2020 Practicum Project

Conservation Paleobiology in Urban Los Angeles

UCLA IoES

La Brea Tar Pits | NHMLAC

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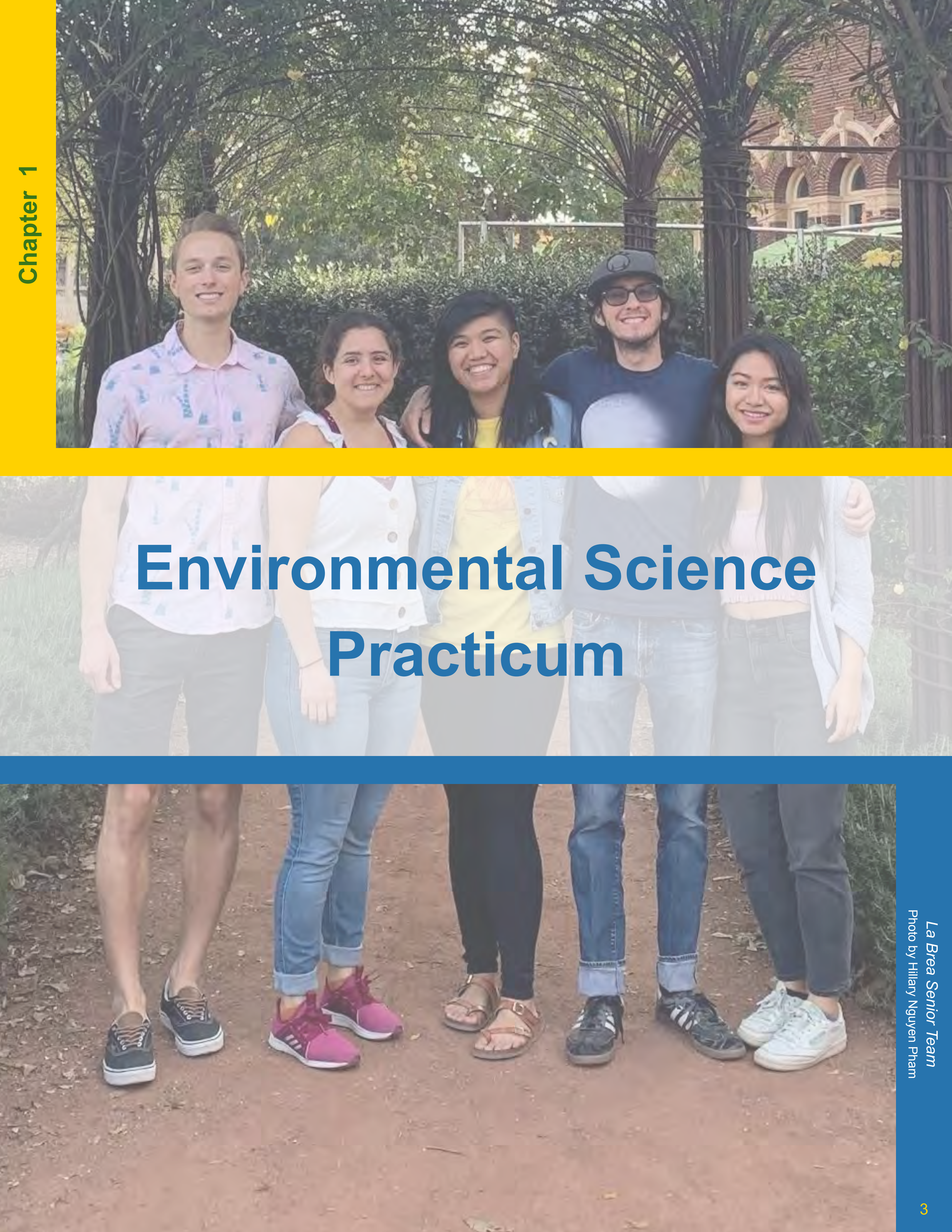
Environmental Science Practicum



La Brea Senior Team
Photo by Hillary Nguyen Pham

Practicum Overview

The Institute of the Environment & Sustainability (IoES) at the University of California, Los Angeles (UCLA) has designed a thorough and engaging capstone program for Environmental Science students. The Senior Practicum is designed to give students "real-world" experience working with professionals and learning the techniques and procedures involved with environmental projects and research. Student teams are partnered with a client that is either an environmentally-focused company, governmental or nonprofit organization, or academic research team;team, and an IoES faculty advisor who supports the team as they conduct their project. Previous practicum project teams have worked with government agencies like the U.S. Fish and Wildlife Service and the National Park Service, while other teams have worked with private companies such as Taylor Guitars and nonprofit organizations like The Bay Foundation and TreePeople.

Students take three separate practicum classes during their senior year. During the fall quarter students are guided in developing teamwork, writing, and basic GIS analysis skills and are introduced to the practicum projects selected for that year. Each client presents an overview of their project, and students elect which ones are of the most interest to them. At the end of the fall quarter, students write individual literature reviews on an aspect of their assigned practicum project. The winter quarter (January through March) of the practicum is the first phase of the project where students begin to work with the advisor and client to devise a plan of action, collect data, and formulate research questions. The spring quarter (April through June) focuses on data analysis and developing high quality products that communicate research and insights from the project. The Practicum year concludes with a final presentation to peers and faculty.

Practicum Students Conducting Field Research
Photo by IoES

Our Client

La Brea Tar Pits & Museum | NHM

The Natural History Museums of Los Angeles County include three museums, one of which is the La Brea Tar Pits & Museum. La Brea Tar Pits is one of the world's most famous fossil localities with more than one hundred excavation sites. These fossil deposits provide an incredible record of the assortment of plants and animals that have lived in the Los Angeles (LA) Basin over the past 50,000 years. Naturally occurring asphalt seeps that formed on the surface trapped flora and fauna during the Late Pleistocene ("Ice Age") and Holocene and are still active today. In addition to being an unprecedented window into Ice Age species and ecosystems, fossils found here give paleontologists insight about past and present climate change, evolutionary adaptation, and extinction.

La Brea Tar Pits & Museum
Photo by Wikimedia Commons

Emily Lindsey, Client Liaison & Advisor

Dr. Emily L. Lindsey is the Assistant Curator and Excavation Site Director at the La Brea Tar Pits and Museum. She is also Adjunct Faculty in IoES at UCLA and the project's advisor. Her research utilizes information from past and modern ecosystems to understand how Ice Age animals and environments functioned, how climate change and human actions intersect to drive extinctions, and to predict future ecological response in the face of modern global change.

Our Team

Alex McFadden | Data Manager and Modeling Expert

Alex is minoring in Geography/Environmental Studies. He hopes to implement GIS for designing Environmental Policy in California and becoming a GIS educator

Hillary Nguyen Pham | Project Manager and Data Collector

Hillary is minoring in Environmental Systems and Society. She aims to be part of nonprofits working to advance environmental justice through community engagement, education, and arts.

Dylan Readel | Lead Editor and Creative Designer

Dylan is minoring in Conservation Biology. He wants to utilize the potential of community science to expand conservation efforts in coastal and wetland ecosystems.

Lian Mae Agriam Tualla | Media Manager

Lian Mae is a double minor in Environmental Systems & Society and Digital Humanities. She plans to combine her passions for media, environmentalism, and social equity through the field of green urbanism.

Cynthia Ulloa | Communications Liaison and Data Collector

Cynthia is minoring in Atmospheric and Oceanic Sciences. She plans to work with outreach programs in her community to provide educational resources on environmental justice/combating racism.

Chapter 2

Introduction

La Brea Tar Pits
Photo by La Brea Tar Pits and Museum

Project Framework

Conservation Paleobiology

Ecosystems that are the focus of conservation research or restoration projects can be divided into two classes: historical and novel ecosystems. Historical ecosystems are those that have been established for centuries and have remained unchanged, while novel ecosystems are those that have come under the influence of human beings, so that their biotic and abiotic characteristics differ from historical ecosystems (Hobbs et al., 2014). Conservation of both types of ecosystems requires understanding the connection between the present and the past conditions (Barnosky et al., 2017). This provides an avenue for assembling and investigating deeper-time, historical and paleontological data which can build a connection between the past and present for the restoration and conservation of ecosystems and their services, a discipline known as conservation paleobiology (Dietl et al., 2015).

Ground Sloth Skeleton, ~12,000 years old
Photo by Alex McFadden

Fossil records showing shifts in diet during periods of cooling or warming can provide conservation biologists with insights about range shifts. In the face of climate change, this knowledge can be used as evidence to modify or expand protected regions (Emslie et al., 1998). The historic impact of human activities on ecosystems can be observed in younger fossil records, as well. Overexploitation of natural resources in the past may show up in the fossil record as a sharp decline in biodiversity (Edgar & Samson, 2004).

Our research used a near-time approach of conservation paleobiology (Dietl et al., 2015). A near time approach requires the use of fossil records that are relatively young. For our project, we looked at the past 50,000-year-old fossil record dating back to when the LA Basin emerged from the ocean. This fossil record was used to draw comparisons between the conditions before and after historic ecosystem disturbances, particularly focusing on anthropogenic changes and the effects from climate change. Examining species survival during past instances of climate warming can provide insight for species responses to human-caused climate change in the future (Dietl et al., 2015).

Team Member Excavating a Fossil
Photo by La Brea Tar Pits

As effects of climate change and consequences of anthropogenic actions are upon us and are worsening, the use of conservation paleobiology has become more important to help scientists understand how to implement conservation projects. Conservation paleobiology has been applied in a variety of mostly historic ecosystems, those that have been relatively unchanged over time. Our project, however, applied conservation paleobiology to a novel ecosystem, Los Angeles, California, using knowledge from the past to inform restoration projects within a relatively new urbanized ecosystem.

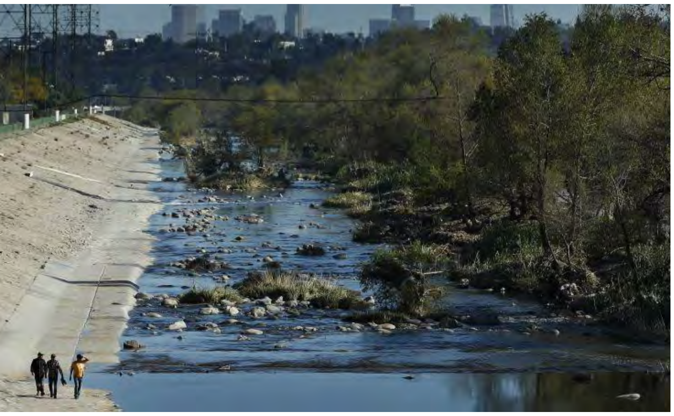
Paleobiology in Novel Ecosystems (PiNE)

Our senior practicum project focused on generating in-depth research and outreach products for an initiative on urban conservation paleobiology, or *Paleobiology in Novel Ecosystems* (PiNE):

> *PiNE is a transdisciplinary problem-solving approach that combines techniques from ecology with data from geohistorical records to guide conservation decision-making in human-modified landscapes. The foundation of PiNE is the use of paleontological, archaeological, and historical data to investigate how ecosystems were structured and how organisms responded to environmental change before and during the process of landscape modification. PiNE gives a quantitative and qualitative approach for connecting the histories of cities with their futures, including the use of taxon-specific and taxon-free metrics, to accommodate novel communities and non-native species in conservation and sustainability planning (Mychajliw et al., in prep.).*

Fossils at La Brea Tar Pits
Photo by Ira Flatow

Applications of PiNE



Life at the LA River
Photo by LA Times

Our project was a case study applying PINE techniques to a restoration goal in the highly urbanized megacity of Los Angeles, California. Los Angeles is a perfect example for this application, as the city is renowned for being a biodiversity hotspot and containing many fossil localities throughout the region. In particular, we decided to focus on the Los Angeles River and how PiNE methods could be used in the restoration of the river. With the use of paleontological and historical data, we investigated how this information could inform the rewilding of the LA river.

Urban Ecology in LA

According to the United Nations Department of Economic and Social Affairs, more than half of the world's population currently lives in urban areas (United Nations, 2018). With a projected 60 percent of people living in cities by 2030, from 3.3 billion to 4.9 billion, urban planning is now more important than ever to create healthy and sustainable cities for humans, flora and fauna within the cities and the surrounding life as well (United Nations, 2018). Cities and surrounding urbanized areas represent a great and often untapped potential for sustainability and conservation (Nilon et al., 2017). Conversely, cities are also vulnerable to natural climate disasters such as cyclones, floods, and droughts, and thus, planning for climate resilience is crucial for the survival and revival of biodiversity in urban ecosystems (United Nations, 2018).

Los Angeles, one of the world's most socially and economically influential cities, is also noteworthy for its ecological importance as it is located within a biodiversity hotspot, the California Floristic Province (Biodiversity Atlas LA, 2019). The population of the greater LA area is projected to be 13,209,000 people by 2030 (United Nations, 2018). Famous for its urban sprawl, the city has to strike a balance between development for its human population and conservation for its wildlife and natural areas. Nevertheless, development and conservation do not have to be mutually exclusive — a growing body of literature suggests green spaces, integrated built and natural environments with a holistic perspective, foster happiness in people and improve both physical and mental health (World Health Organization, 2012). Not only will LA "wildlife" benefit from conservation and sustainable development, but LA residents will, too.

