


Act Green

A near-real time integrated mapping and reporting system for re-wilding efforts:
extending a model from tigers (*Panthera tigris*) to lions (*Panthera leo*), jaguars
(*Panthera onca*), and American bison (*Bison bison*)

Haqiq Rahmani, Luke Hunter, Elizabeth Bennett, Nathaniel Robinson,, Jamie Sanderlin, and Charles Yackulic

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Ecological Forecasting



The background of the slide is a collage of three large, semi-transparent images of animals. On the left is a leopard with its mouth open, showing its tongue. In the center is a bison looking forward. On the right is a lion with a large mane, resting on a sandy surface. The text is overlaid on a white semi-transparent rectangle in the upper half of the slide.

There has broad collaboration from many countries, individuals, and institutions

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Program: Laura Rogers (NASA), Keith Gaddis (NASA), Woody Turner (NASA)

- In an era of rapid and surprising changes
- increasing human influence
- conservation science is moving at the pace of a tortoise
- World is moving faster
- Conservation science needs to go faster too



Human Footprint

Population density
Land use / land cover

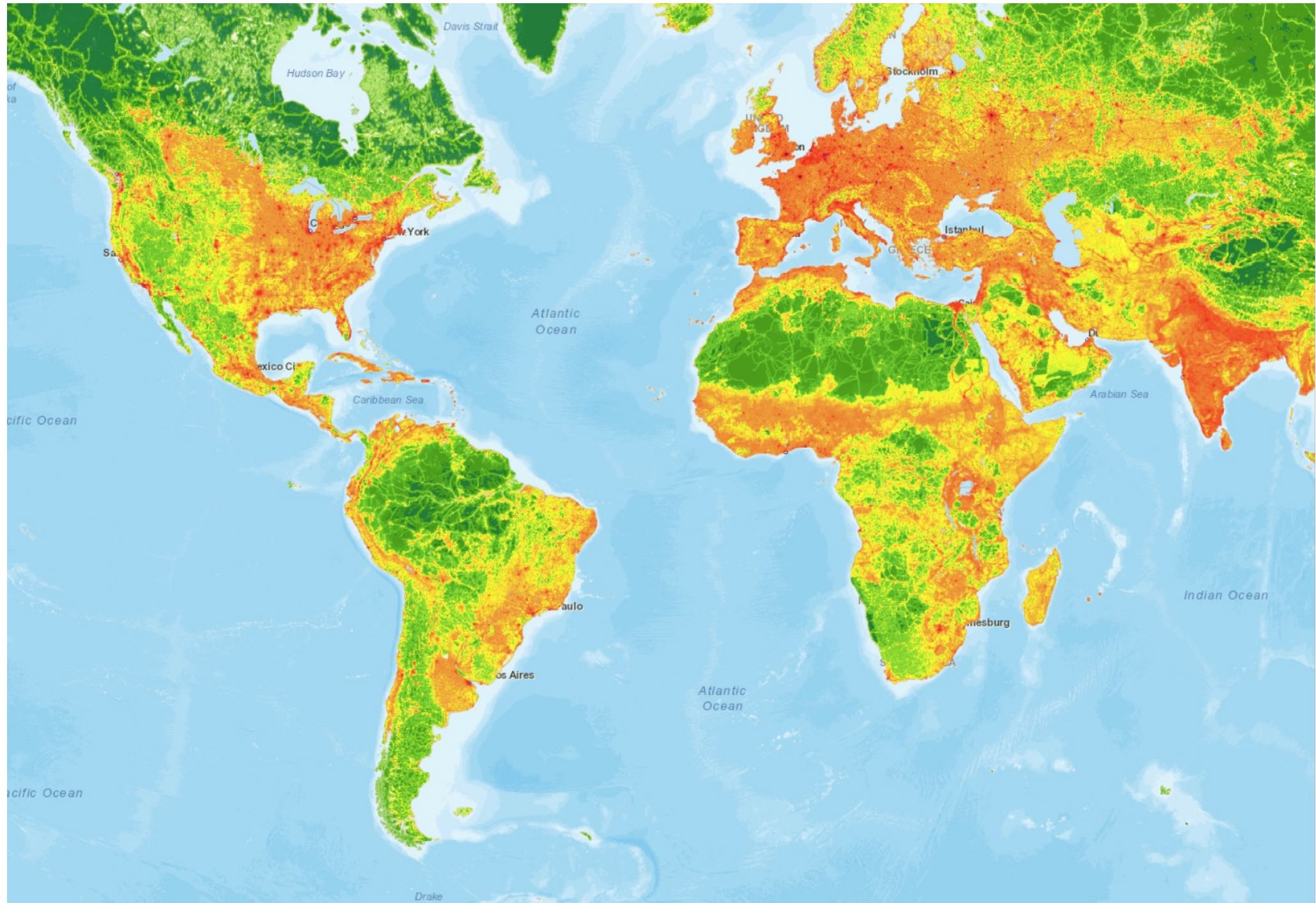
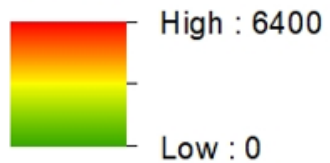
Infrastructure
Structures
Roads
Railways

Accessibility
Populated coasts
Navigable Waters
Roads

Nighttime lights

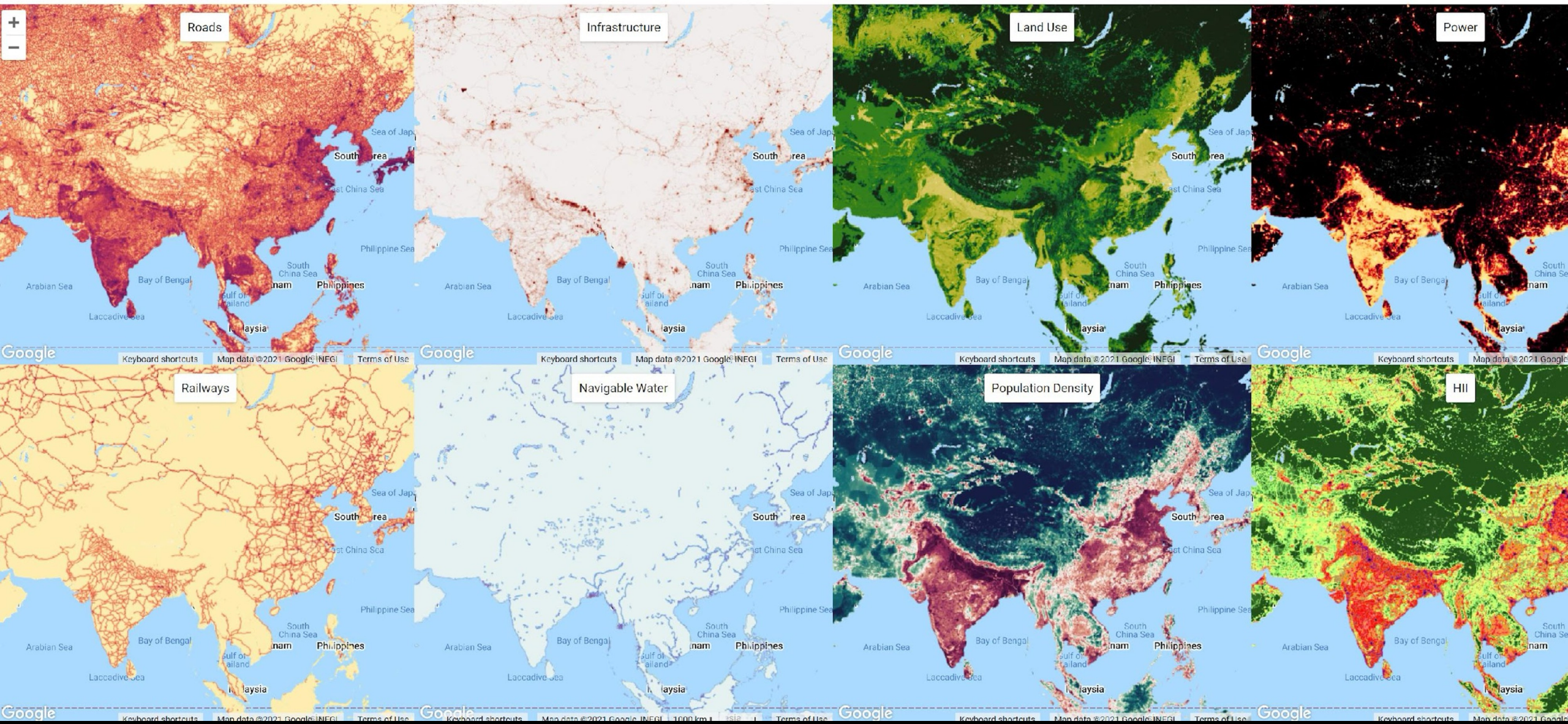
HII 2020-01-01

Value



HII Driver Visualization

2020



Act Green application

will help end-users develop Species Conservation Landscapes to:

- allocate time and effort
- identify and quantify opportunities for reintroduction efforts
- identify study locations to understand species effects on ecosystem functions/services
- Measure the effectiveness for rewilding efforts, documenting success or failure

Primary end-users

is a consortium of leading international organizations

- Wildlife Conservation Society (WCS)
- World Wildlife Fund (WWF)
- the International Union for Conservation of Nature (IUCN)
- Panthera



Google Earth Engine

Analytical steps

Indigenous range map – defines area of interest (AOI)

Time frame of the analysis – defines length of time series

Structural habitat

- What defines habitat?
- What remotely sensed / other inputs can be used to make those maps?

Effective potential habitat

- How are human beings interacting with the species?
- Where are the human beings?

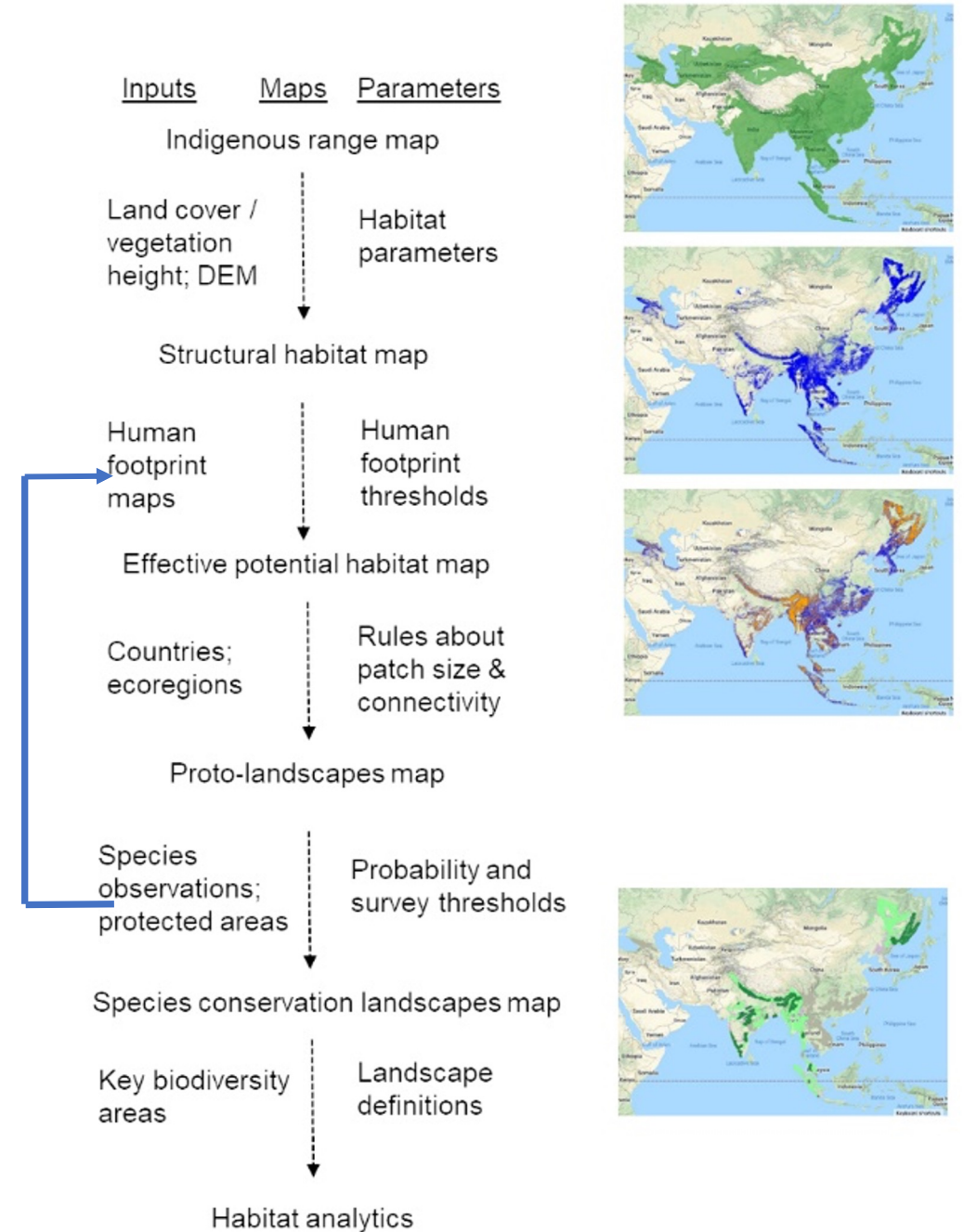
Patch size and connectivity

- What is a minimum patch size to be relevant to this species?
- What distances can be so easily crossed for two patches to be considered connected?

Species observations

- Where and when was the species surveyed?
- Where was it observed?

Figure 1. Schematic diagram of the species conservation landscape process.




Structural Habitat

land use/land cover classes below the elevation cutoff where lion is typically found

– essential habitat types with sufficient cover for the species to hunt and raise cubs

Indigenous range

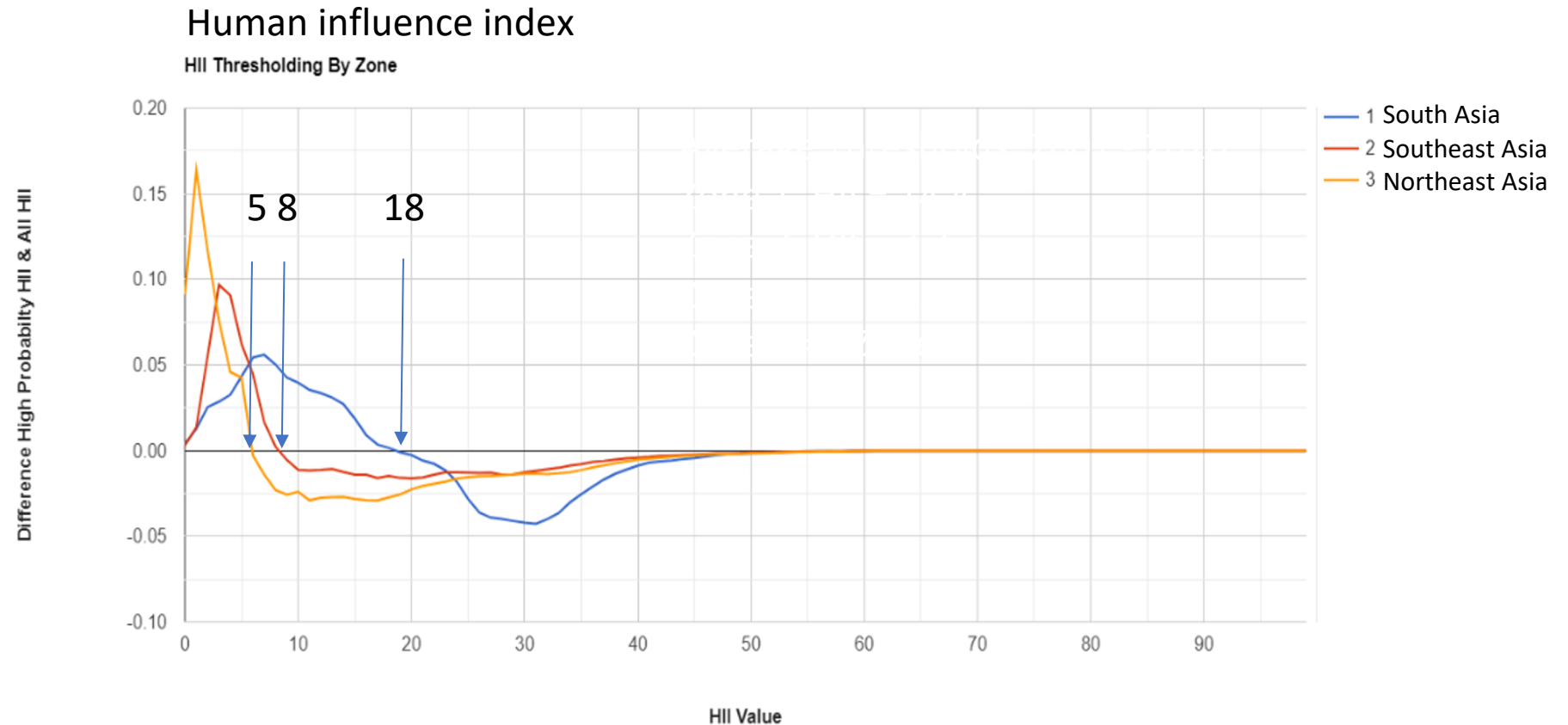
 Structural habitat

-  developed based on:
- relevant ESA land cover types
 - elevation \leq 4200 meter



