Did We Save Our Tigers?

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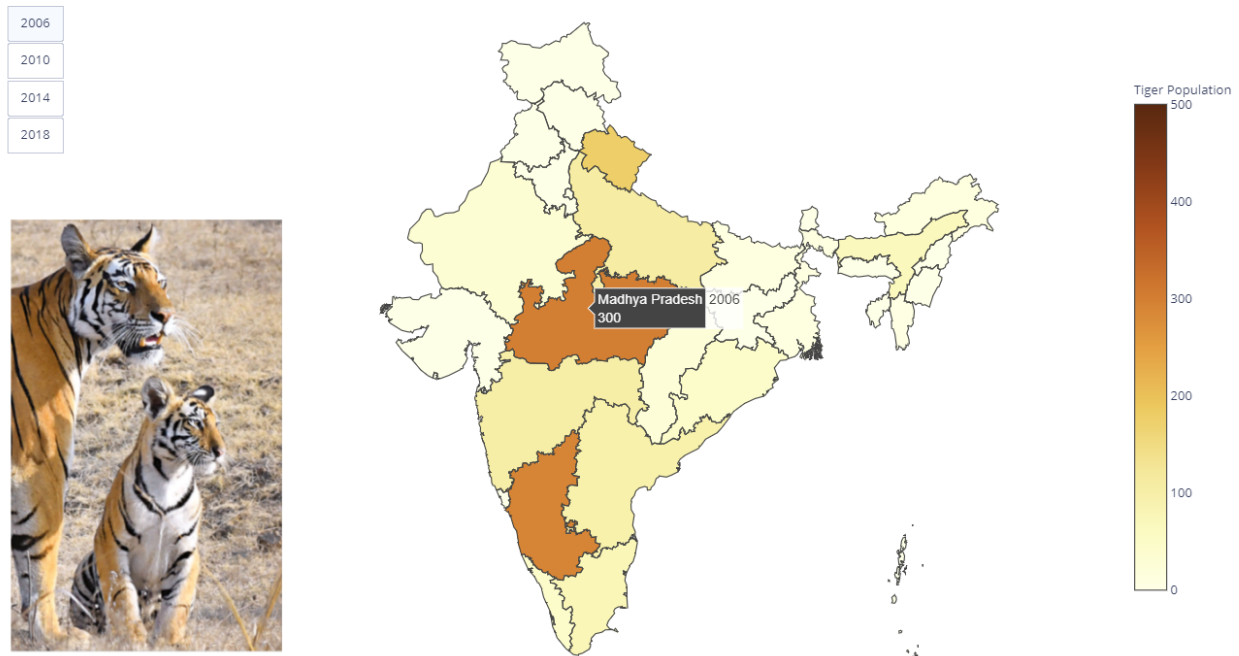

Fig. 1. Idiom 1, Visualization 1: Choropleth representation showing tiger population per state. Tiger's image on the right is sourced from [19].

Abstract— This paper presents an explainer article visualizing the tiger population, and thereby illustrating the progress of tiger conservation efforts in India. A variety of visualization idioms are proposed to showcase different aspects of tiger census data across a period of twelve years in different regions of the country. To enable experts in the field as well as the general audience to explore and analyze the progress of tiger conservation projects in India, interactive idioms are also provided that readers can engage with. In addition, trends in tiger population data can be analyzed more effectively which can be used to propose future conservation measures. The goal of this paper is to help raise awareness for the need of a better environmental habitat to save this endangered species.

Index Terms—Indian tigers, tiger count, visualization, interactive, explainer article

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1 INTRODUCTION

Since the turn of the century, climate change and increasing human population have contributed to the endangerment of several wildlife species, but few have been as severely affected as tigers. They have lost over 95% of their historical range, and from over 100000 tigers in the 1900's, we are down to less than 4000 tigers left in the wild presently, which is a 96% drastic decrease. Three subspecies have gone extinct, and a fourth is regarded mostly extinct in the wild. Although trade in tiger parts is internationally banned, illegal tiger trade still accounts for a big part of a $20 billion per year illegal wildlife market. Increasing threat from agricultural developments, deforestation and climate change to their habitat have resulted in confirmed breeding populations existing in only eight countries worldwide [17, 24]. However, after a century of decline, overall wild tiger numbers are starting to tick upward.

India, that accounts for over 70% of the global tiger population, has had major success with their tiger conservation efforts [24]. Project

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Save Our Tigers, a joint initiative between WCT, NDTV, Aircel and Sanctuary Asia, took off in 2008 and has since implemented multiple stages of their conservation program in collaboration with governmental and non-governmental organizations to revive the tiger population in India [1]. This has been one of several tiger conservation efforts implemented by the country's central government. The low population of tigers in 2006, at 1411 tigers in the entire country, served as a stimulus to the government, and based on current data, the tiger population now stands at 2967, more than double of that in 2006 [5]. This has been one of India's most successful wildlife conservation projects.

Interactive visualizations have been found to play a crucial role in increasing public interest in ecological conservation. Interactive articles related to policy making, like the New York Times Rent Calculator [15] and To Build A Better Ballot [20], allow people to see how policies can impact them and thus increase public interest. Articles like Bloomberg's Hottest Year on Record [10] and NASA's Arctic Sea Ice [4] highlight the impact of climate change, painting a real-world scenario for readers to understand and empathize with, which can increase user engagement. The Economist, among other publications, employs a dedicated data-journalism team to draft interactive data-driven articles [9].

The goal of this project is to visualize the tiger population over the years in India, based on governmental data, using both static and

interactive visualizations. The end goal is to use these visualizations to help analyze the extent to which these efforts were successful and in addition how they can be improved in the future to safeguard the tiger population. Thus, as wildlife conservation enthusiasts, by creating an interactive article centered around tiger conservation, we aim to enable readers to develop significant insights into this conservation effort and provide possible policy recommendations for the same.

The rest of the project is organized as follows: Sect. 2 talks about related work in the field of visualizing wildlife data, wildlife conservation methods, time-series data and interactive visualization articles. In Sect. 3, data and task abstractions are discussed. Sect. 4 talks about our proposed solutions for the tasks, and Sect. 5 details our implementations of the same. Milestones, schedule and contributions are given in Sect. 6. Results including webpage details and usage scenarios are explained in Sect. 7. Strengths, limitations and proposed future work are discussed in Sect. 8. Finally, Sect. 9 gives the conclusion.

2 RELATED WORK

There has been much research in the field of wildlife conservation and several projects that visualize different types of biological data. We explore existing strategies for tiger conservation as well as projects that visualize wildlife data similar to our own. We also discuss different strategies for time-series data visualization and interactive explainer articles that we adopted for our project.

2.1 Existing Tiger Conservation Strategies

There has been significant research into tiger conservation by non-governmental and governmental agencies, as well as international organizations like the World Wildlife Fund [24]. The Indian government also established the National Tiger Conservation Authority [14], a governmental body with the sole aim of tracking tiger populations. While there has been much data that has been gathered from the works of these organizations, there is a lack of visualization tools that can effectively communicate this data. None of them have worked on visualizing tiger populations or detecting and predicting trends to aid conservation efforts. There have also been several publications in the domain of tiger conservation. Conservation priorities for endangered Indian tigers through a genomic lens by Natesh et al. [33] in 2017 aims to identify conservation strategies based on genomic structure. Connectivity of Tiger (Panthera tigris) Populations in the Human-Influenced Forest Mosaic of Central India by Joshi et al. [29] in 2013 analyze and suggest management strategies for tiger corridors. Rastogi et al. [36] mentions that scientists can influence government policy on the environment, but often via complex and iterative interactions. According to them, future studies need to better target managers and policy makers and provide them with context-driven studies, which is something our article attempts to do.

