



# Biodiversity Data and Cloud-Based Analysis Tools

A survey of the present and a squint into the future.

Dave Thau

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Manager of Developer Relations: Google Earth Engine

Digital Data in Biodiversity Research, Berkeley, June 4, 2018



- ☰
- 🔍
- ⚙️
- 🗺️
- 📏
- 👤
- 🔧

Google

Colombia

- +

3D

🧭

🌐

📍



# A planetary-scale platform for Earth science data & analysis

Powered by Google's cloud infrastructure

▶ WATCH VIDEO

## Meet Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets

# Biodiversity

Species are going extinct at an alarming rate. AI can help people accelerate the discovery, monitoring, and protection of biodiversity across our planet.



## What is AI for Earth?

AI for Earth puts Microsoft's cloud and AI tools in the hands of those working to solve global environmental challenges. Through grants that provide access to cloud and AI tools, opportunities for education and training on AI, and investments in innovative, scalable



# Earth on AWS

Build planetary-scale applications in the cloud with open geospatial data.

[Datasets](#)[Use Cases](#)[Call for Proposals](#)[Marketplace](#)

## Landsat on AWS

Landsat 8 data is available for anyone to use via Amazon S3. All Landsat 8 scenes from 2015 are available along with a selection of cloud-free scenes from 2013 and 2014. All new Landsat 8 scenes are made available each day, often within hours of production. The satellite images the entire Earth every 16 days at a roughly 30 meter resolution.

*Image from Landsat 8 satellite, courtesy of the U.S. Geological Survey*

Scale



Earth Engine is Google's **cloud platform**  
for **petabyte-scale analysis** of  
**satellite imagery** and other **geospatial data**.



**Google** Earth Engine





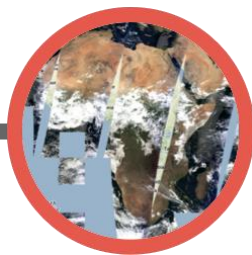
**Colocated Data + Computation + APIs**



# The Earth Engine Data Catalog



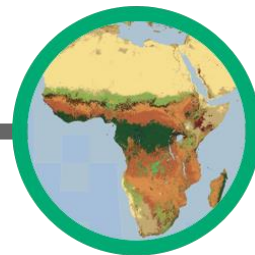
**Landsat & Sentinel 1, 2**  
10-30m, weekly



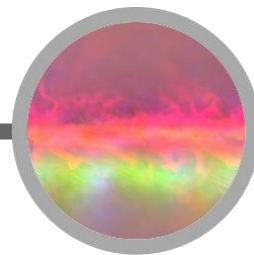
**MODIS**  
250m daily



**Vector Data**  
WDPA, Tiger



**Terrain & Land Cover**



**Weather & Climate**  
NOAA NCEP, OMI, ...

... and upload your own vectors and rasters

> 200 public datasets

> 5 million images

> 4000 new images every day

> 8 petabytes of data

Filter methods...

- ▶ ee.Algorithms
- ▶ ee.Array
- ▶ ee.Classifier
- ▶ ee.ConfusionMatrix
- ▶ ee.Date
- ▶ ee.DateRange
- ▶ ee.Dictionary

```

1 // Compute the trend of nighttime lights from DMSP.
2
3 // Add a band containing image date as years since 1991.
4 function createTimeBand(img) {
5   var year = ee.Date(img.get('system:time_start')).get('year').subtract(1991);
6   return ee.Image(year).byte().addBands(img);
7 }
8
9 // Fit a linear trend to the nighttime lights collection.
10 var collection = ee.ImageCollection('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS')
11   .select('stable_lights')
12   .map(createTimeBand);
13 var fit = collection.reduce(ee.Reducer.linearFit());
  
```

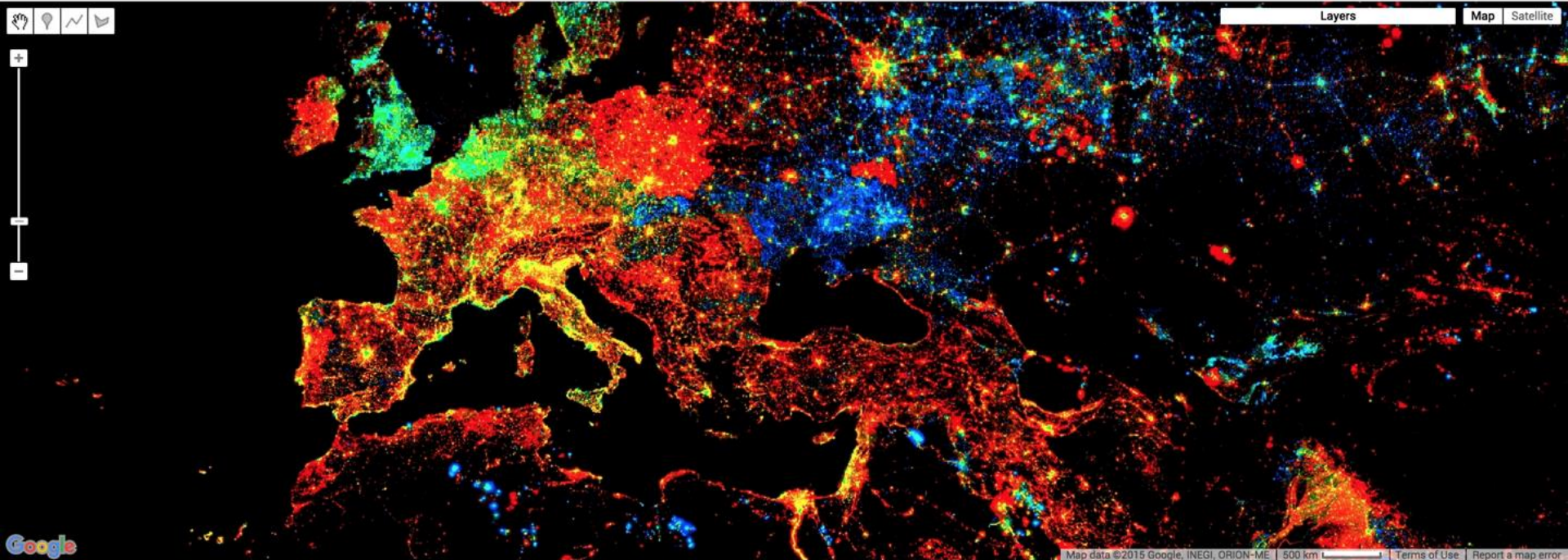
Use print(...) to write to this console.