Social tolerance for species

1. Measure HII of positive observations
2. Sample HII in zone without regard to locations
3. Calculate the frequency histogram of HII values for 1. and 2.
4. Subtract the two histograms
5. Find first value where difference crosses 0

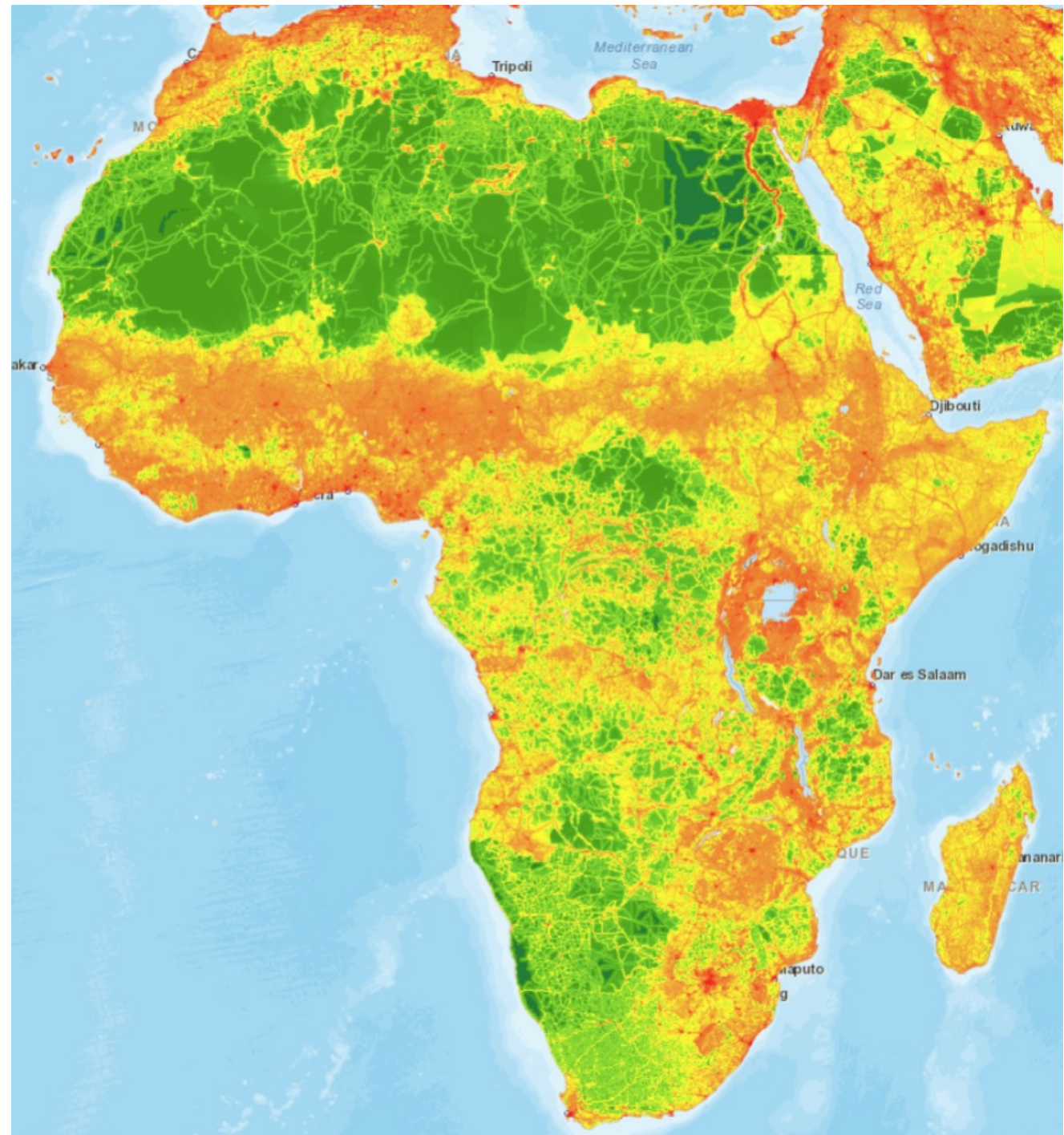


Ever increase human influence

impacting:




- **wildlife**
- **and habitat**

Human/wildlife interaction



Effective potential habitat

areas most likely harboring the species because threats from human activities are lower

-  Indigenous range
-  Structural habitat
-  Effective potential habitat

used Human footprint threshold value ≤ 5
a measure of human influence on the species habitat.



Structural habitat

a satellite view of what looks like habitat for a species;

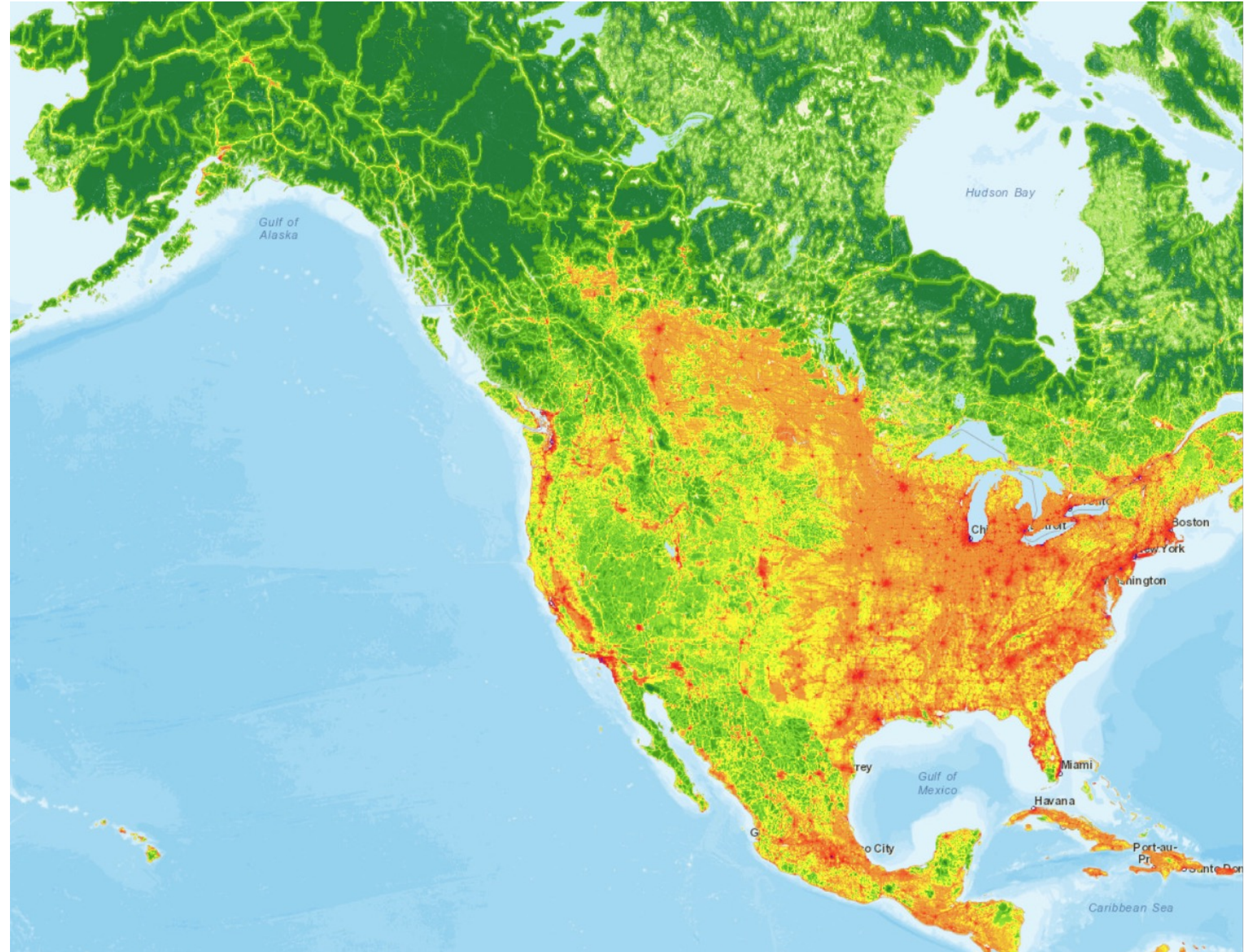
- Indigenous range (Sanderson et al 2008)
- Structural habitat: developed based on
 - relevant ESA land cover types
 - elevation < 3000 meter



Ever increase human influence




- **wildlife**
- **and habitat**

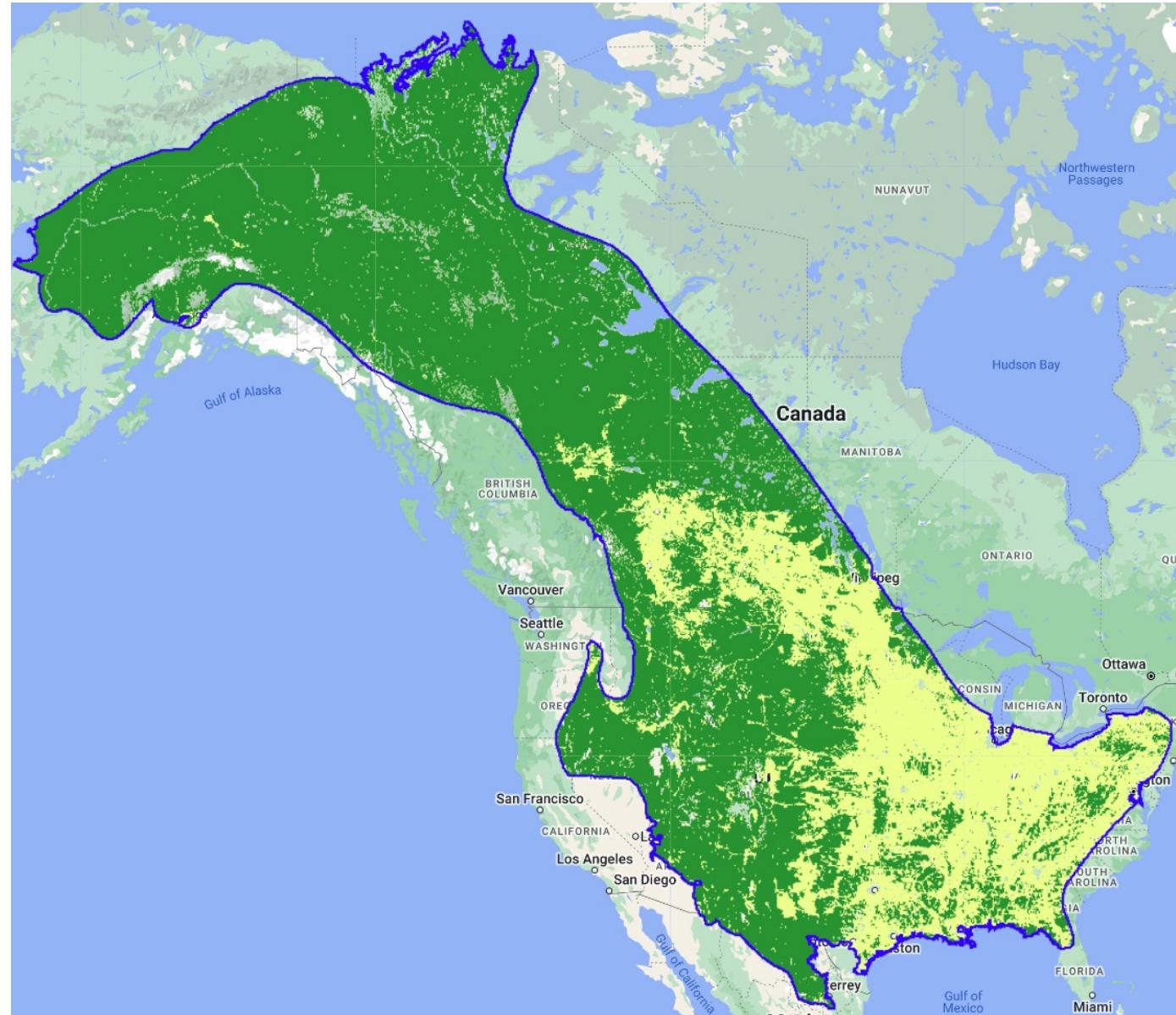
Human/wildlife interaction



Effective potential habitat

is developed by masking structural habitat map based on the Human Footprint Impact and the social tolerance for the species

-  Indigenous range
-  Structural habitat
-  Effective potential habitat



Structural habitat

land use/land cover classes below the elevation cutoff where jaguar is typically found

– essential habitat types with sufficient cover for the species to hunt and raise cubs

 Structural habitat

developed based on:

- relevant ESA land cover types
- elevation:

zone1 \leq 2800m

zone2 \leq 2200m

 excluded (non-habitat)

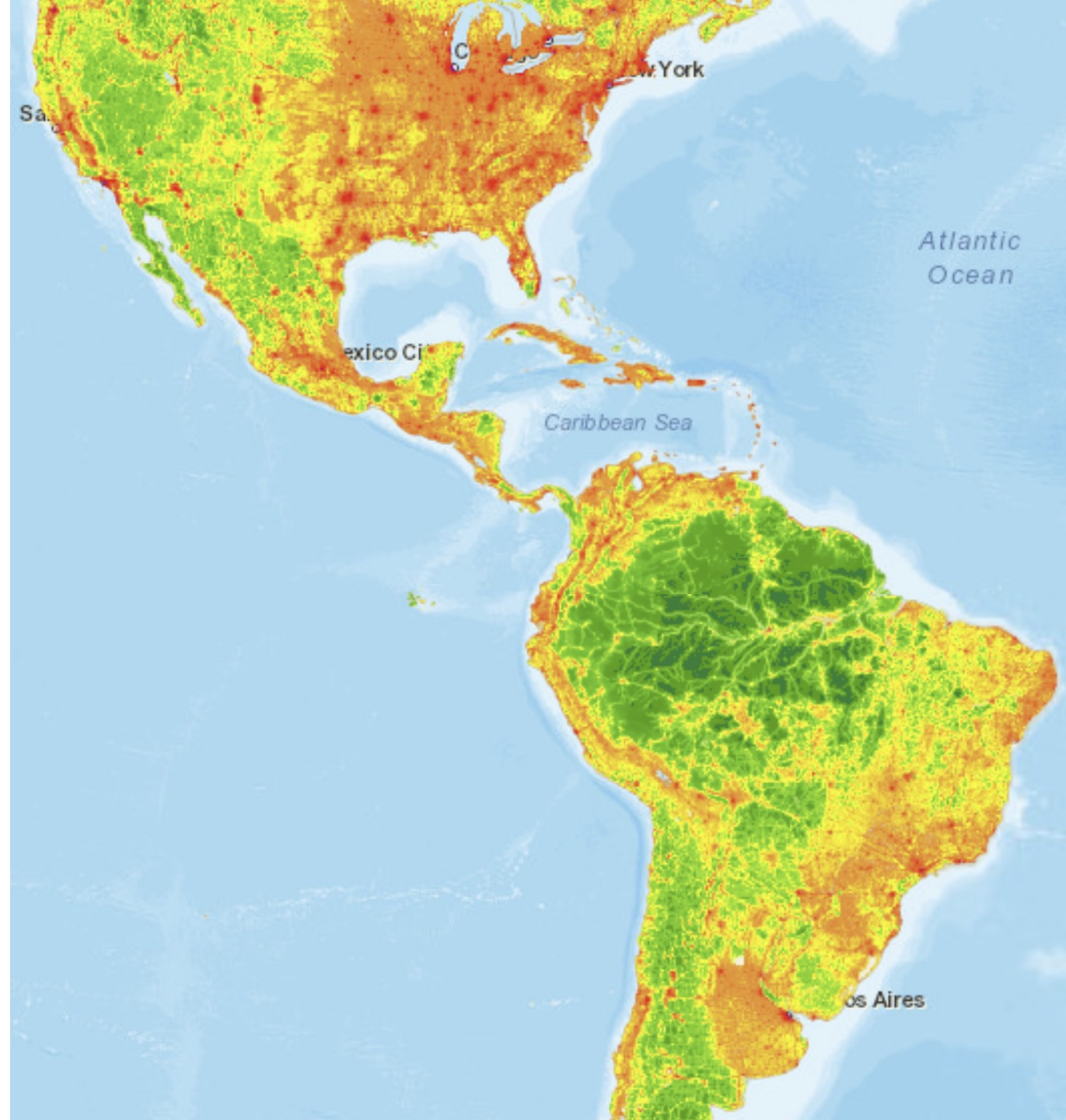


With ever increasing human influence

impacting:

