Enhancing classroom and undergraduate research opportunities with natural history collections

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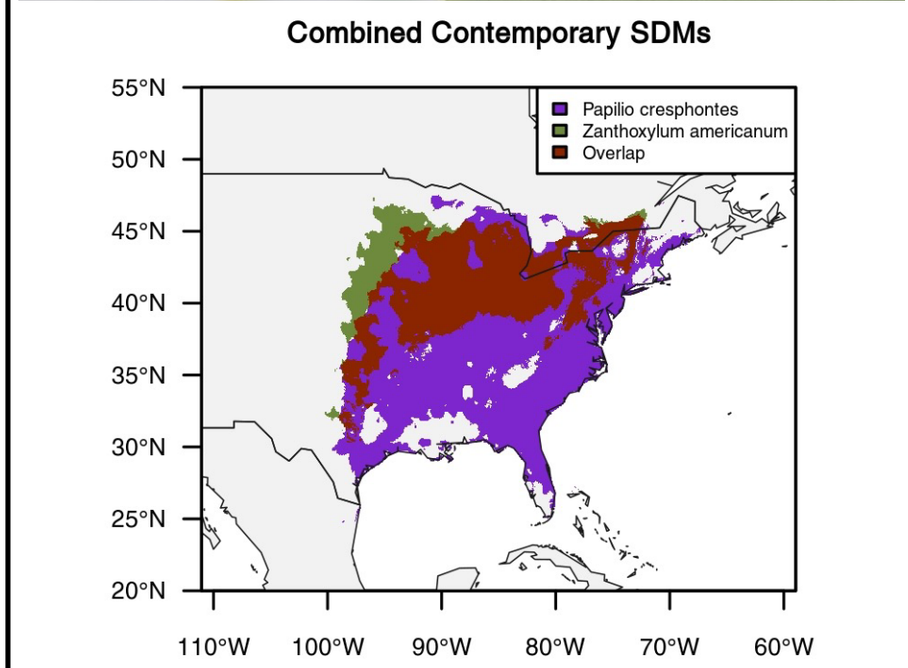
@WLClement



TCNJ THE COLLEGE OF NEW JERSEY

- Public, residential, primarily undergraduate institution
- 6,800 undergraduates
- ~500 Biology Majors
- 30% self-described as members of groups traditionally underrepresented in STEM

TCNJ School of Science: Biology

Natural History Museums & Botanical Gardens

American Museum of Natural History


American Museum of Natural History


New York Botanical Gardens

Biodiversity collections behind the scenes of Natural History Museums

Wikimedia commons

The Team.