Layers

Map

Satellite



# High-Resolution Global Maps of 21st-Century Forest Cover Change

M. C. Hansen,<sup>1\*</sup> P. V. Potapov,<sup>1</sup> R. Moore,<sup>2</sup> M. Hancher,<sup>2</sup> S. A. Turubanova,<sup>1</sup> A. Tyukavina,<sup>1</sup> D. Thau,<sup>2</sup> S. V. Stehman,<sup>3</sup> S. J. Goetz,<sup>4</sup> T. R. Loveland,<sup>5</sup> A. Kommareddy,<sup>6</sup> A. Egorov,<sup>6</sup> L. Chini,<sup>1</sup> C. O. Justice,<sup>1</sup> J. R. G. Townshend<sup>1</sup>

15 NOVEMBER 2013 VOL 342 SCIENCE www.sciencemag.org

**654,178**

Landsat  
Scenes

**700**

Terapixels  
of Data

**1,000,000**

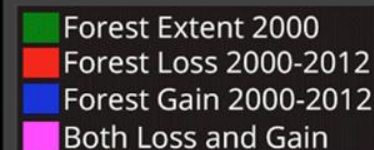
Hours of  
Computation

**10,000**

CPUs  
Used

**4**

Days to  
Complete



[earthenginepartners.appspot.com](http://earthenginepartners.appspot.com)





# Tracking changes and preventing loss in critical tiger habitat

Anup R. Joshi,<sup>1\*</sup> Eric Dinerstein,<sup>2</sup> Eric Wikramanayake,<sup>2</sup> Michael L. Anderson,<sup>2</sup> David Olson,<sup>2</sup> Benjamin S. Jones,<sup>3</sup> John Seidensticker,<sup>2,4</sup> Susan Lumpkin,<sup>2</sup> Matthew C. Hansen,<sup>5</sup> Nigel C. Sizer,<sup>6</sup> Crystal L. Davis,<sup>6</sup> Suzanne Palminteri,<sup>2</sup> Nathan R. Hahn<sup>2</sup>

2016 © The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. Distributed under a Creative Commons Attribution NonCommercial License 4.0 (CC BY-NC). 10.1126/sciadv.1501675

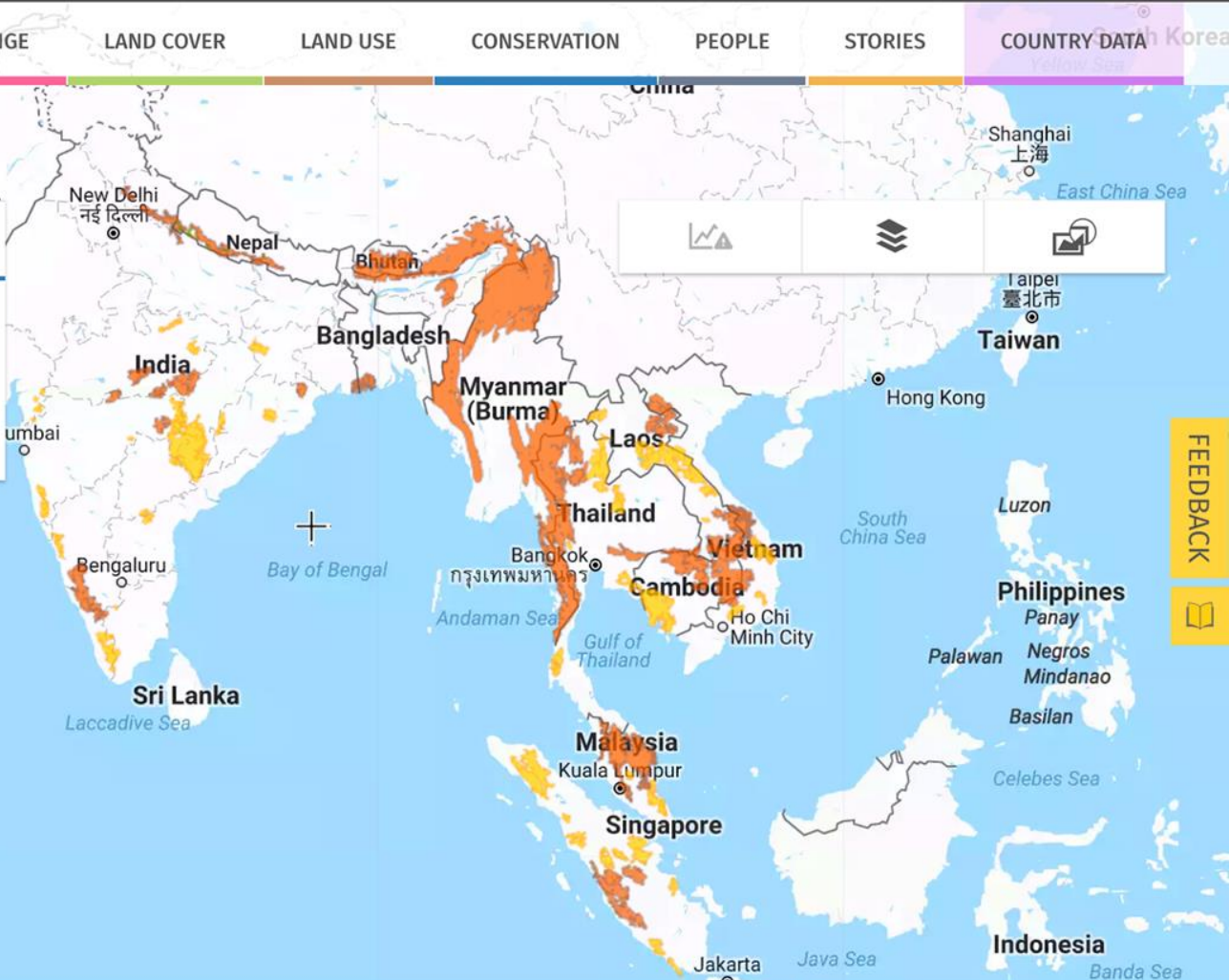
Sci. Adv. 2016;2:e1501675 1 April 2016

*"This study was made possible by free availability of satellite imagery, cloud computing services, and interactive web tools. We were able to analyze 14 years of high-resolution global forest loss data across 76 landscapes that span 13 countries."*



## CONSERVATION

-  Tiger Conservation Landscapes
-  Tiger Conservation Landscapes
-  Tx2 Tiger Conservation Landscapes
-  Terai Arc landscape corridors



Zoom controls: - +

Map interaction icons: Share, Full Screen, Refresh, Search

FEEDBACK



# SOURCEBOOK

UNCBD COP 13



**A SOURCEBOOK OF METHODS AND PROCEDURES FOR  
MONITORING ESSENTIAL BIODIVERSITY VARIABLES IN  
TROPICAL FORESTS WITH REMOTE SENSING**

**GOFC-GOLD**   
Global Observation of Forest and Land Cover Dynamics

**GEO BON**   
Group on Earth Observations  
Biodiversity Observation Network





ELSEVIER

Using  
abundance  
*latifrons*

Michael J.