Broadway, Los Angeles (1926)
Photo by USC Digital Collections

How do we design urban green spaces that are resilient to climate change? What flora and fauna are truly native to a region? How can we look back at our natural past in order to inform and inspire our current decisions and plan for the developed future? These are but a few questions that our research aimed to answer.

Almost all the large mammals went extinct, but most small mammals persisted while only one plant species is known to have gone extinct and many others moved. Much of the ecosystem change has occurred recently with the introduction of invasive species from European colonization and the impacts resulting from urban development.

The LA Basin is a gold mine for Quaternary fossils dating back 100,000 years for several reasons. Firstly, the excellent preservation properties of naturally occurring asphaltic seeps established an extraordinary fossil record at the now-famous La Brea Tar Pits locality (Akersten et al. 1983). Furthermore, alluvial sediment deposit from surrounding hills and mountains led to rapid burial of animal remains throughout the basin. The abundance of species within the LA biodiversity hotspot meant there were more chances for fossilization to occur. Finally, an increase in development, particularly excavation for subways and buildings, means that preserved fossils are likely to be discovered.

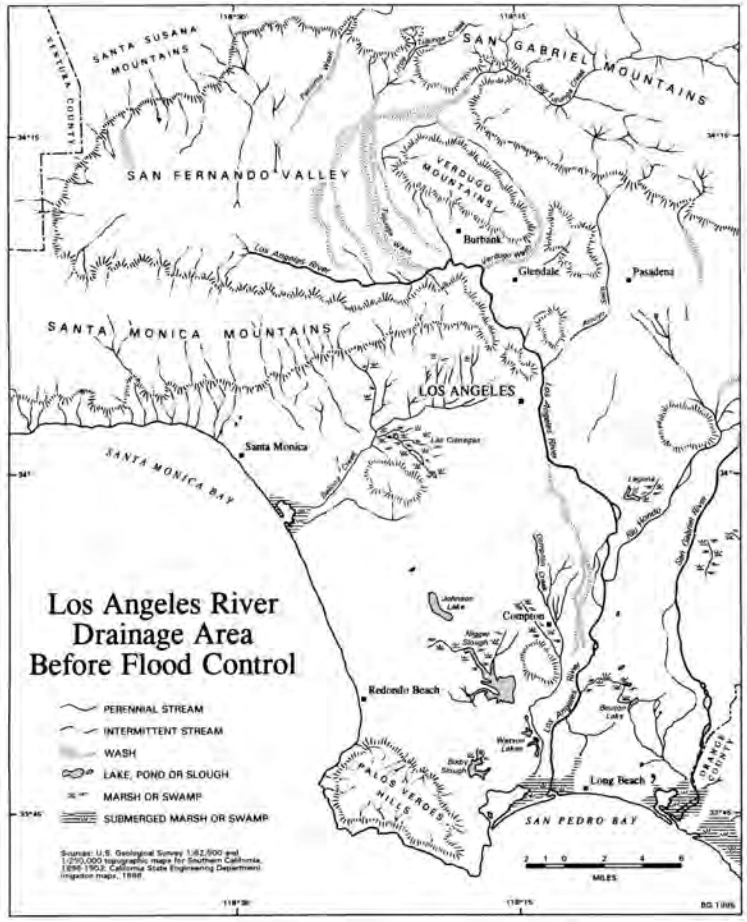
Downtown Los Angeles
Photo by LA Curbed

Los Angeles River

The Los Angeles River once supported a large riparian ecosystem consisting of a diversity of habitats and environments. Flowing through forests of willow, sycamore, elderberry, and wild grape, it was home to a multitude of small mammals, amphibians, and waterfowl. Steelhead trout filled the river while grizzly bears roamed its banks in search of food. The river ran its course when and where it wanted, occasionally raging out of control during hard winter rains.

The first humans to occupy the land around and utilize the Los Angeles River were the Tongva. The Tongva built their villages alongside the river and utilized the natural resources that it and nearby woodlands had to offer. The river was the core of the Tongva diet, medicine, culture, and way of life. The river not only sustained the Tongva with a multitude of resources but also served as a connection between villages. The Tongva were easily able to exchange goods and conduct trade with other villages along the river and connecting waterways. In the late 1700s, the region was colonized by Spanish explorers.

For most of its natural history, the LA River never had a set course. The infrequent nature of strong storms and the deposition of fine soils within the LA basin meant that powerful flows could not carve steep banks to contain the river. Flooding was a natural component of the river. With the increase of urbanization, the extent of permeable surface slowly shrank. Hard surfaces like pavement restrict water from penetrating the ground; water also moves faster on these smooth surfaces. These factors increasingly intensified the effects of flooding. As the region developed more, the flooding of the river took many lives and impacted communities leading to the river's channelization in 1938.



From *The Los Angeles River: Its Life, Death, and Possible Rebirth*
Cartography by Blake Gumprecht

The La River today consists of 51 miles of paved concrete that spans from the Santa Monica Mountains and exits to the ports of Long Beach (Guerin). The majority of wetland and riparian habitats in the basin vanished. Many species once widespread in the ponds and streams were extirpated. Currently, Los Angeles has a multitude of planning initiatives for the River, from the county to city to parcel scale.The *County* of Los Angeles aims to unify the many different visions of the river into one plan called the LA River Master Plan (LARMP). The *City* of Los Angeles aims to complement LARMP with the Los Angeles River Revitalization Master Plan (LARRMP) while specializing on the 32 miles of river within the city. LARRMP aims to foster sustainability practices and enhance habitat and other natural processes, with one key project being the Taylor Yard "G2" Project.

Project Objectives

By combining fossil data, recent species occurrence records, and future climate models, our research sought to understand the past, present, and future distributions of the biodiversity found throughout the LA region. The goals of this project include:

Deep Time Data Modeling

La Brea Stork, Bird Watcher's Digest
Photo by Billie Dodd

Application of deeper-time historical and paleontological records to data modeling within an urban environment to identify plants and animal species that are resilient to climate change, capable to restore lost ecosystem structures, be able to thrive in urban environments in the LA river and region.

Public Communications

To connect LA residents to the natural history of the region —showing people that the LA Basin was once a flourishing ecosystem with an abundance of rivers and wildlife and inspiring imaginations of a better, more sustainable future.

Sustainable Development

The use of the fossil and historic record to inform conservationists, city planners, and community stakeholders about the historical biodiversity of LA County for applications in sustainable development and climate change resilience.

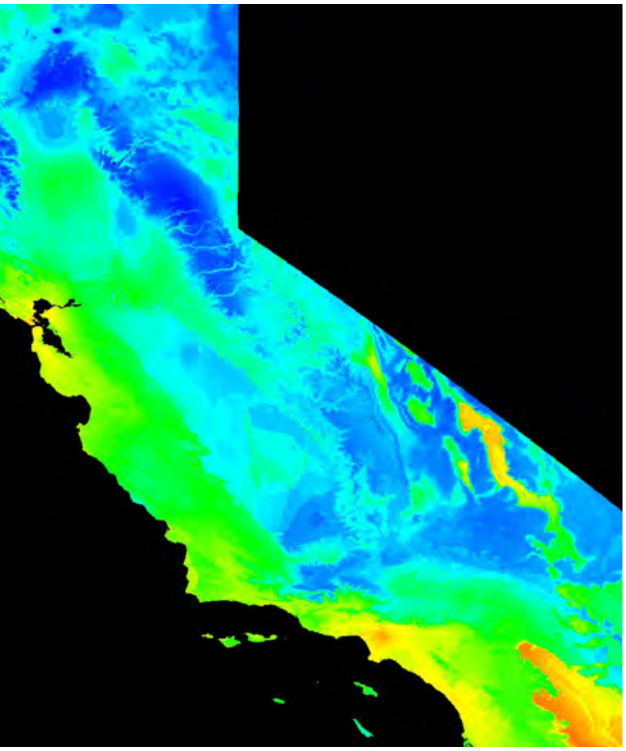
Chapter 3

Products

Los Angeles River
Photo by Shutterstock

Predicting Future Species Habitats

Building Models



Model Results for Coyotes
Results by Alex McFadden

To understand current and future fundamental niches, in other words the habitats species occupy, scientists use Ecological Niche Models (ENMs), or Species Distribution Models (SDMs). ENMs/SDMs predict where species are ~~most~~ likely to be located based on preferred climate conditions ~~and~~ inferred from current distributions. Our project used the modeling software *Maxent* since it is beginner friendly and open source, meaning it is free to download and use. For our models, we used climate data and species occurrence records. For our models, we used bioclimatic variables sourced our climate data from WorldClim.org~~,~~ and ~~Specifically, our project used bioclimatic variables which are climate data specifically designed by *WorldClim* for determining suitable habitats. We~~ gathered species occurrence data from online databases that contain several centuries of preserved specimens along with recent observations resulting from the introduction of *iNaturalist*.

Suitability Maps

We analyzed and distributed the ENMs via suitability maps. Suitability maps are intended to predict and visualize changes in habitat suitability, and therefore possible changes in species distributions, between the current climate and projected future climate scenarios. In other words, the current suitability maps show the regions of LA with favorable habitats for species now, while the future suitability maps show how climate change could alter these favorable habitat locations. The purpose of the maps presented here is to communicate how riparian species, those found around rivers and streams, will be affected by climate change in LA.

We produced four maps for each species: one shows a species' current potential habitat, while the three others show predicted potential species habitats under ~~future~~ three different climate change scenarios ~~in~~ for 2050. These future climate change scenarios were developed by the Intergovernmental Panel on Climate Change (IPCC) and are known as the "best case" (RCP2.6), "intermediate case" (RCP6.0), and "worst case" (RCP8.5) scenarios. The "worst case" is usually referred to as the "business as usual" climate scenario corresponding to complete inaction by humans to slow and stop climate change. While ENMs for each species were produced for the entirety of California, the suitability maps we created focus on LA County.

Scenario	Mean ΔTemperature	Likely ΔTemperature Range
RCP2.6	1.0 °C	0.4 °C to 1.6 °C
RCP4.5	1.4 °C	0.9 °C to 2.0 °C
RCP6.0	1.3 °C	0.8 °C to 1.8 °C
RCP8.5	2.0 °C	1.4 °C to 2.6 °C

Table 1: Global surface warming projections for 2050 under four different scenarios of climate change mitigation (IPCC, n.d.).

We determined the mean suitability, calculated on a scale from 0 to 1, for species in LA County. The mean suitability represents the suitability averaged across all of LA County for a species. If half the map is red, meaning low suitability, and half the map is blue, meaning high suitability, the mean suitability will most likely be around 0.5. Species that see the greatest decrease in mean suitability will suffer the greatest loss in their favorable habitat.

The next pages highlight~~s~~ the California red-legged frog and western fence lizard, two species that displayed dramatically different results for their suitability maps. The frog models show the species will be highly impacted by climate change, while the lizard models do not. We chose to highlight these species since they are both found within riparian ecosystems, the focus of this project. The following two pages showcase the suitability maps for the two species. Additional suitability maps for the arboreal salamander, California slender salamander, coyote, and western pond turtle can be found in the Appendix (*Figures A1-A4*).

California Red-Legged Frog (*Rana draytonii*)

CA Red-Legged Frog
Photo by National Wildlife Federation

The California red-legged frog is a native to Los Angeles and the official state amphibian. Despite this, it is listed as a vulnerable species by the International Union for Conservation of Nature (IUCN). Its vulnerability status is due to the introduction of the American Bullfrog in the late 1800s. The American bullfrog was able to adapt better to human modification of landscape. As a predator of the California red-legged frog, they have contributed to their population reduction. This California red-legged frog is found in aquatic habitats such as streams and ponds that are well vegetated.

Western Fence Lizard (*Sceloporus occidentalis*)

The Western Fence Lizard is commonly found in California and other regions such as Oregon and Nevada. This species is found in areas with boulders and logs where they can bathe in the sunlight. Their diet consists of beetles, ants, caterpillars, and spiders. They are able to change colors to blend into their surroundings. This lizard uses pushups as a defense mechanism to show their blue bellies off which warns others who trespass in their territory.