Dr. Katy Prudic

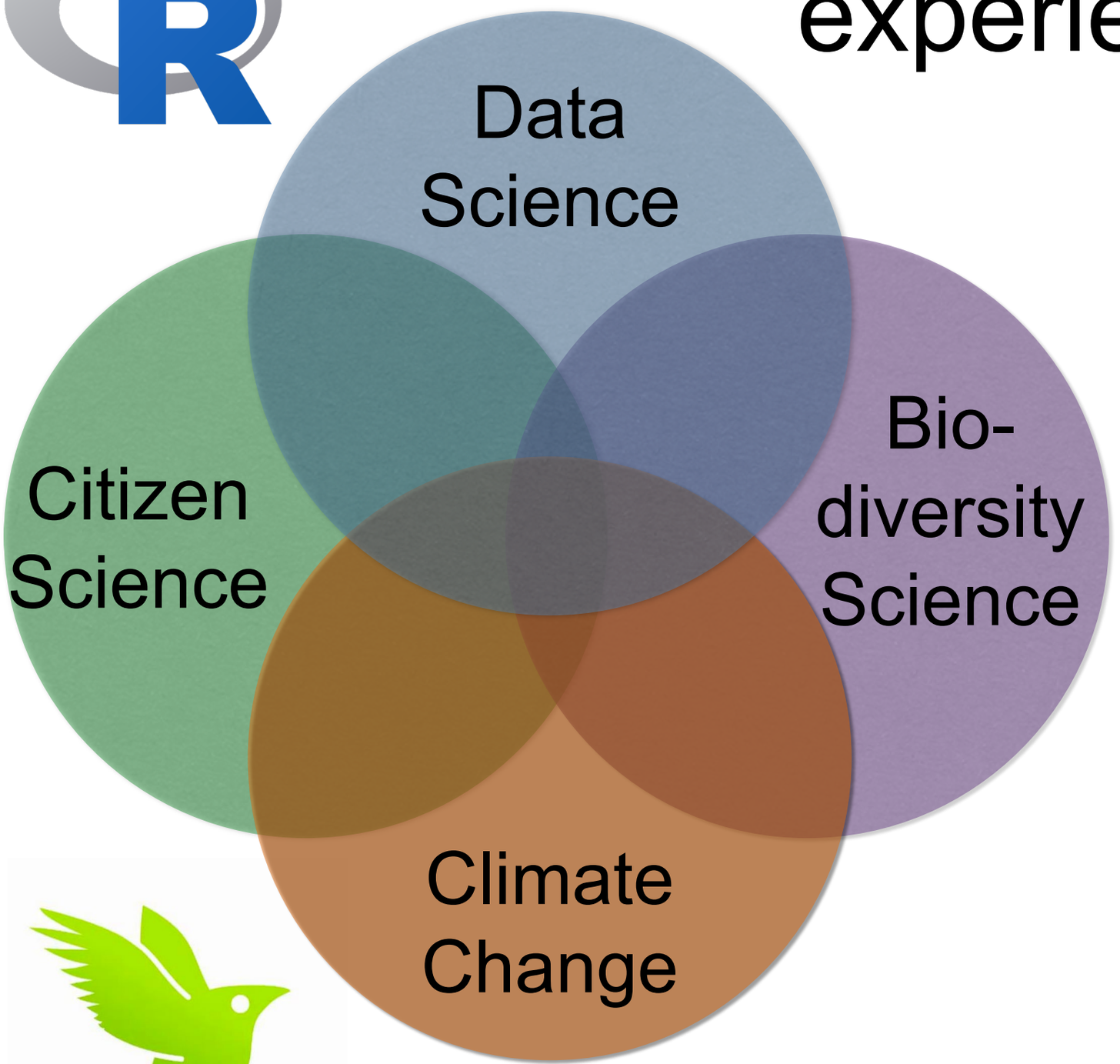
Dept. of Entomology
University of Arizona, Tucson

Dr. Jeff Oliver

Office of Digital
Innovation & Stewardship
University of Arizona Libraries

TCNJ Plant-Insect Course (’14)

Creating an interdisciplinary experience.



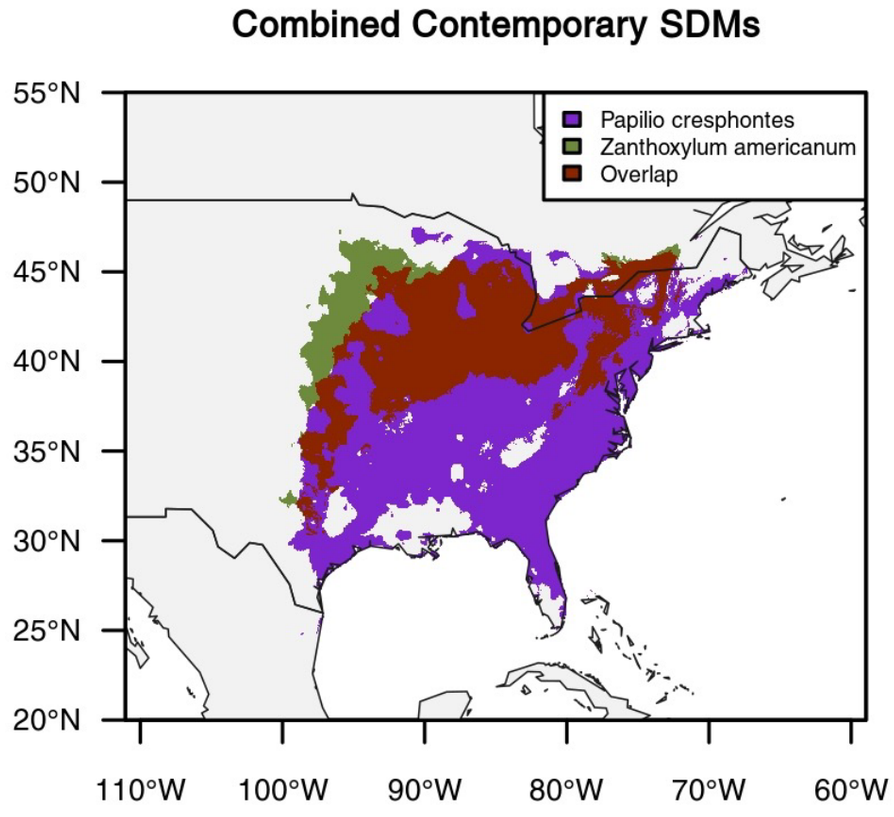
- Develop an inquiry-based group project
- Provide an entry point for data science and big data
- Observation - Hypothesis - Analysis - Evaluation
- Increase awareness of local biodiversity and plant-insect interactions in temperate zones
- Draw students in as scientists

