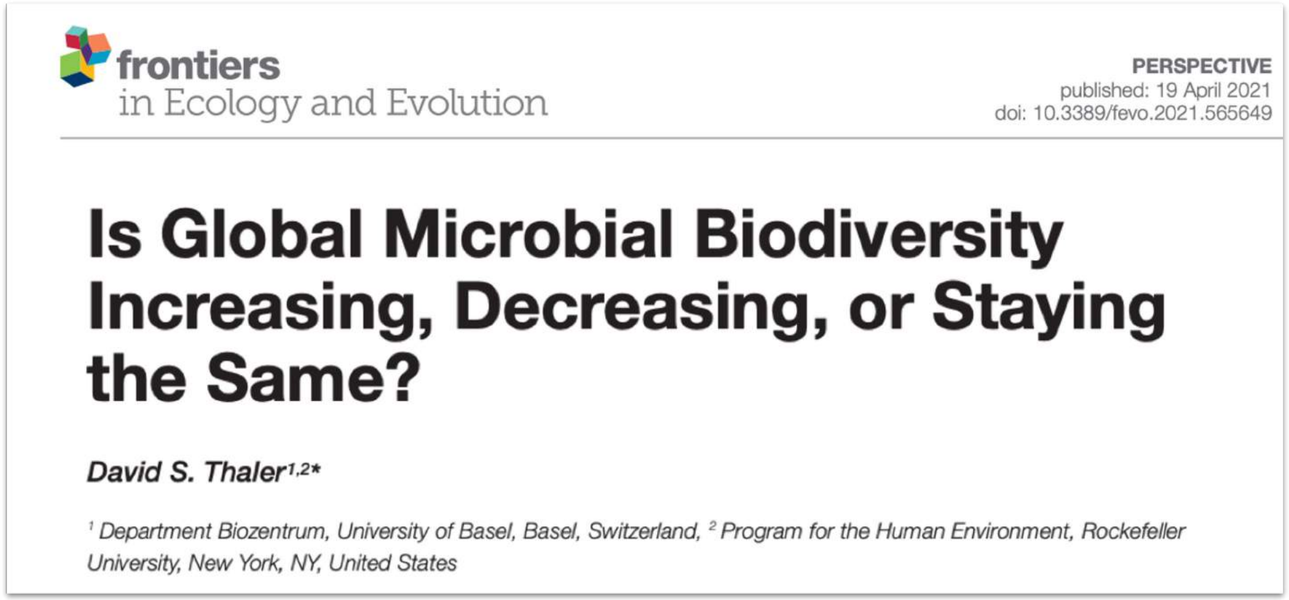
**Ruben Props[1,2], Pieter Monsieurs[2], Mohamed Mysara[2], Lieven Clement[3] and Nico Boon[1]***

[1]*Center for Microbial Ecology and Technology (CMET), Ghent University, Coupure Links 653, B-9000 Gent, Belgium;* [2]*Belgian Nuclear Research Centre (SCK•CEN), Boeretang 200, B-2400 Mol, Belgium; and* [3]*Department of Applied Mathematics, Informatics and Statistics, Ghent University, B-9000 Gent, Belgium*

**"[We describe] a computational method capable of calculating ecological alpha diversity metrics from single-cell flow cytometry data."**

Props, Monsieurs, Mysara, et al. (2016). Measuring the biodiversity of microbial communities by flow cytometry. *British Ecological Society*

# The state of microbial biodiversity



frontiers in Ecology and Evolution

PERSPECTIVE
published: 19 April 2021
doi: 10.3389/fevo.2021.565649

**Is Global Microbial Biodiversity Increasing, Decreasing, or Staying the Same?**

*David S. Thaler*[1,2]*

[1] *Department Biozentrum, University of Basel, Basel, Switzerland,* [2] *Program for the Human Environment, Rockefeller University, New York, NY, United States*

**"In contrast to what we know of the world of plants and animals, we have no idea whether global microbial diversity is increasing, decreasing, or staying the same."**

Thaler (2021). Is Global Microbial Biodiversity Increasing, Decreasing, or Staying the Same?. *Frontiers in Ecology and Evolution*