Western Fence Lizard
Photo by The Nature Collective

California Red-Legged Frog (*Rana draytonii*)

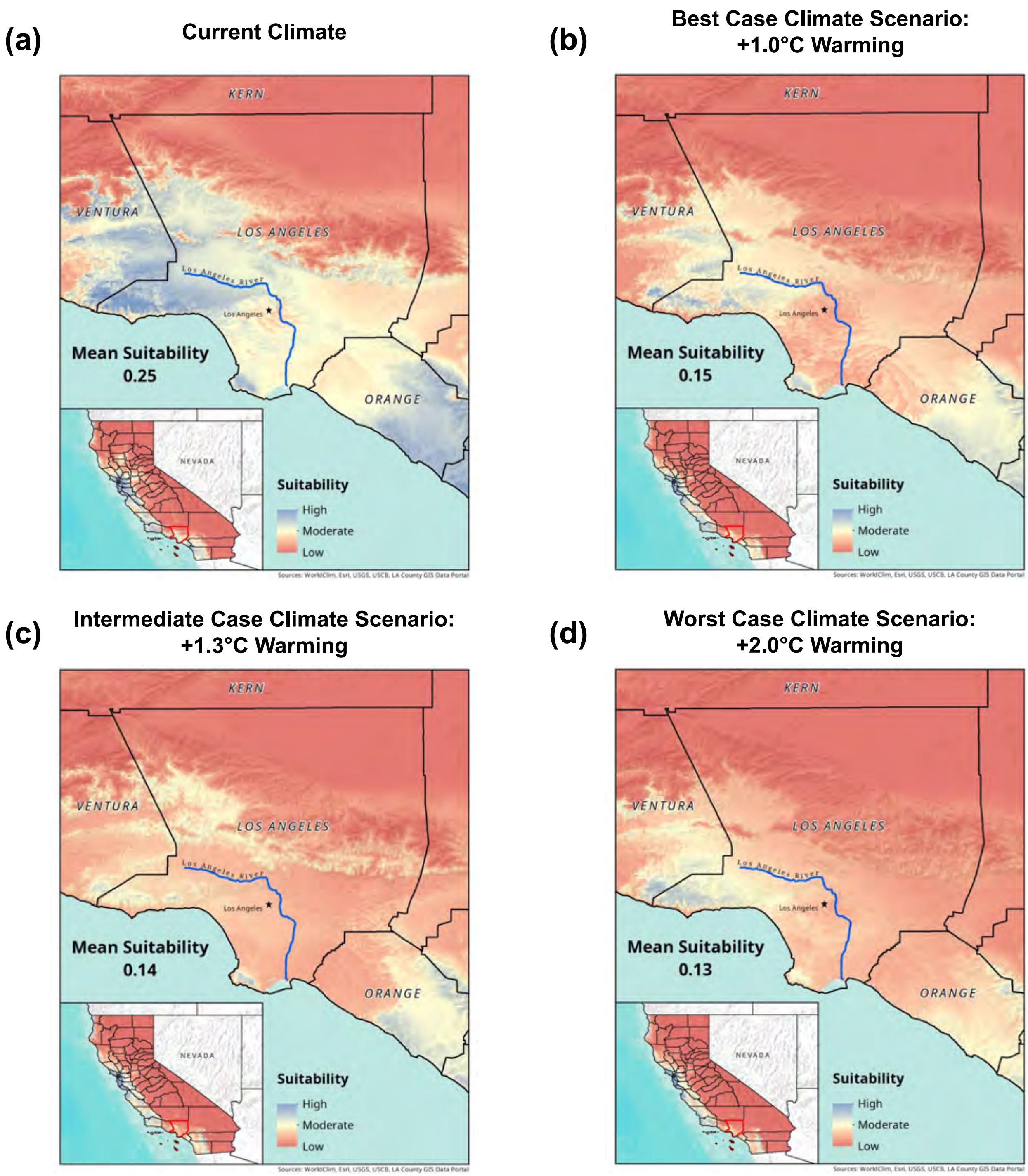


Figure 1: Habitat suitability maps for LA County: (a) current, (b) RCP2.6 in 2050, (c) RCP6.0 in 2050, and (d) RCP8.5 in 2050. Future mean suitability is about half the current mean suitability in all climate change scenarios.

Western Fence Lizard (*Sceloporus occidentalis*)

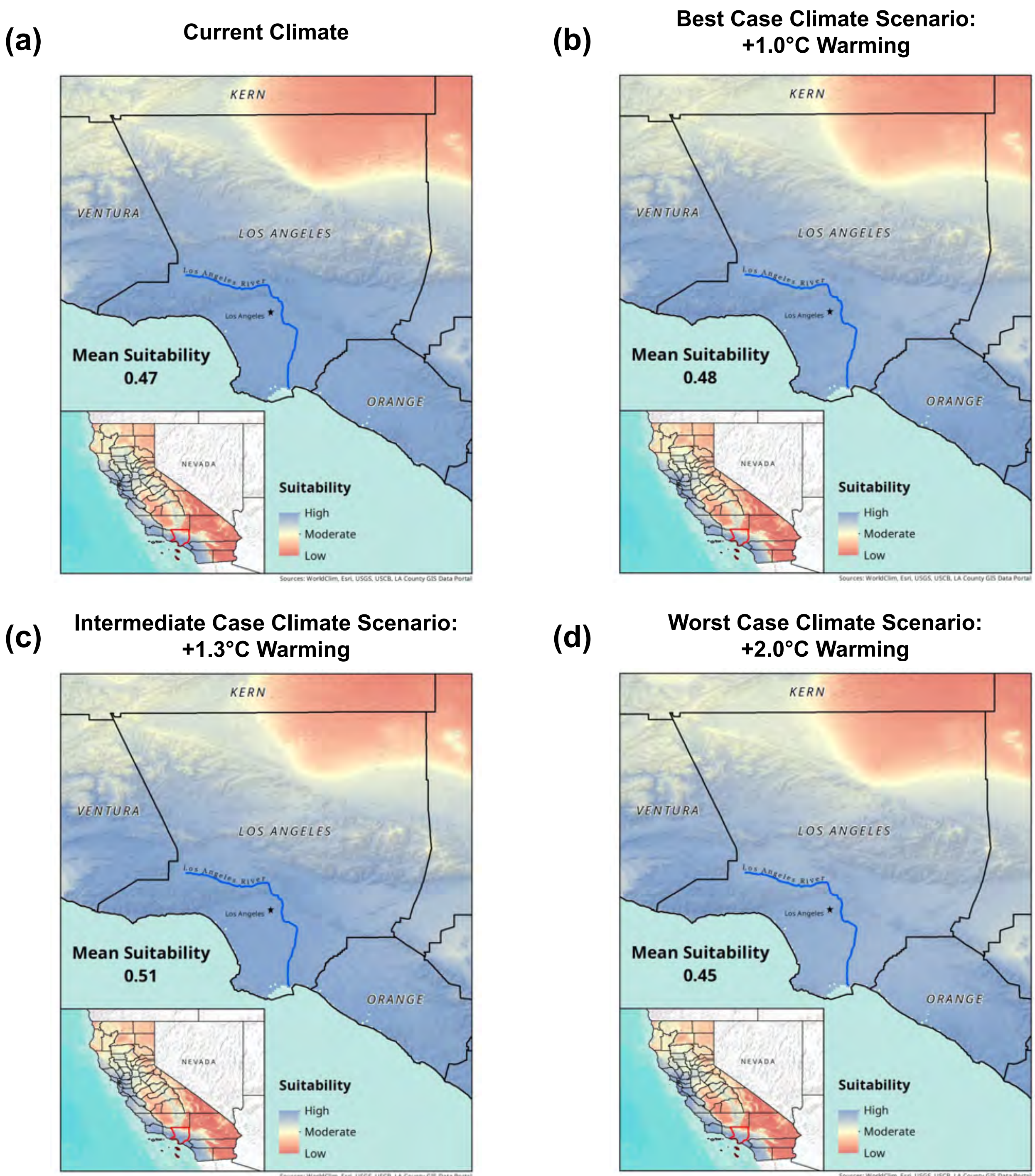


Figure 2: Habitat suitability maps for LA County: (a) current, (b) RCP2.6 in 2050, (c) RCP6.0 in 2050, and (d) RCP8.5 in 2050. Future mean suitability is approximately the same as current mean suitability for all climate change scenarios.

Species Distribution Maps

We created species distribution maps in relation to other data layers that give more insight on why species occurrences have shifted, declined, or increased. These were designed using species occurrence data from GBIF and Esri on ArcMap and ArcGIS Online.

Carnivores in an Urban Environment

Coyote Scavenging Food Leftovers
Photo by Matt Knoth

Large carnivores can be extremely rare in urban environments. Los Angeles is one of the few cities that has mountain lions living within its city limits. Similarly, the coyote's behavior to scavenge gives it success to adapt easier in the city. This map shows the mountain lion, gray fox, and coyote distribution with an overlay of population density (population density per square mile) in LA County.

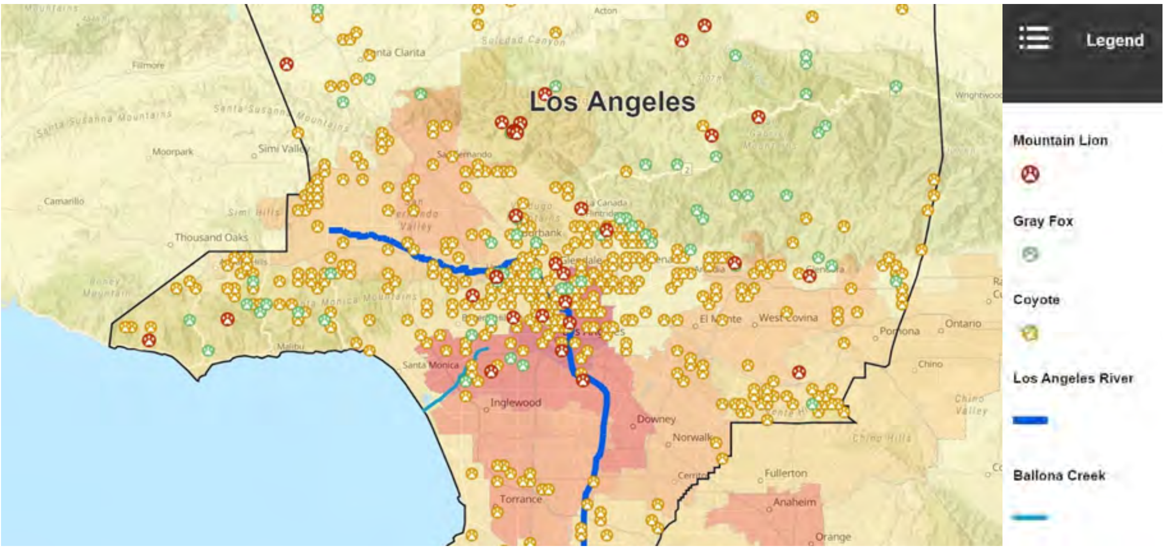


Figure 3: Screenshot of ArcGIS Online map displaying mountain lion, coyote, and gray fox distributions with an overlay of population density.

Historic and Recent Occurrences of Loggerhead Shrikes

Los Angeles county has around 200 different bird species that inhabit this urban area. One of these species includes the songbird, the loggerhead shrike. The loggerhead shrike is a common bird in the LA region, but recently their numbers have started to decline over time due to loss of open habitat. This map shows the historic and recent occurrences of the loggerhead shrike throughout the Los Angeles region.

Loggerhead Shrike Eating Worm
Photo by Christopher Clark

CA Red-Legged Frog Displacement

Invasive American Bullfrog
Photo by Tim Adriaens

The California red-legged frog faced drastic declines in population due to numerous factors: urbanization, reduction of natural water sources like ponds and streams, and the introduction of the predatory American bullfrog that consumes the native frog. This map visualizes the displacement of the California red-legged frog along with the newfound habitat of the bullfrog in Los Angeles County. The bullfrog is able to maintain a significant habitat in the most urbanized regions of LA while the native frog is restricted to surrounding mountains.

Species Records Visualizations

In order to look at temporal aspect of species distributions, we made two types of visualizations, graphs and animations. These visualizations not only illuminate patterns on species occurrences themselves, but also larger shifts in data collection efforts and techniques through institutions and community science.

Records Graphs and Animations

Specimens from NHM collections
Photo by Dylan Readel

Record graphs are formatted similar to Gantt Charts, with each tick representing an individual occurrence of that species. iNaturalist recordings are represented in gold. Figure 3 shown on the next page is only a small section of the mammal occurrence graph. Record animations portray occurrence in a live format, over a 60 second Carto map. Mapped locations provide another layer of information compared to the occurrence graphs. Figure 3 and 4 on the following pages depict a graph and an animation respectively.

Collection Patterns

With these visualization we can see periods that either lack or have an abundance of data. In addition to species' population changes, these graphs reflect historical differences in the changing methods of natural historical data collection and local collection focus. We see that there is a shift from specimen collection by institutional scientists to community science observations on web resources like iNaturalist. In our analysis of the visualizations, we noticed a general positive trend of many species in the late 2000s. Much of this is due to iNaturalist observations being included in GBIF databases.