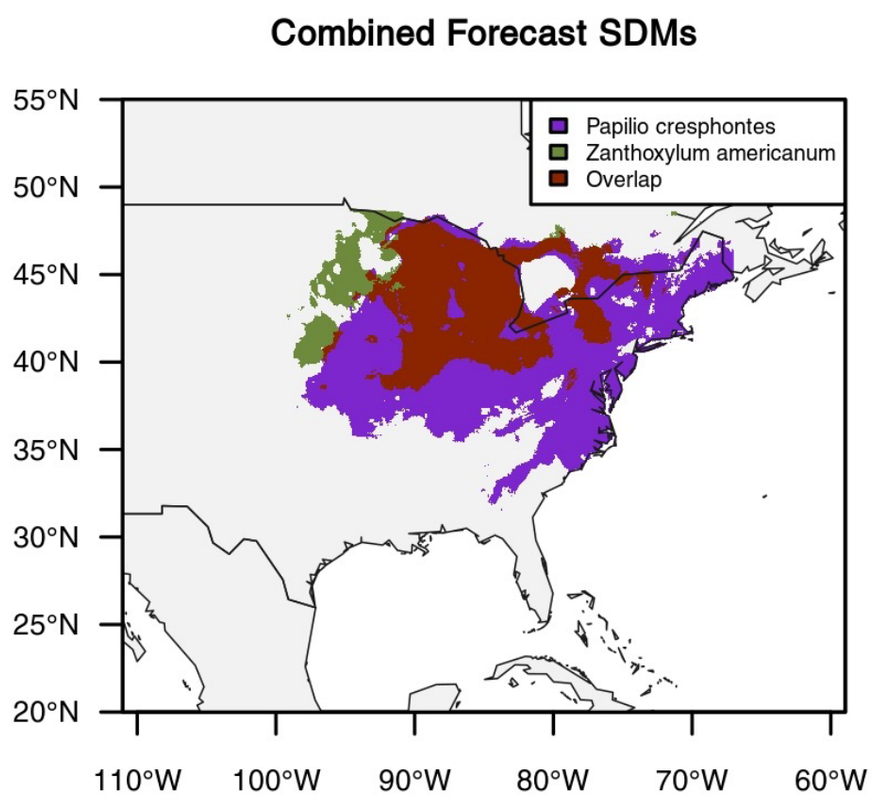
Objectives & Learning Goals

Question: How will climate change affect the distributions of butterflies and their larval hosts across a continent over time?

Learning Goals

1. Describe how biodiversity science data initiatives, such as ecoinformatics, can make use of citizen science and museum digitization efforts to ask and inform questions in ecology.
2. Use research computing tools (Citizen science crowd sourced data, R programming language, GitHub collaborative web platform, data visualization) to study a butterfly-host plant interaction
3. Communicate findings in the form of an oral presentation
4. Synthesize potential outcomes of the effects of climate change on plant-insect interactions





Project Introduction

Wikimedia commons

1. Introduce biodiversity science and data science
2. Compare and contrast citizen science data and museum data

We are at a transition point in biodiversity research

Wikimedia commons

- Research funding is decreasing
- Need for conservation research is increasing
- Wildlife enthusiasts:
  - 72 million US residents watch wildlife for fun
  - 10 million US residents watch butterflies a minimum of 85 hours a year each
  - ~ $1,700,000,000 in butterfly volunteer hours a year