# W3 Lesson 2

# Snapshot Karoo

DeepLearning.AI

# AI and Climate Change

## Snapshot Karoo

# Snapshot safari









# Karoo national park

# The animals


10/20/2017 3:34 AM ID:3


1/28/2018 9:48 AM


1/5/2018 12:26 AM


10/6/2017 7:07 AM

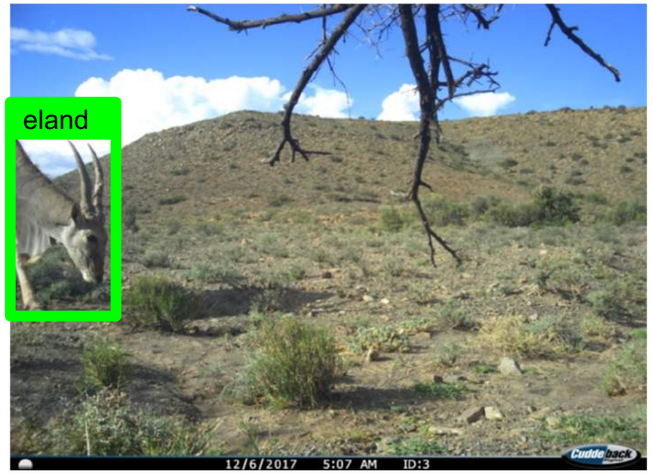

10/10/2017 7:42 AM

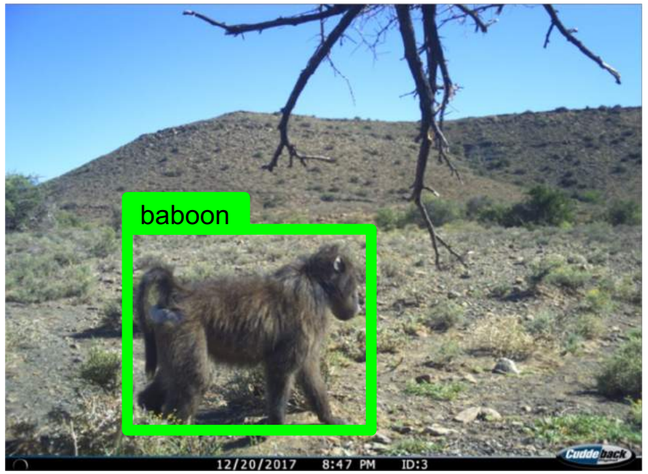

1/25/2018 7:20 PM

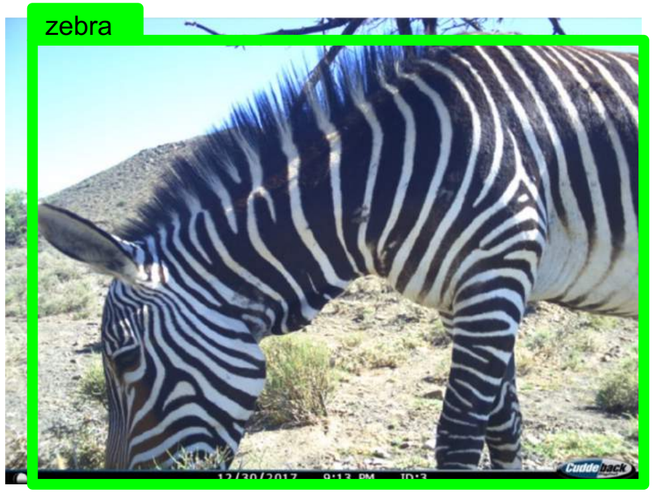

10/26/2017 11:17 AM

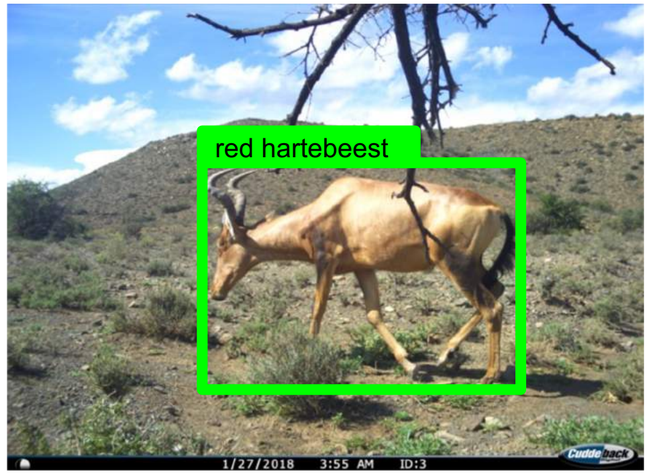

11/20/2017 5:21 AM

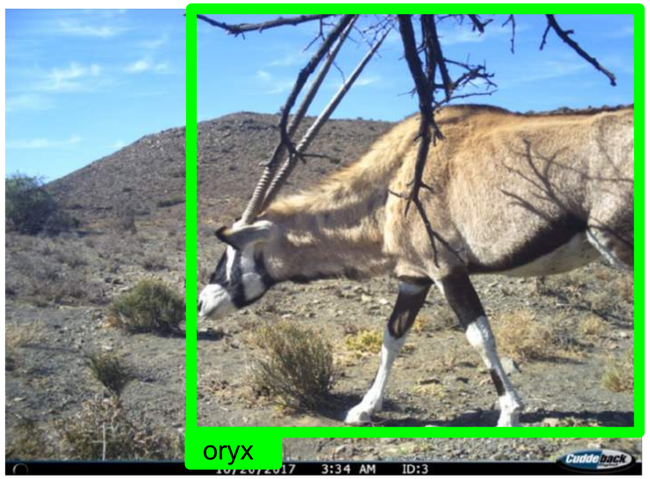
# The animals

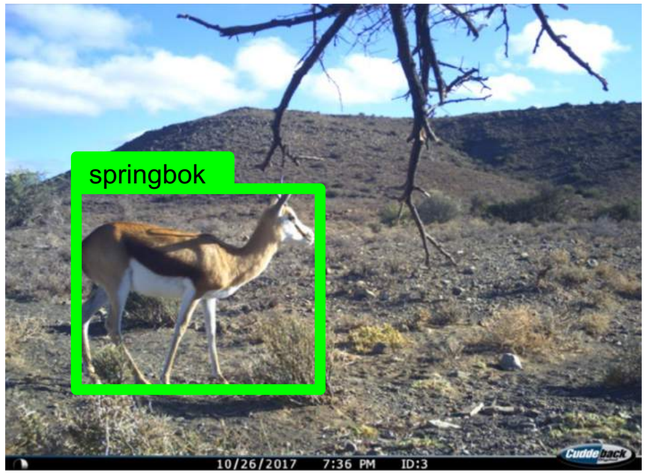

eland
12/6/2017 5:07 AM ID:3


baboon
12/20/2017 8:47 PM ID:3

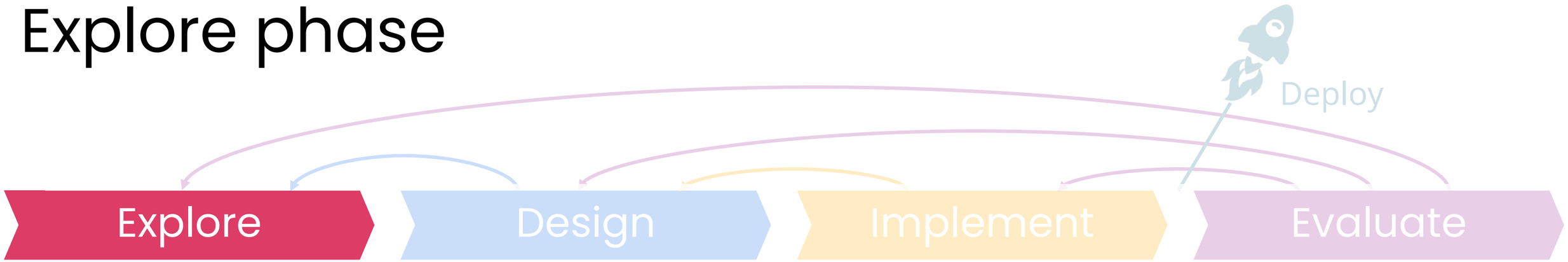

zebra


red hartebeest
1/27/2018 3:55 AM ID:3


oryx
3:34 AM ID:3


springbok
10/26/2017 7:36 PM ID:3

# Explore phase




1. Engage stakeholders
2. Define the problem
3. Determine if AI could add value

# Explore phase


1. Engage stakeholders