2.2 Existing Wildlife Data Visualizations

Pocock et al. [34] found that network approaches in visualization were useful in explaining interspecies interactions and the place of humans within such interactions in an environment. Such visualizations could be used to support public engagement and enhance citizen science in biodiversity conservation. Janicki et al. [27] discovered with antmaps.org [3] that tools that facilitate data-user interaction in biodiversity informatics are increasingly popular. The main features of antmaps.org include understanding the distribution of a particular species (similar to our proposed visualization of the tiger population distribution over a geographic area), and the ability for users to interact with the dataset through the map itself. This is also something we implement by making graphs interactive and allowing users to navigate further and see more information based on their choices. Antmaps.org has since its release obtained generally favourable reviews from general biologists and well as general public, showcasing the potential and appeal of such visualizations.

Other efforts in visualization in biodiversity include Cagnacci et al. [25], who propose a spatial information system for GPS collars data, which can aid in ecosystem management. Wall et al. [41] address real-time monitoring of animal movement for elephants, which can

help advance our understanding and provide critical information for conservation action. Prasad et al. [35] talk of integrating satellite data, digital elevation models, and known information of biodiversity for a better understanding of biodiversity issues. Hansen et al. [38] devised an automated digital surveillance system that can help wildlife authorities track illegal wildlife trade. In an industry worsened by commercialization of hunting and over-exploitation of ecosystems, global digital awareness and surveillance can help protect biodiversity.

Conserve.IO [8] deploys a mix of mobile, web and crowd-sourcing technology to simplify and scale the collection of conservation data, with projects such as Whale Alert and Sharktivity. Bumble Bee Watch [6] is a collaborative effort to track and conserve North America's bumble bees, with an interactive map that shows bee sightings globally. Where The Wild Things Glow [21] by Jonni Walker is a visualization for bioluminescent organisms in Australia. WWF Global visualization projects like Saving Wildlife [18] and Why Are Snow Leopards Disappearing [22] are other examples of data visualization to highlight the need for wildlife conservation. We see very few such visualization efforts for tiger conservation, and hence see potential in our project for the same.

2.3 Time-series Data Visualization Strategies

Our data comprises time-series census data for tiger populations. Hence, we look into various existing time-series data visualization strategies to draw inspiration from. Novel visualization work for Time-Series data include ATLAS [39], for interacting with massive time-series datasets, Stack Zooming [28], Spiral Representations [42] and Cluster and Calendar [40] based visualizations. As our data set was not large enough, we did not implement solutions like ATLAS and Stack Zooming. Spiral Representations and Cluster and Calendar, while innovative, did not seem appropriate for our dataset and hence we did not think along similar directions for our idioms. Muller et al. [31] suggest several static and dynamic techniques for time-series data, and provide a taxonomy for the same. Monmonier [30] suggests strategies for visualization of geographic time-series data, such as time-series charts with trend lines, change maps and temporal scroll bars, that we implement in our project.

2.4 Interactive Article Strategies

Hoham et al. [26] discuss communication with interactive articles, which can respond to changing constraints and thus help inform public of past, present and future policies. Along with several creative examples, Hohman et al. also suggests guidelines to keep in mind when creating interactive articles. Interactive articles must be well written and seamlessly integrated with graphics. They must be designed for a diverse set of devices and must be accessible to a diverse demographic. There also needs to be a careful trade-off between interactivity and the core subject as too much interactivity could be distracting to users. Shneiderman [37] talks of the Visual Information Seeking Mantra, the basic principle for visual design, as Overview first, zoom and filter, then details-on-demand. We include this in our implementation over several instances, like showcasing overviews of the map first, allowing users to filter years/states as desired, and showing information on hover or clicks. These are all guidelines we have kept in mind as we developed our interactive article.

3 DATA AND TASK ABSTRACTIONS

Munzner [32] presents a high-level what-why-how framework for creating visualizations. We incorporate the same framework: what data is to be presented, why is the data to be visualized, and how the visual encodings and interaction idioms will solve the problem, in this paper. We discuss the what and the why questions in this section and the how in the next section. The domain-specific terminology describes the data and tasks in a wildlife conservation context, whereas the abstract terminology provides a generic visualization context for the same data and tasks.

3.1 Domain description

Wildlife conservation is a vast domain that refers to the practice of protecting wild species and their habitats in order to maintain natural ecosystems [23]. It includes species and habitat conservation, and addressing ways to curb threats to wildlife. Tiger conservation, a part of wildlife conservation, refers not just to increasing the number of tigers, but also protecting their habitat, reducing poaching and addressing human-wildlife conflict due to urbanization. The tiger is an apex predator which plays a pivotal role in the health and diversity of an ecosystem. The extinction of this top predator is an indication that its ecosystem is not sufficiently protected and will consequently not exist for long thereafter.

3.2 Domain task

The main goal of our visualization article is to enable readers to be better informed and analyze tiger conservation efforts in India so they can help form better policies for the same.

Task 1: Understand data from visualizations: Readers should be able to comprehend and understand the census data being represented. They should be able to interact with the visualizations and understand the changing data. For instance, on looking between census data of 2 different periods, readers should be able to understand the change in population for a particular region.

Task 2: Identify trends in visualizations: Readers should be able to analyze the visualizations and find trends in the data being shown. Interacting with the visualizations should allow them to infer data like expected future progress of the population in a region, based on past data.

Task 3: Analyse progress of a region: Readers should be able to analyze the visualizations for a particular region being shown. Interacting with the visualizations should allow them to infer data like whether regions have been doing good with current conservation strategies or if they need remedial measures.

Task 4: Comparative analysis for regions: Readers should be able to compare the progress of different states with each other, to know which states have been doing well and which states need to refine their conservation methodology.

Task 5: Overall understanding of current tiger scenario: Readers should be able to gain a concise understanding of the current status of tiger populations in various regions of India, with the context of previous populations.

3.3 Domain data

Our domain data is the tiger population data in a time-series format, and is obtained from the report: Status of Tigers in India 2018 [19]. It is available for the years 2006, 2010, 2014 and 2018. The existing data consists of the following for each year:

- Region and states in India where tiger populations exist and are counted.
- The number of tigers in each state with an upper and lower bound.
- The data is available for 23 states in India.

3.4 Abstract task

At a higher level, our explainer article presents information to the reader for consumption. Readers can *discover* new information about tiger conservation, or verify their hypotheses. The article also *presents* the data to the readers in a simple and user-friendly way. Readers can consequently also share and present this data to others. The reader may also just casually interact with the article, *enjoying* the content rather than necessarily having an underlying purpose. Our main targets are to enable users to analyse the data and *spot trends and outliers*.

3.5 Abstract data

The counts for the tiger population is the main quantitative data attribute and is essentially ordered. The region or states on the other hand are categorical attributes. In addition, derived data such as increase or decrease in tiger population compared to the previous year or percentage increase or decrease per state, will be computed for each region for the visualization.
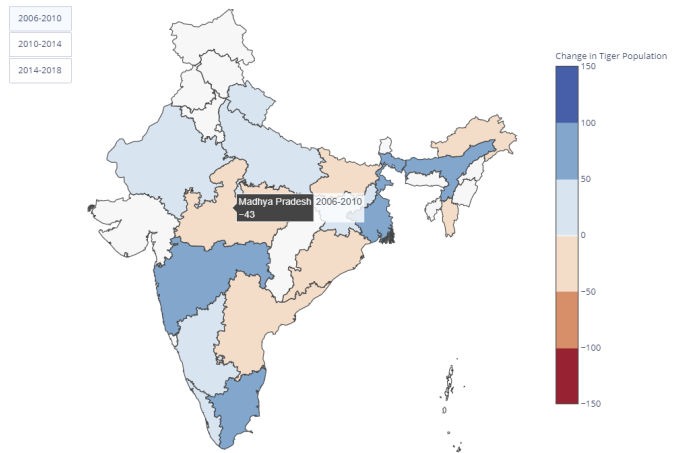

Fig. 2. Idiom 1, Visualization 2: Animated scatter plot showing population for each state for a particular year.