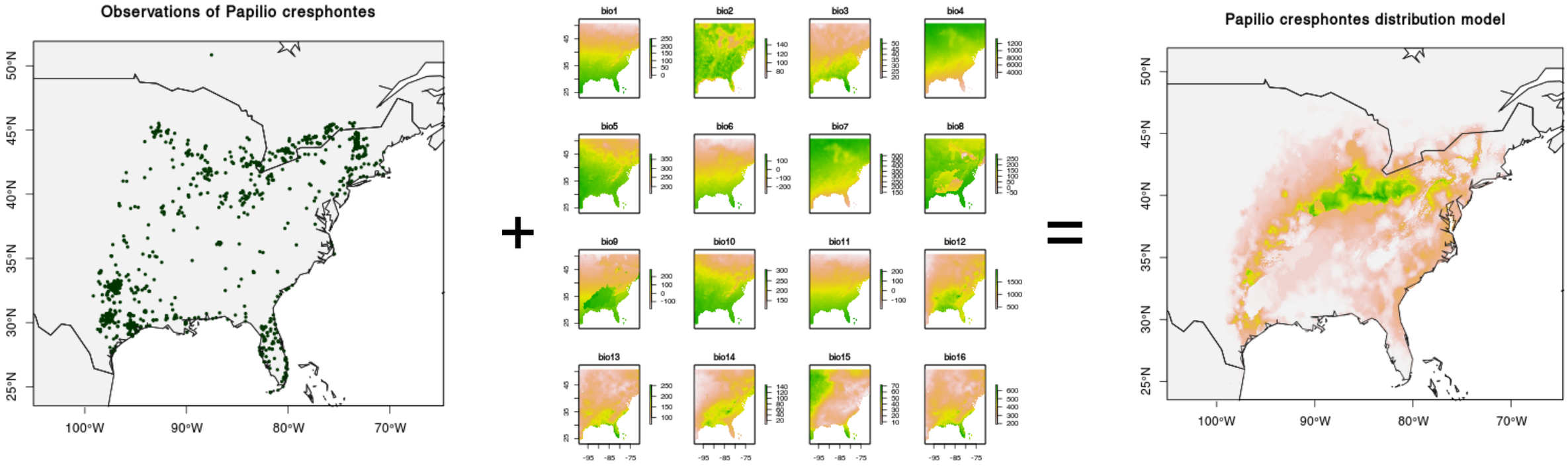
Biases in the data?

Project Introduction

1. Introduce biodiversity science data science
2. Compare and contrast citizen science data and museum data

Wikimedia commons

3. Introduce Species Distribution Modeling (SDM)



Student Example: By the end of Class 1…

Eurytides marcellus

Common name: Zebra swallowtail

Physical Appearance

- long swallowtails
- 2.5-4 inches in wingspan
- Black stripes on white/pale green background on upper surface of wing

Foraging Behavior

- larvae feed on host plants
- adults forage on nectar plants on open fields and shrubby areas