S

f

# Map-of-Life, habitat suitability modeling



Species Info

Map a Species

Species Lists by Location

About MOL

News

Help

Overview

Habitat Distribution

Habitat Change

Reserve Coverage

Info

Select a species

Pick random

Birds

## Bornean Stubtail *Urosphena whiteheadi*

Learn more

Update

### Habitat Associations ON OFF

Elevation  ON  OFF

900 - 2600 meters



Tree cover:  ON  OFF

75 - 100%



Landcover  ON  OFF

Woodlands

Forests Woody Savannas

Shrublands

Open Closed

Herbaceous

Savannas Grasslands

Cultivated

Cropland Cropland Mosaics

Barren Urban

Barren Urban

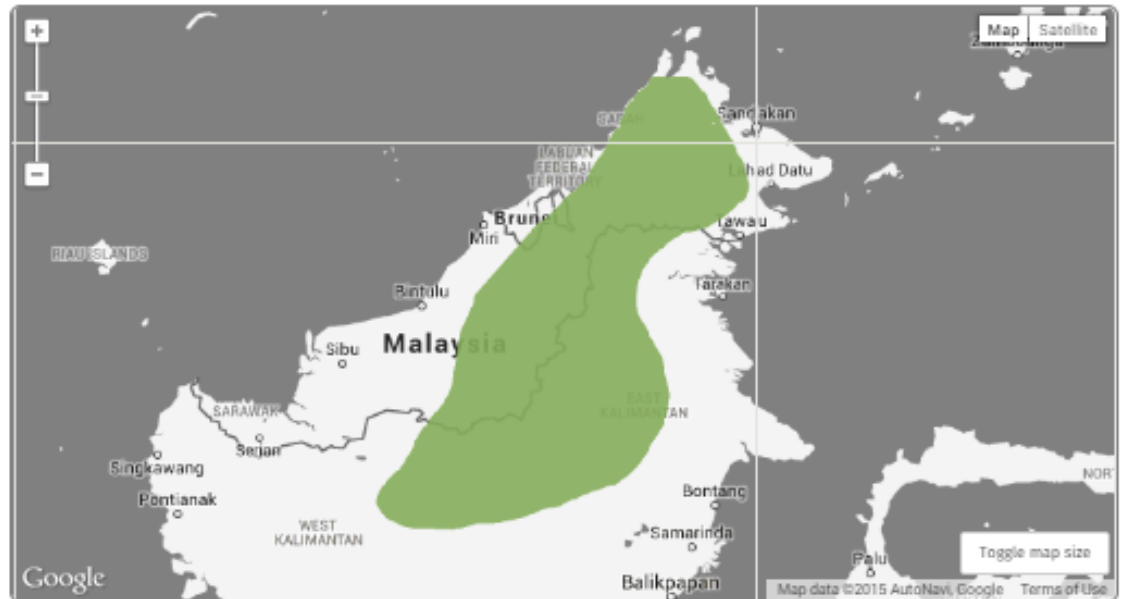
Water

Wetlands Water Bodies

Records outside suitable range

Records in suitable range

Suitable range



# Map-of-Life, habitat suitability modeling



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Forests  Woody Savannas

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Open  Closed

Herbaceous

Savannas  Grasslands

Cultivated

Cropland  Cropland Mosaics

Barren Urban

Barren  Urban

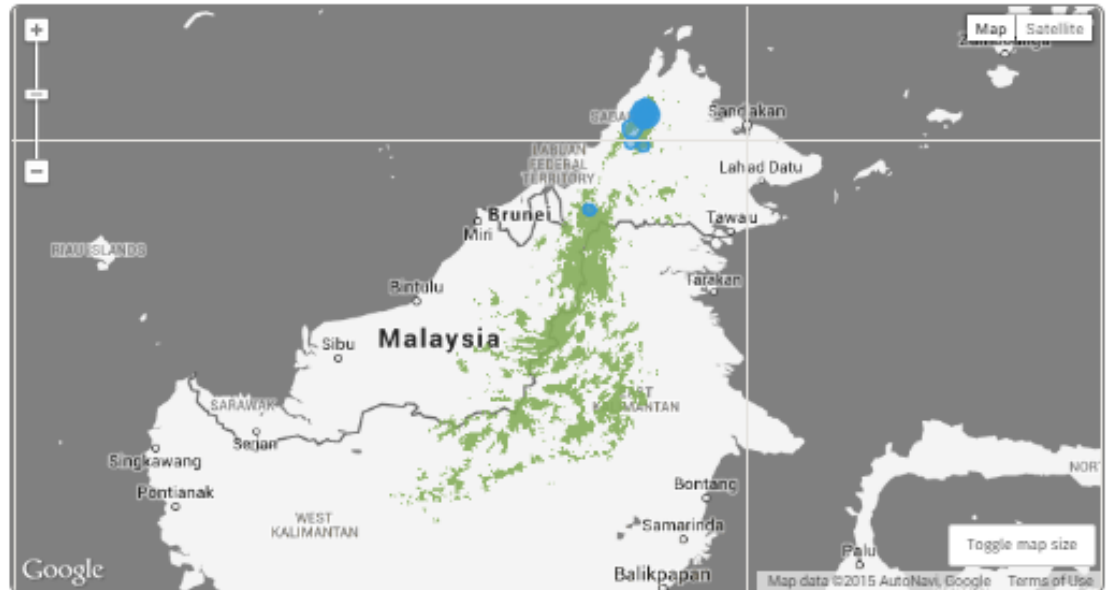
Water

Wetlands  Water Bodies

Records outside suitable range

Records in suitable range

Suitable range



Geographic distribution





Half-Earth is a call-to-action to commit  
half of the planet's surface to nature.

## WHY ONE HALF?



[STORY](#)[EXPLORE](#)[GLOBAL](#)