4 SOLUTION

To achieve the tasks discussed in the previous section, both static and interactive visualizations have been designed and are discussed below.

4.1 Idiom 1 : Choropleth Maps

4.1.1 Visualization 1: India Map with Tiger Count

For spatial visualizations, an interactive color-coded choropleth map (Fig. 1) is plotted with data representing the tiger population count. The sequential color saturation channel shows the population of tigers in each state and the area mark is used to encode the states. This visualization could pose some challenges for people with color blindness. To overcome this, color-blind friendly colors are chosen in our visualizations, with color schemes selected from ColorBrewer [7]. Simply using the color channel to indicate the population may cause cognitive overload to the user in distinguishing between different shades of colors for states when the year is changed. To alleviate this problem, a pop-up window appears when the mouse is hovered over any state, that shows the total number of tigers for that state, instead of users having to rely just on the color channel. Table 1 describes the what-why-how framework for this visualization.

4.1.2 Visualization 2: India Map with Change in Tiger Count

For spatial visualizations, an interactive color-coded choropleth map (Fig. 2) is plotted with data representing the change in tiger population count. The diverging color saturation channel shows the change in population of tigers in each state over a period of four years, and the area mark is used to encode the states. This visualization could pose some challenges for people with color blindness. To overcome this, color-blind friendly colors are chosen in our visualizations, with color schemes selected from ColorBrewer [7]. Simply using the color channel to indicate the change in population may cause cognitive overload to the user in distinguishing between different shades of colors for states when the year is changed. To alleviate this problem, a pop-up window appears when the mouse is hovered over any state, that shows the total change in number of tigers for that state, instead of users having to rely just on the color channel.

In addition, it might not be immediately obvious at first glance which states have their tiger population increased or decreased compared to a previous range of years. Hence, the diverging color scheme in this visualization distinctly breaks the colors into two categories, broadly classifying all states in shades of red as states with decrease in tiger population and all states in shades of blue as states with increase in tiger population. States in white have no recorded data for that period. Table 2 describes the what-why-how framework for this visualization.

Table 1. What-Why-How framework for Idiom 1-Visualization 1

What: Data	Data types: States (Categorical), Tiger population (Ordered)
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Know tiger population for states
	Find states with low or high tiger population
How: Encode	Map: Create choropleth map for all the states
	and their tiger populations.
How: Manipulate	Change: Change over time for tiger population in each state
	Select: Select specific data points to view population

Table 2. What-Why-How framework for Idiom 1-Visualization 2

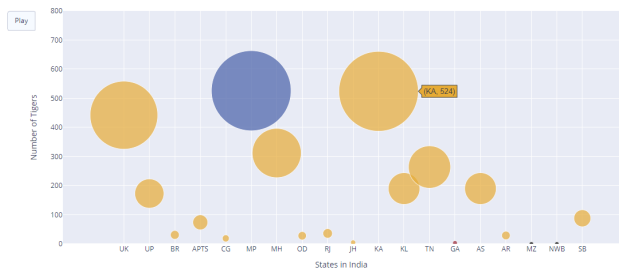| What: Data | Data types: States (Categorical), Tiger population (Ordered) |
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Know tiger population for states
	Find states with low or high tiger population
How: Encode	Map: Create choropleth map for all the states
	and their tiger populations.
How: Manipulate	Change: Change over time for tiger population in each state
	Select: Select specific data points to view population

Fig. 3. Idiom 2: Animated scatter plot showing population for each state for a particular year.

Fig. 4. Idiom 3: Multiple line charts to allow comparison between populations across multiple states.

4.2 Idiom 2: Scatterplot

Idiom 2 (Fig. 3) is an animated interactive scatter plot which is an optimal way to visualize and compare magnitude data. This idiom provides the user with the ability to view population data for all states irrespective of their size in one go for a particular year. Idiom 2 uses the vertical and horizontal spatial position on the common scale and point marks to encode the tiger population in each state. The size channel is used to encode the magnitude of the population for each state. The color channel encodes the maximum and minimum populations for each year, with blue representing the maximum population and red the minimum. Table 3 describes the what-why-how framework for this visualization.

4.3 Idiom 3: Line Chart with region based division

Idiom 3 (Fig. 4) is a line chart that shows the year on the X-axis and the population of tigers on the Y-axis. This graph uses point marks, connections and the vertical and horizontal spatial position on the common scale to show the progress of tiger populations over the course of 12 years. This idiom also uses the color channel to encode each state, and each of the regions are encoded in particular shades to allow easy differentiation between regions. For the states with missing population numbers for some years, NaN values were used, which appears as discontinuous lines on the graph. Table 4 describes the what-why-how framework for this visualization.

4.4 Idiom 4: Quasi-geographic small multiples

A problem with idiom 3 is the overlapping lines which make it difficult to see the trend lines when many states are kept visible. Additionally,
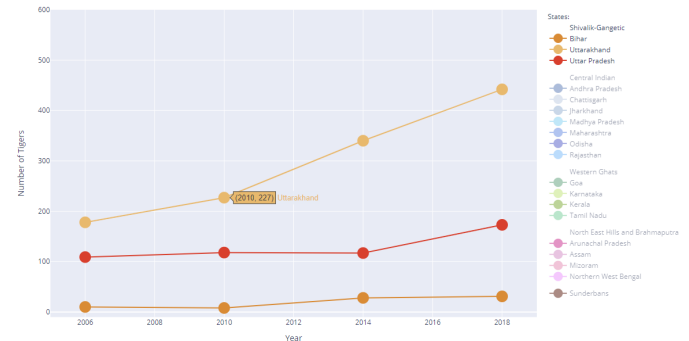
idiom 3 does not link directly to idiom 1 with the spatial positioning of the states. Due to these limitations, we created idiom 4 (Fig. 5). In this idiom, the positioning of the plots correspond roughly to the positions of the states in India. Similar to idiom 3, this idiom uses point marks, connections and the vertical and horizontal spatial position on the common scale to encode the tiger population over years. This idiom also uses the color channel to encode each state and further groups states into regions by using similar shades for states within a region. Table 5 describes the what-why-how framework for this visualization.