Using iNaturalist in the Field
Photo by Missouri Department of Conservation

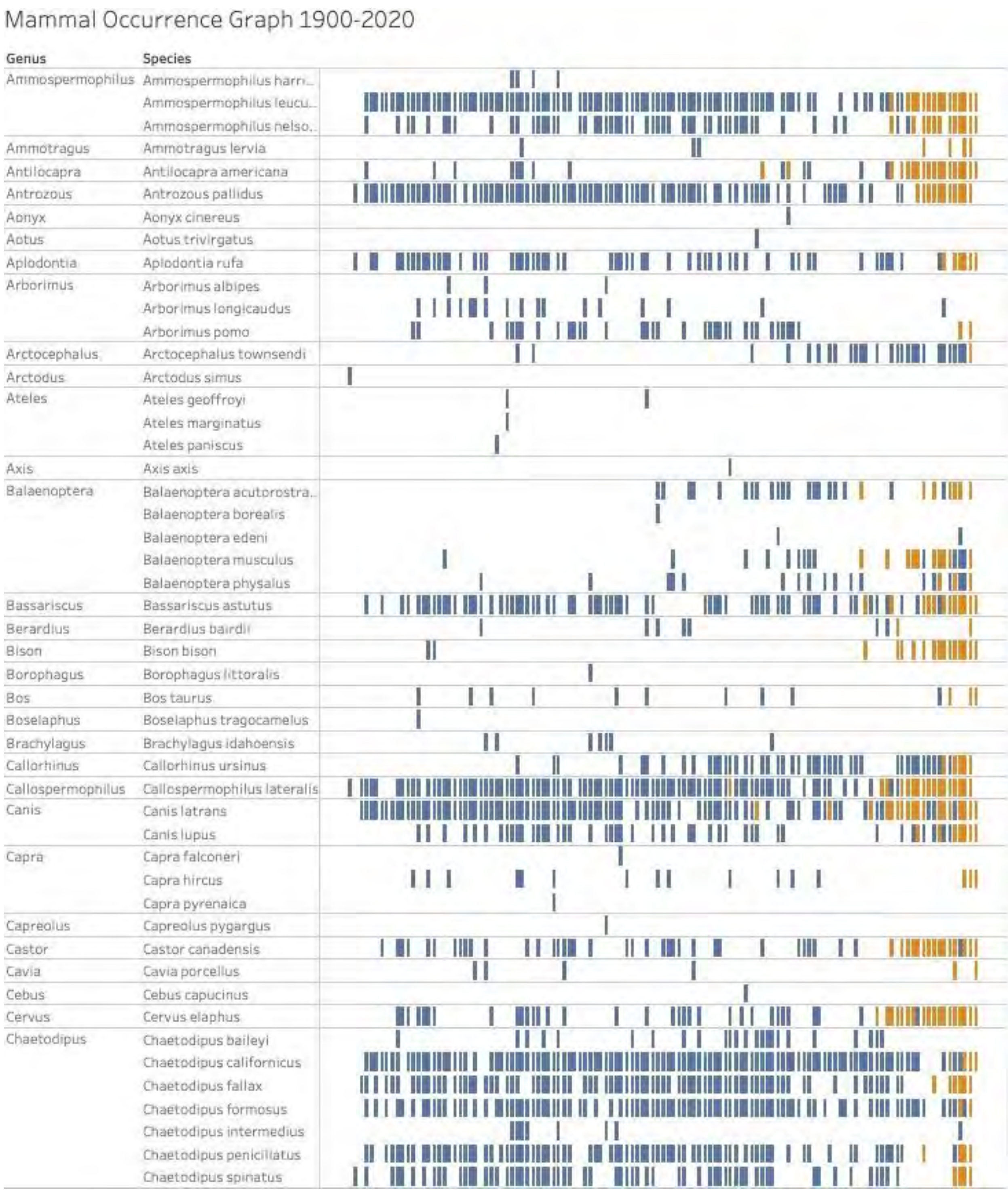


Figure 4: This is the first page of the occurrence graph of Mammals in Los Angeles County from 1900-2020. The yellow ticks are research grade occurrences from iNaturalist.

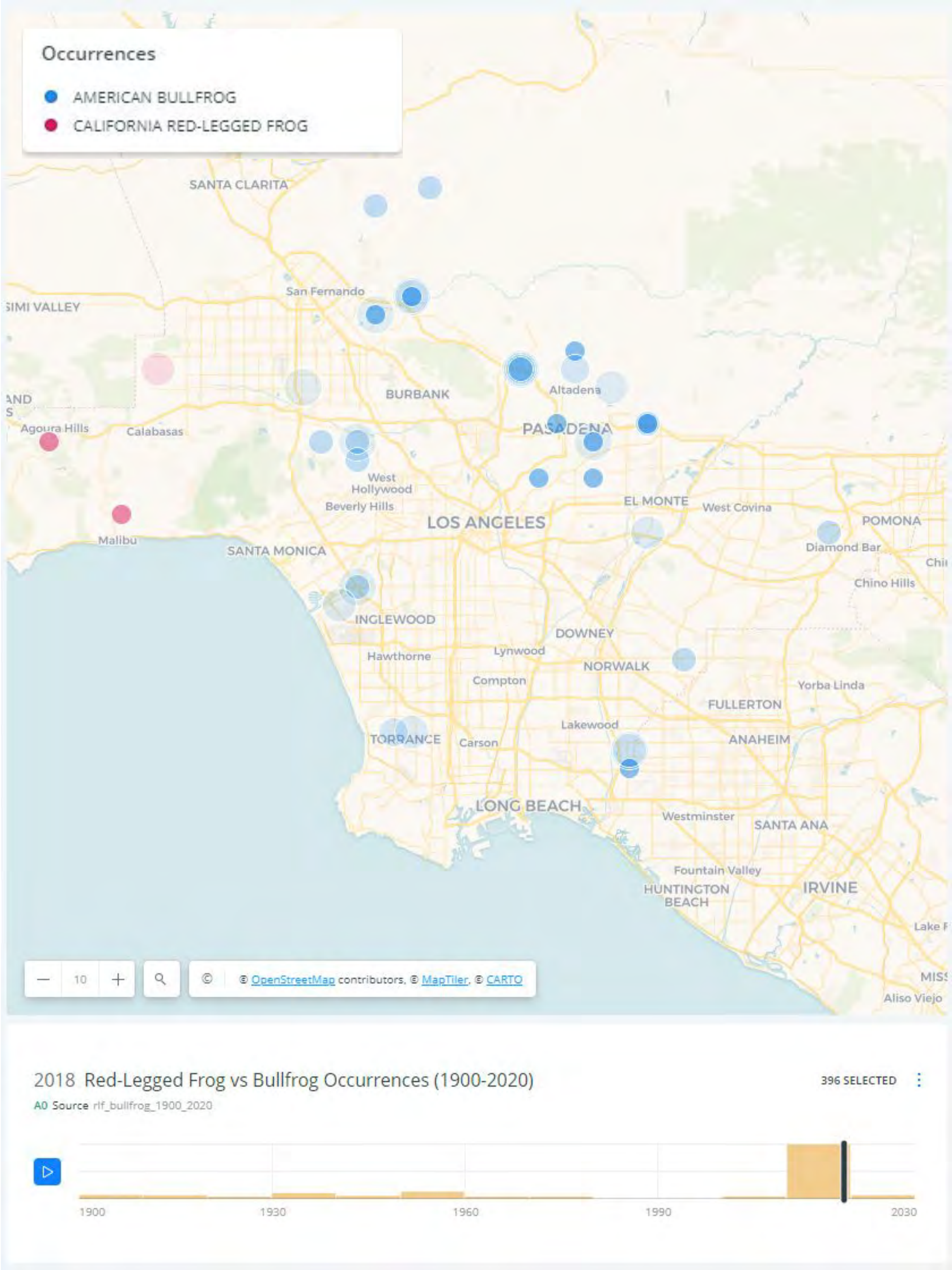


Figure 5: ~~This is a~~ Screenshot of the Carto animation ~~comparing~~ depicting the occurrences of Red-Legged Frogs and Bullfrogs in LA County through time. The animation is paused at the year 2018 in which there is a large influx of bullfrogs (shown in blue) relative to red-legged frogs (shown in red).

ArcGIS StoryMap

To connect the public to our research, we created an ArcGIS StoryMap about the history of the LA River, its ecosystems, and novel insights about present and future distributions of species around the river. An ArcGIS StoryMap is a web-based application on the ArcGIS Online platform that enables content creators to share their maps in the context of narrative text and other multimedia. Our story map is meant to be a public-facing accompaniment to a scientific article introducing PiNE (Mychajliw et al., in prep.) and will also be hosted on the IoES website.

Our story map is divided into three parts: past, present, and future of the LA River. The past component includes a brief overview of the LA Basin from 100,000 years ago and a historical interactive map of human interactions and impacts on the river. Information about the Tongva, European colonization, and channelization were some of the aspects included in this section. The present component contains multiple interactive maps outlining the varied responses species have had across the LA River. For example, we highlighted species that were provided opportunities to capitalize on urban expansion and others that were disturbed and experienced population declines. Lastly, the future component presents proposed rewilding, redevelopment, and revitalization initiatives for the LA River, as well as our suitability maps comparing current and future distributions of selected species.

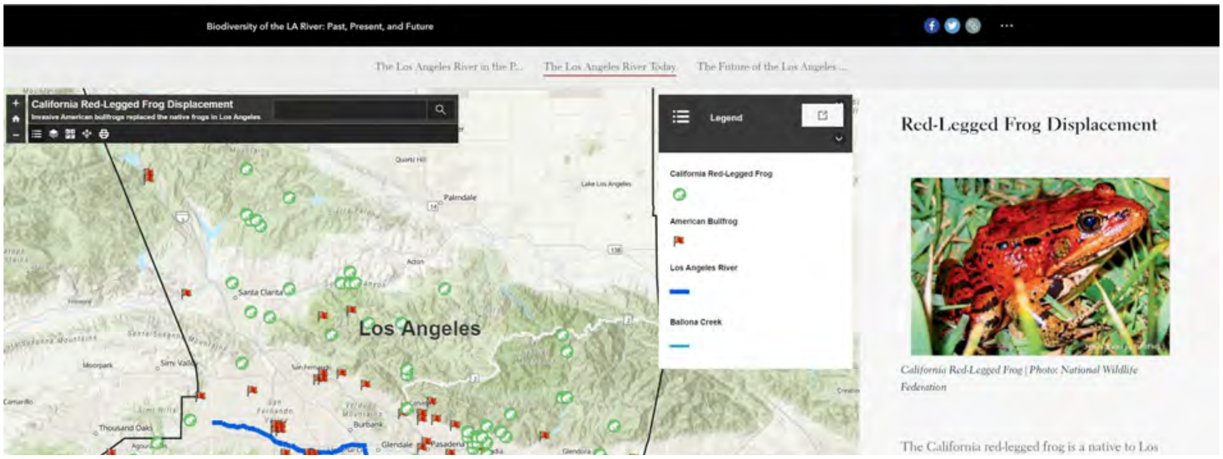


Figure 6: Screenshot of the present section of StoryMap.

USC Exhibit

We were invited to contribute to this exhibit that is in partnership with the University of Southern California (USC) in their newly established Torrey Webb Sustainability Space. This space has the potential to communicate sustainable science stories to the public, and we hope to share our research in this exhibit to connect Angelenos with the deeper history and cultural significance of local natural ecosystems.

As a result of the COVID-19 pandemic, this project has been put on hold, and we pivoted our focus to an online science communication format through the ArcGIS StoryMap. Our team used the plans and ideas for the exhibit to develop an online ArcGIS StoryMap that parallels the potential for the exhibit. Our team has devised preliminary concepts for what we hope a future practicum team or the La Brea Tar Pits & Museum could eventually develop into a full scale exhibit.

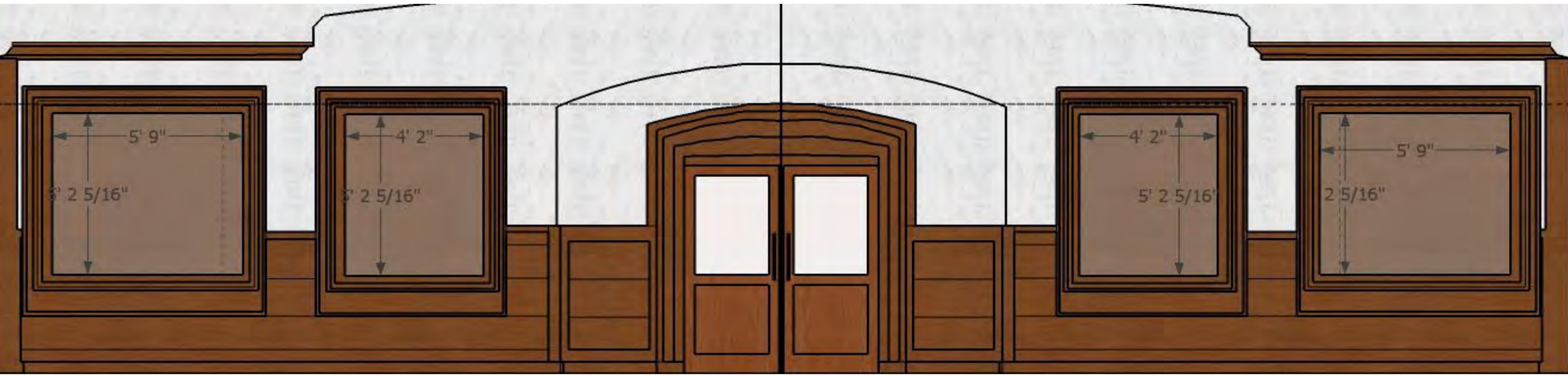


Figure 7: Architectural plans for the Torrey Web Sustainability Space.

We hope to have a mix of multimedia, cartographic visualizations, and fossils on display. Taking inspiration from the StoryMap, listed here are some suggestions for future teams:

- the history of the LA River, using the depiction of the river metaphorically as a timeline;
- fossils of relevant species such as coyotes;
- a slideshow of the LA River throughout time, from the Pleistocene to future rewilding initiatives; and
- suitability map GIFs of changing future climate scenarios.