Species Richness ⓘ

Birds ⏮

Mammals ⏮

Amphibians ⏮

Turtles ⏮

Plants ⏮

Cacti ⏮

Conifers ⏮

Species Rarity ⓘ

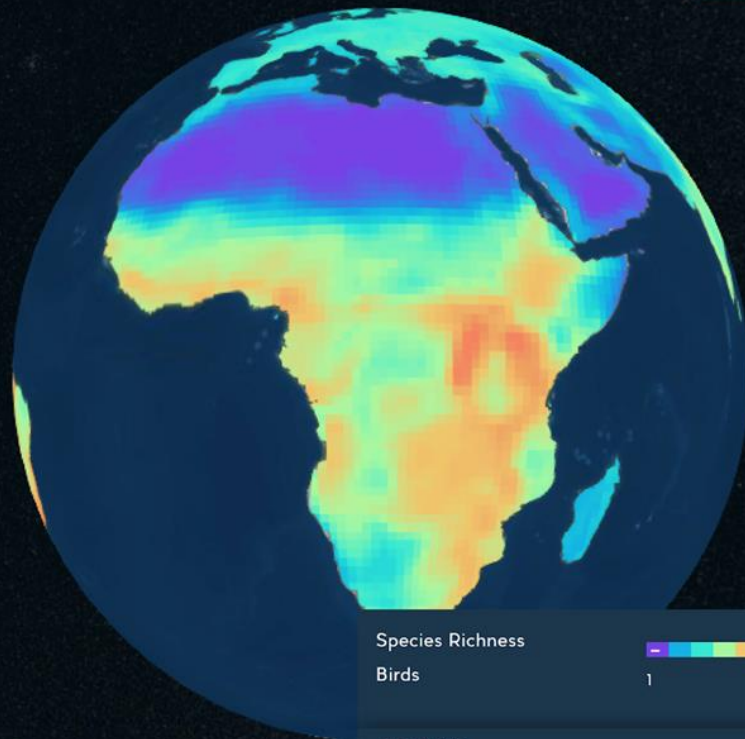
Birds ⏮

Mammals ⏮

Amphibians ⏮

Turtles ⏮

Plants ⏮



Species Richness

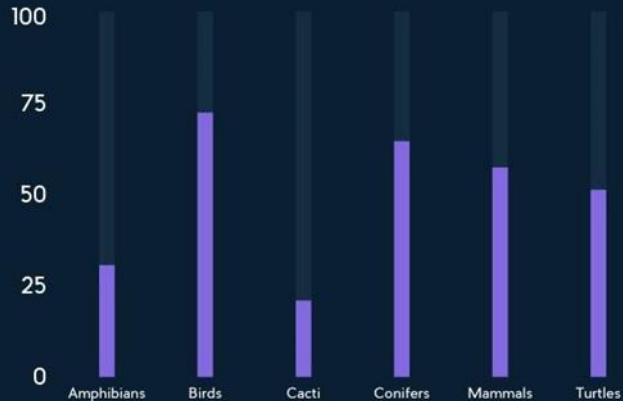
Birds

1 1010

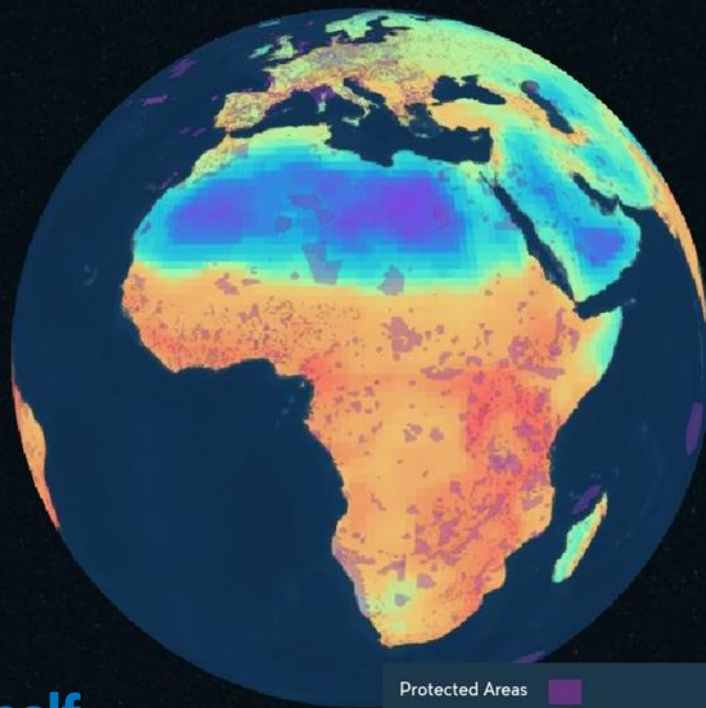
LEGEND

PARTNERS ...

This global **Protected Areas** network plays a key role in the conservation of nature and safeguarding of species. However, by overlaying global species **richness** and **rarity** with the protected areas network, we can see that many species remain insufficiently protected.



■ Percentage of species for which the global protected area network provides sufficient coverage.



PARTNERS ...

Protected Areas

Species Richness

All Taxa

1

1416

LEGEND



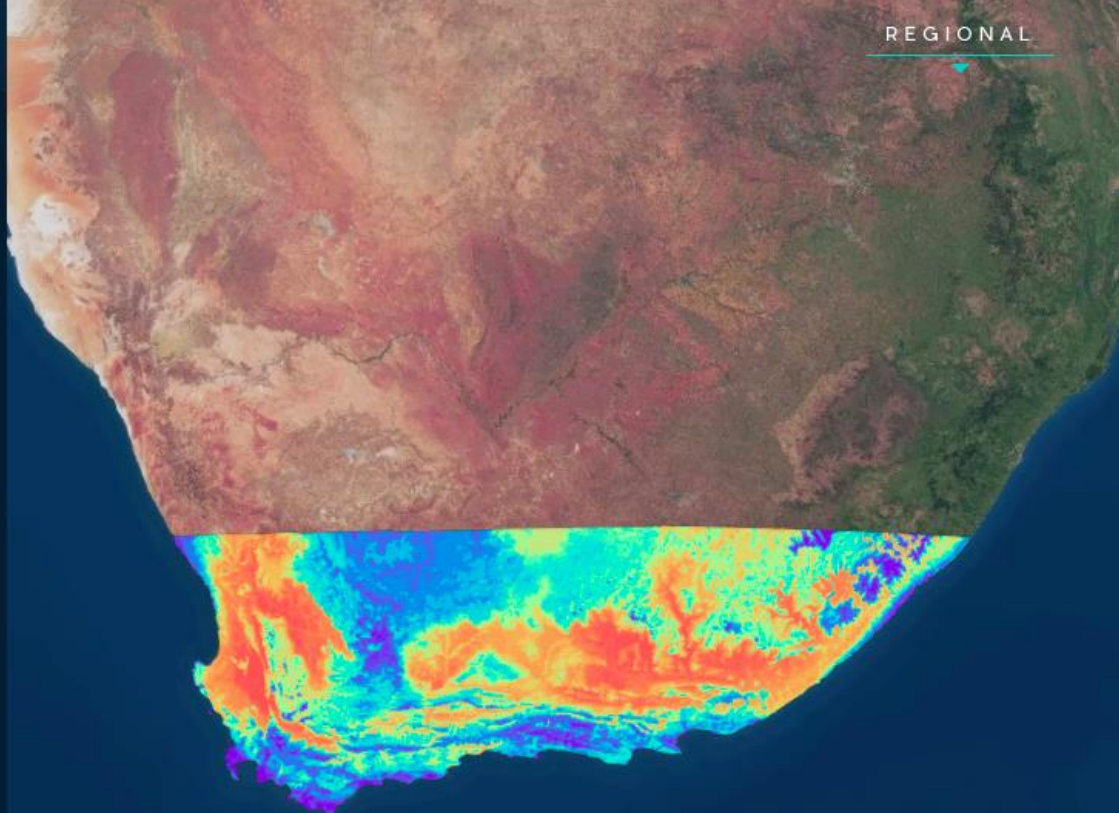


## What does this look like in action?

Here is a first look at the underpinnings of such a detailed map for South Africa's Cape region, a global hotspot of unique and threatened biodiversity.

Using remote sensing data and models, we have mapped the **richness** and **rarity** of **mammals** for every square kilometer in the region. Notice the intricate fine-scale variation in biodiversity patterns that is missed by the coarser-resolution global map.

**Protected Areas** cover ca. 15% of this region and have been instrumental for the conservation of its unique flora and fauna. While the regional governments and institutions are dedicated to safeguarding this heritage, many key areas remain unprotected.



PARTNERS ...