Asimina triloba

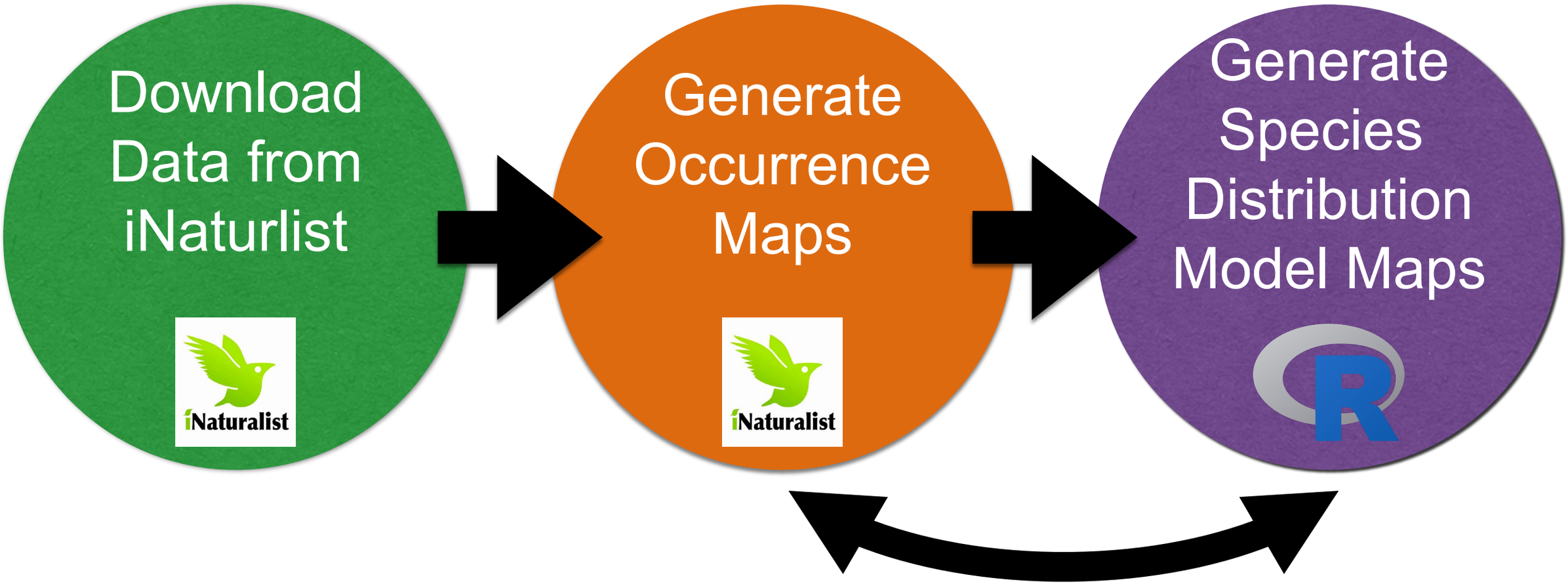
Common name: common pawpaw

Range

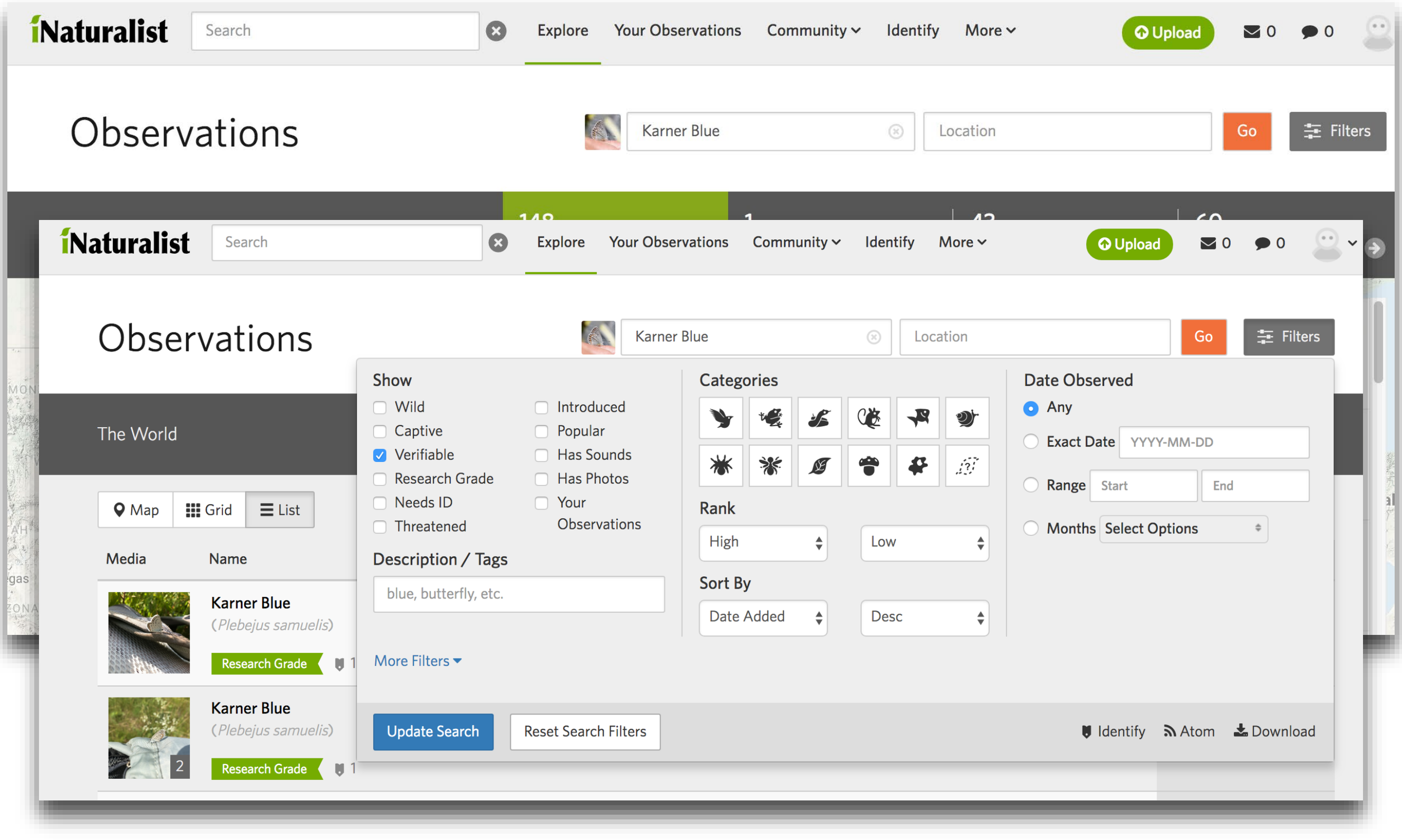
- commonly found in the eastern portion of the United States (Zhao et al. 1992)
- Only feeds on the *Asimina* family