2. Define the problem
3. Determine if AI could add value


# Explore phase

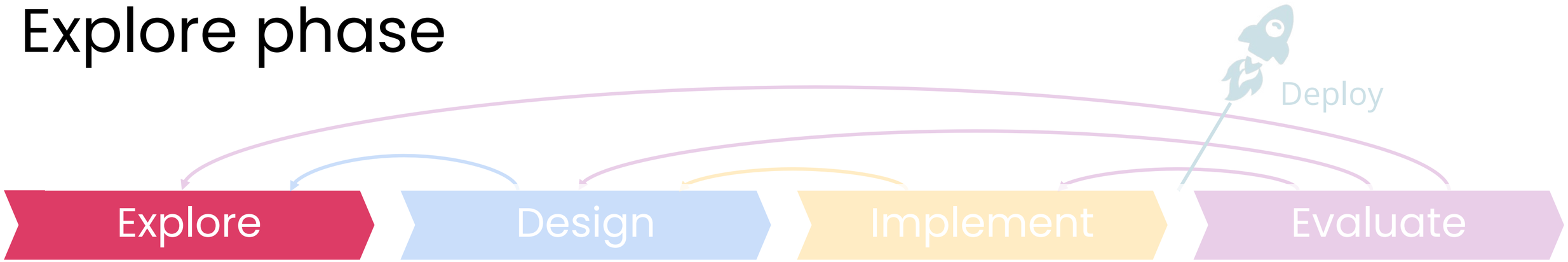
Explore

1. Engage stakeholders
2. Define the problem
3. Determine if AI could add value

**A good problem statement should:**

1. Be clear, concise, and specific.
2. Define the problem you are hoping to address.
3. Identify key stakeholders.
4. Give an idea of what success looks like.
5. Not mention the specific technology you aim to deploy.

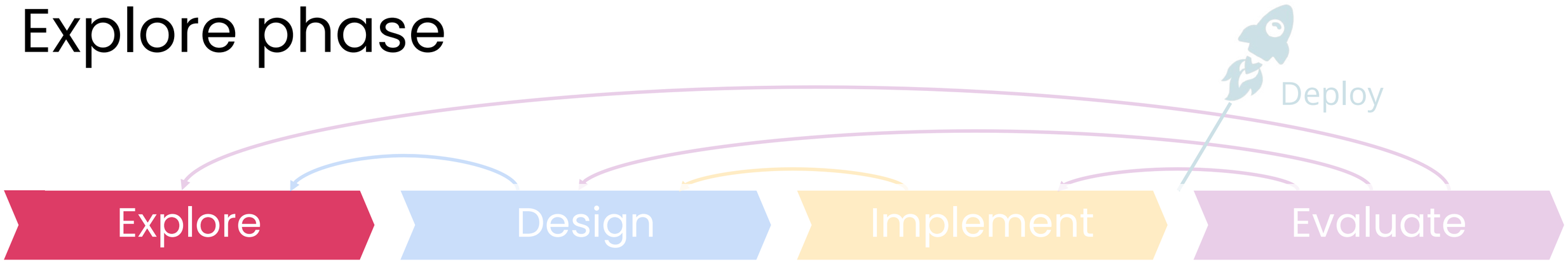
# Explore phase




1. Engage stakeholders
2. Define the problem
3. Determine if AI could add value

"Researchers and conservation biologists need **daily information** on the number of animals sighted at various locations throughout the Karoo national park in order to **monitor trends in biodiversity and animal populations** to inform policies that can be enacted to protect and preserve park ecosystems."