Species Richness

Mammals

8

49

LEGEND

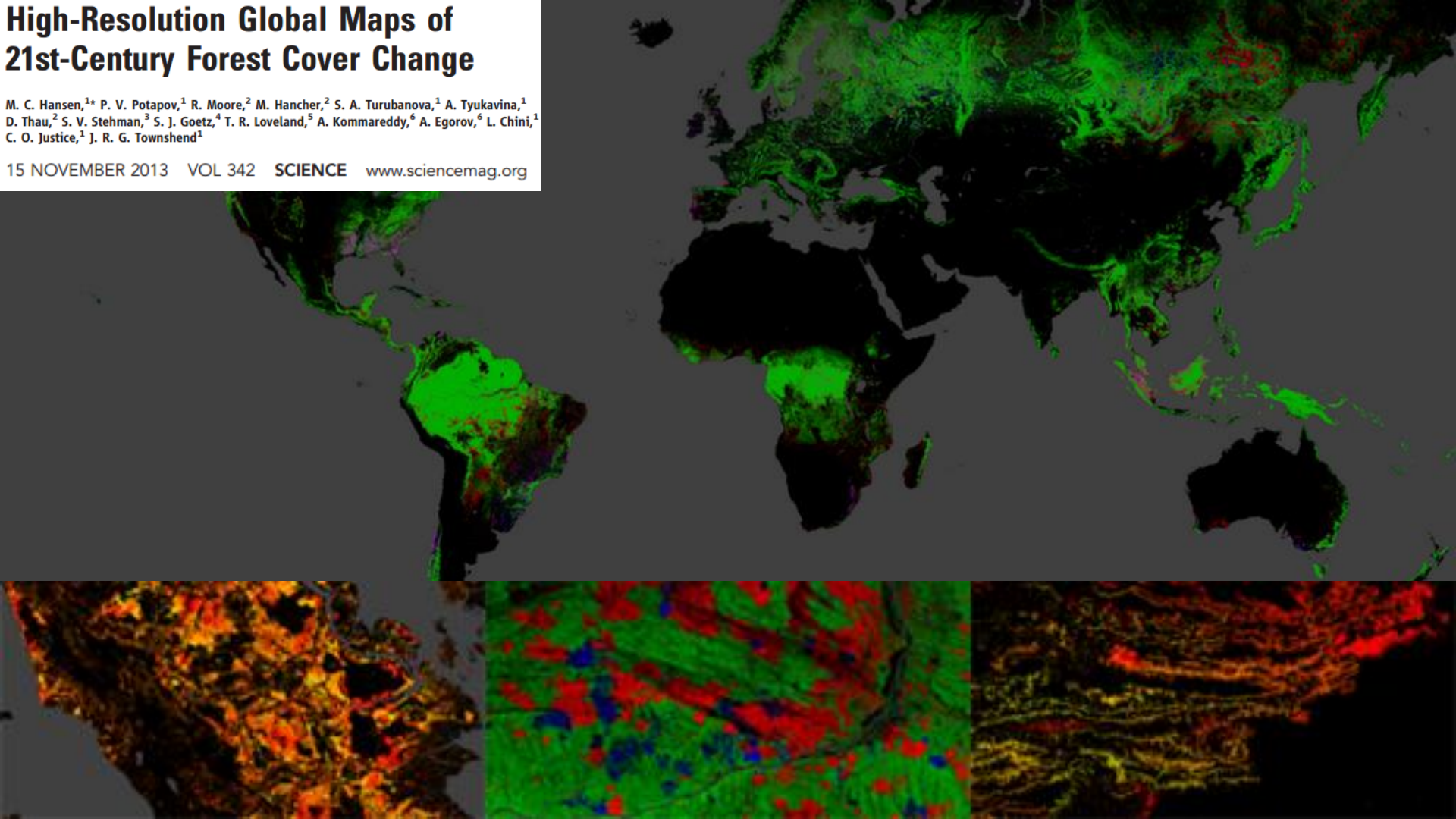
Speed



# High-Resolution Global Maps of 21st-Century Forest Cover Change

M. C. Hansen,<sup>1\*</sup> P. V. Potapov,<sup>1</sup> R. Moore,<sup>2</sup> M. Hancher,<sup>2</sup> S. A. Turubanova,<sup>1</sup> A. Tyukavina,<sup>1</sup>  
D. Thau,<sup>2</sup> S. V. Stehman,<sup>3</sup> S. J. Goetz,<sup>4</sup> T. R. Loveland,<sup>5</sup> A. Kommareddy,<sup>6</sup> A. Egorov,<sup>6</sup> L. Chini,<sup>1</sup>  
C. O. Justice,<sup>1</sup> J. R. G. Townshend<sup>1</sup>

15 NOVEMBER 2013 VOL 342 SCIENCE www.sciencemag.org





**GLOBAL  
FOREST  
WATCH**



The potential of machine learning to dramatically improve processing of images for conservation is being explored by ZSL's Conservation technology team.

Zebra 96%

Giraffe 93%

Bird 76%

Giraffe 88%



## ZSL puts machine learning to work on studying camera trap data

 By [Jessica Twentyman](#) February 2, 2018

**SUMMARY:** Conservation charity ZSL is working with Google to develop models that identify wildlife species from image data captured in the wild.

# Collaboration







10,279,172

Observations to Date

SIGN UP



EXPLORE



BJ Stacey ~ Shark Eye Snail from Essex County, Massachusetts, USA

## How It Works



Scripts | Assets

Enter scripts...

+ New repository

- Owner (7)
- Writer (4)
- Reader (7)
  - users/csadams/S4G\_Public\_I...
  - users/csadams/S4Gbeta\_test
  - users/gorelick/EE101-ZRH
    - 01\_hello\_world.js
    - 02\_javascript.js
    - 03\_hello\_image.js
    - 04\_style\_an\_image.js
    - 05\_filter\_a\_collection.js
    - 06\_style\_a\_collection

Get Link

Run

Reset

Linked Maps

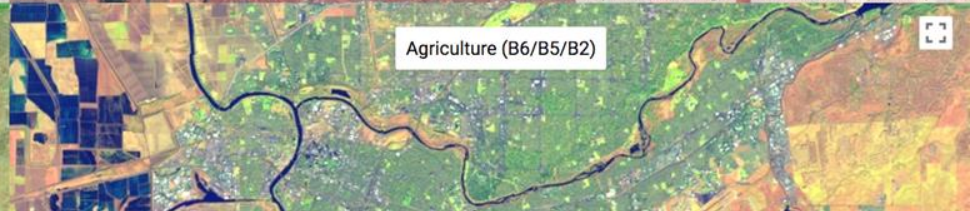
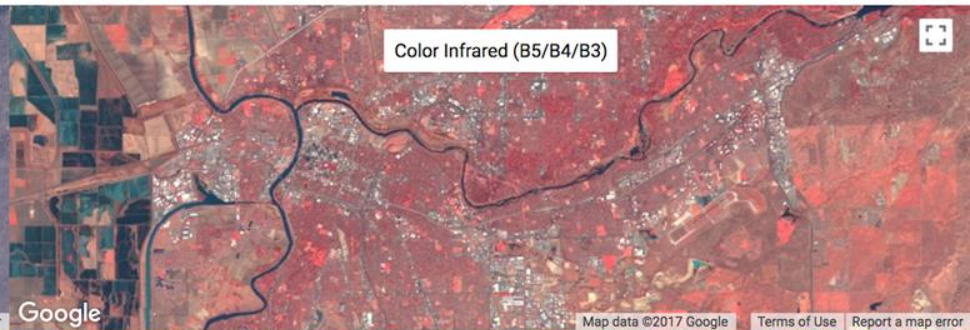
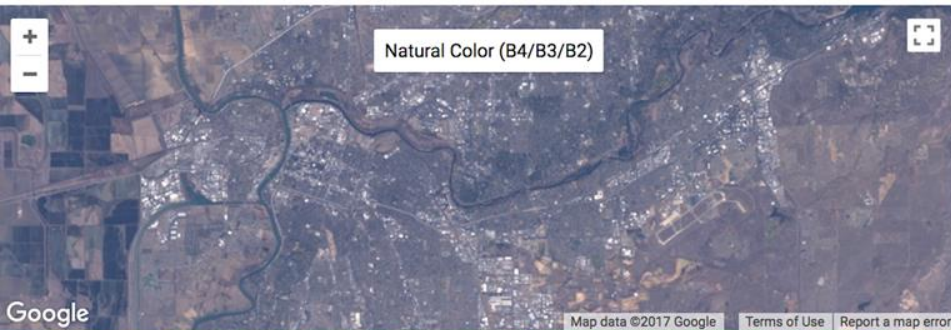
```

1 // Display a grid of linked maps, each with a different visualization.
2
3 var image = ee.Image('LANDSAT/LC8_L1T_ANNUAL_TOA/2013');
4
5 var NAMES = [
6   'Natural Color (B4/B3/B2)',
7   'Shortwave IR (B7/B5/B4)',
8   'Color Infrared (B5/B4/B3)',
9   'Agriculture (B6/B5/B2)'
10 ];
11
12 var VIS_PARAMS = [
13   {gamma: 1.3, min: 0, max: 0.3, bands: ['B4', 'B3', 'B2']},
14   {gamma: 1.3, min: 0, max: 0.3, bands: ['B7', 'B5', 'B4']},
15   {gamma: 1.3, min: 0, max: 0.3, bands: ['B5', 'B4', 'B3']},
16   {gamma: 1.3, min: 0, max: 0.3, bands: ['B6', 'B5', 'B2']}
17 ];
18
    
```

Inspector Console Tasks

Use print(...) to write to this console.