4.5 Idiom 5: Bar Chart Race

Since our data has time-varying semantics and uses a time series dataset, bar charts can be used to visualize data statically or as a bar chart race where the changes in tiger population over the years for each state is shown with a live animation. These are particularly useful for showing the overall picture of the entire data for multiple years. Idiom 5 (Fig. 6) is a racing bar chart that has the tiger population on the X-axis, and Indian states on the Y-axis, as shown in Figure 11. This graph uses the vertical spatial position of the common scale channel to encode the rank of the state when all states are sorted according to their tiger population in descending order. The color channel is used to differentiate between different states. Additionally, the line mark is used with a length channel to encode the tiger population for each state. A potential concern with using this type of visualization is the speed of the animation and the movement of the categories which may cause a cognitive overload and become difficult to follow. This may specifically be a problem

Table 3. What-Why-How framework for Idiom 2

What: Data	Data types: States (Categorical), Tiger population (Ordered)
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Know tiger population
	Know states with minimum and maximum tiger population
	Analyse increase/decrease in tiger population
How: Encode	Arrange: Express, separate, and order
	the tiger population values
How: Manipulate	Change: Change over time for tiger population in each state
	Select: Select specific data points to view population

Table 4. What-Why-How framework for Idiom 3

What: Data	Data types: States (Categorical), Tiger population (Ordered)
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Find trends in tiger population for one state across years
	Find trends in tiger population for one region
	Find trends in tiger population across states
	Find trends in tiger population across regions
	Find outliers in tiger population across states in a region
	Find outliers in tiger population for one state across years
How: Encode	Arrange: Express, and order the tiger population values
How: Manipulate	Change: Change over region for tiger population
	Select: Select specific data points to view population

as we have a lot of different states to represent. An alternative to bar chart race, may be a method proposed in this article [2] where the chart is basically an alphabetically ordered scatter chart and during the race none of the categories will jump around. Due to time constraints we could not pursue this alternative solution. Table 6 describes the what-why-how framework for this visualization.

4.6 Idiom 6: Overall plot

Idiom 6 (Fig. 7) is a cumulative horizontal bar chart that has the years on the X-axis and the states on the Y-axis and shows the population for each state for each year using a line mark. This graph uses the vertical and horizontal spatial position on the common scale channel, and the color channel. Additionally, the line mark is used with a length channel to encode the tiger population for each state. The color channel allows for easy differentiation between each year, and can further be used to show states with least and most tiger populations. Table 7 describes the what-why-how framework for this visualization.

5 IMPLEMENTATION

We implemented a total of six idioms and included them throughout the explainer article. This article was developed using HTML, CSS. The idioms were developed using Python, the Plotly library, Matplotlib and Plotly Express. All code was shared and updated on a common repository to enable collaboration.

5.1 Idiom 1 : Choropleth Maps

5.1.1 Visualization 1 - India Map with Tiger Count

This choropleth visualization uses a geoJSON file to create the boundary of the states and create the layout for the India map. We then transform our dataset into a form that corresponds with the geoJSON file conventions so that we can map each state's data accurately. Plotly's graph_objects module then allows us to create a choropleth map based off the geoJSON file, and 'traces' for each year are created, which essentially show the tiger population for each state for that year. Several such traces for multiple years are created, along with a layout to show the map. Finally, buttons are added to switch between years, and an HTML file is generated to embed the plot into our article. We built upon existing work on Kaggle [11] to show data for multiple years and encode data according to our requirements, and sourced the geoJSON

file from the same source. We also used existing make_subplots and graph_objects modules from the Plotly library to make the plots.

5.1.2 Visualization 2 - India Map with Change in Tiger Count

This choropleth visualization is built based on the previous one, with added processing for the derived data attribute of change in tiger population. We take the difference of tiger population between two years at the start of processing our data set, and create a derived attribute of the difference for each time period. As Plotly does not facilitate diverging distinct color scales, we referenced this article by Kyle Pastor [12] to create a custom diverging scale of red to blue. We then map this difference while giving it a range of -150 to 150, where the negative preceding a number represents a decrease in population, to the choropleth, and generate an HTML file to embed the plot in our article.

5.2 Idiom 2: Scatterplot

This idiom is a looping animated scatterplot showing the tiger numbers for each state through the years. This allows the users to see which states have the largest populations. No particular libraries other than plotly were used to create this idiom.

5.3 Idiom 3: Line Chart with region based division

This idiom is an interactive line chart that allows users to add multiple states for comparison via the legend. The legend is grouped by regions in India, allowing users to view trends across states and regions over time. This visualization is slightly different than what was originally proposed. It does not utilize a menu to add/remove trace lines to the graph. If the user double clicks the legend, all the traces will be removed with the exception of the clicked region group. No particular libraries other than Plotly were used to develop this idiom.

5.4 Idiom 4: Quasi-geographic Small Multiples

This multiplot provides a quasi-geographic view of population trends for individual states. The charts are arranged similar to the geographic location of the states in India. This chart shows the trend lines for all states at one glance. The regions are further color-coded and visible on the legend on the right-hand side. Clicking on any particular state in the legend hides the trendline for that state. A double-click on the state name in the legend isolates the graph for that particular state, hiding

Table 5. What-Why-How framework for Idiom 4

What: Data	Data types: States (Categorical), Tiger population (Ordered)
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Find trends in tiger population for one state across years
	Find trends in tiger population across states in a region
	Find outliers in tiger population across states in a region
	Find outliers in tiger population for one state across years
How: Encode	Arrange: Express, and align the tiger population values
How: Manipulate	Select: Select specific data points to view population

Table 6. What-Why-How framework for Idiom 5

| What: Data	Data types: States (Categorical), Tiger population (Ordered)
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Get an overview of how states have progressed over 12 years
	Know which states have had the maximum growth in tiger population
How: Encode	Arrange: Express, and align the tiger population values
How: Manipulate	Change: Change over time for tiger population in each state
	Select: Selecting specific data points to view population
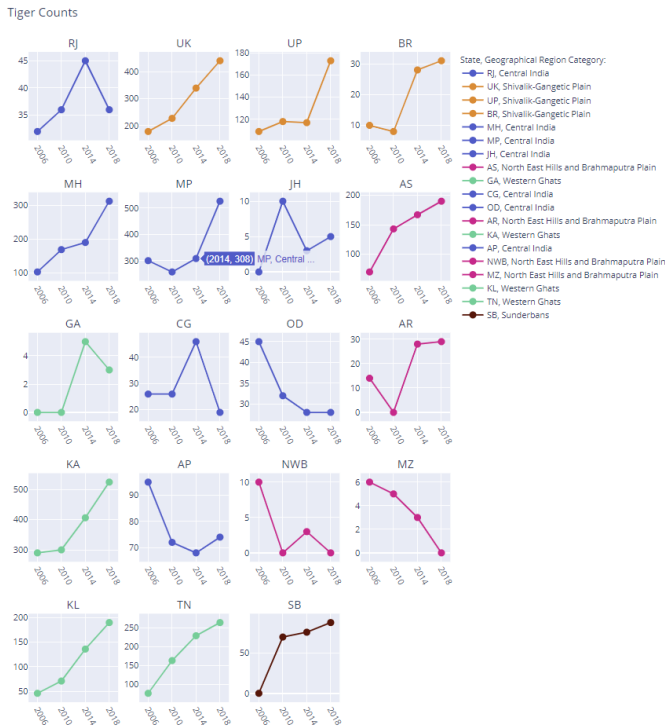
Fig. 5. Idiom 4: A quasi-geographic view of the population trends for individual states.

Fig. 6. Idiom 5: Animated bar chart race showing the change in population of each state through the years.

the remaining graphs. No particular libraries other than Plotly were used to produce this idiom.