# Explore phase




1. Engage stakeholders
2. Define the problem
3. Determine if AI could add value

## Do no harm

1. Any pictures of humans or vehicles, or anything with the potential of containing personally identifying information (PII) should be treated as private and not stored, shared, or published
2. Consider protecting the identity and location of endangered species that may enable poachers to easily locate them

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# AI and Climate Change

## Biodiversity

### Explore the Data

jupyter C2_W3_Lab_1_Karoo_Image_data_exploration Last Checkpoint: Last Monday at 6:37 AM (autosaved)

File Edit View Insert Cell Kernel Widgets Help Trusted Python 3

Run Code

In [2]:
```
!ls data
```

```
baboon            gemsbokoryx       mongoosesmallcapegrey  springbok
birdother         hare              mongooseyellow         steenbok
birdsofprey       hartebeestred     monkeyvervet           tortoise
bustardkori       hyenabrown        ostrich                train
bustardludwigs    jackalblackbacked porcupine              wildebeestblue
caracal           klipspringer
duiker            kudu
eland             lionfemale
foxbateared       lionmale
foxcape           meerkatsuricate
```

**KAR_S1: Images from Karoo dataset**

Within one folder there are images of the same class. See the example below.

In [3]:
```
!ls data/rhinocerosblack
```

```
KAR_S1_A01_R1_IMAG00049.JPG  KAR_S1_C02_R1_IMAG0024.JPG
KAR_S1_B03_R1_IMAG0331.JPG   KAR_S1_C02_R1_IMAG0025.JPG
KAR_S1_B03_R1_IMAG0332.JPG   KAR_S1_E01_R1_IMAG0145.JPG
KAR_S1_B03_R1_IMAG0333.JPG   KAR_S1_E01_R1_IMAG0350.JPG
KAR_S1_C02_R1_IMAG0023.JPG   KAR_S1_E01_R1_IMAG0553.JPG
```

The file name contains some meta information about the image:

* KAR_S1: It indicates that the image is from the Karoo dataset season 1
* A01 | A02 | B01 | B02 ...: The camera trap location code
* R#: Repetition. This is always R1 in this dataset
* IMG####: A consecutive number of the image. Must be unique within each location

## 2.1 Load Metadata

To find out which image belongs to which class and at which location it was taken, you can loop through all of the images in

jupyter C2_W3_Lab_1_Karoo_Image_data_exploration Last Checkpoint: Last Monday at 6:37 AM (autosaved)

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Run Code

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bustardkori         hyenabrown          ostrich                train
bustardludwigs      jackalblackbacked   porcupine              wildebeestblue
caracal             klipspringer        rabbitriverine
duiker              kudu                reedbuckmountain
eland               lionfemale          reptilesamphibians
foxbateared         lionmale            rhebokgrey
foxcape             meerkatsuricate     rhinocerosblack
```

**A01, A02, B01, .... indicates camera trap location**

Within one folder there are images of the same class. See the example belo

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```
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```

```
KAR_S1_A01_R1_IMAG00049.JPG  KAR_S1_C02_R1_IMAG0024.JPG
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## 2.1 Load Metadata

To find out which image belongs to which class and at which location it was taken, you can loop through all of the images in

**Rhinoceros Black Images taken from:**

- **A01 camera location**

jupyter C2_W3_Lab_1_Karoo_Image_data_exploration Last Checkpoint: Last Monday at 6:37 AM (autosaved)