### 2013 Landsat 8 TOA Visualizations

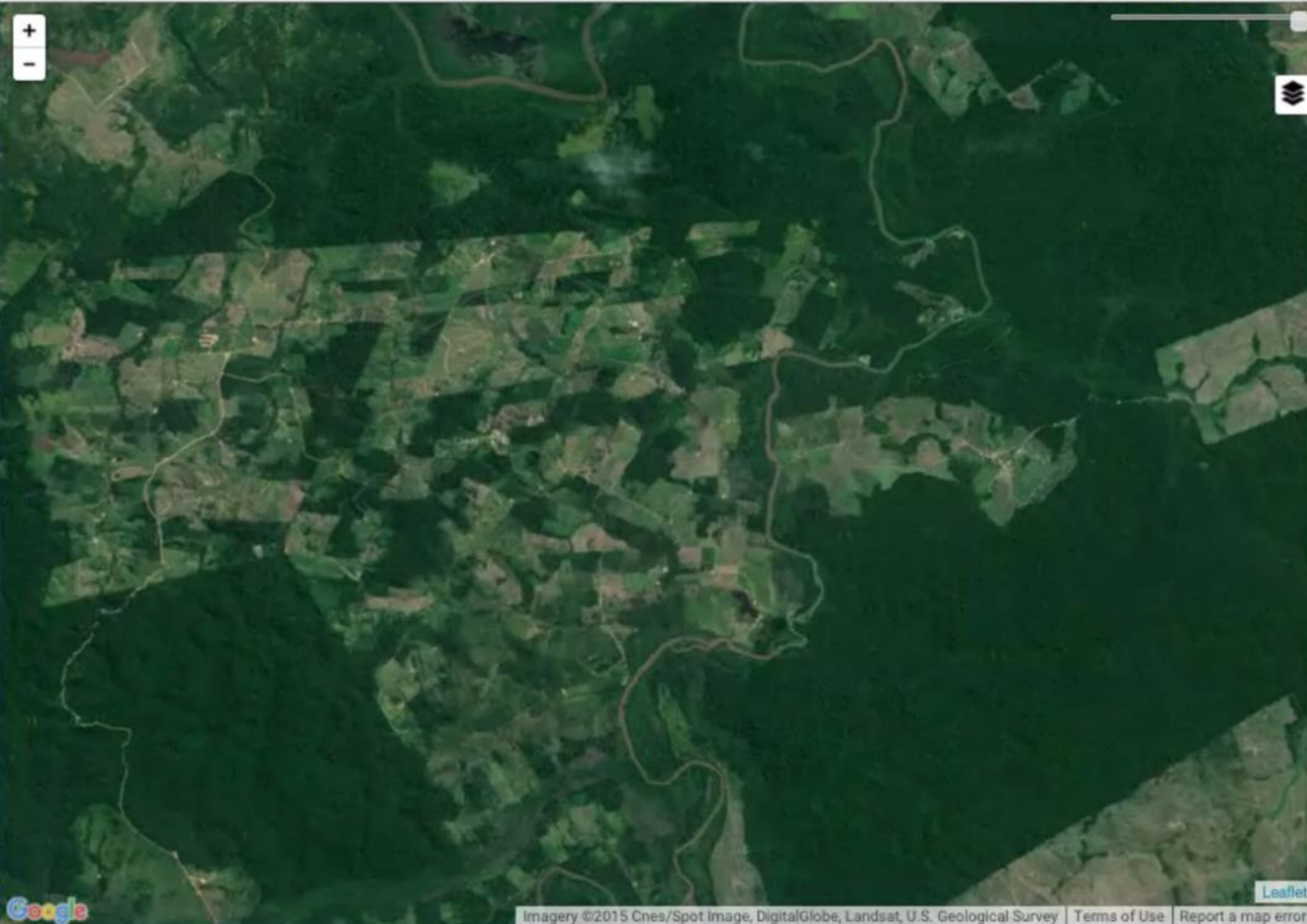




# MapBiomas - collaboration of 77 land cover / land use experts across Brazil







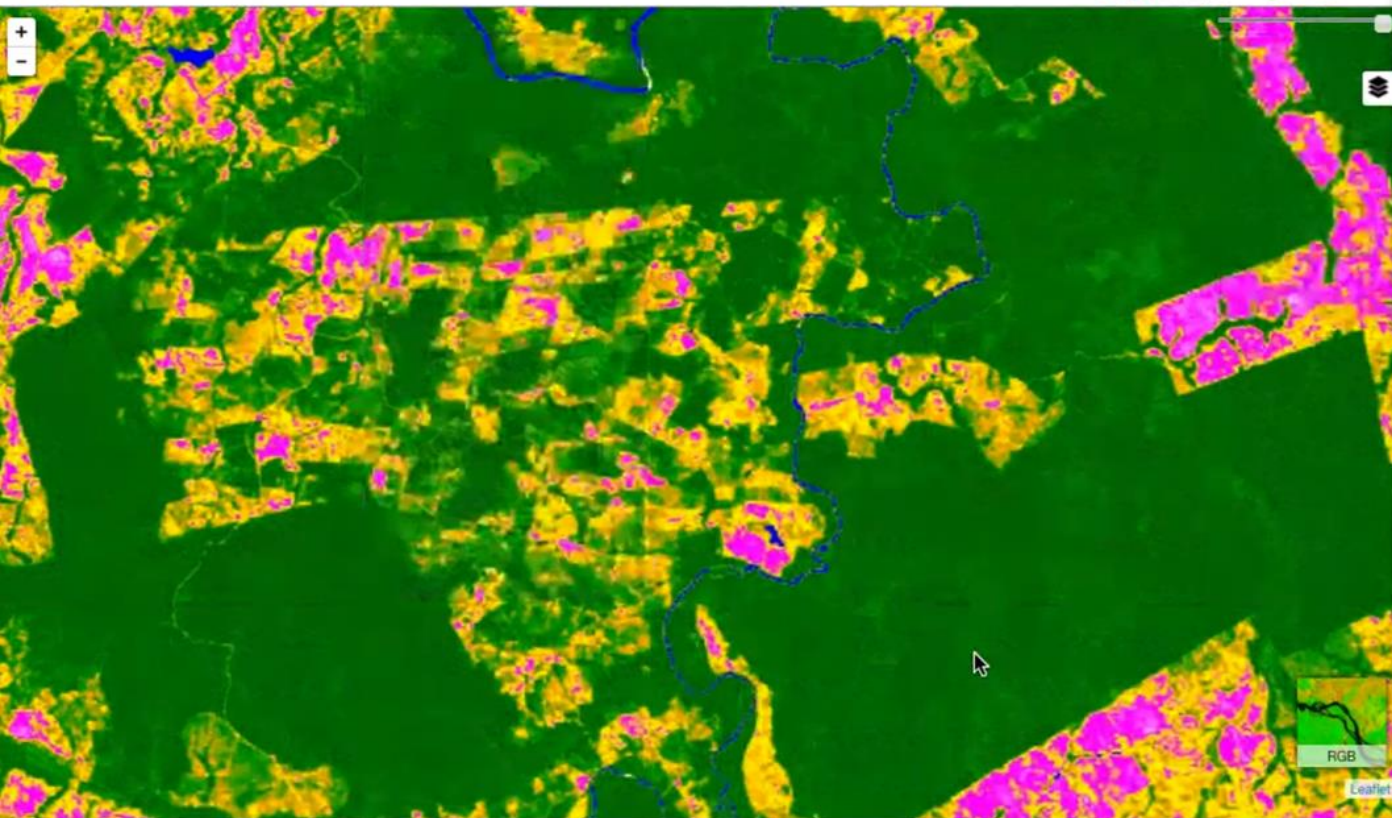
Leaflet | Map data © OpenStreetMap contributors