Class 2

Learning Goal 2: Use research computing tools to study a butterfly-host plant interaction



Working with iNaturalist



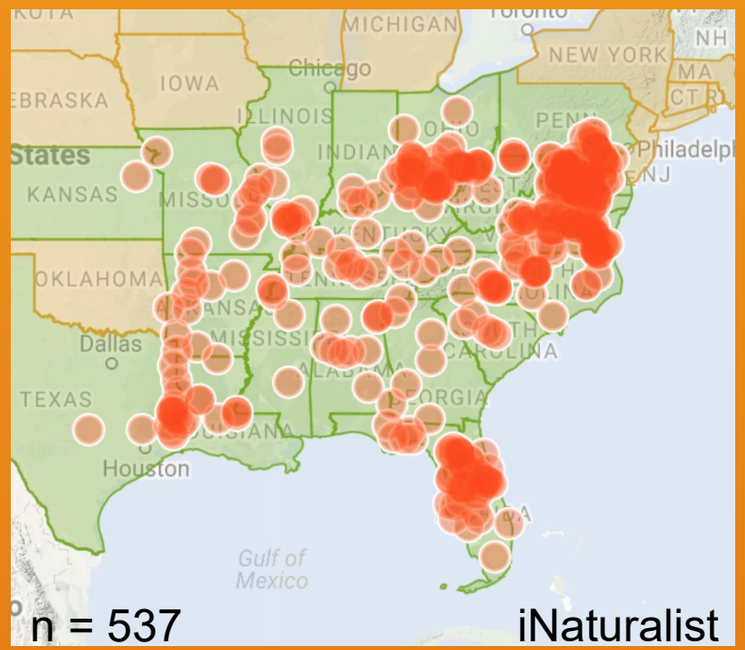
Git, R, & RStudio

- Students clone a Git repository
- Students run scripts in RStudio
- Tutorials walked students through modifying scripts, saving scripts, and running scripts
- Explanation of code available for instructors