5.5 Idiom 5: Bar Chart Race

This idiom is a chart in the form of a looping animation that would show the gradual increase/decrease in tiger population for each state over time, as well as the cumulative increase/decrease. The animation allows states to move up or down, showing the increase or decrease of each state in a more dynamic manner. Some searching and exploration was required to find the best tool for developing this chart. First, we explored Tableau, however Tableau did not show the intermediate stages between each animation frame. We also explored the bar_chart_race open source
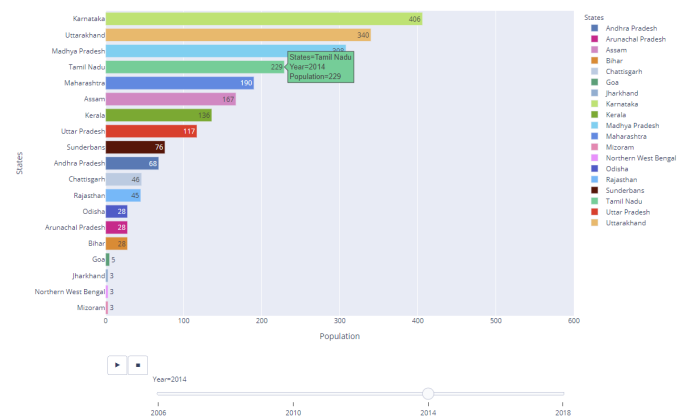
library, however the resulting animation had an odd positioning for the state names. Ultimately, the animations were created using Plotly express.

5.6 Idiom 6: Overall plot

Idiom 6 presents the user with an overview of the entire dataset in one image. To create this visualization we read the dataset and create 'traces' for every state across all years, and then display the same after creating a layout to show the states on the Y-axis and the years on the X-axis. This visualization is created using Matplotlib and the Plotly graphing_objects module.

6 MILESTONES, SCHEDULE AND CONTRIBUTIONS

The milestones, schedule and group/individual contributions are given in Table 8.

7 RESULT

Our developed visualizations work effectively at raising awareness about tiger conservation campaigns and analysis of tiger populations. Here, we discuss our final implementation of the same as a webpage, and possible usage scenarios. This project code can be found on Github[1].

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[1] https://github.com/bramyarao/547-Infoviz-Final

Table 7. What-Why-How framework for Idiom 6

| What: Data	Data types: States (Categorical), Tiger population (Ordered)
	Data set Types: Flat table
Why: Actions	Consume: Discover, Present, Enjoy
Why: Target	Get overview of tiger population in all states across 12 years
	Find trends in tiger populations for one state over multiple years
	Find trends in tiger populations across multiple states
How: Encode	Arrange: Express, and order the tiger population values
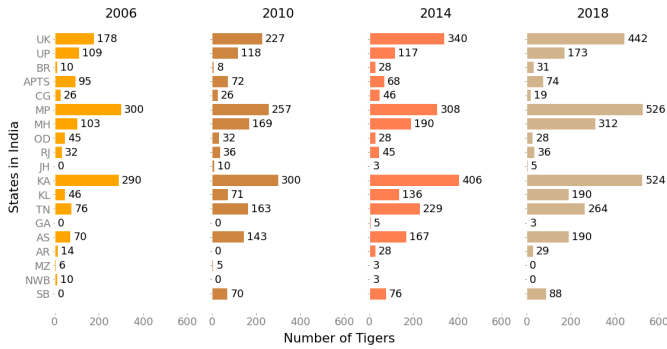
Fig. 7. Idiom 6: Cumulative bar chart showing entire dataset in one visualization.

7.1 Webpage

Our explainer article is built as a webpage[2] using HTML and CSS. It integrates interactive visualizations arranged in a logical and cohesive manner, built using Plotly in Python. For each visualization, we have a preceding paragraph that highlights how readers can interact with the visualization as well as the type of information they can gather from it. Screenshots for the webpage are provided in Fig. 8, Fig. 9, Fig. 10, Fig. 11 and Fig. 12.

7.2 Usage Scenario

Throughout the project, we evaluated and improved our design by integrating informal user feedback during the peer-review sessions. Presented below are two tasks with different usage scenarios for the intended use of our explainer article.

7.2.1 Task 1: Visualizing trends in tiger population over time

Imagine, as a wildlife conservationist, you want to know whether tiger populations in India have actually increased post the implementation of nation-wide conservation efforts. You would like to know which states have had the most success with such efforts, and which states are still seeing a decline in tiger population. You also want to know if there has been a steady or drastic change over the years and if there are particular states that need more intensive conservation policies. Hence, you want to see the tiger population changes over time.

Scenario 1: You navigate to the website[3]. You use idiom 4 (quasi-geographic small multiples, Fig. 5) to quickly find which states have had an increasing or decreasing trend in the population. To further analyze the data, you use idiom 3 (line plot with region based division, Fig. 4) to view the data for those states. You select the state you want to see the data for. Multiple trend lines are shown for the whole region, with circle marks showing the exact population over the years. Based on the shape of the line, you can analyze whether there has been a steady/drastic increase/decrease in the tiger population. You can also compare several states in the Northern region of India. You click on the legend and continue to add more states, and each appears colored differently, allowing you to see trends over specific regions. You can

now analyze which states need better policies, and how effective the campaign has been in each region.

Scenario 2: You use idiom 5 (racing chart, Fig. 6) to visualize the data. The dynamic bar chart shows the population of tigers across all the years. You can see states sliding up and down depending on the increase/decrease of tiger populations. Based on the arrangement of the states at any given point, you can see which states are faring well or poorly in their conservation efforts.

7.2.2 Task 2: Visualize the population across the country for a particular year

Imagine, as a wildlife conservationist, you wish to view the tiger population for each state in a particular year. You would like to know which state has the most population, and which state has the least. You can then analyze why in that particular year certain states have seen an increase/decrease in populations, and what measures can be taken for the same.

Scenario 1: You navigate to the website[4]. You use idiom 1, visualization 1 (Choropleth map for tiger population, Fig. 1) to visualize data. You are presented with a choropleth map that uses the color saturation channel to show approximate populations for each state. You can select the year using buttons. Hovering on each state gives you the exact tiger population for that year. By looking at the color saturation and population numbers, you can thus analyze what changes are needed in existing policies for which states and what events across the year may have caused such changes.

Scenario 2: You use idiom 2 (Scatterplot, Fig. 3) to visualize the data. You are presented with a scatterplot graph that shows the population of each state in a particular year. The color encoding allows you to easily see which states have the most or least populations for that year. This allows you to view the population per year and analyze which states need improved policies, and reasons of increase/decrease in particular years.

7.3 Analysis

Based on our visualizations and their intended tasks, we were able to observe some trends and outliers in the data. We further analysed the socio-political and ecological environment during that time in those regions, and could derive connections between the change in tiger populations and surrounding factors:

- From our choropleth idioms, we see the decrease in population from 2006-2010 for Madhya Pradesh, which is attributed to increased urbanization and human settlements and loss of forest area. In many of these areas, the loss in forest coincided with mining activity, National and state highways development and with disturbance caused by political insurgencies. Thus, this indicates the need for the establishment of wildlife corridors to ensure tiger conservation. However, Maharashtra tiger reserves saw increased tiger colonization in the same period, and hence saw an increase in the tiger population. [14]

- From our sequential color-encoded choropleth visualization, we see Madhya Pradesh, Maharashtra, and Karnataka, have some of the highest tiger populations in every period. This arises from the fact that they also have the largest number of tiger reserves, with 6 in Madhya Pradesh (Bandhavgarh, Kanha, Panna, Pench,

Table 8. Milestones, Schedule and Group/Individual Contributions [KS: Kattie SepehriUD:Unma Desai, RRB: Ramya Rao Basava]