LA River Mini Documentary

In order to provide more context to our area of interest, we created a mini documentary showcasing the LA River. We felt that getting closer and more intimate with the LA River through the medium of video would increase the audience's emotional investment toward the river. Our team formatted the video in three sections: a brief timeline of the river from the Pleistocene to the recent past, footage of our river tour, and closing remarks from our team members about the importance of our research and the river.

Figure 8: Screenshot from our documentary

We sourced media from a variety of YouTube and Vimeo channels. Online archival material for the river timeline along with footage filmed on location was used for the river tour and closing remarks. We used other publicly-accessible media for B-roll and background music. Full media sources can be found in the video and video description on YouTube.

The video accompanied our final presentation for the practicum project, and the audience reacted positively. We plan to make the video publicly accessible through the IoES website — it will also be available to watch on YouTube.

Chapter 4

Discussion

La Brea Tar Pits
Photo by LA River Master Plan

Our suitability maps allowed us to visualize changes in suitability which showed us the possible changes in species' distributions. The results we obtained from our suitability maps varied among the species we looked at. These results provided significant insight on how different species would be affected by projected future climate changes. Through our models and maps, we found that the California Red-Legged frog had the largest decrease in suitable habitat under the worst case scenario (RCP 8.5) while under the best case scenario (RCP 2.6), they had the smallest decrease in distribution. These results are significant because they show us that this frog species has a low likelihood of being found near the Los Angeles River. This is partly due to the introduction of the invasive American Bullfrog which has eradicated this population. For the Western Fence Lizard, on the other hand, current distribution did not experience a large change in distribution under any of the scenarios. These results show us this species' resilience as climate changes; they have a high likelihood of being found throughout the Los Angeles region. Refer to our Appendix to look at other species' models and suitability maps.

American Bullfrog
Photo by SD Herps

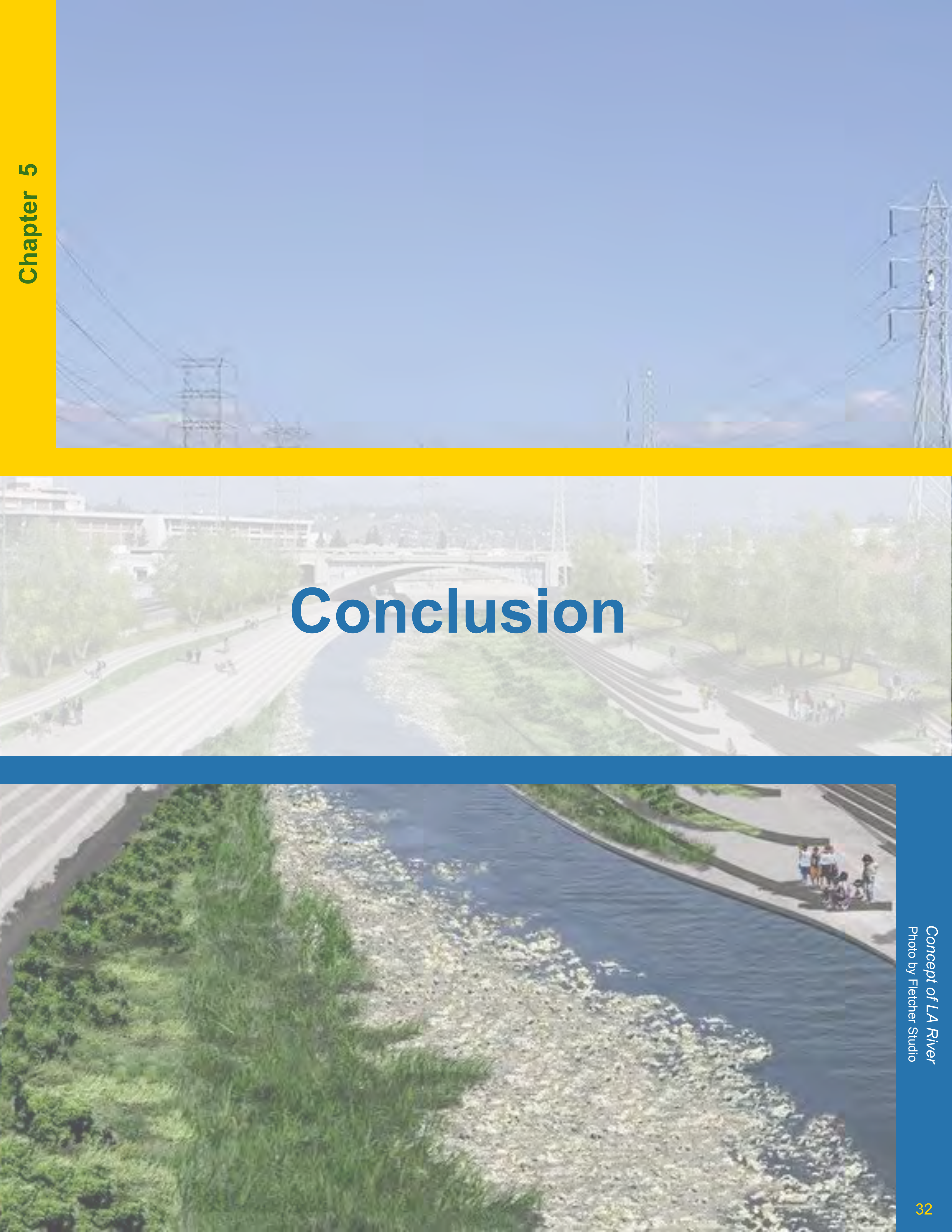
Our species occurrence visualizations displayed the data in two ways. The species occurrence graphs displayed a trend of many occurrences being recorded towards the late 2000s due to iNaturalist being introduced in 2008. Museum collections are critical for science research, but museum acquisitions have declined in recent decades, hindering researchers' ability to use collections for their analysis on species' response to habitat modification, urbanization, and global climate change (Spear et al., 2017). iNaturalist allowed for community science observations to be uploaded to an online database. Traditional museum collecting decreased the last few decades due to low funding and less popularity for science collecting, giving to the rise of community science observations instead (Spear et al. 2017).

For all species, citizen-science records from iNaturalist were generated much faster than museum records in the past decade. Citizen science may be a key method to heighten museum collections data, particularly from urban areas, where consistent data collection is essential for our understanding of ecosystem change in highly modified and variable landscapes (Spear et al., 2017). We created multiple species' Carto Animations focusing on native and invasive species, to see how they impacted each other. In this particular graphic, we displayed two species: California Red Legged Frog and the American Bullfrog. Towards the end of the timeline, there is a large influx of occurrences of the latter. This is due partly because of records from iNaturalist but also due to the American Bullfrog preying on smaller amphibians, such as the native CA frog, which increased its populations. Additionally, with the expansion of suburban neighborhoods in LA having year round water for landscape maintenance, the bullfrog was able to adapt to this ecosystem change, enabling it to inhabit residential properties.

LA River, East Side
Photo by Lisa Corson

Chapter 5

Conclusion



Concept of LA River
Photo by Fletcher Studio

The exceedingly high past and present biodiversity of Los Angeles County creates an ideal environment for one of the first case studies that utilizes conservation paleobiology applied in an urban setting. These deeper time records will be useful in terms of applying it towards modern planning or green urbanism. With Los Angeles' historical changes in its biodiversity and ecosystems, species distributions are different now compared to in the past. The ecological niche models, suitability maps, and species' occurrence visualizations that we produced, demonstrated how species' future distributions will change or not change compared to their past and present distributions. These methods helped us understand how species, such as the Western Fence Lizard and the California Red-Legged Frog, would react to climate change. These findings can contribute to conservation and sustainability questions, such as which species have the potential to be brought back into a rewilded portion of the Los Angeles River. Our research and final products were brought together in the form of a Story Map. We hope that by sharing this with the public, it will bring more awareness to the ecosystems that have surrounded the Los Angeles River over many thousands of years and connect the public with different resources to initiate viable restoration plans.

As this project moves forward, we would like to see future teams take the following actions to the methodologies and the areas of focus. Expanding on this first year of the project and incorporating these next steps will provide better insight that will help create the bridge that balances urban life and wildlife. These next steps include, but are not limited to:

1. integrating more data sources that have an emphasis on plant species
2. incorporating more deeper time records into distribution models
3. applying the research to other restoration projects
4. communicating the findings to urban planners

Acknowledgements

Our practicum team wants to recognize and express gratitude to every person that volunteered their time to enhance our project research, product design, and overall practicum experience. Without the help from these people, we would not have been able to produce such high quality and impactful deliverables which will benefit future sustainable development of the LA River.

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Kat Superfisky (not sure what title to put here, she does a lot)

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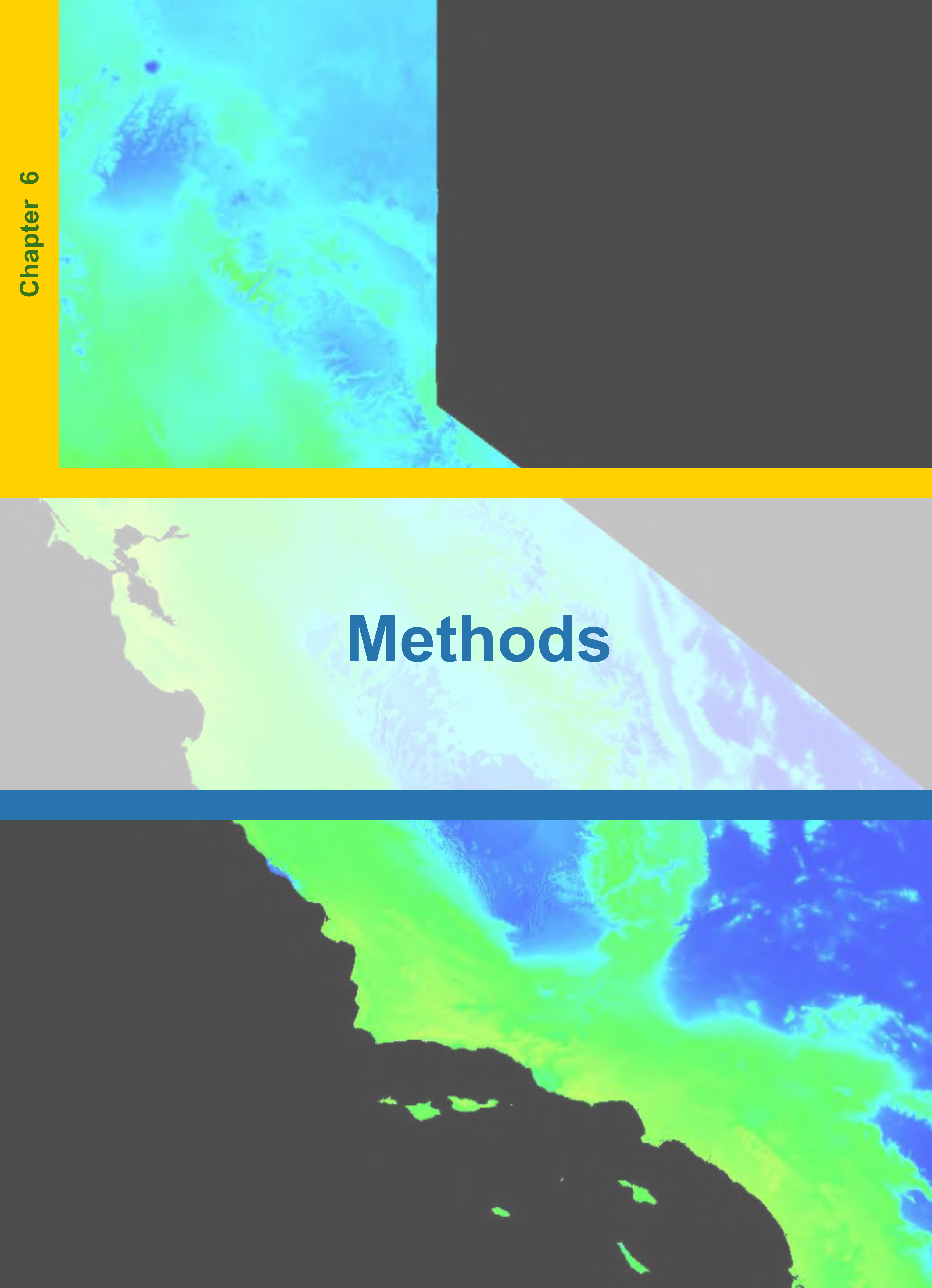
Chapter 6

Methods



California Raster Map
Photo by Alex McFadden

Species Occurrence Data Collection

To establish an understanding of the current and recent history of biodiversity of Los Angeles County, we collected species occurrence data and compiled a large-scale species data collection. Data was collected from several online databases that aggregate species occurrences from institutions such as museums and universities and citizen science websites like iNaturalist. These online databases include the Global Biodiversity Information Facility (GBIF) and Integrated Digitized Biocollections (iDigBio). GBIF includes species occurrence records from a multitude of institutions along with research grade iNaturalist occurrences. For the future of the project, using the Paleobiology Database (PBDB) along with records from Rancho La Brea: A Record of Pleistocene Life in California (Stock and Harris, 1992) can establish more of an understanding of the Late Pleistocene biodiversity of LA as the time period collection is extended than the period we used for our analyses.