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Run Code

In [2]:
```
!ls data
```

```
baboon            gemsbokoryx          mongoosesmallcapegrey
birdother         hare                 mongooseyellow
birdsofprey       hartebeestred        monkeyvervet
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## 2.1 Load Metadata

To find out which image belongs to which class and at which location it was taken, you can loop through all of the images in

**Rhinoceros Black Images taken from:**

- **A01 camera location**
- **B03 camera location**

jupyter C2_W3_Lab_1_Karoo_Image_data_exploration Last Checkpoint: Last Monday at 6:37 AM (autosaved)

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```
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- **A01 camera location**
- **B03 camera location**
- **C02 camera location**

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- **C02 camera location**
- **E01 camera location**

DeepLearning.AI

# AI and Climate Change

## Biodiversity

## Visualize the Data

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# AI and Climate Change

## Project Spotlight: Why Monitor Biodiversity? – Sara Beery

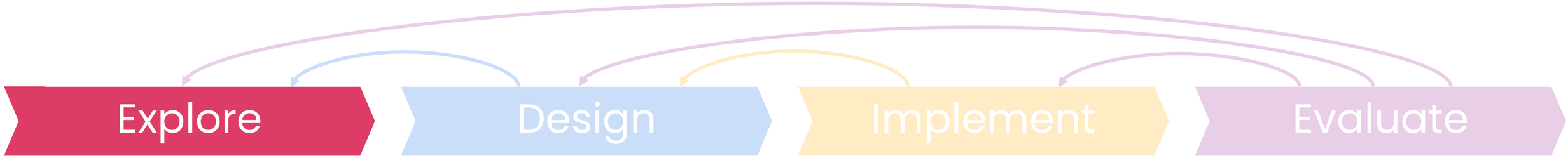
DeepLearning.AI

# AI and Climate Change

## Biodiversity

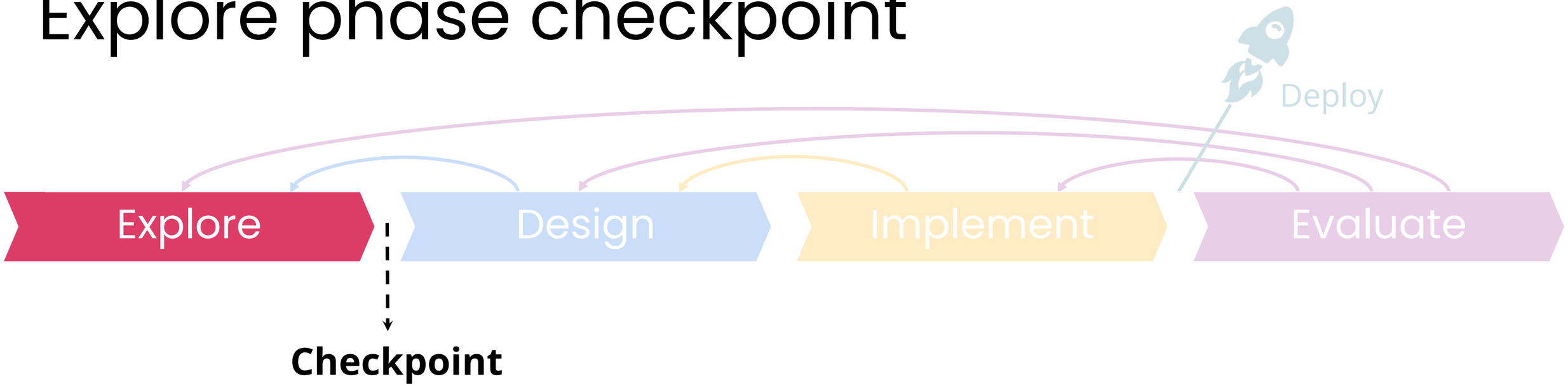
## Explore Phase Checkpoint

# Explore phase



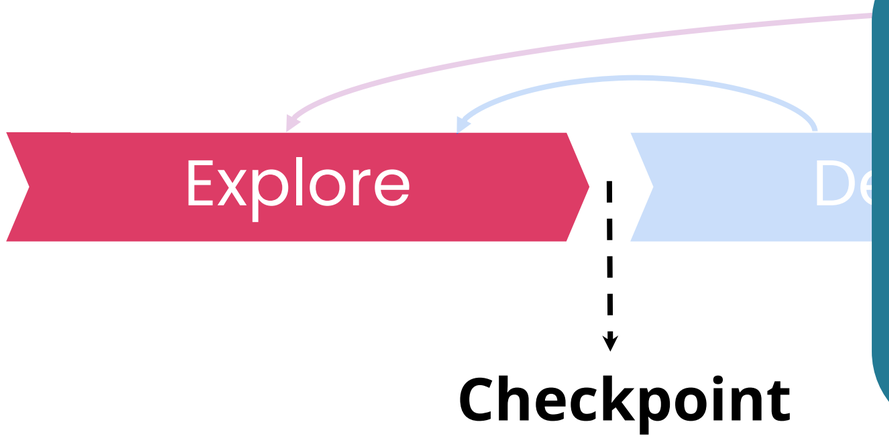

1. Engage stakeholders ✓
2. Define the problem ✓
3. Determine if AI could add value ✓

# Explore phase checkpoint




- What is the specific problem you are addressing?
- Who are the stakeholders?
- Do you have access to or can you collect the necessary data?
- Could AI add any value? Where?
- How does the “do no harm” principle come into play?

# Explore phase checkpoint




"Researchers and conservation biologists need daily information on the number of animals sighted at various locations throughout the Karoo national park in order to monitor trends in biodiversity and animal populations to inform policies that can be enacted to protect and preserve park ecosystems."

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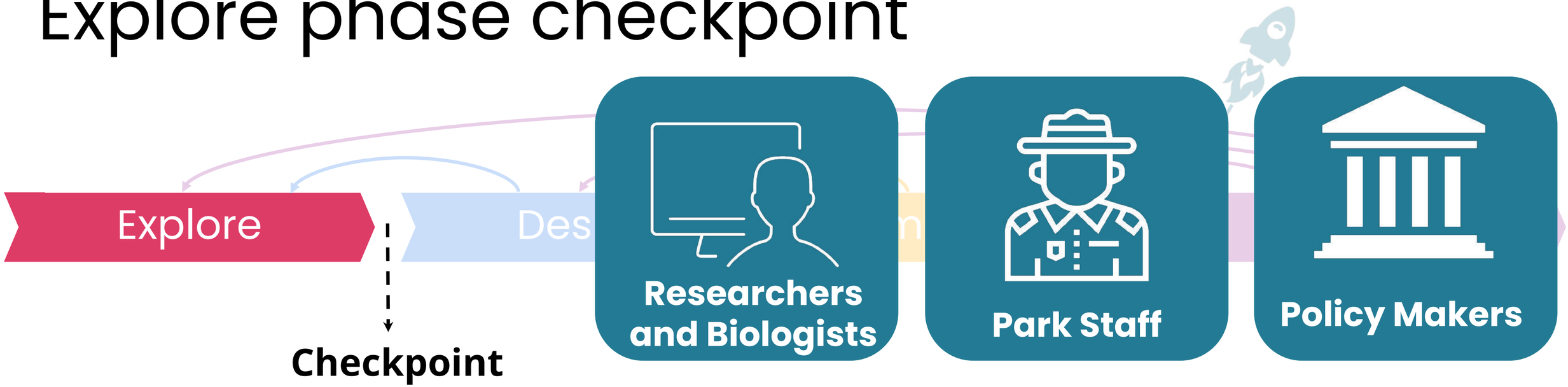