Deadline/Date of Completion	Task	Number of hours
October 23, 2020	Project proposal: - Proposal write up - Creating potential idiom designs in Adobe illustrator - LaTeX setup and writing	- All members: 4 - UD: 4 - RRB: 4
October 30, 2020	First pass: Start initial prototype of all idioms, HTML setup. - Idiom 1: Viz 1: Choropleth map for tiger count - Idiom 1: Viz 2: Choropleth map for change in tiger count - Idiom 2: Scatter plot - Idiom 3: Line plot - *Idiom 4: Quasi-geographic small multiples* - Idiom 5: Racing plot - Idiom 6: Overall bar plot - Webpage: HTML, css and embedding figures	 - UD: 2 - UD: 2 - RRB: 2 - KS: 2 - *Was not designed yet* - Not yet started - RRB: 2 - RRB: 8
November 10, 2020	Second pass: interactive prototype of all visualizations. Started webpage for explainer article. - Idiom 1: Viz 1: Choropleth map for tiger count - Idiom 1: Viz 2: Choropleth map for change in tiger count - Idiom 2: Scatter plot - Idiom 3: Line plot - *Idiom 4: Quasi-geographic small multiples* - Idiom 5: Racing plot - Idiom 6: Overall bar plot - Webpage: HTML, css	 - UD: 8 - UD: 2 - RRB: 6 - KS: 5 - *Was not designed yet* - KS: 3 - RRB: 6 - UD: 2
November 18, 2020	Project update: - Introduction and related work - Solution and milestones - Data and Task abstraction - Review write-up of project update - Prepare for peer review - - LaTeX writing - Idioms progress: Idiom 1, 2 - partially completed. Idiom 5 - to be completed.	 - UD: 12 - KS: 6 - RRB: 3 - All members: 4 - All members: 3 - RRB: 3
November 24, 2020	Third pass: Refine visualizations and webpage. Incorporate feedback from peer review.	All members: 10
December 10, 2020	Fourth pass: Incorporated instructor feedback and complete idioms, webpage. - Idiom 1: Viz 1: Choropleth map for tiger count - Idiom 1: Viz 2: Choropleth map for change in tiger count - Idiom 2: **Animated scatter plot** - Idiom 3: **Line plot with region based division** - Idiom 4: **Quasi-geographic small multiples** - Idiom 5: Racing plot - Idiom 6: Overall bar plot - Webpage: HTML, CSS, article content	 - UD: 6 - UD: 4 - RRB: 8 - KS: 6 - RRB: 8 - KS: 8 - RRB: Complete - UD: 10
December 10, 2020	Presentation preparation: - Presentation slides - Review webpage, slides - Demo Video and Teaser Image - Clean code, Github pages and repository setup, Readme.md file	 - UD: 4, KS: 4 - All members: 4 - UD: 4 - RRB: 3
December 14, 2020	Final report	All members: 15

Satpuda and Sanjay Dubri), 6 in Maharashtra (Bor, Melghat, Navegoan Nagzira, Pench, Sahyadri and Tadoba) and 5 in Karnataka (Bandipur, Bhadra, Biligiri, Anshi Dandeli and Nagarhole). [14]

- From the quasi-geographic small multiples visualization, we see states like Odisha and Mizoram have continuously decreasing tiger populations from 2006 to 2018, while Chhattisgarh saw a drastic decrease from 2014 to 2018 from 46 to 19 tigers. On further analysis, the loss in Chhattisgarh is linked to poor law and order in the state and similarly in Odisha and Mizoram, the situation remains critical with proper sampling and data unavailable, and forest land being lost to mining. [13, 16]

8 DISCUSSION

Our interactive explainer project aims to raise awareness about tiger conservation efforts. By providing multiple interactive visualizations, we hope a wide range of users can benefit and enjoy from the variety of options to interact with the data.

8.1 Strengths and Limitations

With this project, we built interactive visualizations and an informative explainer article that is readily accessible in a website format. Our project enables readers to see trends and outliers, and showcases data in multiple ways to engage with a diverse reader demographic. We also enable readers to analyze the data shown, and recommend or review future policies for wildlife conservation with renewed insight. Some of our idioms are interactive and others are animated to create a more engaging explainer article. In each subsequent idiom, we tried to overcome any limitations that challenged previous idioms to present the data in a clear way.

Our idioms are also scalable, and can easily integrate more data if available. They can also be used for representing similar census data for other species, allowing experts in various fields to visualize and analyze diverse biological data.

Our limitations include the fact that our data set was comparatively small and not exhaustive. We would ideally have liked a global dataset or one with data for more years. Unfortunately, this is due to the limited amount of conservation research on tiger populations in India as the

Did We Save Our Tigers?

Kattie Sepehri, Unma Desai, Ramya Rao Basava

The huge variety of life on Earth contributes to our lives and well-being in more ways than we think. From offering a wealth of natural medicines to safeguarding us from climate shocks and improving soil health, we need wildlife for our survival, well-being and prosperity. However, the way we live and work – from the food we eat to how we build our infrastructure – is causing a steep decline in their numbers. In the past 40 years alone, we've seen, on average, a decline of 60 per cent in populations of species (World Wildlife Fund).

The tiger is a unique animal which plays a pivotal role in the health and diversity of an ecosystem. It is a top predator which is at the apex of the food chain and keeps the population of wild ungulates in check, thereby maintaining the balance between prey herbivores and the vegetation upon which they feed. The extinction of this top predator is an indication that its ecosystem is not sufficiently protected, and neither would it exist for long thereafter (WWF India).

Healthy tiger habitats help mitigate climate change, provide fresh water to animals and people, reduce the impact of natural disasters, and improve the health of local people. The presence and promise of tigers motivate governments to help protect Asia's forests. Tiger landscapes overlap nine major watersheds that provide water for as many as 830 million people in Asia, including in urban areas in India, Malaysia, Indonesia, and Thailand. Protecting tigers means protecting vital fresh water sources and functions. More than 30% of Asian elephant populations live within tiger landscapes, including in Bhutan, India, Indonesia, Malaysia, Myanmar, Nepal, and Thailand. That means protecting tiger habitats is important for elephants, too. And all Sumatran rhinos and Sumatran orangutans—both critically endangered—live within the tiger's range. Where tigers thrive, so do other diverse plants and animals. When we invest in wild tigers, we can help save many other species (World Wildlife Fund).

Tiger Conservation in India

In India, tigers inhabit a wide variety of habitats ranging from the high mountains, mangrove swamps, tall grasslands, to dry and moist deciduous forests, as well as evergreen forest systems. By virtue of this, the tiger is not only a conservation icon but also acts as an umbrella species for majority of eco-regions in the Indian subcontinent.

India accounts for over 70% of the global tiger population, and has had major success with its tiger conservation efforts. Project Save Our Tigers, a joint initiative between WCT, NDTV, Aircel and Sanctuary Asia, took off in 2008, and has implemented multiple stages of their conservation program in collaboration with governmental and non-governmental organizations to bring the tiger population in India back from the brink of extinction. The success of India in conserving and doubling its wild tiger population in a span of about 12 years is commendable especially when the tiger is highly threatened globally due to the high illegal demand of its body parts. The extremely low number of 1411 tigers in 2006 is what spurred the Indian government into action, and based on current data, the tiger population now stands at 2967, more than double of that in 2006.

Every four years, India takes stock of its tiger population. This exercise is of massive scale in terms of area covered and personnel involved. It uses cutting edge science and technology to evaluate tiger habitat across 18 tiger bearing states of India (NCTA Tiger Status Report). Below, we visualize this data in a number of ways to provide further insights and analysis.