Imagery ©2015 Cnes/Spot Image, DigitalGlobe, Landsat, U.S. Geological Survey | Terms of Use | Report a map error



Imagery ©2015 TerraMetrics | Terms of Use | Report a map error



SB-22-X-C

Período

Ano

2008



5/31/2008



10/30/2008

Cobertura de nuvem



Sensor

Landsat5

GVS (v1)

GV (v2)

NDFI (v3)

NDFI (v4)

75

55

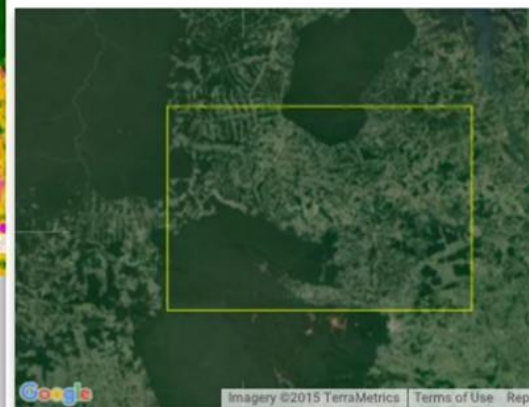
180

190

ELEVACÃO

SALVAR

SALVAR

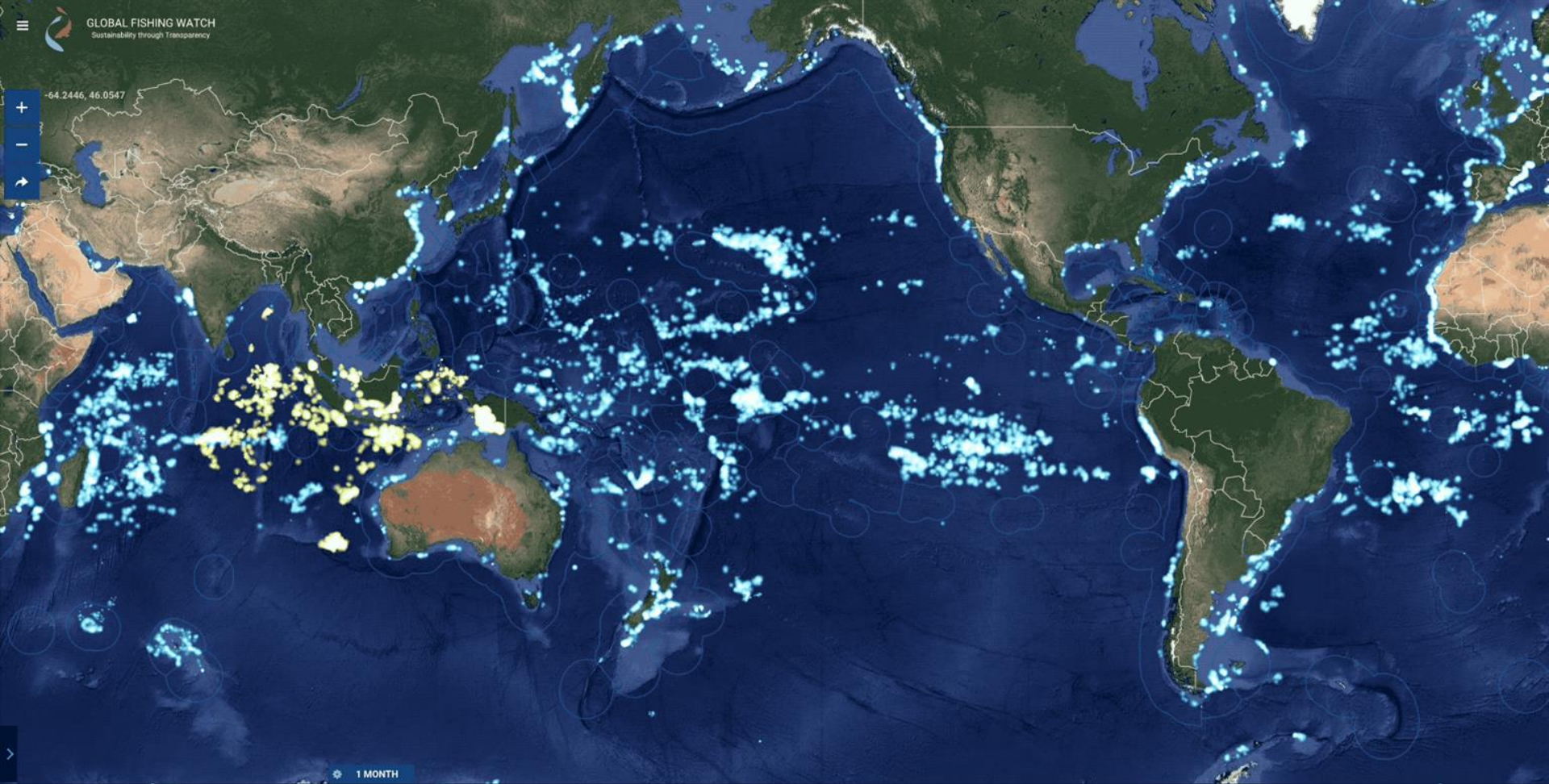


Impact





-64.2446, 46.0547



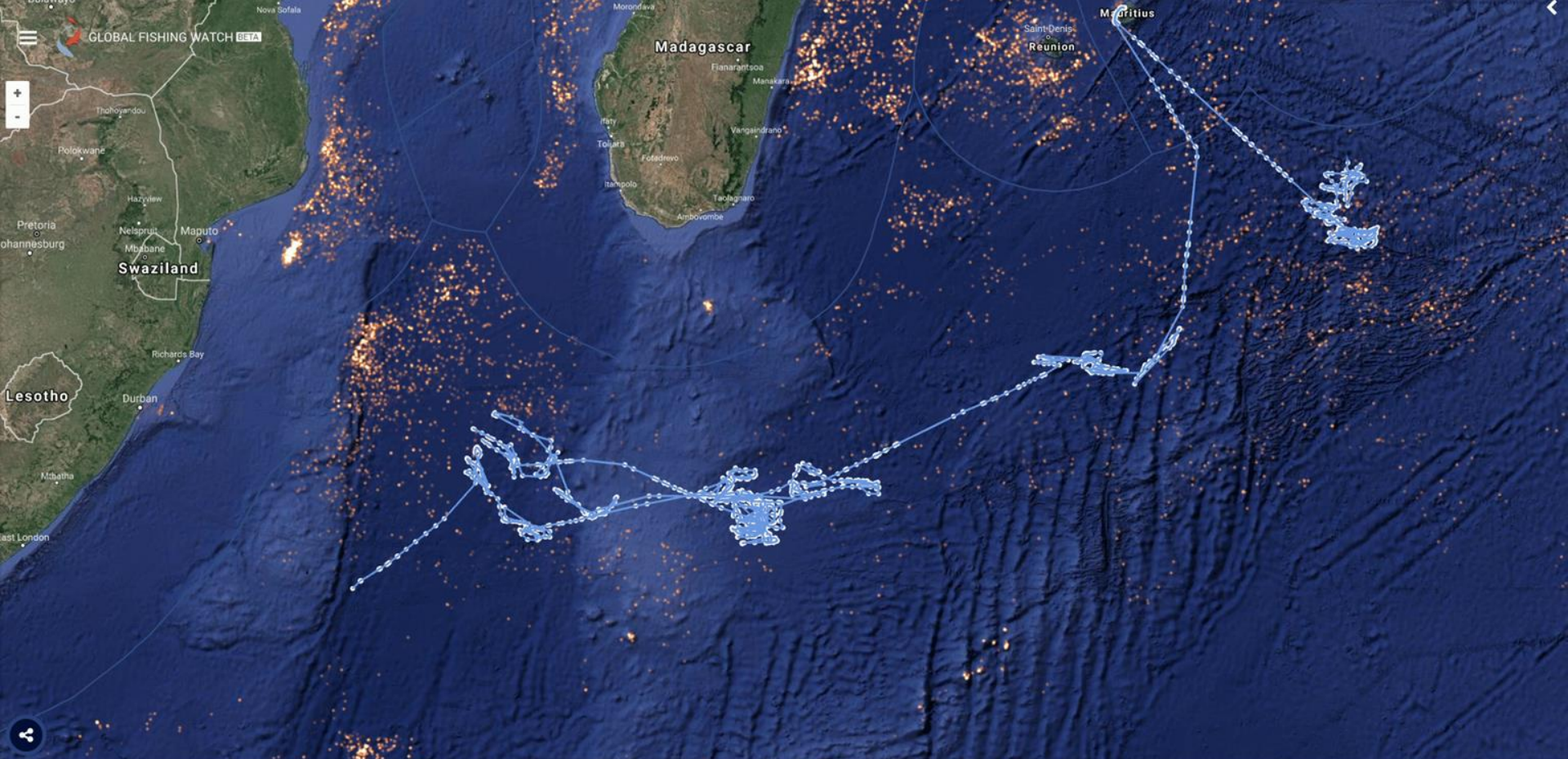
1 MONTH











GLOBAL FISHING WATCH BETA

Madagascar

Mauritius  
Reunion

Swaziland

Lesotho

12 NOV 2013

+ -

10 FEB 2014



CT

NOV

DEC

JAN

FEB

MAR

2014

90 days

-39.6226, 27.9053



# Thousands of sharks found on boat in huge illegal haul

The confiscation of the Chinese ship and arrest of its 20 crew in the Galapágos show just how hard it is to protect marine sanctuaries.

**\$6M**

Fine on Chinese Transshipment Vessel



Satellite

GLOBAL FISHING WATCH

Feedback

# Kiribati & PIPA

Provided evidence to help the Kiribati government prosecute the first case of illegal fishing in PIPA.

Resulted in a \$2.2M fine (~1% of the country's GDP)

Layers

- MPA
- EEZ
- Bathymetry
- Fishing Effort
- Vessel Track

Vessel Information

|          |                  |
|----------|------------------|
| Name     | MARSHALLS203     |
| Class    | —                |
| Flag     | Marshall islands |
| IMO      | 9587544          |
| MMSI     | 538060018        |
| Callsign | V7TX4            |



Timeline navigation: 22 MAY 2015 to 21 JUL 2015 (60 days)

Month selection: MAY | JUN | JUL | AUG

Map controls: Home, Refresh, Play/Pause

Map data ©2016 Google Imagery ©2016 TerraMetrics | Terms of Use



## FOREST CHANGE

- Tree cover gain
- Tree cover loss

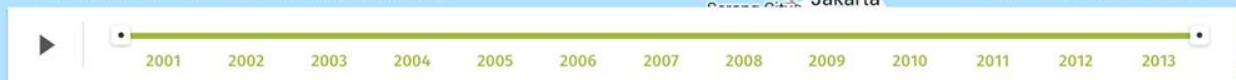
Displaying loss with **> 30 %** canopy density.

Tree cover loss is not always deforestation. ?

# globalforestwatch.org



Tree cover loss (zoom in for most accurate viewing)



View country data

SELECT COUNTRY



## FOREST CHANGE

- Tree cover gain
- Tree cover loss

Displaying loss with **> 30 %** canopy density.

Tree cover loss is not always deforestation. ?

# globalforestwatch.org



Tree cover loss (zoom in for most accurate viewing)



Map interface sidebar with icons for search, draw shape, country/region, other data layers, and a data summary panel.