- **wildlife**
- **and habitat**

Human/wildlife interaction



Effective potential habitat

areas most likely harboring the species because threats from human activities are lower

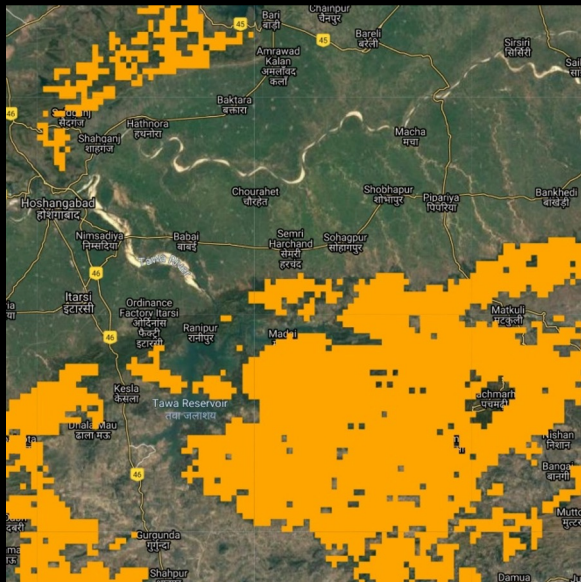
- Indigenous range
- Structural habitat
- Effective potential habitat

human footprint threshold values:

zone1 ≤ 5
zone2 ≤ 4



Landscape delineation



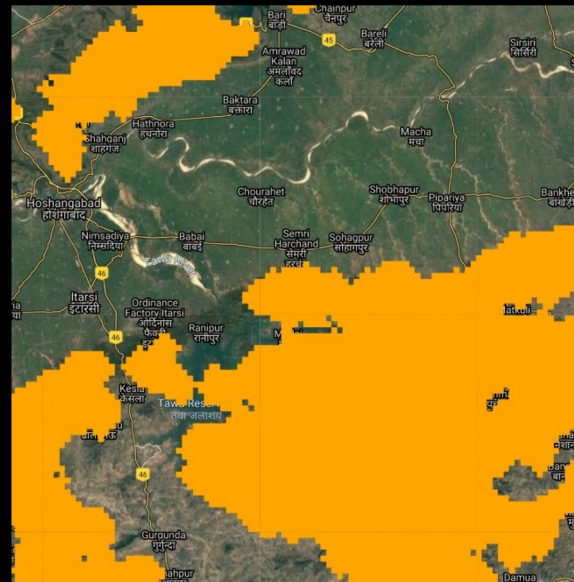
Potential effective habitat

Core patch size (large enough for ≥ 5 tigers, depending on ecoregion)

Stepping stone patch size (1/10 of core)



Connectivity (within 4 km of another habitat patch)



Potential Landscapes

Segment by state or province*



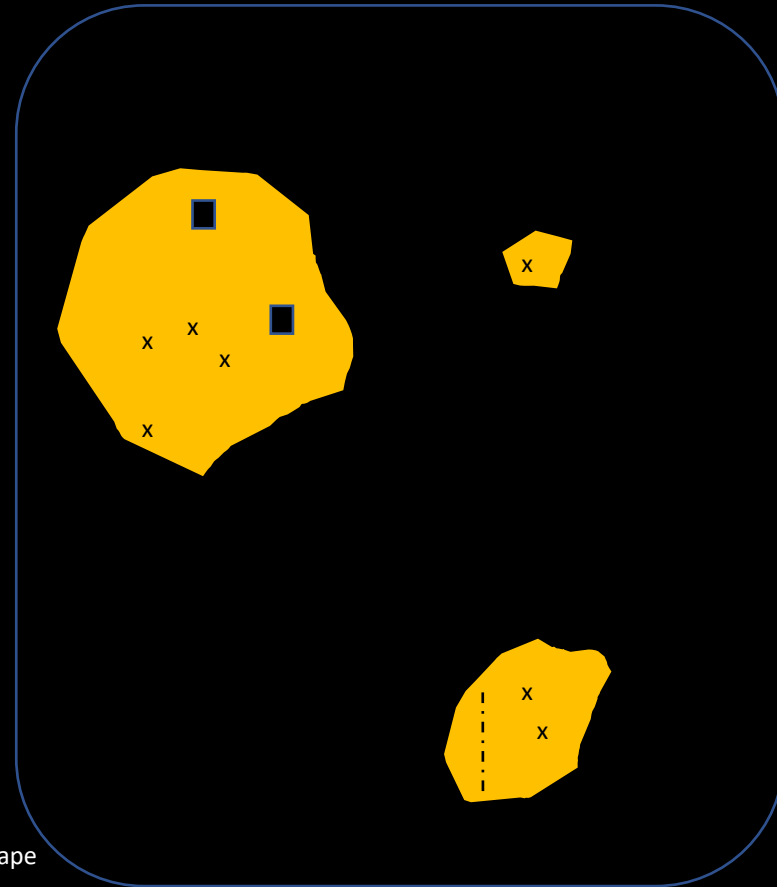
Segmented potential landscapes by state or province





* Proxy for management approach (country, state)

Species survey data

- Four types of observations
 - Camera trap observations, with measures of effort per camera
 - Camera trap observations with density, with measures of overall search effort
 - Sign survey, with measures of effort per grid cell
 - Ad hoc observations, positive only observations
- All observations must have
 - Time period (start and end date)
 - Location (either lat/lon or grid cell)
 - Source (observer, paper or report reference)
- Systematic search of the literature

Estimate species probability



-  Proto-landscape
-  Sign survey
-  CT survey
-  Ad hoc observation

State/province

- Find observations within the last 5 years
- Estimate unconditional probability of species presence in a patch based on patch size, percentage protection, positive observations, and survey effort per state/province
- Estimate conditional probability given those factors and observational data within last five years
- Estimate survey effort as $1 - \text{difference of the conditional / unconditional probability}$

Method: Modified from Nichols et al (2008)

Landscape classification



Segmented potential landscapes

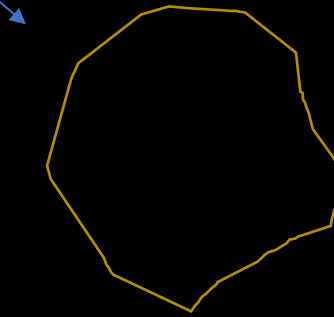
Within indigenous range = 1
Within extirpated mask = 0
Conditional prob. of tigers (P_{tig})
Survey effort for tigers (S_{tig})
Area (km²)
State/province

Have tigers been observed?

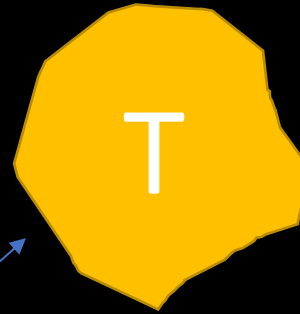
$P_{\text{tig}} >$ Tiger Presence Threshold

95%...
If all ad hoc,
also least 3
observations

No



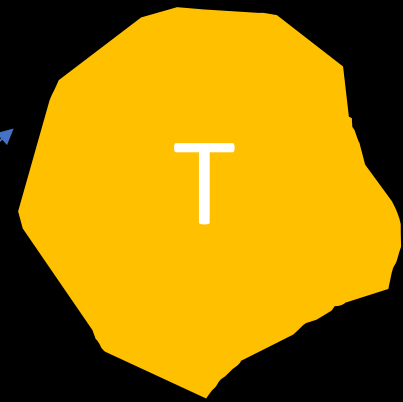
Yes



Is it big enough?

Area $>$ Core patch size for ecoregion

Yes



TCL

No



Fragment with tigers

Has it been surveyed?

$S_{\text{tig}} >$ Sufficient Survey Threshold

or
Extirpated area = 1

Yes



Restoration Landscape

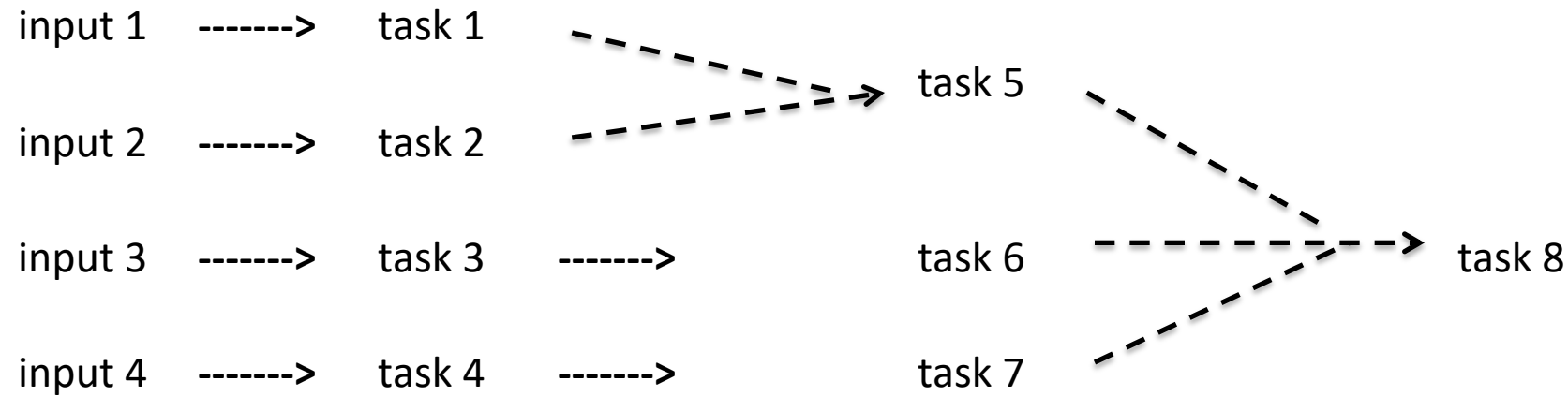
No



Survey Landscape

Species Conservation Landscape

more than a species map



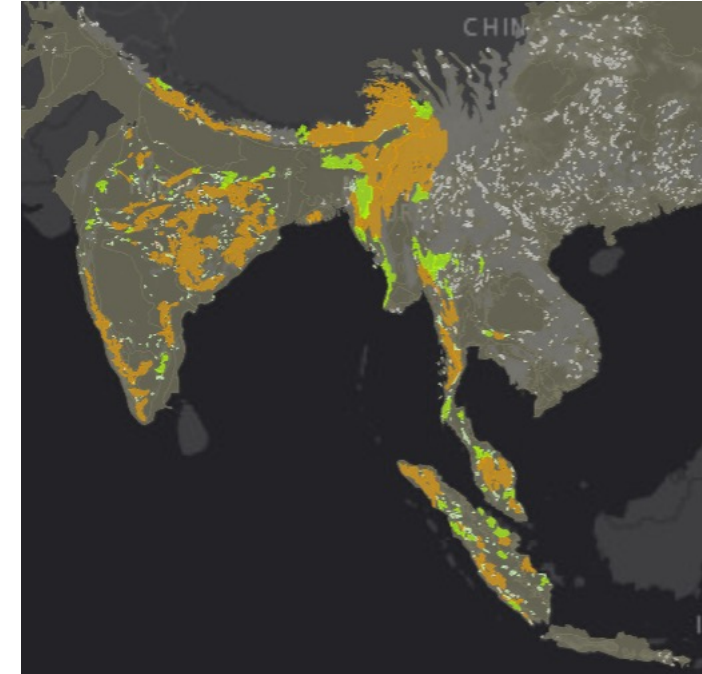
etc.

well-defined inputs

well-defined system

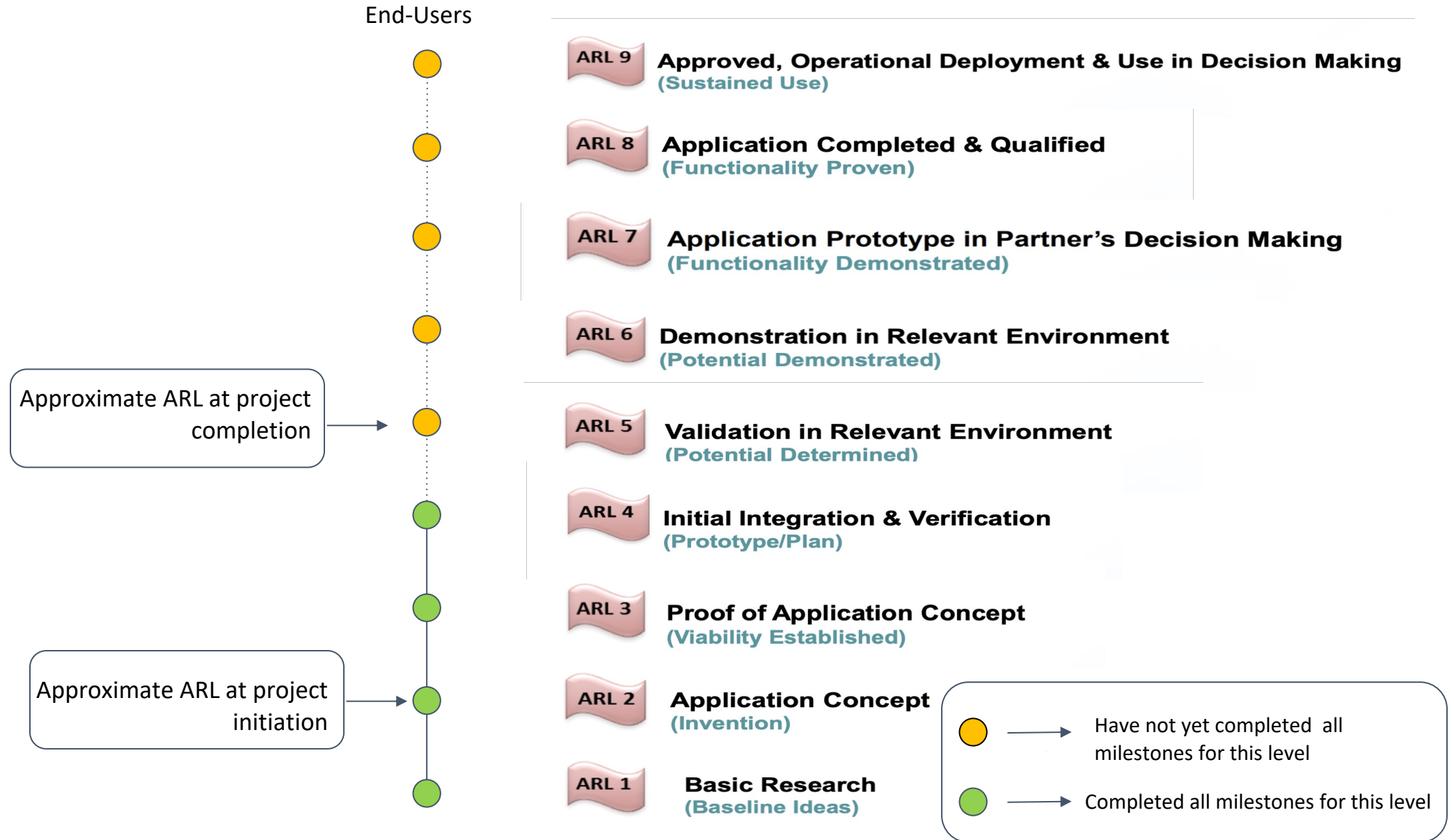
well-defined platform

well-defined outputs



- SCL can be extended to any species of interest
- can run the system any time whenever the inputs change
- the open architecture allows the end-users to customize based on their needs

The Application Readiness Level Metric





TCL 3.0 demonstration: an example of SCL modeling

[jaguar, lion and bison models to follow...](#)

TIGER CONSERVATION LANDSCAPES

Where do tigers live? And how are their habitats changing? Here we show maps and data from new 20-year analysis of tiger conservation landscapes at range-wide, national, and landscape scales using the [Google Earth Engine](#) and satellite imagery from [NASA](#) and the [European Space Agency](#). Tiger conservation landscapes are large blocks of habitat with low [human footprint](#) suitable for tigers. We recognize three main types: species landscapes, where tigers have been known to live during the previous five years; survey landscapes, where the status of tigers is uncertain; and restoration landscapes, where tigers have been extirpated. We also map fragments of habitat where tigers are found (species fragments), status uncertain (survey fragments), and have disappeared (restoration fragments) each year from 2001 — 2020. As new data becomes available, we will update the results on the website.