A geographic overview of the tiger population in India from 2006–2018

India is made up of 29 states and 7 union territories, with tiger populations existing in 18 of these areas. This interactive visualization shows the tiger population for each state in each year (2006/2010/2014/2018). Readers can select the year they want to see the data for, from the buttons on the upper-left side. Hovering on the state also shows the exact population. The colour indicates the magnitude of the population. A geographic overview allows readers to associate states with the tiger populations, as well as spot geographic trends in populations. For instance, Madhya Pradesh, Maharashtra, and Karnataka, have some of the highest tiger populations in every period. This arises from the fact that they also have the largest number of tiger reserves, with 6 in Madhya Pradesh (Bandhavgarh, Kanha, Panna, Pench, Satpuda and Sanjay Dubri), 6 in Maharashtra (Bor, Melghat, Nawegaon Nagzira, Pench, Sahyadri and Tadoba) and 5 in Karnataka (Bandipur, Bhadra, Biligiri, Anshi Dandeli and Nagarhole). The Bandipur, Bandhavgarh and Tadoba reserves account for the maximum population in each of these states.

Tiger Population in India in 2014

Fig. 8. Webpage screenshot 1

How has the population changed over the years?

While the previous visualization showed tiger population for each region in a year, this visualization provides a comparative view of whether populations have increased or decreased as compared to the previous year. Large increase or decreases in populations might be cause for concern, and warrant further exploration. This visualization shows readers the increase in population over a period of 4 years, with increases in shades of blue and decreases in shades of red. Hovering on the states shows the exact number, with a negative sign preceding the number indicating a decrease. The upper-left corner buttons allow readers to select which period they would like to see the data for. Again, this visualization helps in viewing geographic trends and analyzing the reason behind increase or decrease in population. For instance, we see the decrease in population from 2006-2010 for Madhya Pradesh, which is attributed to increased urbanization and human settlements and loss of forest area. In many of these areas, the loss in forest coincided with mining activity. National and state highways development and with disturbance caused by political insurgencies. Thus, this indicates the need for the establishment of wildlife corridors to ensure tiger conservation. However, Maharashtra tiger reserves saw increased tiger colonization in the same period, and hence saw an increase in the tiger population.

Change in Tiger Population in India from 2010-2014
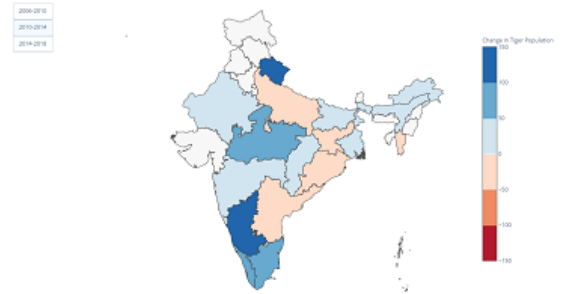
A Scatterplot view of tiger population for individual states

Each bubble shows the tiger population for a particular year in a particular state. Hovering on the bubbles shows the exact number and the year. The blue bubble shows the state with the largest population that year, and the red bubble shows the state with the least. Readers can click on the Play button to see the animated scatterplot. Viewing the graphs for every year shows the clear increase in tiger population over time, showing the positive impact of the conservation effort. It also shows a view of the populations irrespective of the geographic size of the region. The states are still ordered by region, hence also showing that the central and southern regions of India, near the center of the graph, have the highest populations.

Note: The full names of the state abbreviations are given in the Footnotes at the end of this webpage. These are consistent for all visualizations given on this webpage.
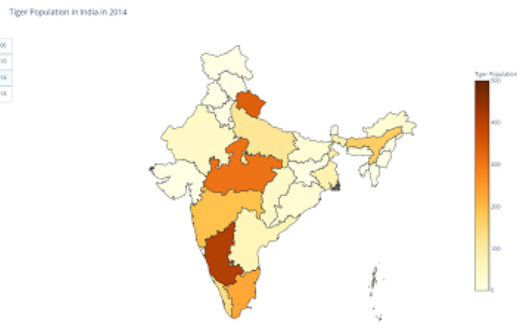

Fig. 9. Webpage screenshot 2

Government of India started recording these numbers in 2006 with four year intervals. We also did not manage to factor in all environmental or socio-political factors like deforestation, urbanization or climate change in the analysis of our data due to time constraints.

Another limitation is the size of the states in idiom 1 which can cause a misrepresentation of the tiger population. This is a common problem with choropleth maps and the user may immediately associate the size of the state with the number of tigers. To counter the same, we used a scatterplot representation to show the true magnitude of the population. In idiom 5, one limitation is slowing down the speed of the animation as we have a lot of different states to represent and hence all of them are not clearly visible. While this is certainly feasible, we were unable to find a viable solution for the same due to time constraints. We were also unable to create inter-connected visualizations due to complexity and time constraints, and tried to compensate for the same by creating additional visualizations.
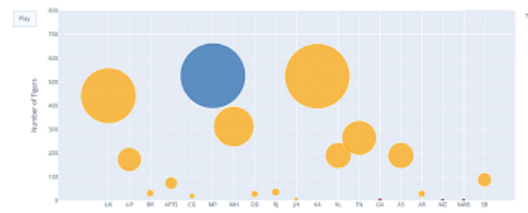
8.2 Future Work

For future work, we would like to perform such analysis on a global scale, and for multiple species, which would allow wildlife experts globally to analyze data and recommend conservation policies. We would also like to factor in socio-political aspects like urbanization and warfare, as well as environmental aspects and disasters into our data, which would greatly improve the depth and extent of our analysis. Another feature we would like to add would be live data analysis using web scraping and the ability to make predictions for future population growth.

Some improvements could be made to our existing idioms as well. For example, idiom 1 could be transformed into a bubble plot or cartogram where the size channel is used to indicate the number of tigers for each state. Another alternative could be the necklace map, encoding the total number of tigers with the size of the circles that are positioned relative to the states in each region. Idiom 5 could also be improved such that the speed of the animation is slowed down and the animation runs smoother. We would also like to make inter-connected visualizations such as integrating trendline charts within the choropleth maps, which would make it easier for readers to comprehend and analyze the data.

9 CONCLUSION

This paper introduces a novel interactive explainer article based on time-series tiger census data that enables readers to find trends and analyze how conservation efforts have fared across several states in India over time and thus provide insights on how to improve such efforts. We use web technologies like HTML and CSS, and Python libraries like Plotly and Matplotlib to create several engaging idioms for the data that can also be adapted for other datasets. We hope that analysis of such data helps highlight the need for conservation research to provide the public with additional data sets. Additionally, our aim is that such projects raise awareness about wildlife conservation while also helping wildlife conservationists, organizations and governments, analyze and improve their conservation efforts.

Tiger population trends from 2006-2018 by region

We attempt to show a **trend line for every state over a period of 12 years**, from 2006-2018. Using state-wise data over the years, we see a stacked line chart to show the change in tiger population over time. States (in different colours for distinguishing) can be selected/deselected from the right side. Hovering on the state circle marks on the graph shows the exact population in that year for that state, along with the state name. Viewing the graphs for every state over time can help us see which states are succeeding and which states need to amp up their conservation efforts. Odisha, for instance, has done poorly, with numbers falling from 45 to 28, whereas Madhya Pradesh has done excellently, with tiger numbers rising from 300 to 526. We further group the states by regions, allowing further analysis. For instance, the eastern region comprising Assam, Arunachal Pradesh, Mizoram and Northern West Bengal has not seen much increase over the twelve year period. However, in comparison, the southern region of Karnataka, Kerala, and Tamil Nadu has seen a consistent increase. The regions are space-separated vertically on the right-hand side, and clicking on any one state in a region shows the trendlines for all the states of that region. Clicking on a visible region in the legend makes it invisible.
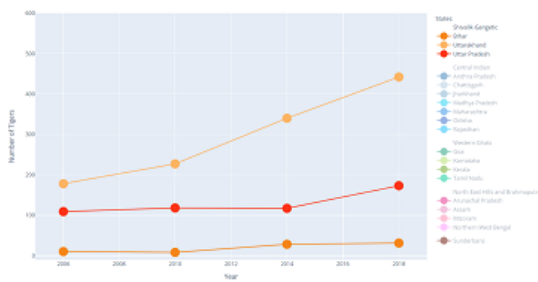
A quasi-geographic view of population trends for individual states