Species occurrences were limited to an overall time period of 1900-2020 to focus on more recent species locations and potential habitat. Species occurrences were further divided corresponding to time periods of significant progress in the channelization process of the LA River. These periods of time include the following: 1900-1938 (initial channelization), 1938-1960 (additional channelization), 1960-1991 (expansion and completion of channelization), and 1991-2020. Data was cleaned so that only the essential information for each species was present in the spreadsheets. This was critical in the analyses because data for some animal groups could be in the range of tens of thousands of occurrences for just LA County. The spatial extent of the data was of LA County and this was achieved either through the use of database filters if permitted by the website or by using ArcMap to clip species occurrences to the extent of LA County.

For ENMs to be computed, species occurrence data is required and inputted as a spreadsheet with location coordinates. It is recommended that the data is cleaned so that latitude and longitude only include precision to the second decimal, and then occurrences with duplicate coordinates are removed. This process of thinning the species occurrences provides more robust outcomes for the ENMs. The next page will cover additional information regarding the cleaning of species occurrence datasets.

Cleaning Species Occurrence Data

In order to prepare our datasets for use in our Ecological Niche Models, suitability maps, and species occurrence visualization, we went through several steps to clean the data. Cleaning the data helped us narrow down the datasets to the primary variables we will be using as well as to get rid of any duplicates in the data.

The latitude and longitude coordinates, alongside the species name, were moved onto a new Excel Sheet. We filtered our species datasets to ensure that we have the species we want. We also filtered our latitude and longitude values in order to remove values with missing coordinate information.

Next, we rounded the latitude and longitude coordinates in order to remove any duplicates that appear within our data. For our purposes, we rounded our coordinates to two decimal places for better precision. After this function is performed, our cleaned data is moved to a new Excel sheet. We made sure that when these values were pasted over, we used “Paste Special: Values” so our rounded values were copied exactly. On this new and final Excel spreadsheet, we removed the coordinates that had any duplicates.

Our final step was to input the species name and save the Excel spreadsheet as a csv (comma separated values file). The data is finally clean and ready to be used for our deliverables!

Scientific Name	Lattiude	Longitude
Lithobates catesbeianus (Shaw, 18	40.59	-122.42
Lithobates catesbeianus (Shaw, 18	36.89	-121.6
Lithobates catesbeianus (Shaw, 18	38.52	-121.76
Lithobates catesbeianus (Shaw, 18	37.49	-119.63
Lithobates catesbeianus (Shaw, 18	38.39	-122.69

Table 2: A screenshot of a cleaned dataset for the American bullfrog.

Ecological Niche Modeling

For our projects models, we downloaded bioclimatic variables (climate data specifically designed to measure species distributions) from WorldClim.org. To predict future species distributions, we downloaded bioclimatic variables produced by the Community Climate System Model 4 (CCSM4) for the year 2050. Future climate scenarios were based on projections from the Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC). The CCSM4 provides different climate predictions for each of the IPCC emission scenarios, so datasets are downloaded to understand the effects of these scenarios (RCP 2.6, 6.0, 8.5) on the species future distributions. Both of these data sets were provided as GeoTIFFS at the 30 ArcSecond resolution. In total, there are 19 bioclimatic variables.

Since our region of interest for our models is California, we used ArcGIS Desktop to reduce the bioclimatic variables to the size and shape (also known as extent) of California. From there, we converted the reduced GeoTIFFS to the .asc data type, the required data type for use in *Maxent.* To streamline this process, we created a simple tool in ArcGIS Desktop modelbuilder to quickly trim the extent of each of the bioclimatic variables and convert all of the data to the .asc format. It's very important that extent off the variables are the exact same. If they are not, *Maxent* will not run properly.

After the bioclimatic variables have been trimmed to our region of interest, we analyzed the variables through *ENM Tools*, a software that conducts correlation tests to determine which bioclimatic variables are related to each other. The software outputs a csv that calculates the correlation between variables. This is meant to remove the total number of bioclimatic variables. In the case of our project, we reduced the number of bioclimatic variables to 7: BIO 1, BIO 2, BIO 3, BIO 7, BIO12. BIO 15, BIO18. The specific names for these bioclimatic variables are listed in the Appendix

Once the data was trimmed and the correlation tests determined the appropriate bioclimatic variables, we inputted the species occurrence data and bioclimatic variables into *Maxent*. For settings, our model was replicated 10 times and used the crossvalidate replication type. For the projection layer directory/file input, we inputted our bioclimatic variables produced by the CCSM4 to visualize changes in species distributions based on climate predictions for the year 2050.

Suitability Maps

Suitability maps were created in the GIS software ArcMap version 10.7 for desktop. Suitability rasters were imported to ArcMap as ASC files from Maxent. Four suitability layers were imported for each species corresponding to the current suitability and three future suitabilities under different climate scenarios.

Shapefiles were downloaded from the internet and imported to ArcMap through the import function. Both the US counties and US states shapefiles were obtained from the United States Census Bureau (USCB). An LA County layer was created from the US counties shapefile. An LA flowline shapefile obtained from the LA County GIS Data Portal was used to create the LA River layer. The world terrain basemap was imported directly from ArcMap and was sourced from Esri and the United States Geological Survey (USGS). A major US cities layer obtained from Esri and the USCB was used to create a Los Angeles city marker. A color gradient of red to blue representing low to high suitability was used to best communicate the suitability range while still being accessible for color blind viewers.

Table 3: Data and their corresponding sources used for creating suitability maps.

Data	Source
US counties shapefile	USCB
US states shapefile	USCB
LA flowline shapefile	LA County GIS Data Portal
World Terrain Basemap	Esri, USGS
Major US cities	Esri, USCB

Spatial Statistics for Suitabilities

The mean suitability for each species was calculated using spatial statistics tools in ArcMap version 10.7 for desktop. Four suitability rasters for each species were imported to ArcMap as ASC files from Maxent. A suitability raster is the raw species suitability data that are output by Maxent.

The Spatial Analyst tool known as Zonal Statistics as Table was used to calculate mean suitabilities. According to the ArcGIS Desktop website, the tool works by calculating a statistic "for each zone defined by a zone dataset, based on values from another dataset (a value raster)." For our analyses, the zone dataset used for every suitability calculation was an LA County shapefile created from a US counties shapefile sourced from the USCB. *Figure 7* gives example inputs for the Zonal Statistics as Table tool. The LA County shapefile only contained one zone, the entirety of LA County, so the "zone field" was filled with the NAME field from the LA County shapefile. This field was used to indicate on the table that the statistics were for LA County, however, it did not affect the analysis. In fact, any field could have been chosen since our shapefile for LA County only contained a single zone.

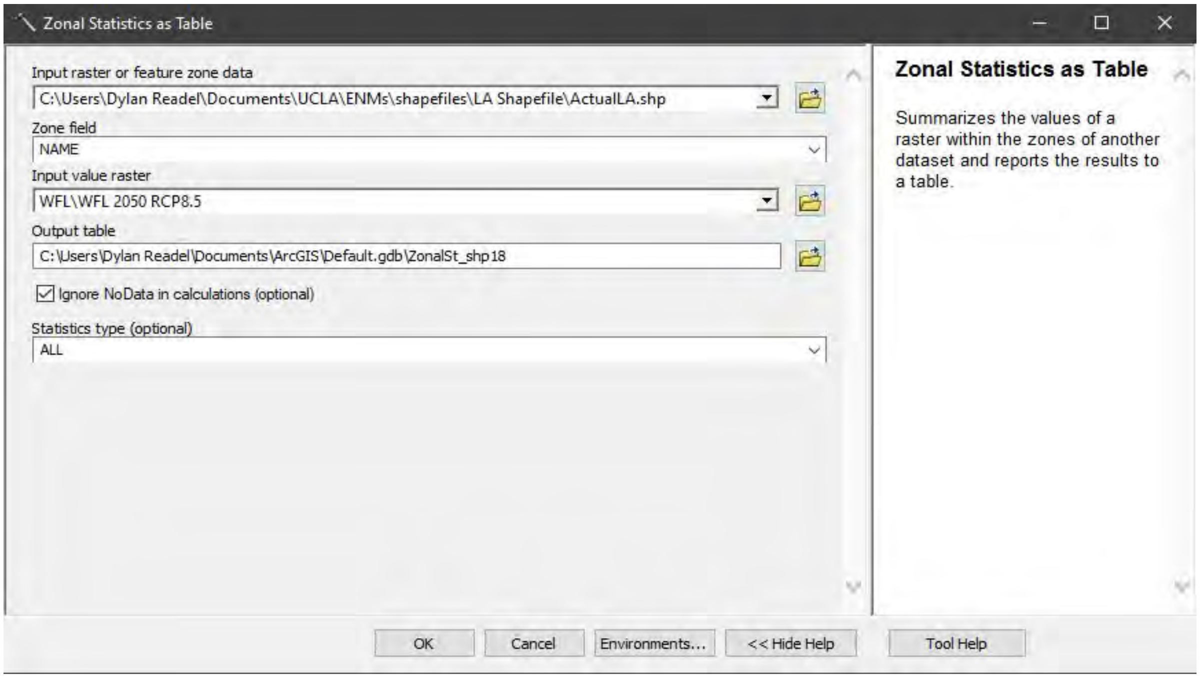
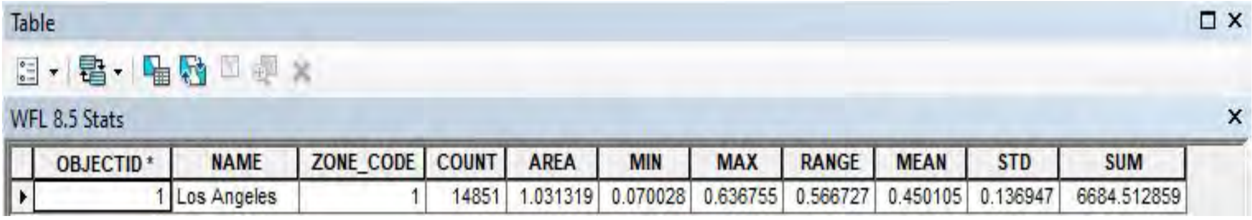


Figure 9: A screenshot of the Zonal Statistics as Table tool from ArcMap. A suitability raster for the western fence lizard is used as an example.

The value raster datasets we used were the suitability rasters imported from Maxent. Each species had four suitability rasters: one current suitability raster and three future climate scenario suitability rasters. Only one species suitability statistic table is calculated at a time, so only one suitability raster was added to the Zonal Statistics as Table tool at a time. The "Ignore NoData in calculations" option was checked. The "Statistics type" was set to ALL to include every statistic: count, area, minimum, maximum, range, mean, standard deviation, and sum. *Figure 8* shows the output table containing all the statistics. Many of these are not useful for our analyses, however, calculating all statistics at once was more convenient than going back and calculating again.

Four suitability statistic tables were calculated for each species. All tables were exported to an Excel spreadsheet. Mean suitabilities were visualized as a bar graph to easily analyze changes in suitability under future climate scenarios. Furthermore, mean suitabilities were overlaid on suitability maps to add a quantitative component to the visual suitability.



Table

WFL 8.5 Stats

OBJECTID *	NAME	ZONE_CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Los Angeles	1	14851	1.031319	0.070028	0.636755	0.566727	0.450105	0.136947	6684.512859

Figure 10: A screenshot of the output for the Zonal Statistics as Table tool. The statistics in this table correspond to the western fence lizard under the 2050 "worst case" scenario.

Species Records Visualizations

To create these visualizations, we used species occurrences from the Global Biodiversity Information Facility (GBIF). We filtered the data to be records from 1900 to 2020 in the state of California, and some visualizations were further filtered to Los Angeles County. From there, we cleaned the data down to event date, Genus, species, latitude, and longitude.

Graphs - Tableau

In the data visualization software Tableau, we imported species and taxa of interest. Then we dragged the column header "Event Date" in the *Column* field and "Genus" and "Species" into the *Row* field. From there, we correlated mark colors to Institution code to distinguish iNaturalist data from institutional data. To do so, we dragged the column header "Institution Code" over to *Color* in *Marks*. To portray individual species recordings, we enabled "Exact Date" under "Event Date". To create the highlighted portion that signifies the channelization of the Los Angeles River, we created Reference Lines by right-clicking on the time axis.