[GO TO MAP](#)

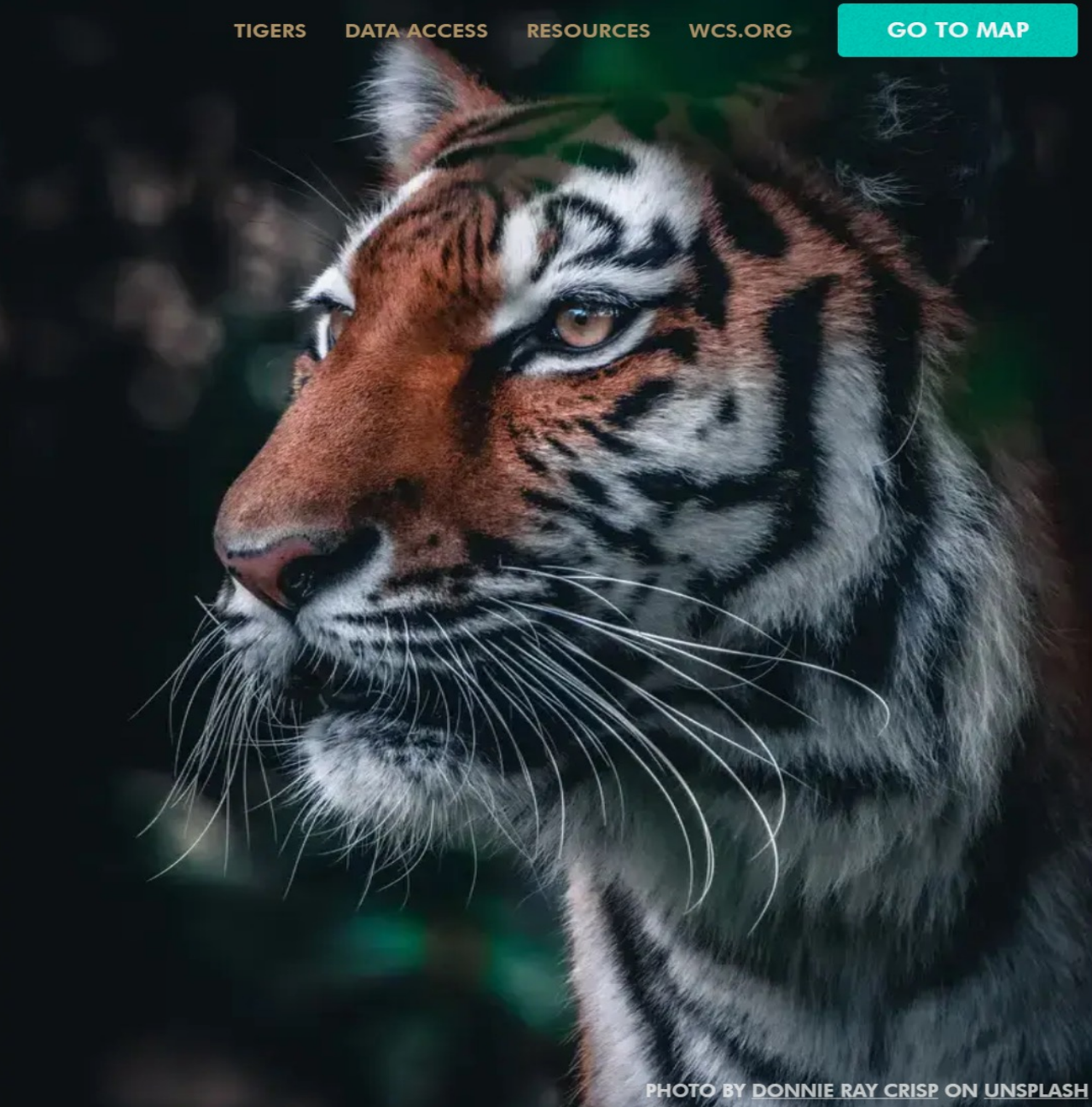
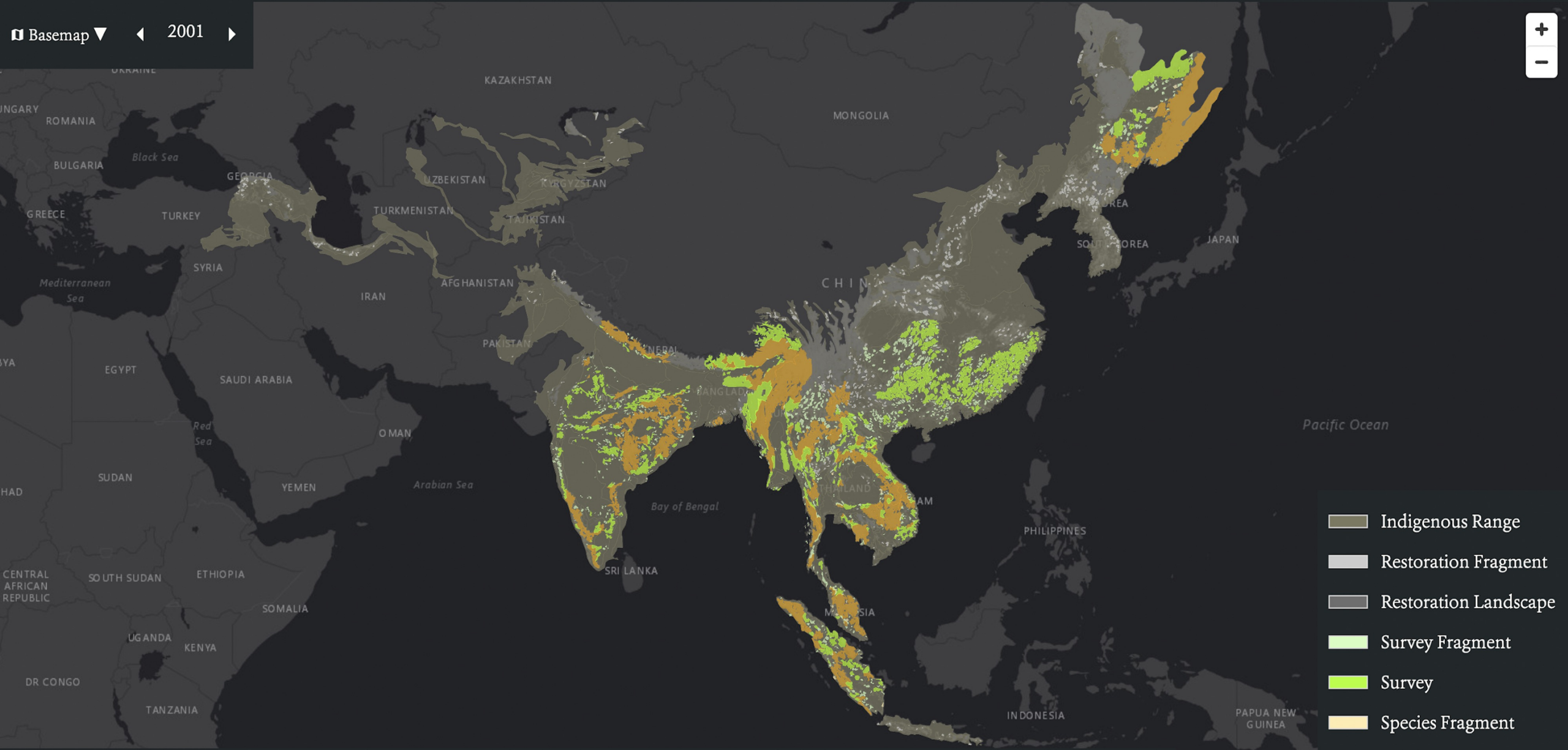


PHOTO BY DONNIE RAY CRISP ON UNSPLASH

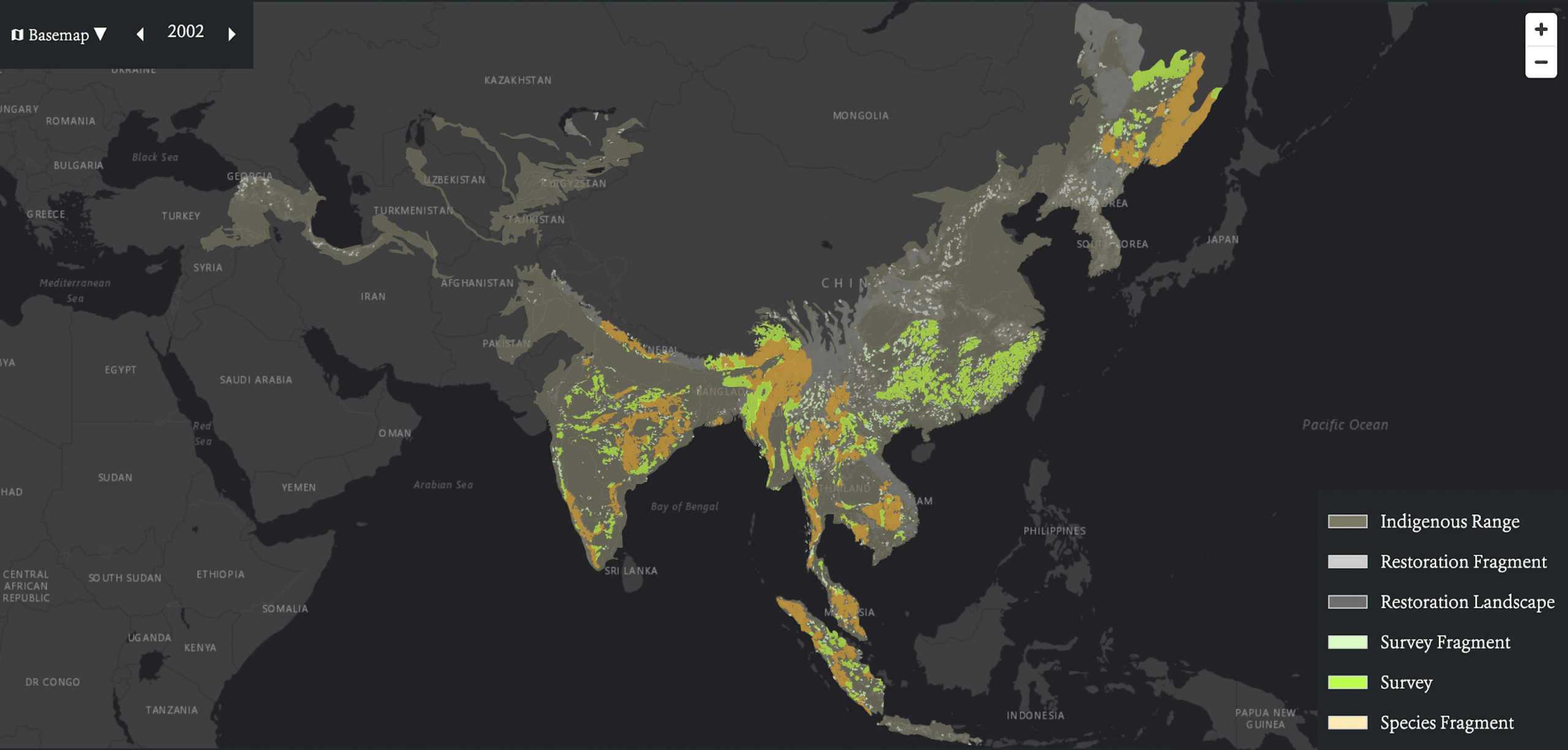
Basemap ▼ ◀ 2001 ▶

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 Basemap ▾  2002 

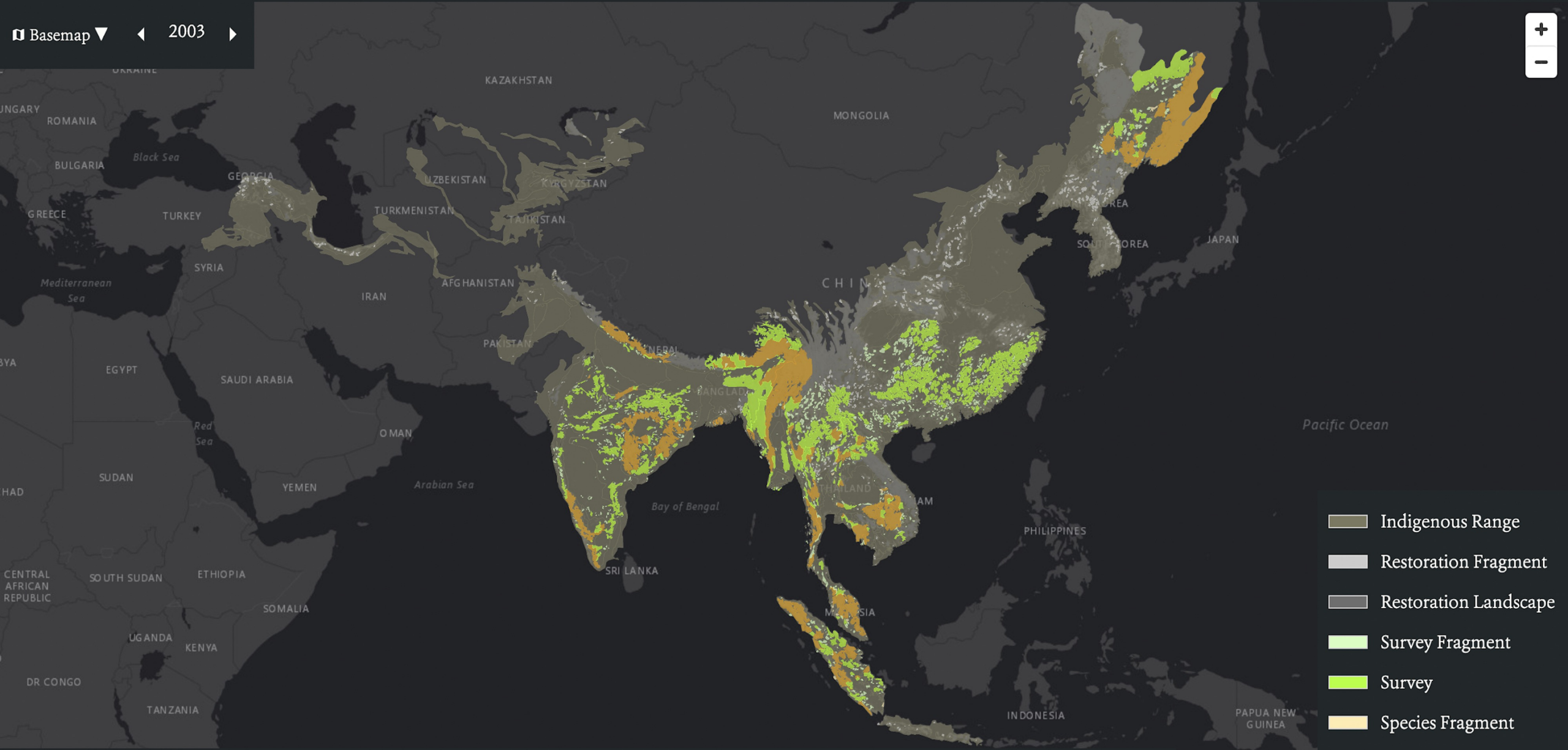
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