Multiline charts arranged similar to the geographic location of these states on the India map show the **trend line for all states at one glance**. The regions are further colour-coded and visible on the legend on the right-hand side. Clicking on any particular state in the legend hides the trendline for that state. A double-click on the state name in the legend isolates the graph for that particular state, hiding the remaining graphs.
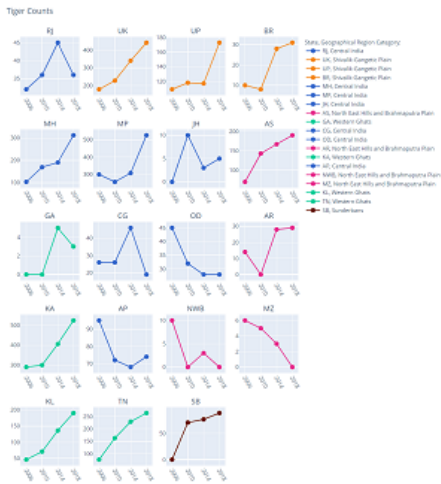
Fig. 10. Webpage screenshot 3

Conservation effort results, in motion

The racing bar chart provides a holistic data story in a concise and easy to understand format. It shows the **overall population trend** from 2006-2018 for all the states with tiger populations. The Play button on the bottom-left allows readers to start the animation, and the Stop button allows them to pause and focus on the chart if required. Hovering on the bar for any state shows the details of the tiger population in that year. A double-click on any one state isolates that state, whereas a single-click hides it from the chart.
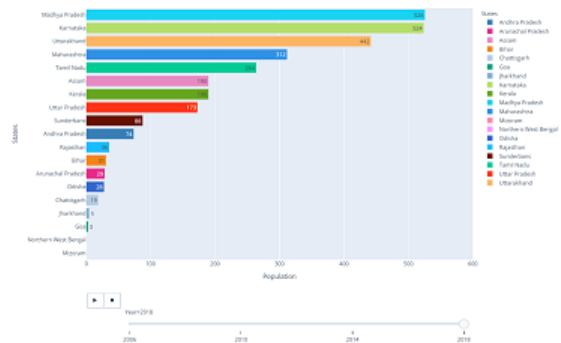
An overview of the entire tiger population in India from 2006-2018

This visualization offers a **complete overview of tiger populations over 12 years, for 18 Indian states and the Sunderbans**. Looking at the data at one glance, we can see which states have done well, and which states have done poorly. States like Karnataka, Uttarakhand, and Kerala have seen a steady increase in tiger population. This is a positive sign that conservation campaigns are working well in these states. These can thus serve as examples for states like Orissa and Andhra Pradesh, where numbers have fallen. Arunachal Pradesh and Goa have bounced back from zero populations, suggesting bringing new tigers into states for breeding and raising tiger population might be a feasible conservation technique. Thus, seeing this data at a glance can help readers understand where future efforts need to be concentrated, and what different techniques might work best in which states.
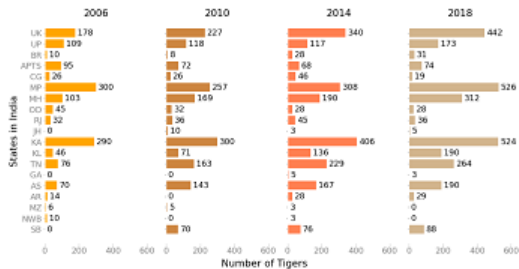
Fig. 11. Webpage screenshot 4

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Data Source

Tiger population data was taken from the Government of India's open source data platform data.gov.in, and latest data for 2018 was integrated from the National Tiger Conservation Authority's Tiger Status Report published in 2019.

Goals and Future Work

Our interactive explainer project aims to raise awareness about tiger conservation efforts. By providing multiple interactive visualizations, we aim to reach a wide range of readers, informing them about the extent to which those conservation efforts were successful and in addition help there provide insights on how they can be improved in the future. Further, we hope this helps biologists, wildlife conservationists, and policy makers find trends and analyse how conservation efforts have fared in several states and regions in India over time and where such efforts might need to be improved. We also hope that analysis of such data helps emphasize the need for conservation data to be more easily available on public forums.

Previous data gathered by the National Tiger Conservation Authority in tiger status evaluation exercises resulted in major changes in policy and management of tiger populations and provided scientific data to fully implement provisions of the Wildlife (Protection) Act 1972, as amended in 2006. The major outcomes that were direct or indirect consequence of information generated by the monitoring exercises were tiger landscape conservation plans, designation and notification of inviolate critical core and buffer areas of tiger reserves, and identification and declaration of new tiger reserves, among other results. Thus, visualization and analysis of such efforts can help in the creation of better policies and measures for wildlife conservation.

For future work, we would like to perform such analysis on a global scale, and for multiple species. We would also like to combine the analysis of various socio-political and environmental factors with such conservation campaigns that can help provide a better understanding of where efforts need to be concentrated and what policies need to be formulated. **We hope such projects raise awareness about wildlife conservation while also helping wildlife organizations, conservationists, and governments review and improve their conservation efforts.**

Footnotes

State abbreviations full forms

The order of the states in the plots is based on their regions in India. The fullnames for the state abbreviations are given in the table below along with the region to which they belong. In addition, it is to be noted that not all states are given in the table. This is due to the fact that either tiger populations do not exist in the missing states or a count survey was not done in these states.

No.	State abbreviation	State fullform	Region
1	UK	Uttarakhand	Shiwalik-Gangetic plain
2	UP	Uttar Pradesh	Shiwalik-Gangetic plain
3	BR	Bihar	Shiwalik-Gangetic plain
4	APTS	Andhra Pradesh and Telangana*	Central Indian
5	CG	Chattisgarh	Central Indian
6	MP	Madhya Pradesh	Central Indian
7	MH	Maharashtra	Central Indian
8	OD	Odisha	Central Indian
9	RJ	Rajasthan	Central Indian
10	JH	Jharkhand	Central Indian
11	KA	Karnataka	Western Ghats
12	KL	Kerala	Western Ghats
13	TN	Tamil Nadu	Western Ghats
14	GA	Goa	Western Ghats
15	AS	Assam	North East Hills and Brahmaputra
16	AR	Arunachal Pradesh	North East Hills and Brahmaputra
17	MZ	Mizoram	North East Hills and Brahmaputra
18	NWB	Northern West Bengal	North East Hills and Brahmaputra
19	SB	Sunderbans	Sunderbans

* The two states Andhra Pradesh and Telangana were separated in 2014. To keep the tiger count consistent for the years before 2014, the total count is combined for these two states for each year (for which data is available). Hence they are abbreviated together as APTS.

For further information on tiger conservation in India, we recommend the comprehensive report published by the National Tiger Conservation Authority in India available here.
Further information on wildlife conservation can also be found on these websites: WWF India and WWF

Thanks for reading!

This explainer article was written in HTML and CSS. The plots have been written in Python, using the Plotly library.
Developed by Kaltie Sepehri, Uma Desai, Ramya Rao Basava

Fig. 12. Webpage screenshot 5

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