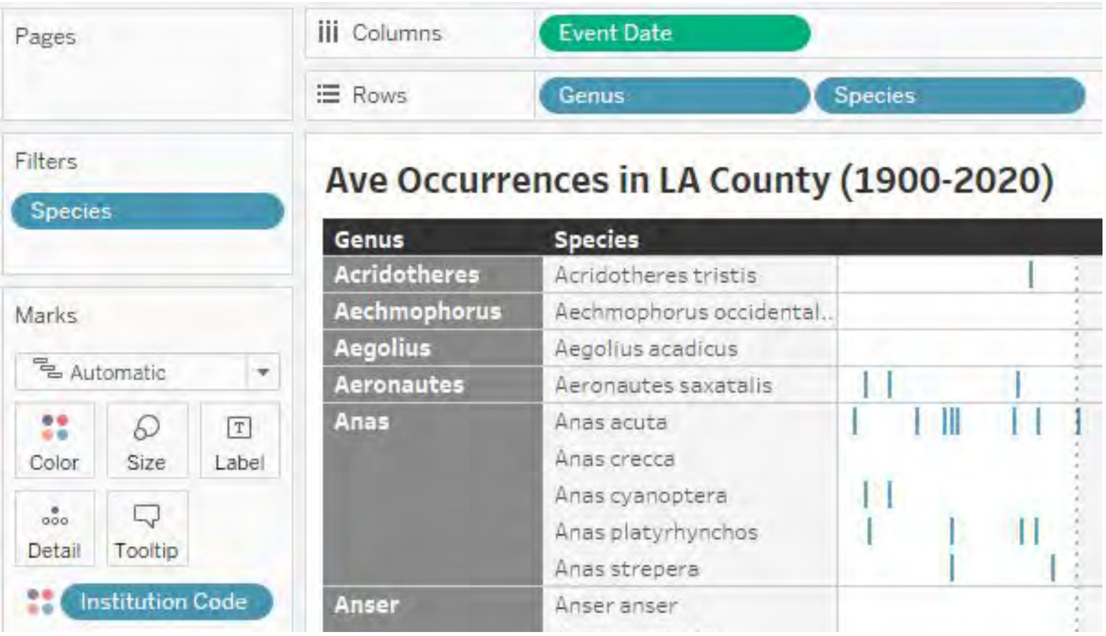


Figure 11: A screenshot of the Tableau settings for the occurrence graphs using bird data.

Animations - Carto

Similarly to Tableau, we import species and taxa of interest into [Carto](). In layer options, we chose "ANIMATED" for the Aggregation Type. To portray specific species, we used the "Points" type whereas for Taxa animations, we used the "Heatmap" type to show more general distribution trends. In species comparisons, we selected "By value" for point color and then selecting the column header "species". To customize the timeline widget, we set the Type to "TIME SERIES" and inputted "eventdate" in the column field. This ensures that the widget portrays chronological information from the "eventdate" column. Figure 11 and 12 portrays the settings for the Carto map and associated timeline widget of the American Bullfrog and California Red-Legged Frog.

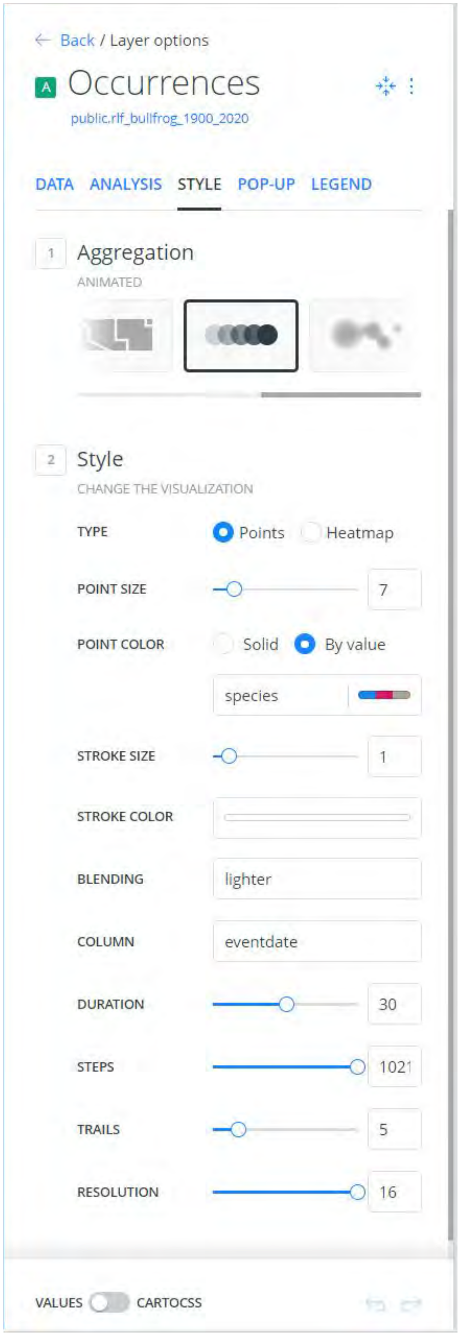


Figure 12 (left): A screenshot of the Carto map settings.

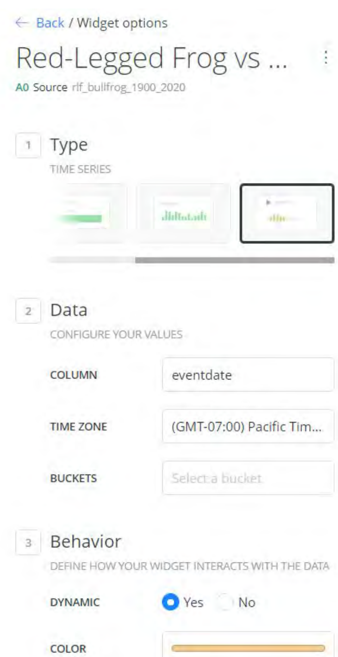


Figure 13 (right): A screenshot of the Carto timeline settings.

Chapter 7

Appendix

La Brea Museum
Photo by Lian Mae Tualla

Arboreal Salamander (*Aneides lugubris*)

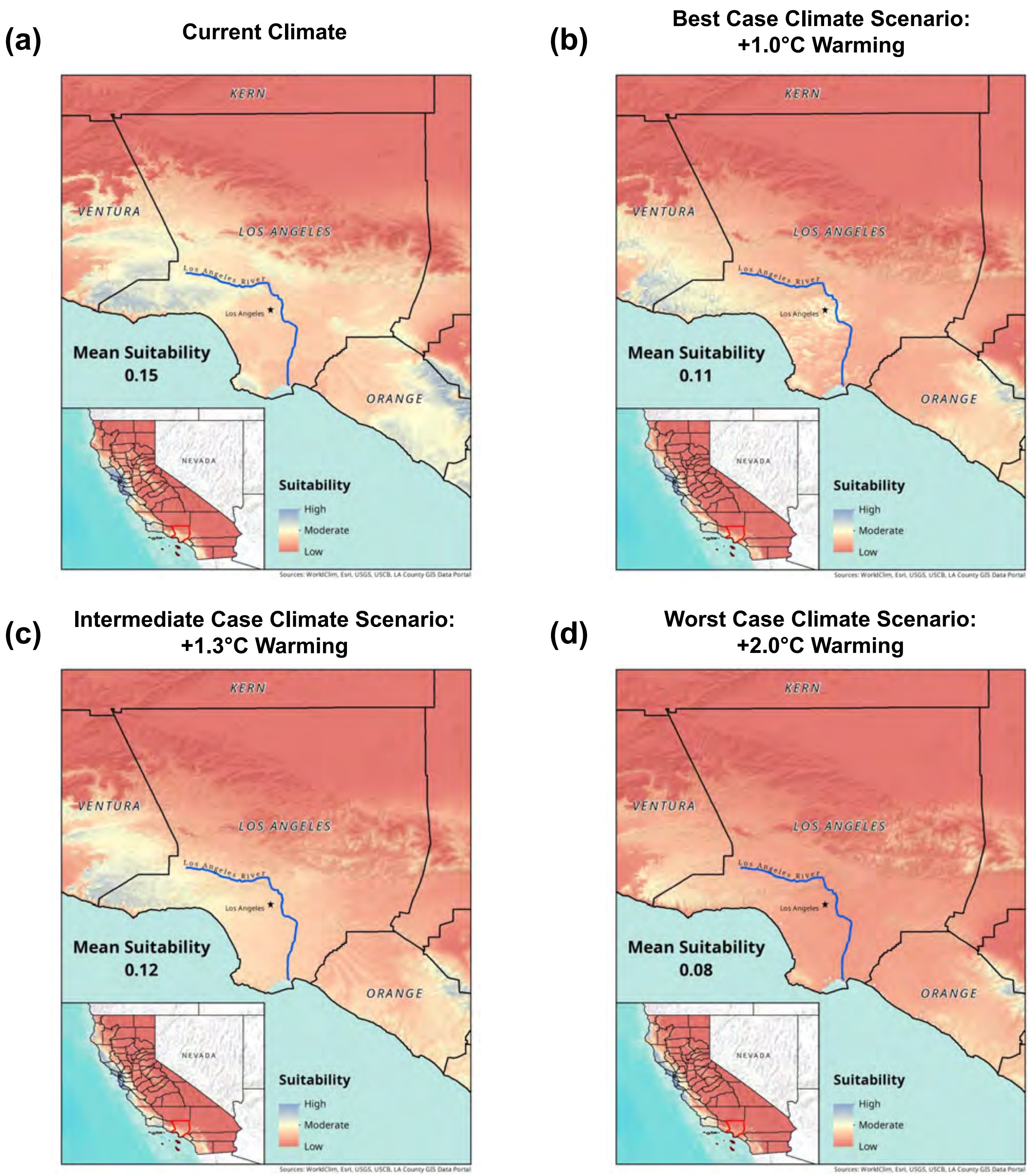


Figure A1: Habitat suitability maps for LA County: current (a), RCP2.6 in 2050 (b), RCP6.0 in 2050 (c), and RCP8.5 in 2050 (d). Mean suitability under the worst case scenario is almost half the current mean suitability..

California Slender Salamander (*Batrachoseps attenuatus*)

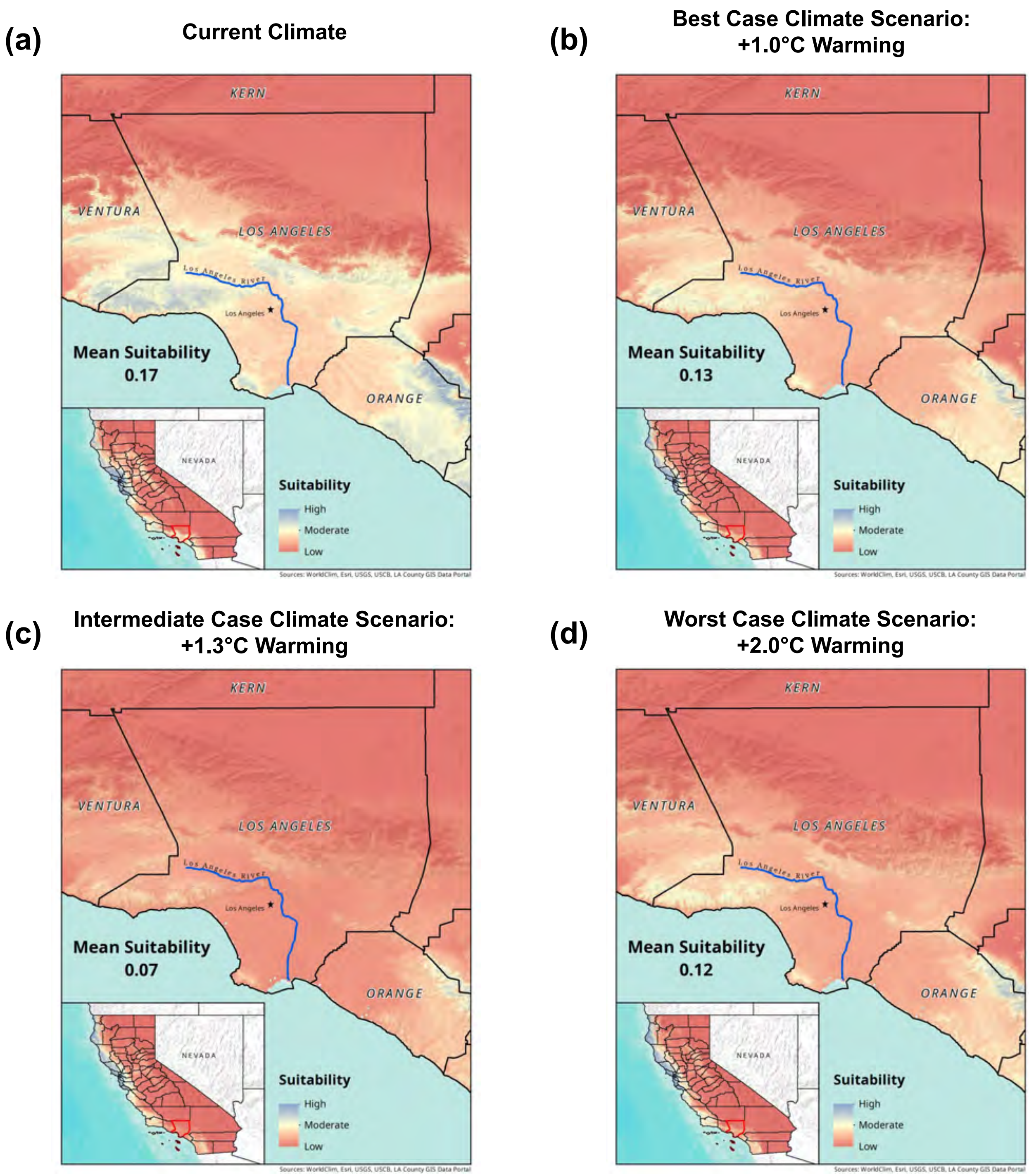
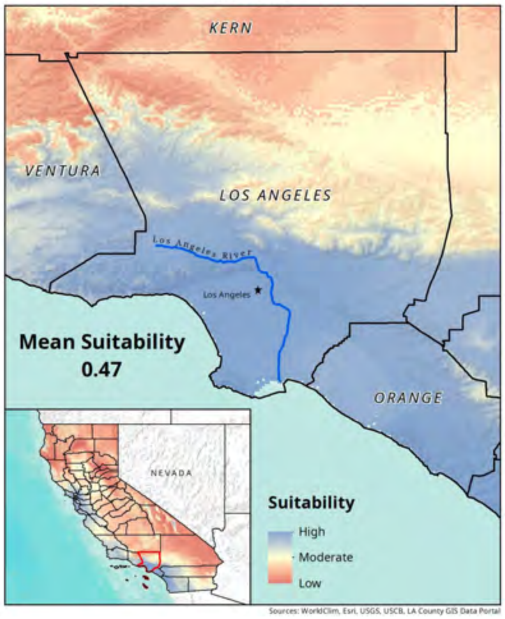