-  Indigenous Range
-  Restoration Fragment
-  Restoration Landscape
-  Survey Fragment
-  Survey
-  Species Fragment
-  Species

 Basemap ▼  2003 

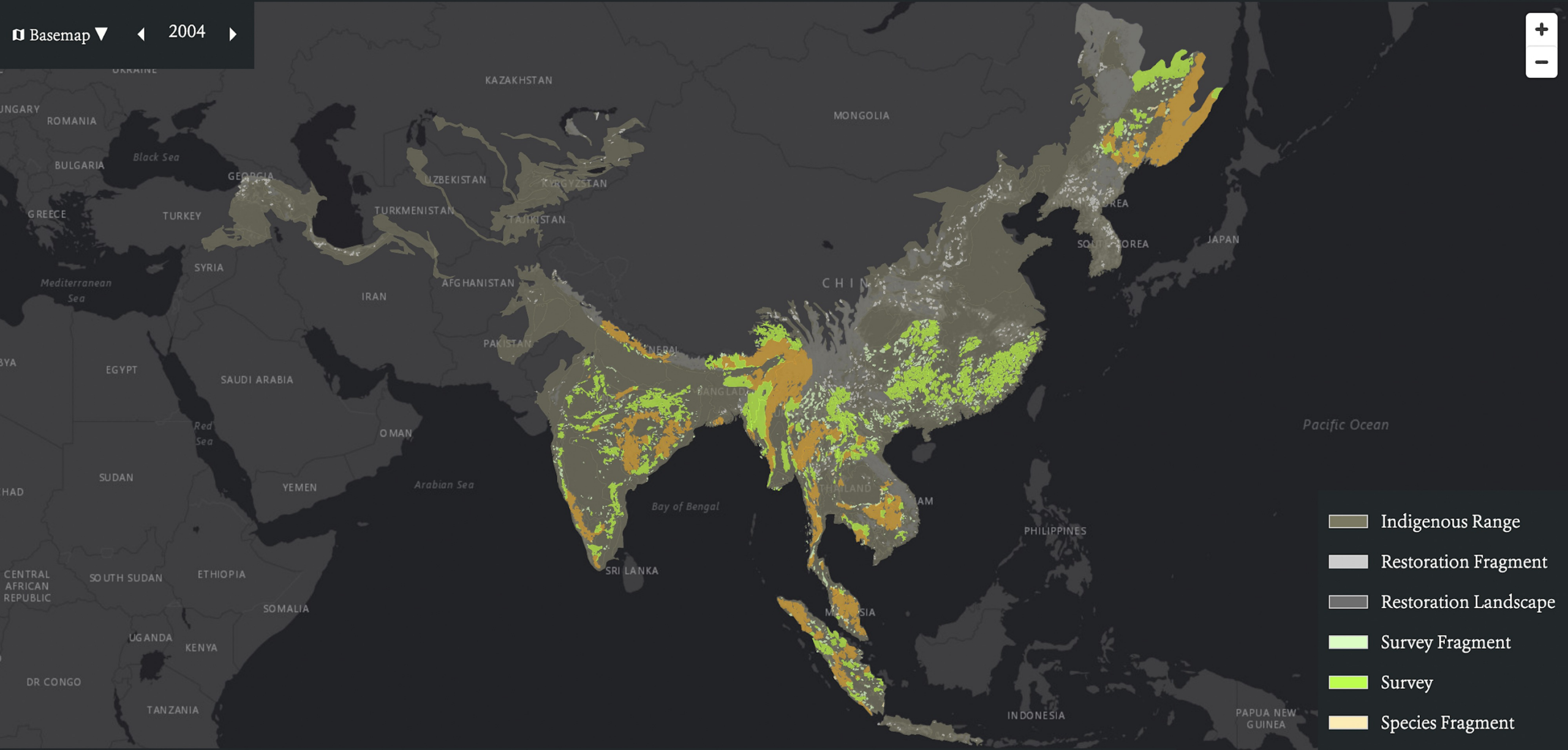


-  Indigenous Range
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-  Survey
-  Species Fragment
-  Species

 Basemap ▼  2004 

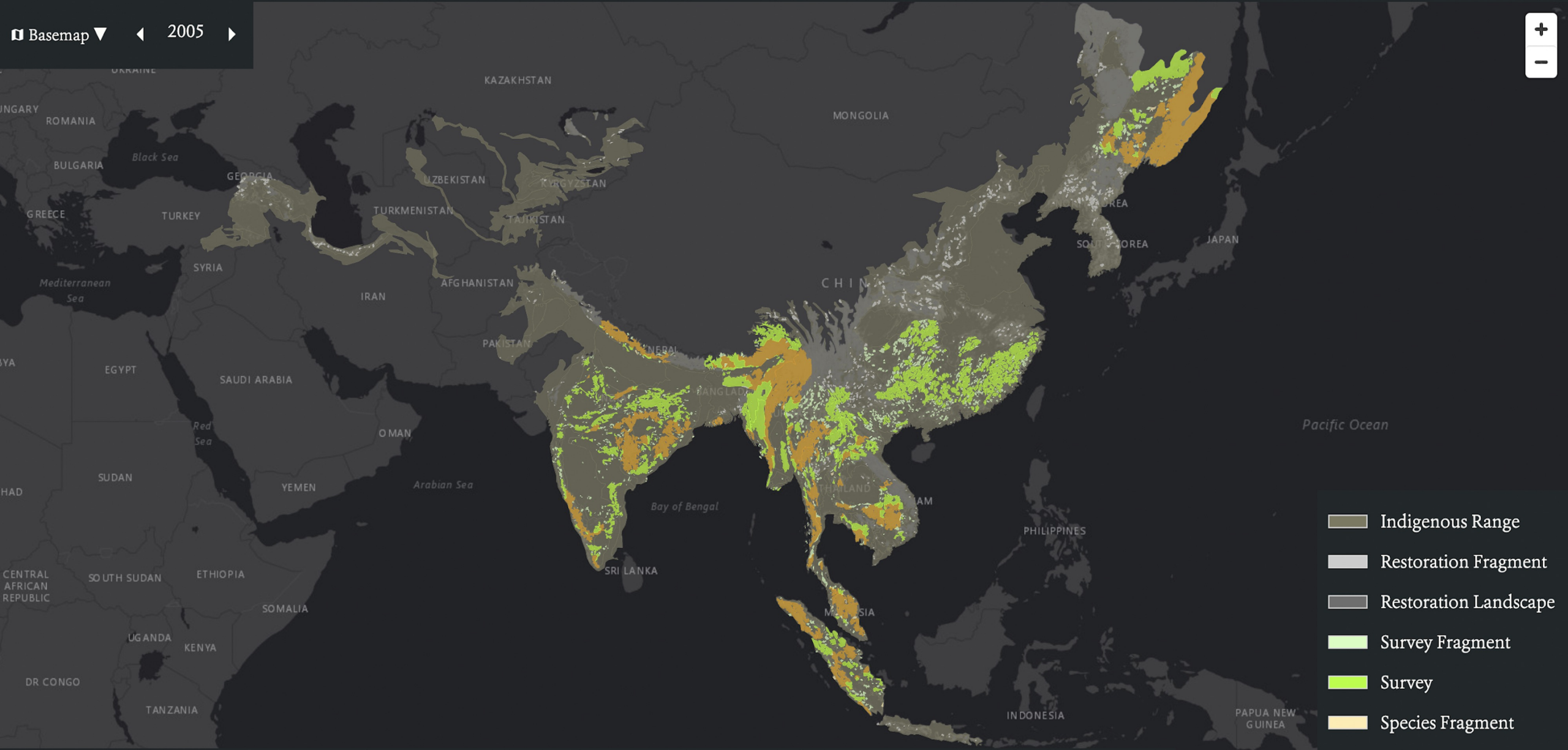
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-  Restoration Landscape
-  Survey Fragment
-  Survey
-  Species Fragment
-  Species

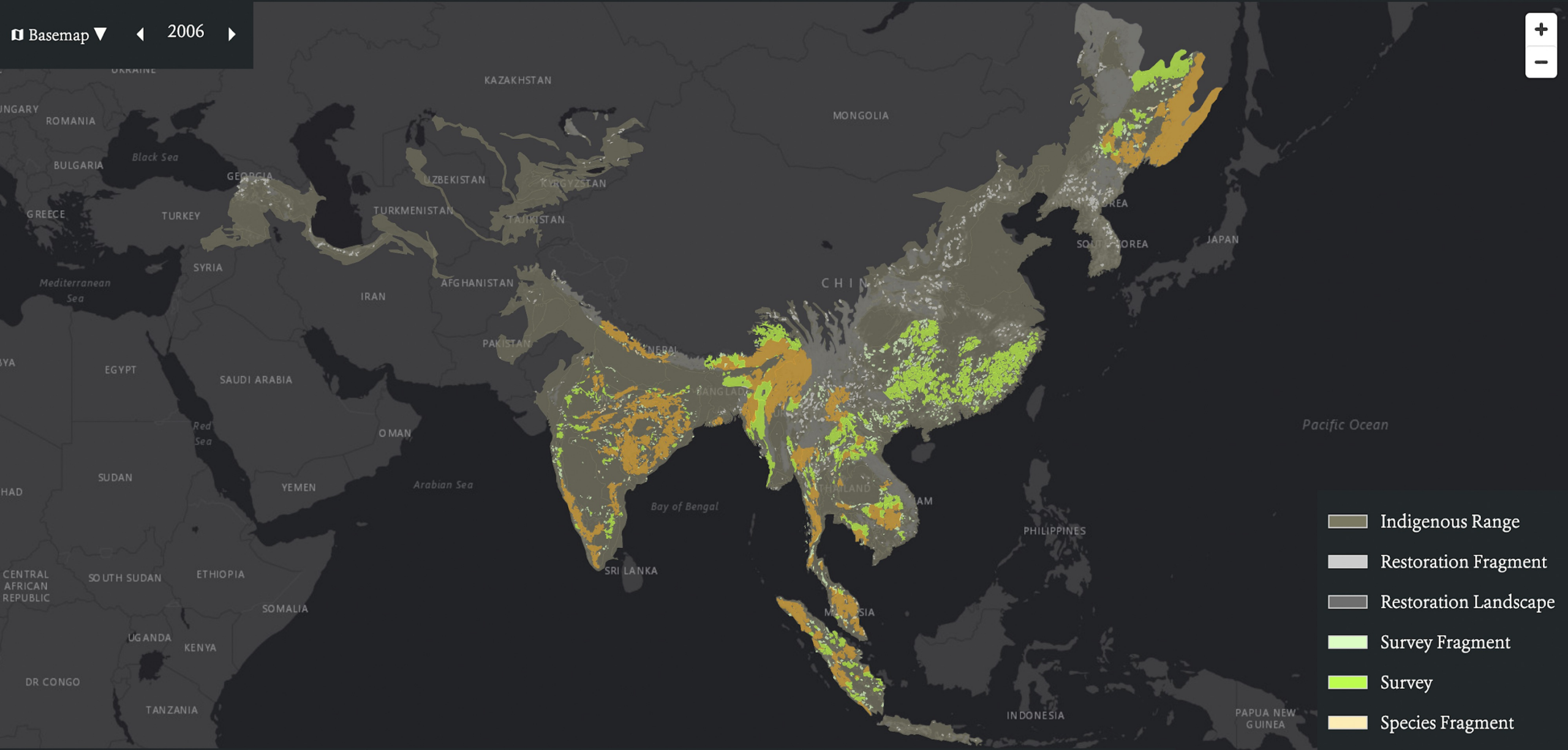
Basemap ▾ ◀ 2005 ▶

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-  Indigenous Range
-  Restoration Fragment
-  Restoration Landscape
-  Survey Fragment
-  Survey
-  Species Fragment
-  Species