- What is the specific problem you are addressing? ✓
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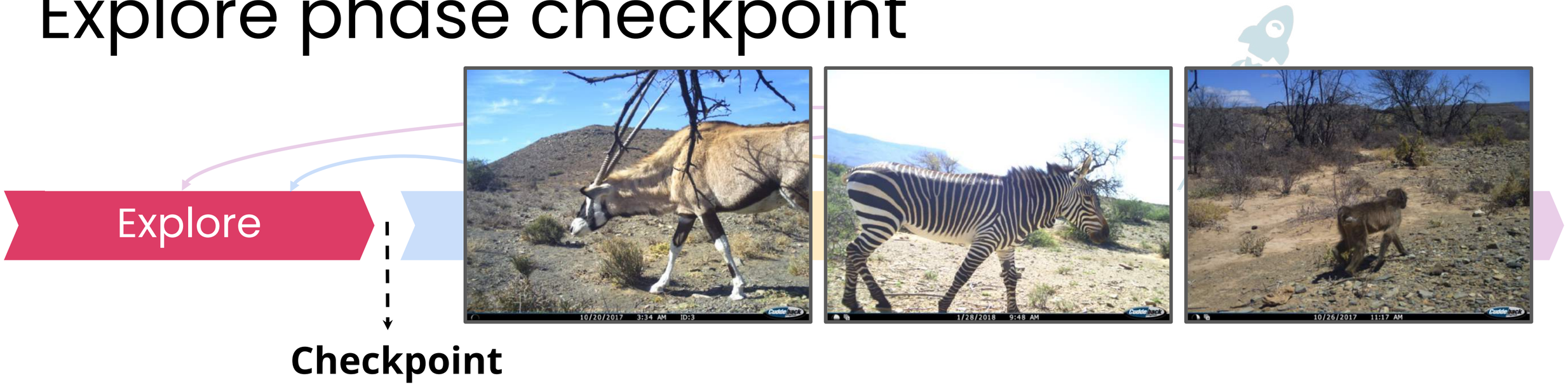


**Checkpoint**

- What is the specific problem you are addressing? ✓
- Who are the stakeholders? ✓
- Do you have access to or can you collect the necessary data? ✓
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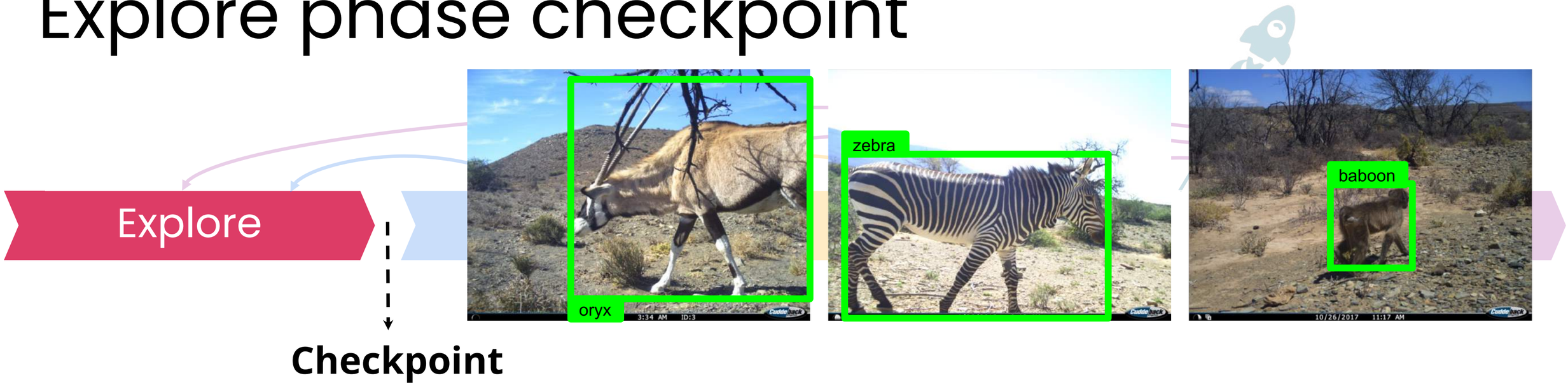


**Checkpoint**

- What is the specific problem you are addressing? ✓
- Who are the stakeholders? ✓
- Do you have access to or can you collect the necessary data? ✓
- Could AI add any value? Where? ✓
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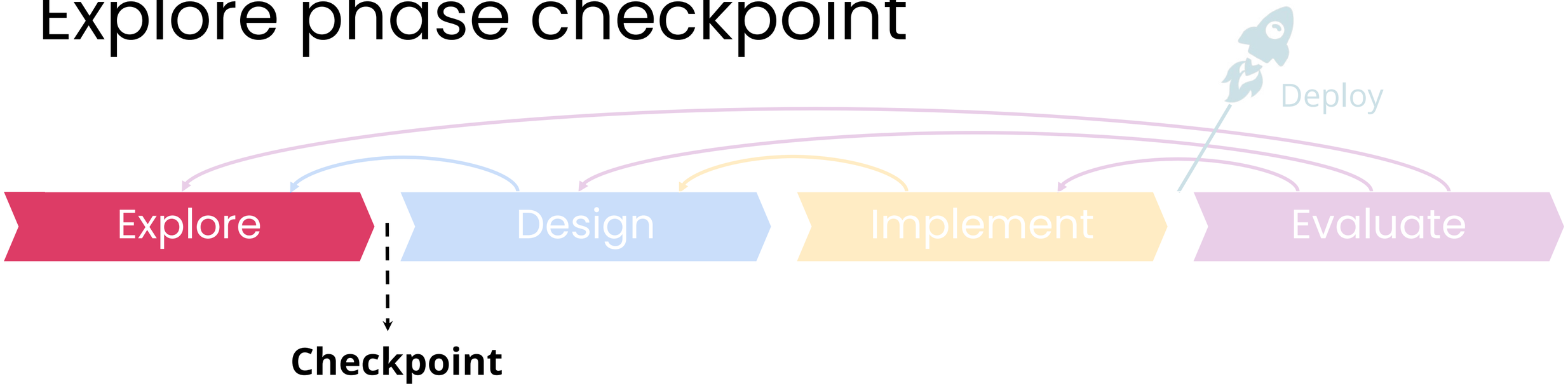
# Explore phase checkpoint




**Checkpoint**

- What is the specific problem you are addressing?
- Who are the stakeholders?
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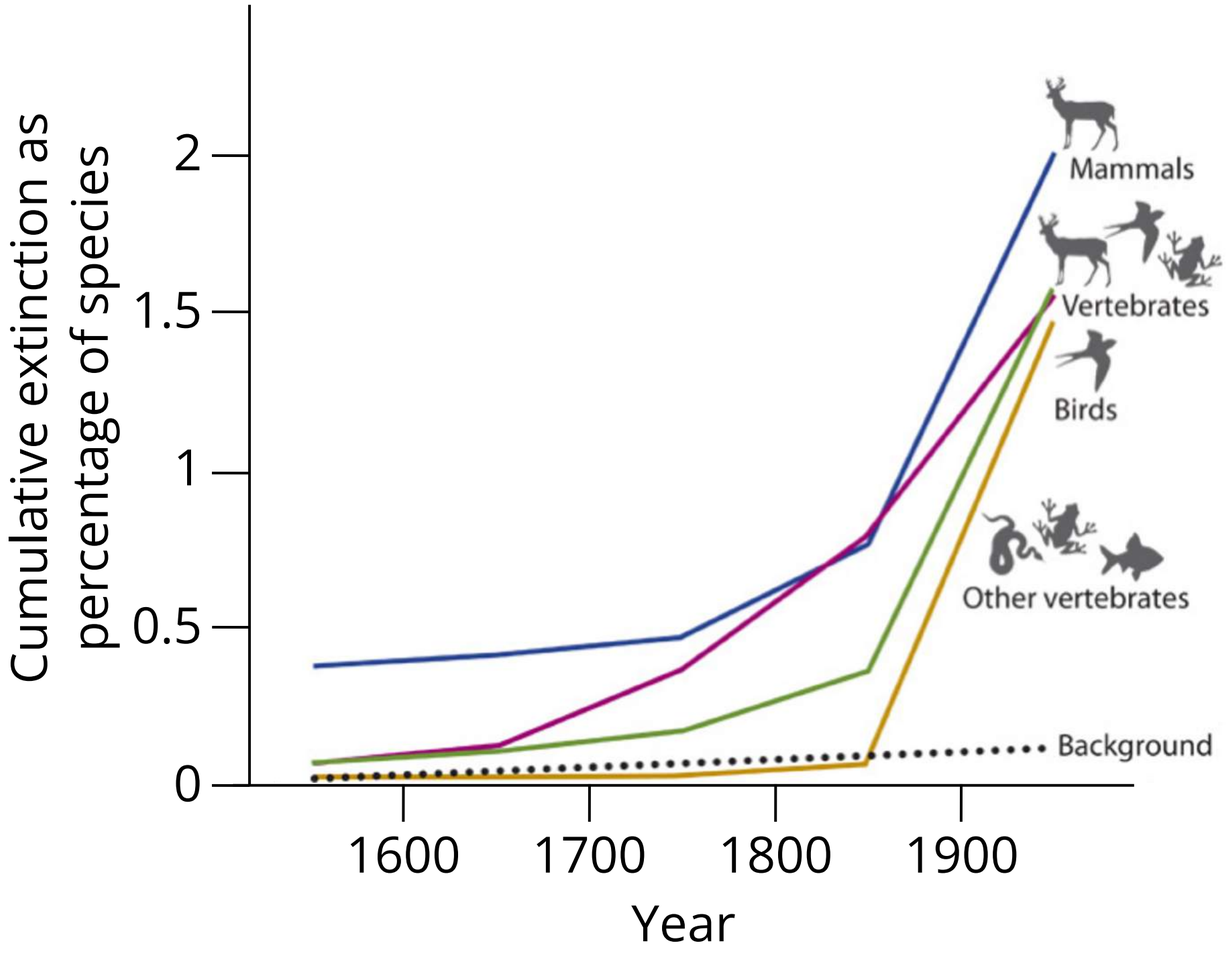
# AI and Climate Change

## Week 3 Summary

# Rise in extinction rates

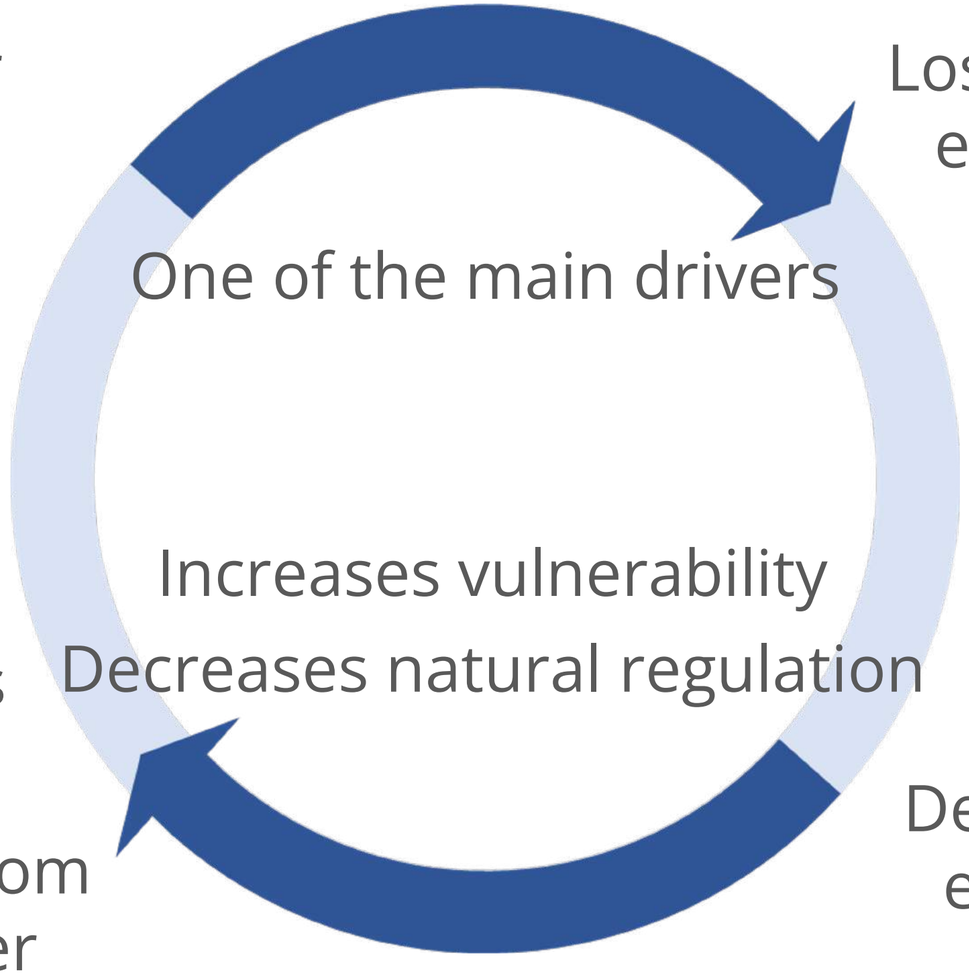



Reasons for extinction:

- Hunting and fishing
- Land development
- Environmental pollution
- Climate change

Ceballos et al., 2015, Accelerated modern human-induced species losses: Entering the sixth mass extinction. DOI: 10.1126/sciadv.1400253

# Climate change and biodiversity



# UN estimates for greenhouse gas reduction

- Halting deforestation (3 Gt/year)
- Actively managing and restoring forests (5 Gt/year)
- Nature-based solutions across all ecosystems

  (11.7 Gt/year)

Nature based solutions are actions to protect, sustainably manage, and restore natural or modified ecosystems that are natural sinks or reservoirs of carbon.

# Explore phase

Researchers and Biologists

Park Staff

Community

Policy Makers

## Explore

1. Engage stakeholders ✓
2. Define the problem ✓
3. Determine if AI could add value ✓

"Researchers and conservation biologists need daily information on the number of animals sighted at various locations throughout the Karoo national park in order to monitor trends in biodiversity and animal populations to inform policies that can be enacted to protect and preserve park ecosystems."