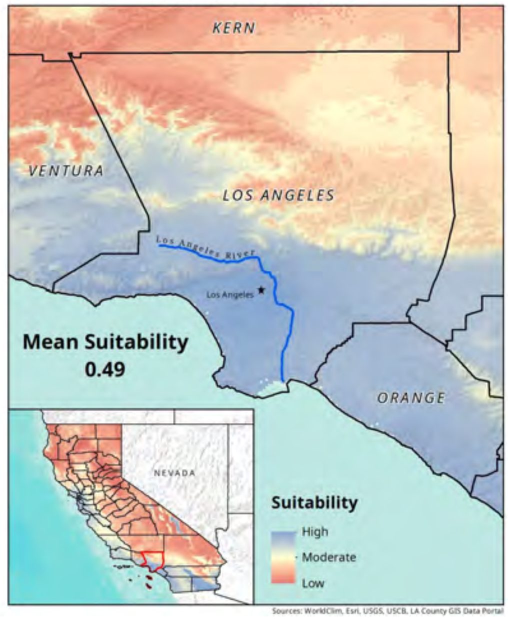
Figure A2: Habitat suitability maps for LA County: current (a), RCP2.6 in 2050 (b), RCP6.0 in 2050 (c), and RCP8.5 in 2050 (d). The mean suitability is the worst under the intermediate scenario, however, mean suitability is relatively poor in all scenarios.

Coyote (*Canis latrans*)

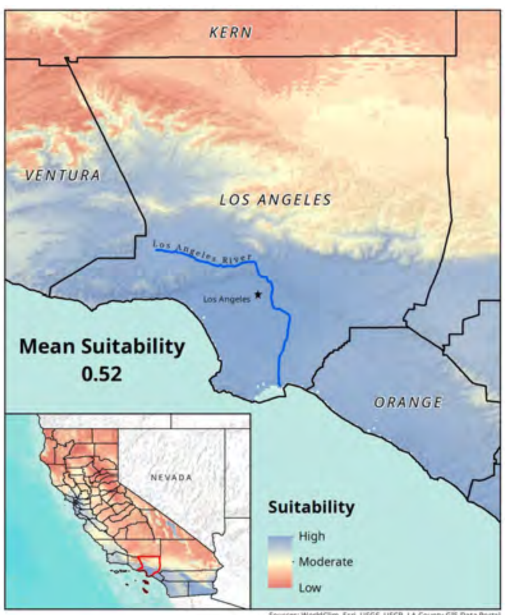
(a) **Current Climate**



(b) **Best Case Climate Scenario: +1.0°C Warming**



(c) **Intermediate Case Climate Scenario: +1.3°C Warming**



(d) **Worst Case Climate Scenario: +2.0°C Warming**

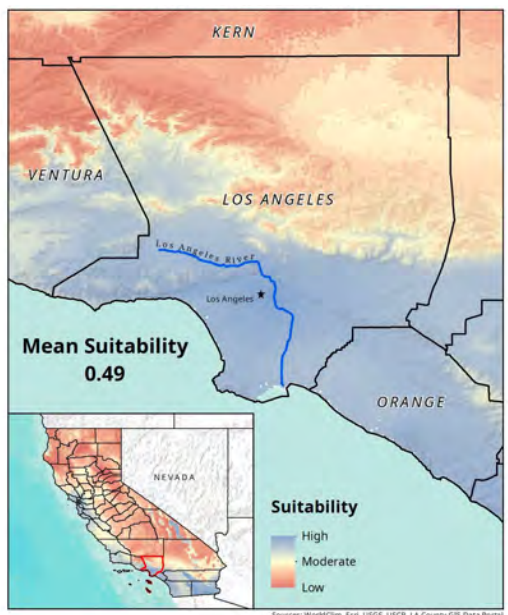


Figure A3: Habitat suitability maps for LA County: current (a), RCP2.6 in 2050 (b), RCP6.0 in 2050 (c), and RCP8.5 in 2050 (d). Coyotes experience almost no decrease in mean suitability even under the worst scenario.

Western Pond Turtle (*Actinemys marmorata*)

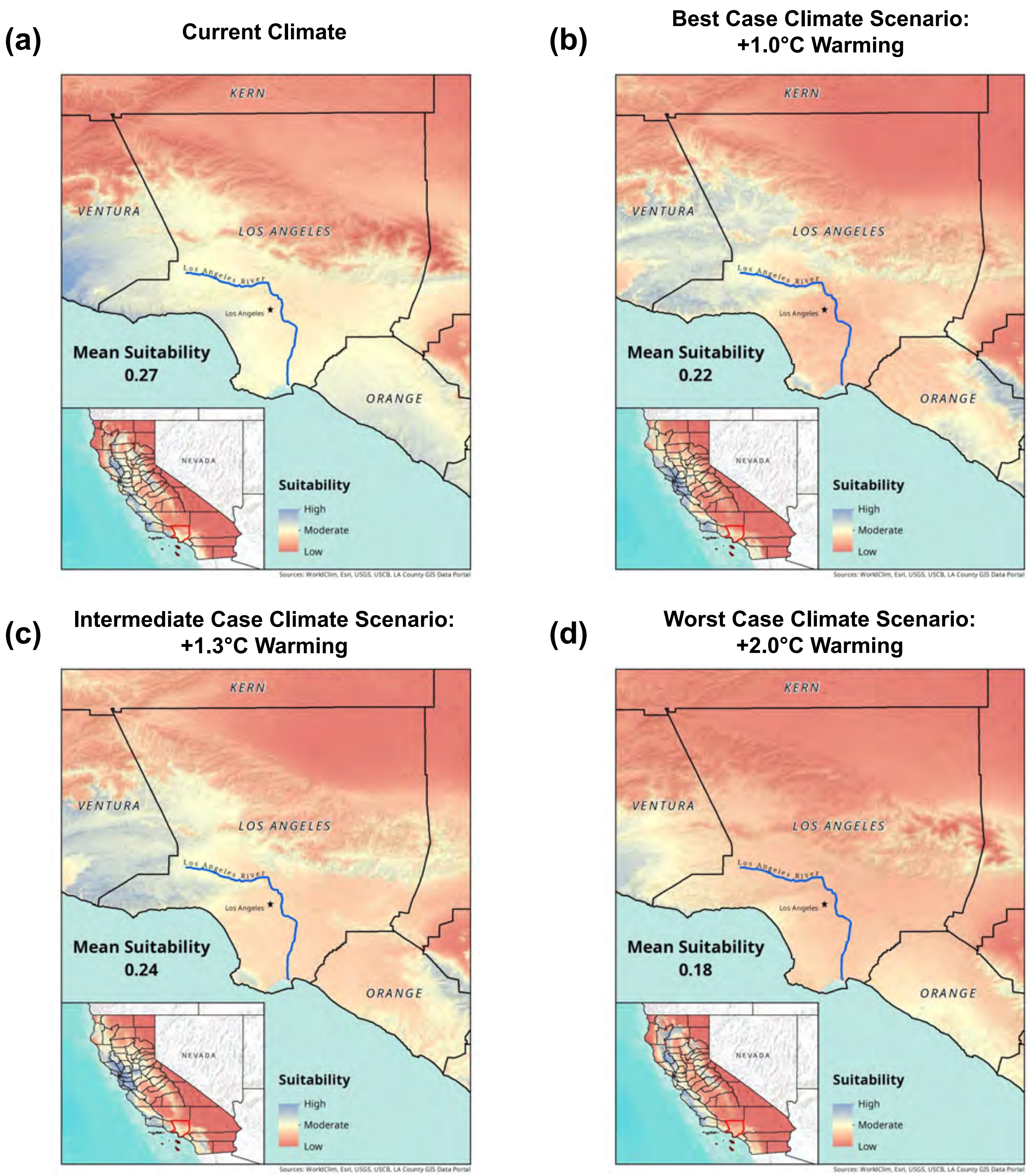


Figure A4: Habitat suitability maps for LA County: current (a), RCP2.6 in 2050 (b), RCP6.0 in 2050 (c), and RCP8.5 in 2050 (d). This species experiences a 33% decrease in mean suitability under the worst scenario.

Taxon Record Animations

(a)
(b)
(c)

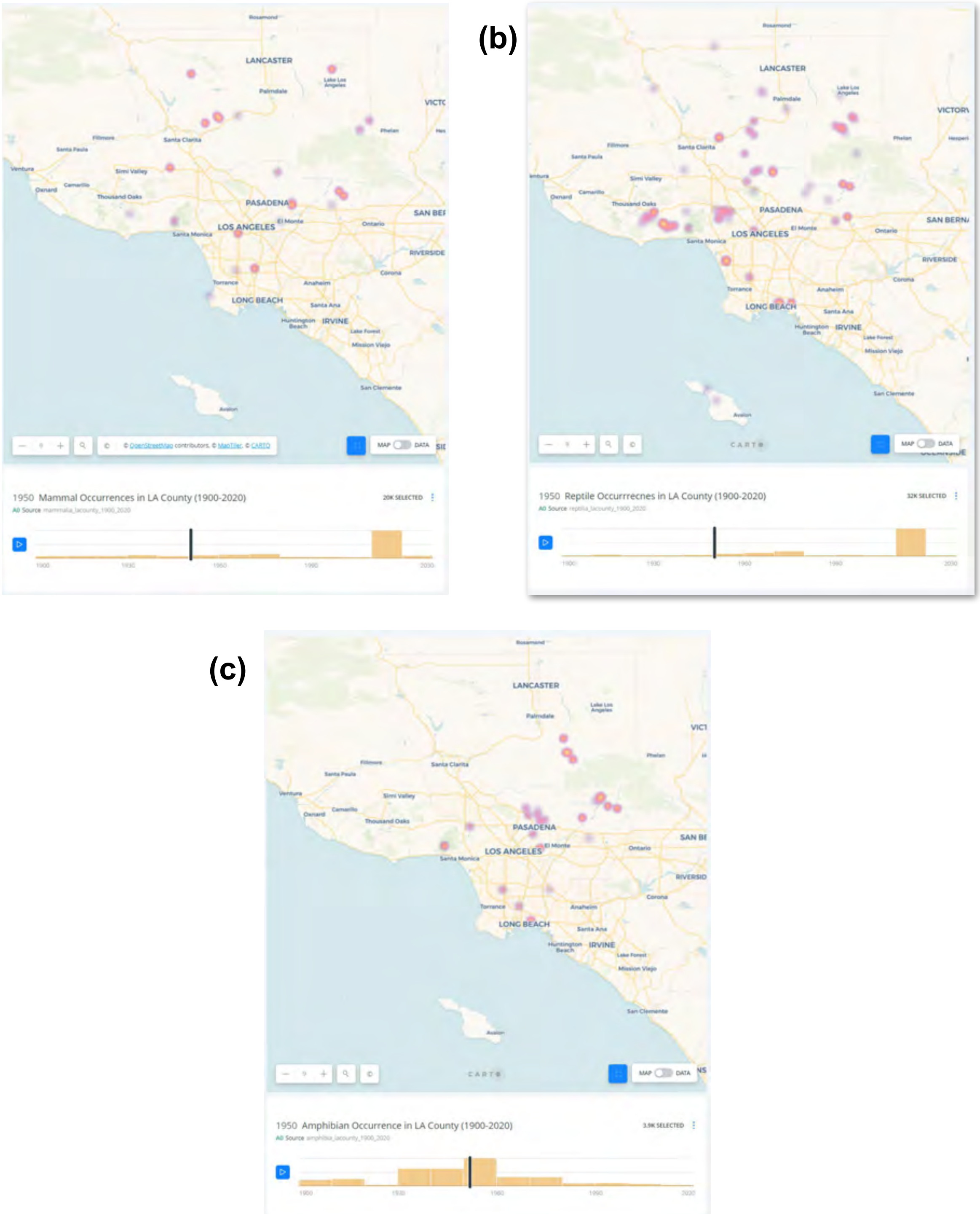


Figure A5: Screenshots indicating the records in LA County from 1900 to 2020 for: Mammals (a), Reptiles (b), and Amphibians (c).

Bioclimatic Variables

Table A1: Bioclimatic Variables highlighted in gold were used in analyses.

BIO Reference Number	Climate Variable
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (×100)
BIO4	Temperature Seasonality (standard deviation ×100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

Chapter 8

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Fossil Collections at La Brea
Photo by Lian Mae Tualla

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