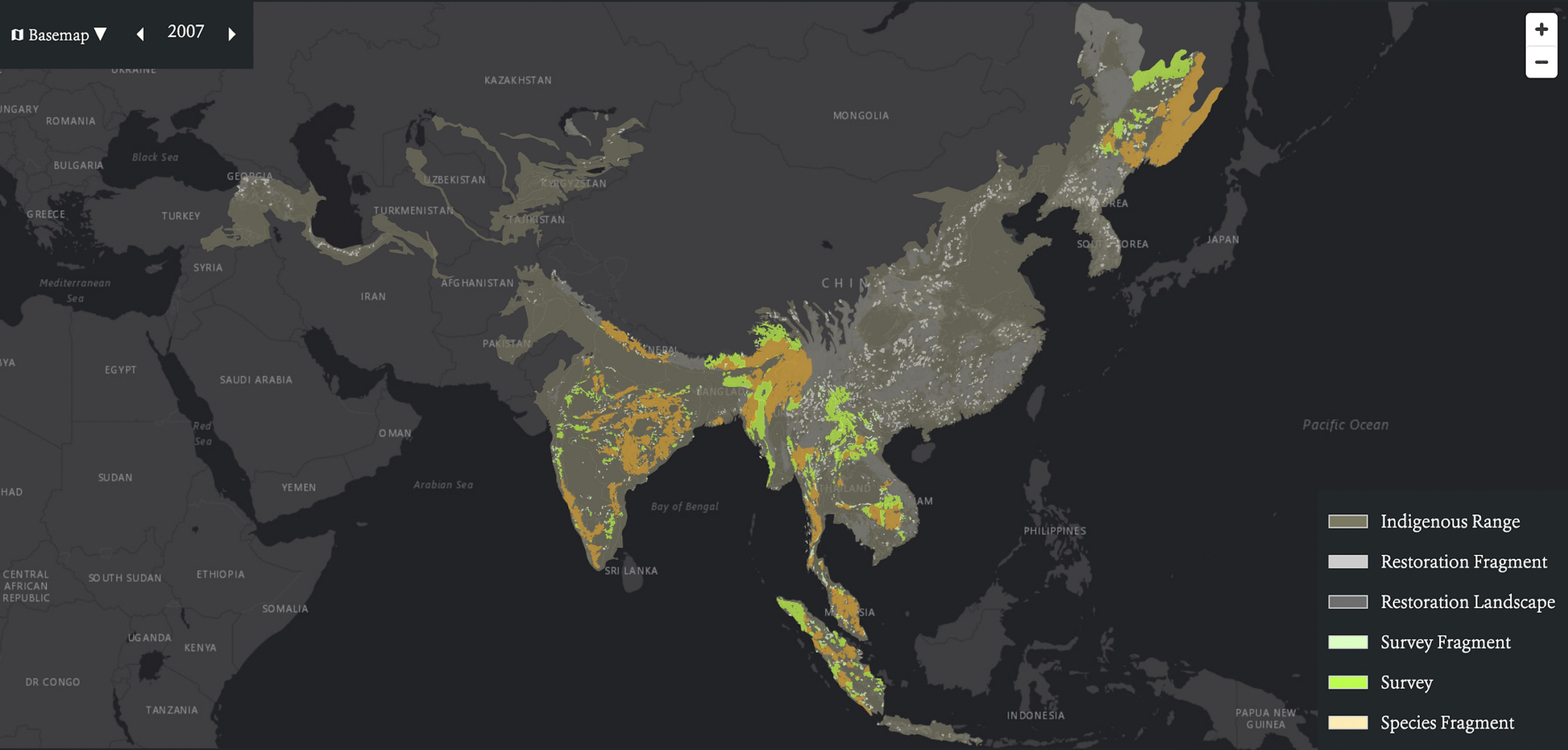
Basemap ▼ 2006 ▶



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Basemap ▼ 2007 ▶

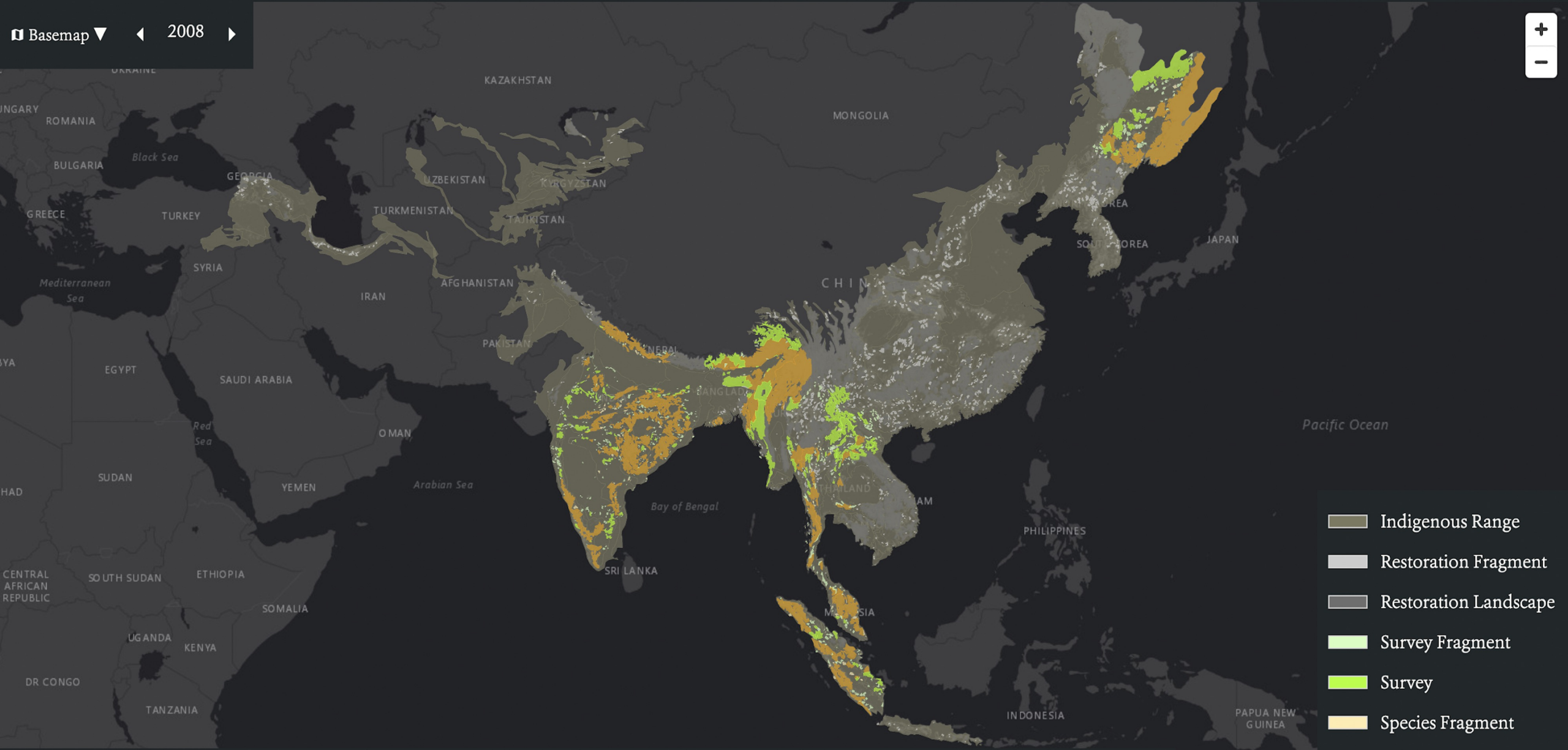
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-  Indigenous Range
-  Restoration Fragment
-  Restoration Landscape
-  Survey Fragment
-  Survey
-  Species Fragment
-  Species

 Basemap ▾  2008 

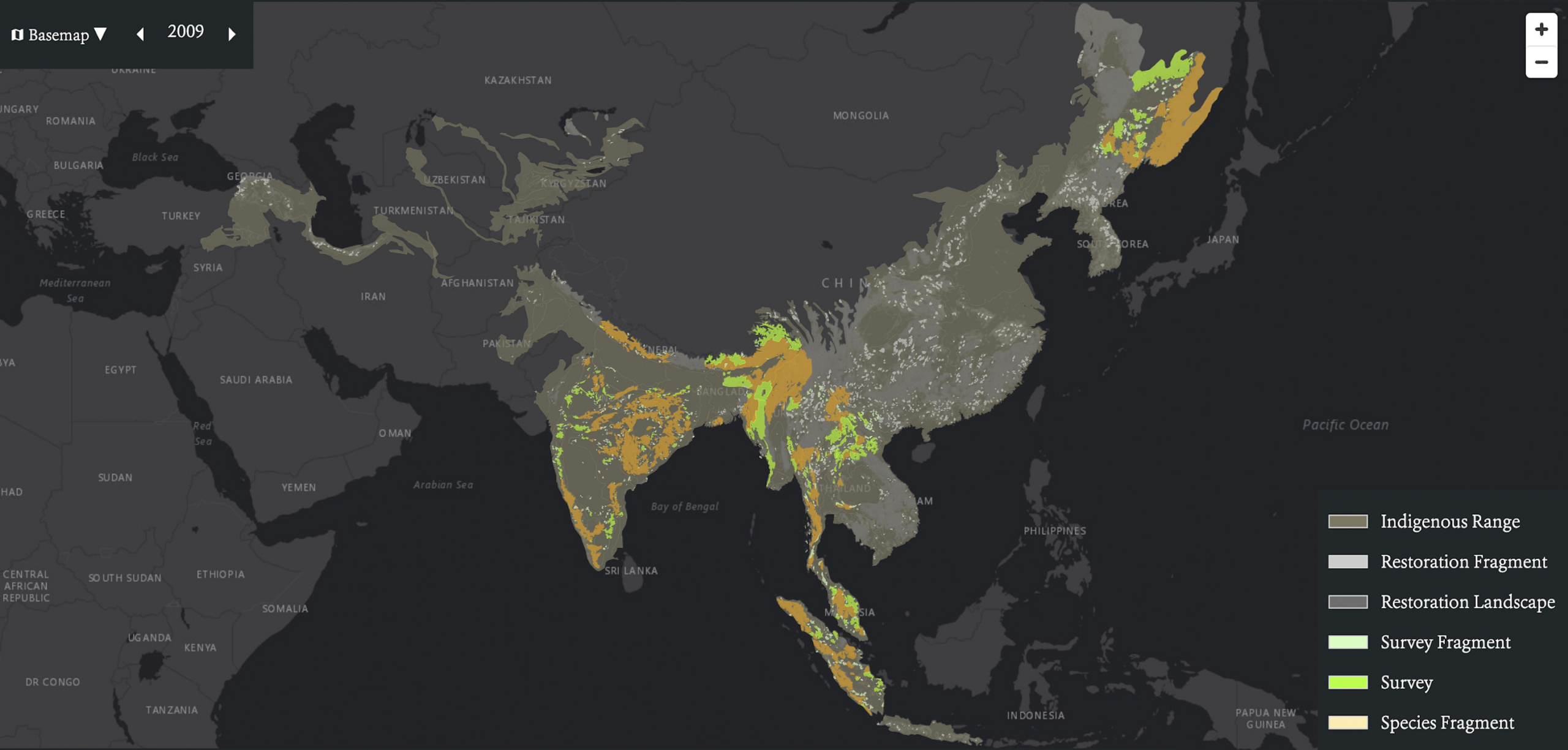
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-  Indigenous Range
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-  Species

Basemap ▾ ◀ 2009 ▶

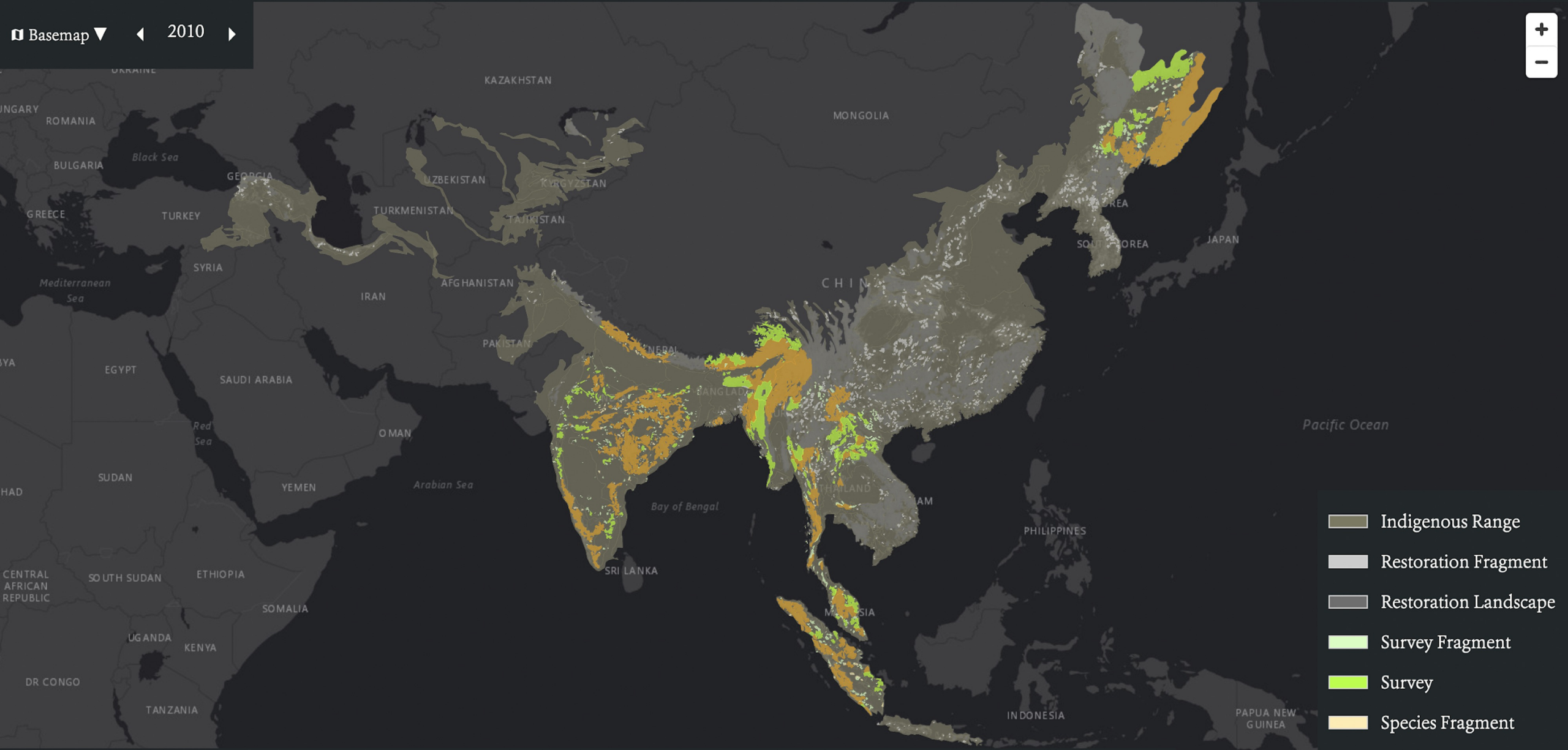
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


- Indigenous Range
- Restoration Fragment
- Restoration Landscape
- Survey Fragment
- Survey
- Species Fragment
- Species

 Basemap ▼  2010 

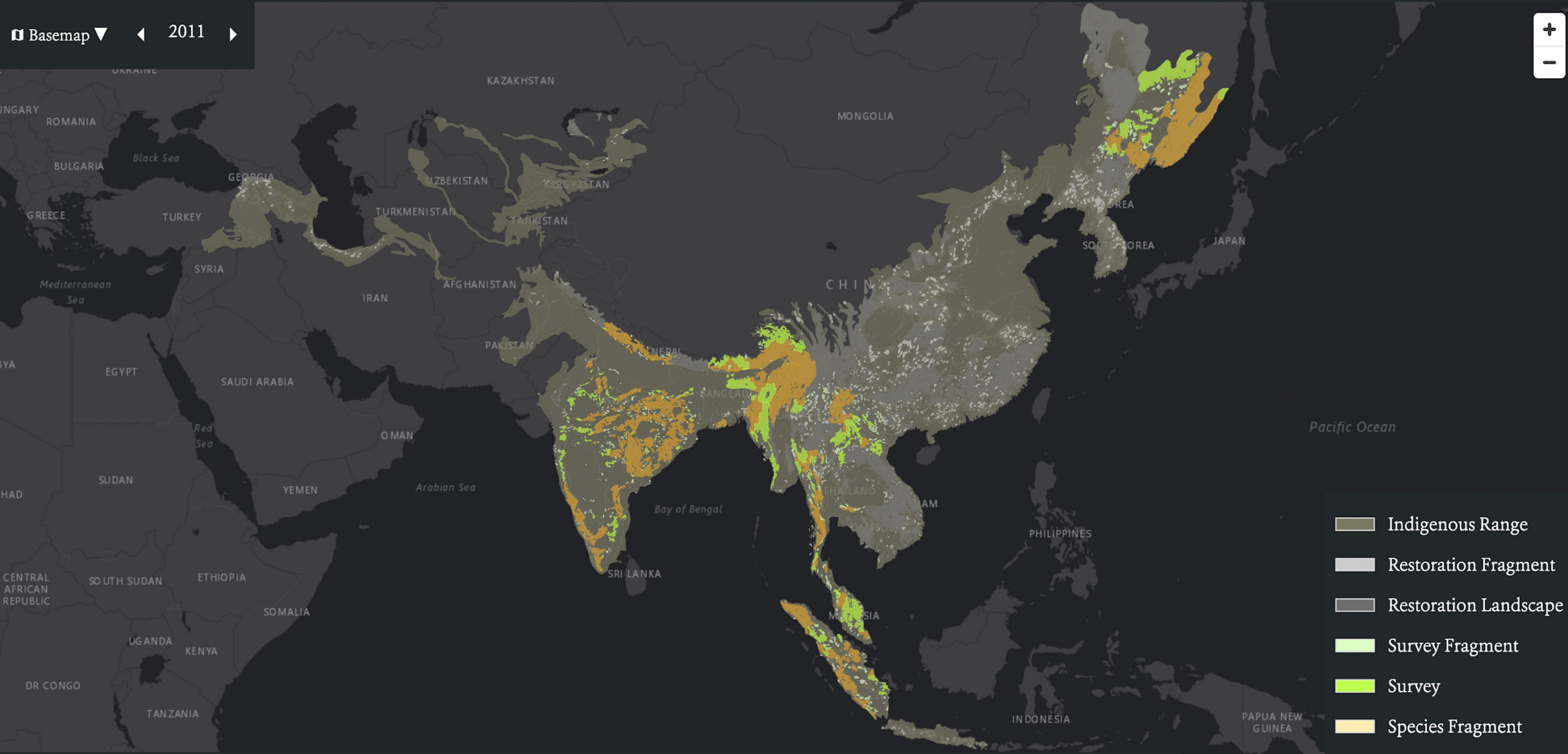
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-  Indigenous Range
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-  Survey
-  Species Fragment
-  Species