TOTAL SELECTED AREA  
**27,746,793 ha**

LOSS 2001-2013 with >30% canopy density  
**3,754,595 ha**

GAIN 2001-2012  
**2,016,743 ha**

This algorithm approximates the results by sampling the selected area. Results are more accurate at closer zoom levels.

# Indonesia Govt UKP4 utilizing GFW in law enforcement

Convening 7 Head of Provincial Police Force (1/2)...evidence, evidence, evidence evidence



## UKP4 dan 7 Kapolda Koordinasi Penanggulangan Kebakaran Hutan

Sabtu, 20 Desember 2014 10:46 WIB

Vina P Setyorini



Jakarta (Antara Kalbar) - Unit Kerja Presiden Bidang Pengawasan dan Pengendalian Pembangunan bersama Badan Pengelola REDD+ koordinasi dengan tujuh kepala kepolisian daerah yang di wilayah hukumnya terjadi kebakaran hutan dan lahan.

"Kenapa tujuh Kapolda yang diundang? Karena di wilayah mereka sekarang terdapat titik api, yang jika koordinasi cepat dilakukan masalah lebih besar bisa ditanggulangi," kata Deputi VI Unit Kerja Presiden Bidang Pengawasan dan Pengendalian Pembangunan (UKP4) bidang Penegakan Hukum Mas Achmad Santosa kepada wartawan di Jakarta, Jumat (19/12).

kebakaran hutan di Riau mengakibatkan kabut asap.

Tujuh kepala kepolisian daerah itu adalah Kapolda Kalimantan Barat Brigjen Pol Anief Sulistyanto, Kapolda



FOREST CHANGE

Tree cover gain

Tree cover loss

Displaying loss with  canopy density.

Tree cover loss is not always deforestation.

LAND COVER

Intact Forest Landscapes

Intact Forest Landscapes

Reduction in extent 2000-2013

[Deforestation in Peru by a company called United Cacao was revealed](#) using GFW's monitoring systems.



Tree cover loss (zoom in for most accurate viewing)

Lat/long: -3.979459, -73.065723



FEEDBACK





# Questions:

What would we need for global biodiversity watch? It's definitely more complicated than forests and fishing vessels.

Or, is that even useful? How about invasive species watch? Global Habitat Watch? Global Phylogeny Watch?

Is Half Earth a useful guiding principle for biodiversity and conservation?

A satellite-style map of the world, showing continents and oceans. The word "Thanks!" is overlaid in large, bold, white text in the center of the image. The map uses a color palette of blues for the oceans, greens and browns for the continents, and a white bar at the bottom with segments of blue, red, yellow, and green.

**Thanks!**