 Basemap ▼  2011 

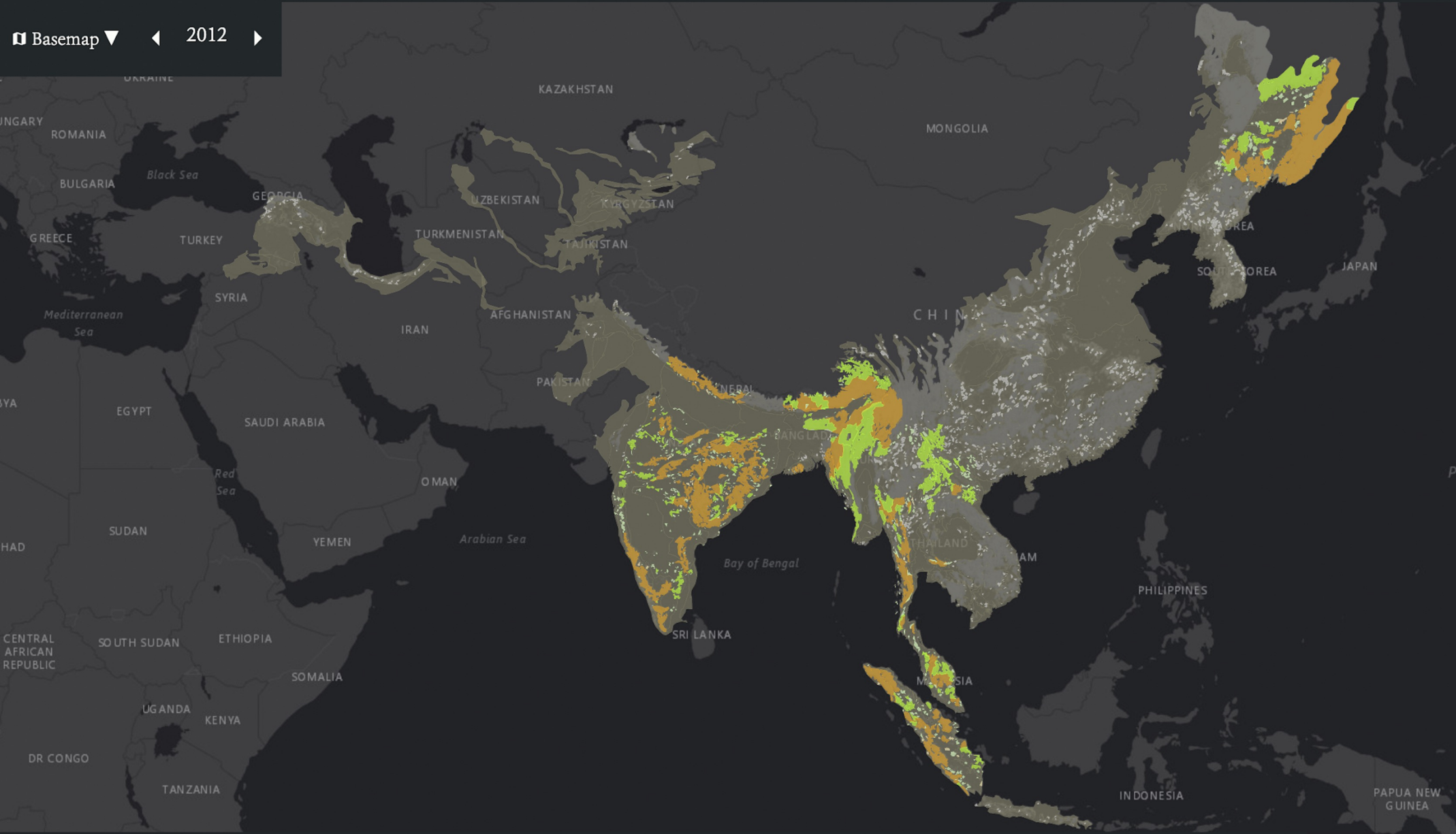
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-  Indigenous Range
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 Basemap ▼  2012 

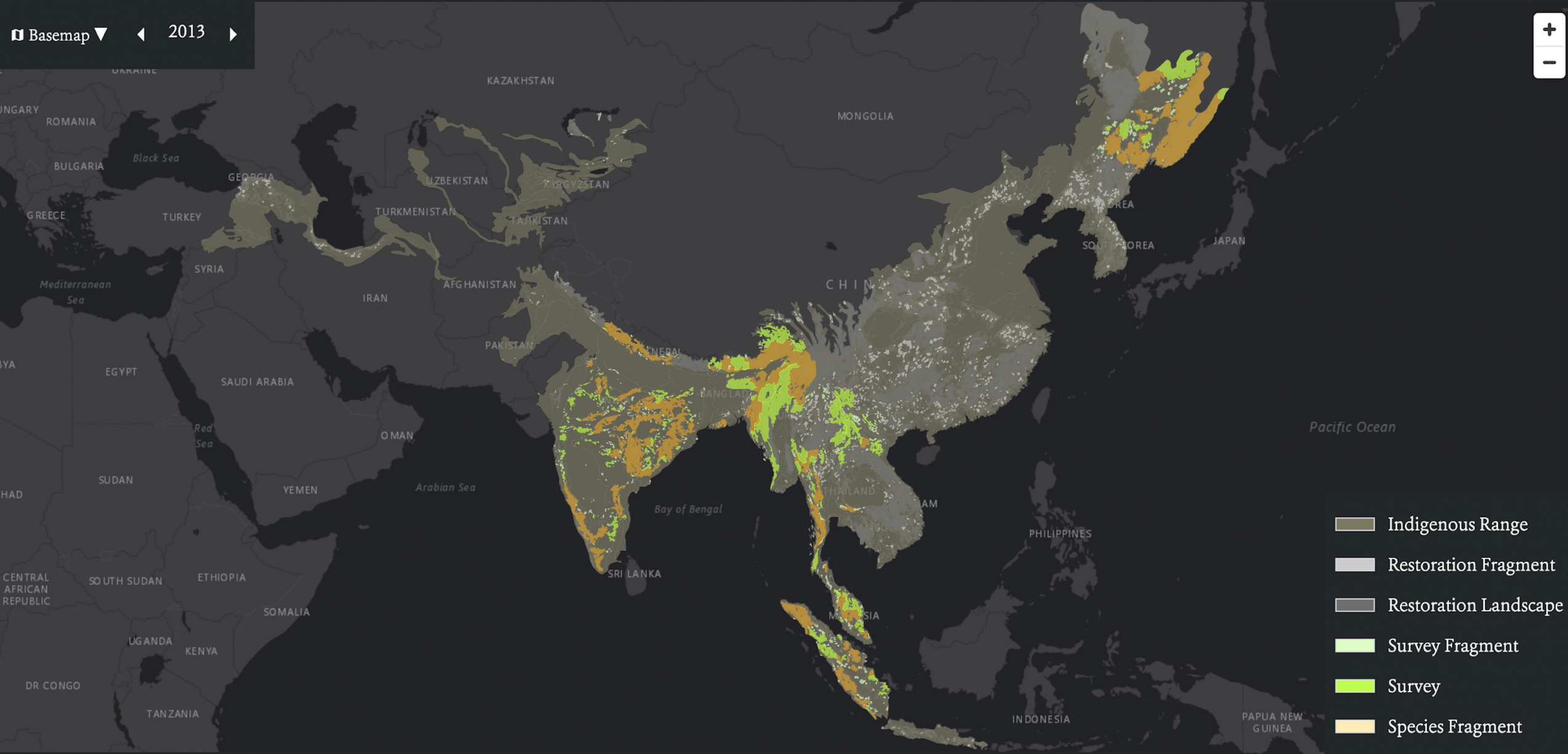
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-  Indigenous Range
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-  Survey
-  Species Fragment
-  Species

Basemap ▾ ◀ 2013 ▶

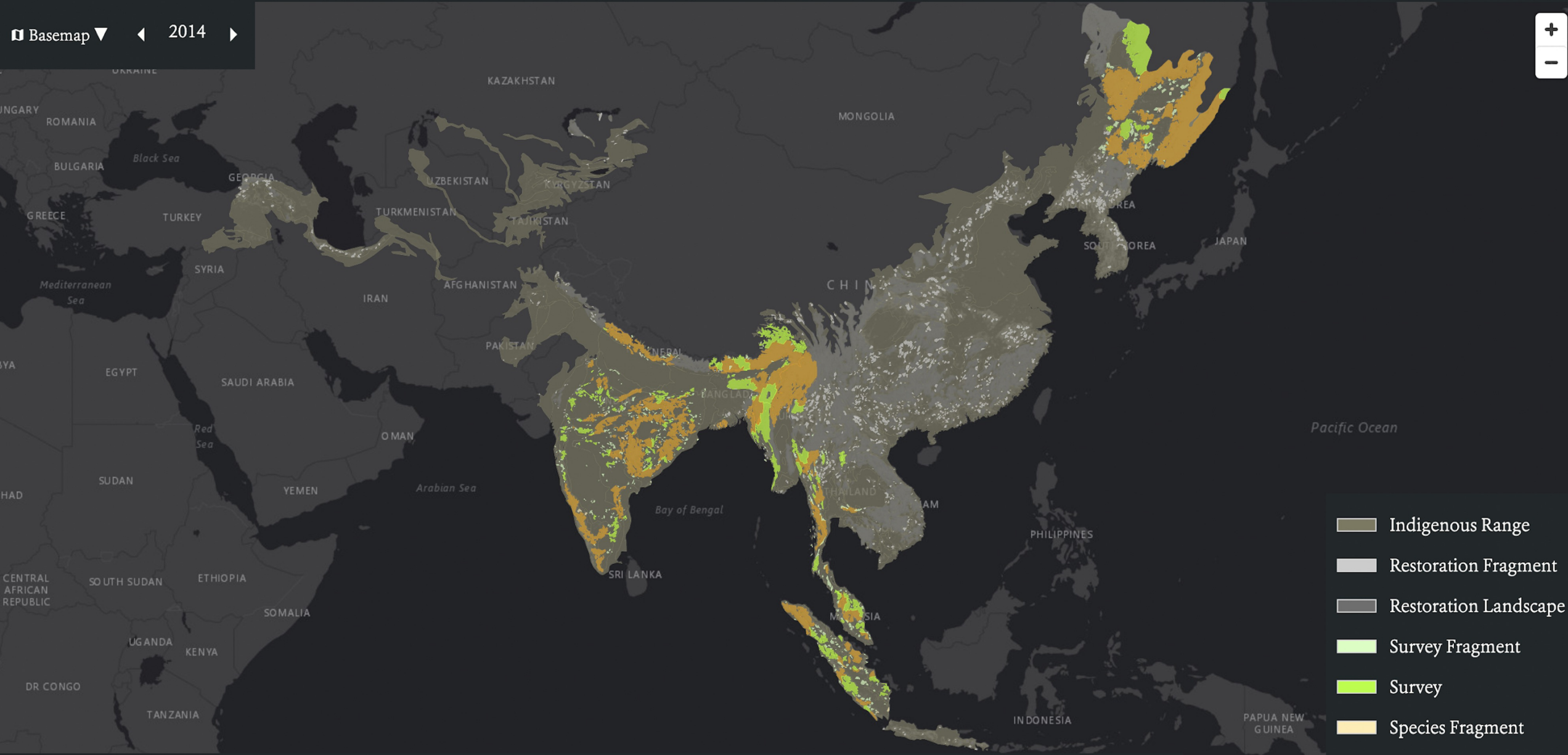
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Basemap ▾ ◀ 2014 ▶

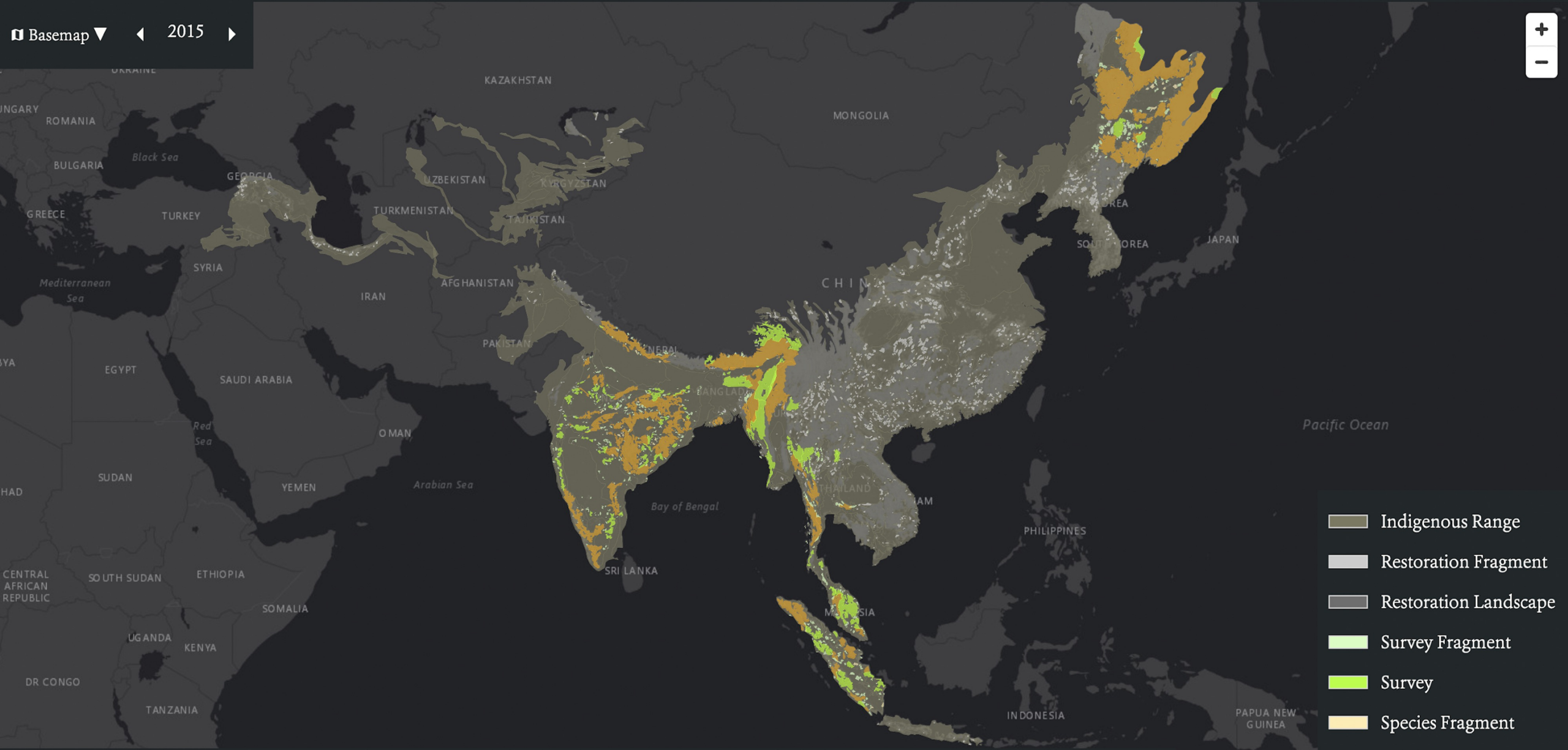
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


- Indigenous Range
- Restoration Fragment
- Restoration Landscape
- Survey Fragment
- Survey
- Species Fragment
- Species

 Basemap ▾  2015 

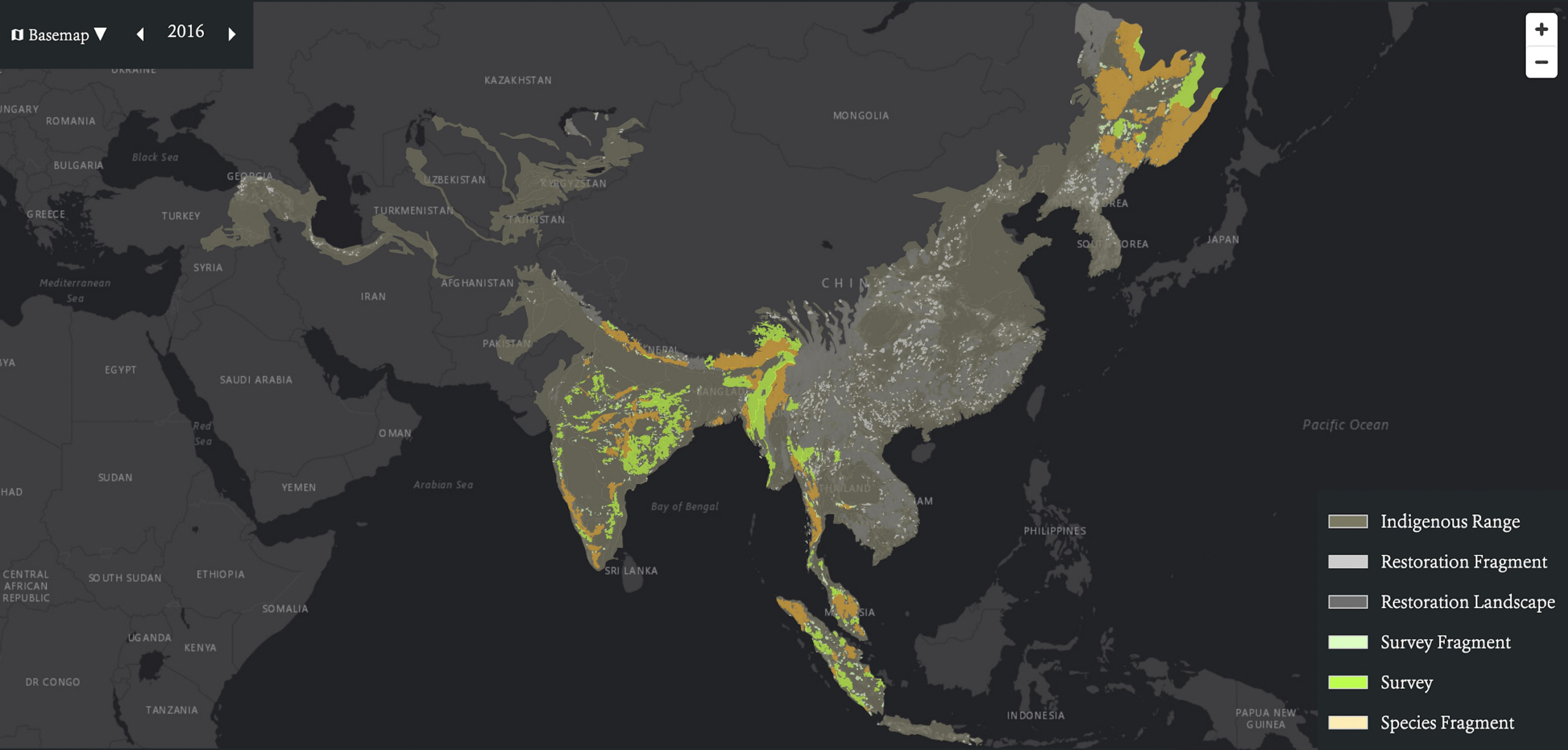
 




-  Indigenous Range
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-  Survey Fragment
-  Survey
-  Species Fragment
-  Species

Basemap ▼ 2016 ▶

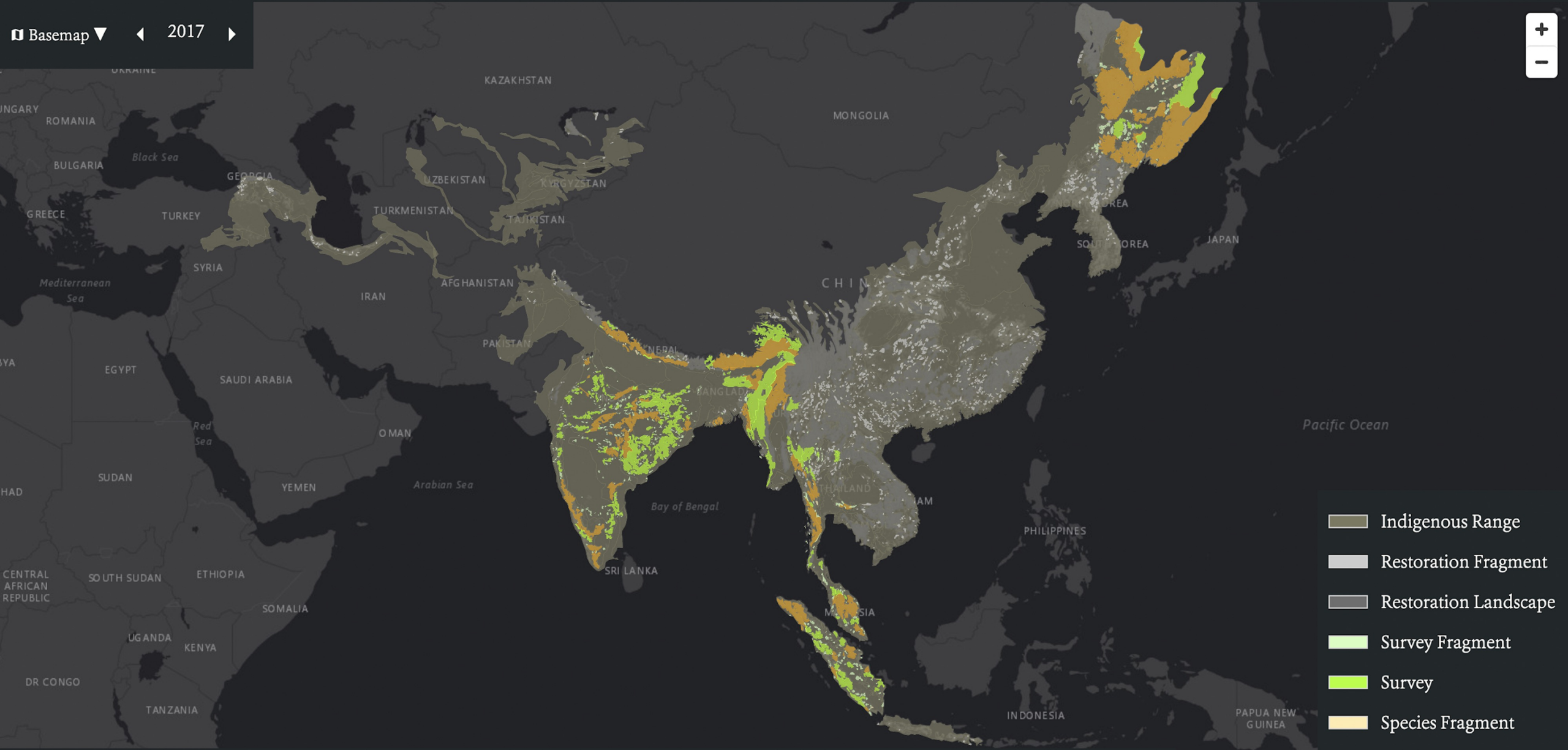
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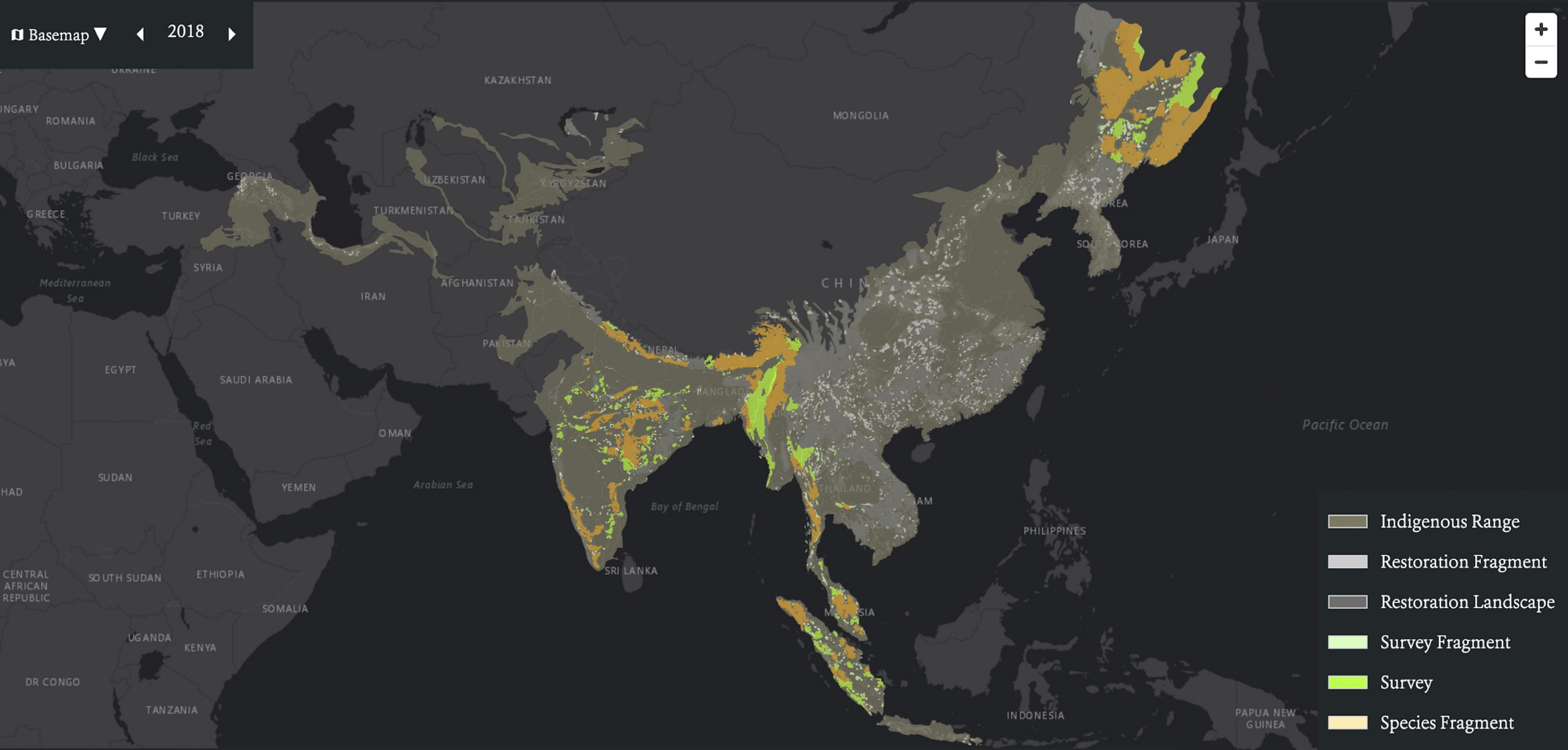
 Basemap ▾  2017 



-  Indigenous Range
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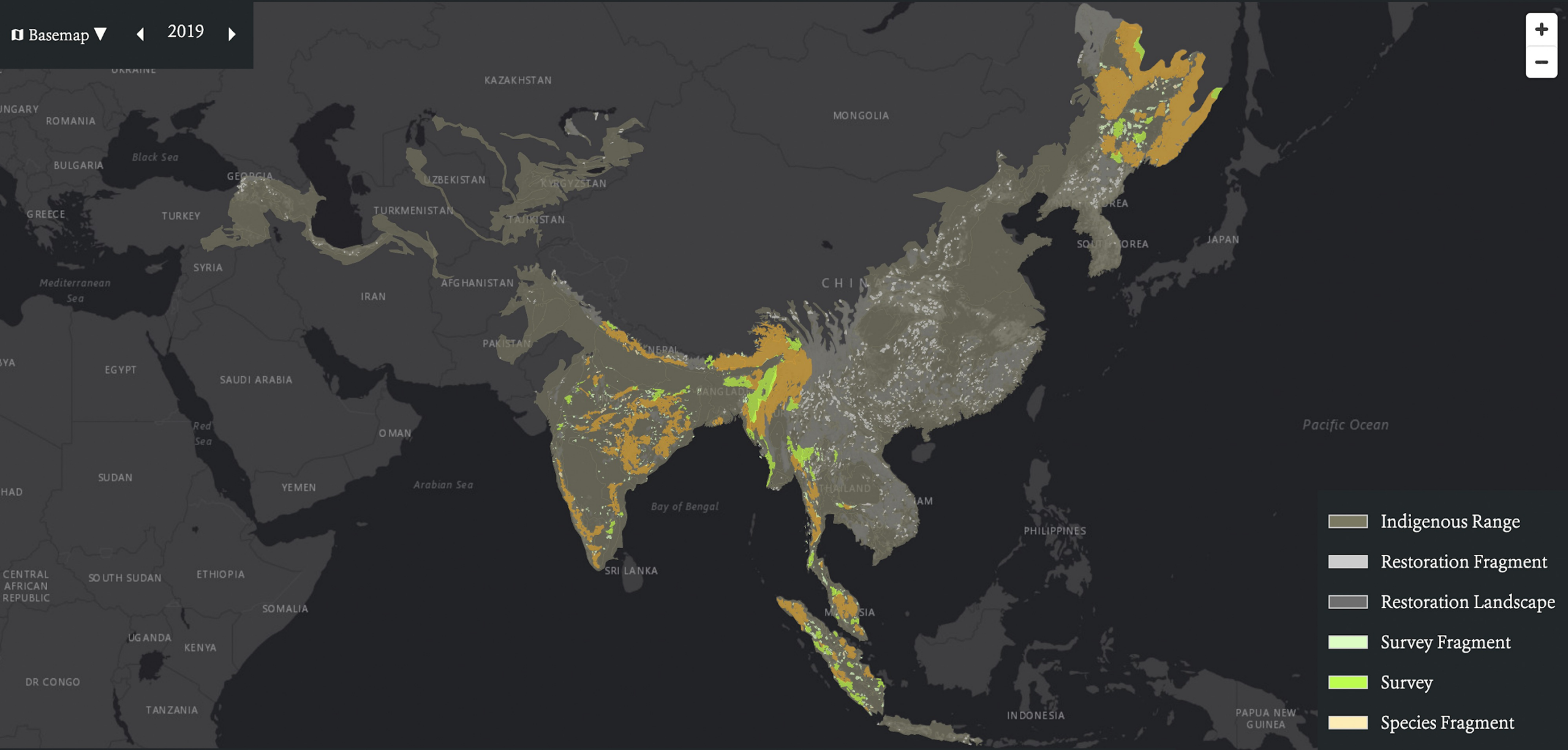
Basemap ▼ 2018 ▶



-  Indigenous Range
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Basemap ▼ 2019 ▶

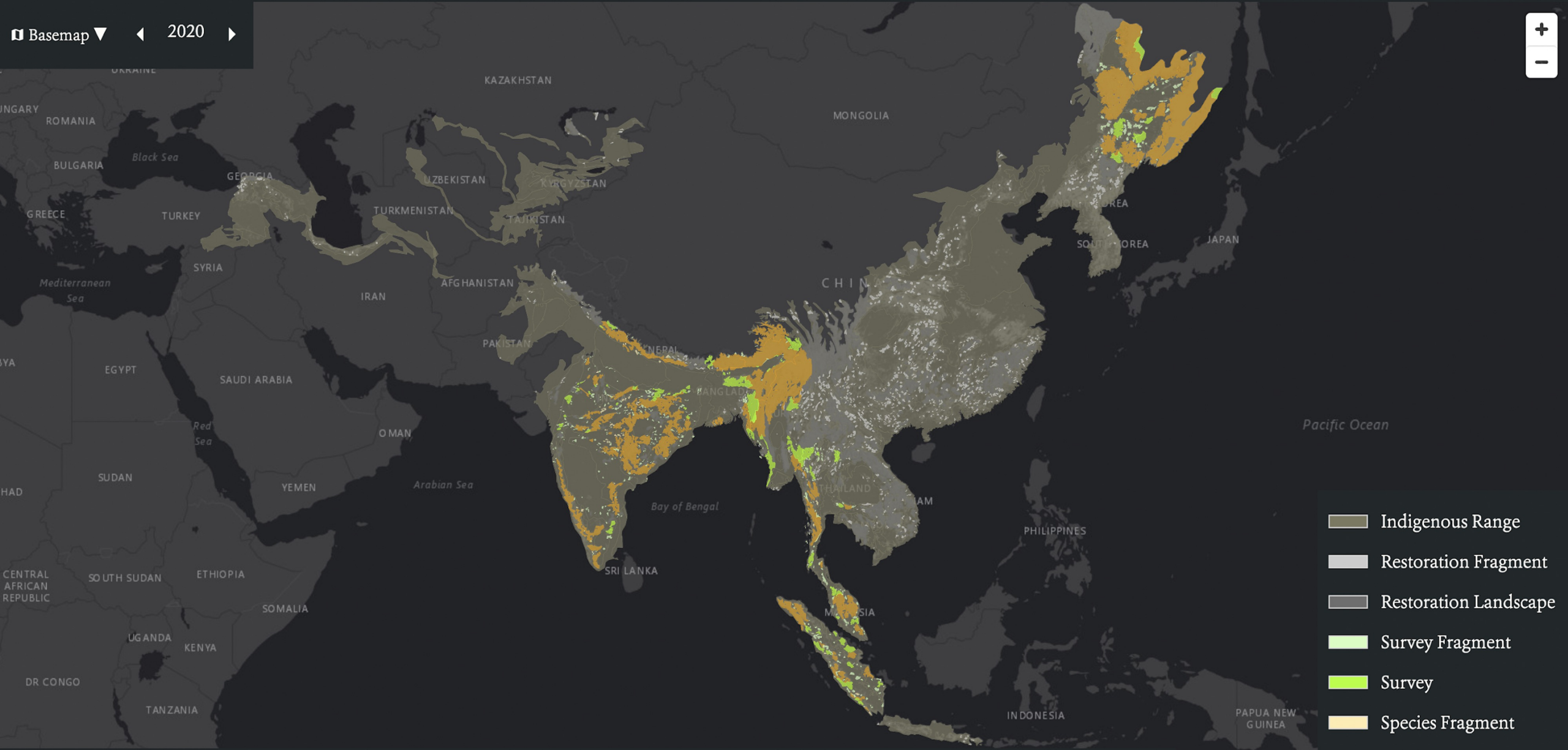
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-  Indigenous Range
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-  Restoration Landscape
-  Survey Fragment
-  Survey
-  Species Fragment
-  Species

Basemap ▼ 2020 ▶

+
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-  Indigenous Range
-  Restoration Fragment
-  Restoration Landscape
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-  Survey
-  Species Fragment
-  Species