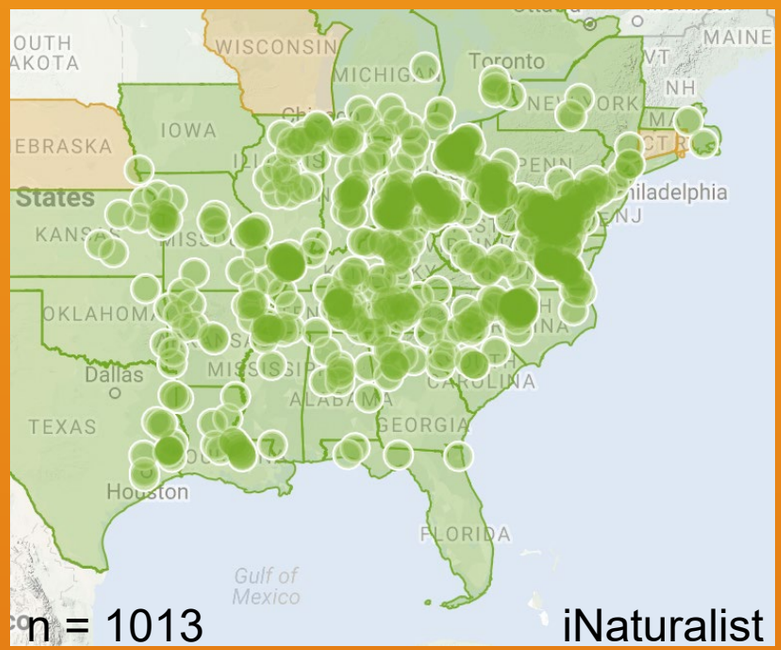
```r
# Script to run Species Distribution Model using "bioclim" approach
# Jeff Oliver
# jcoliver@email.arizona.edu
# 2017-09-07

rm(list = ls())

################################################################################
# SETUP
# Gather path information
# Load dependancies

butterfly.data.file <- "data/Karner_data.csv"
plant.data.file <- "data/Lupine.csv"
outprefix <- "KarnerLupine2070"
outpath <- "output/"

# Make sure the output path ends with "/" (and append one if it doesn't)
if (substring(text = outpath, first = nchar(outpath), last = nchar(outpath)) != "/") {
  outpath <- paste0(outpath, "/")
}

# Make sure directories are writable
required.writables <- c("data", outpath)
write.access <- file.access(names = required.writables)
if (any(write.access != 0)) {
  stop(paste0("You do not have sufficient write access to one or more directories. ",
              "The following directories do not appear writable: \n",
              paste(required.writables[write.access != 0], collapse = "\n")))
}

# Load dependancies, keeping track of any that fail
required.packages <- c("rgdal", "raster", "sp", "dismo", "maptools")
missing.packages <- character(0)
for (one.package in required.packages) {
  if (!suppressMessages(require(package = one.package, character.only = TRUE))) {
    missing.packages <- cbind(missing.packages, one.package)
  }
}
```

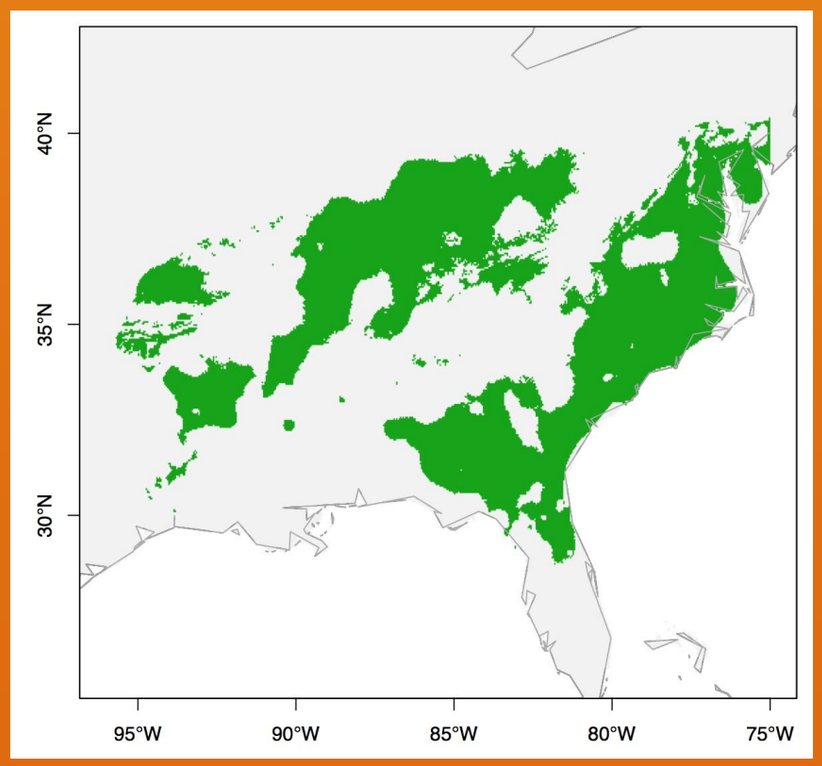
Occurrence Map and Species Distribution Model

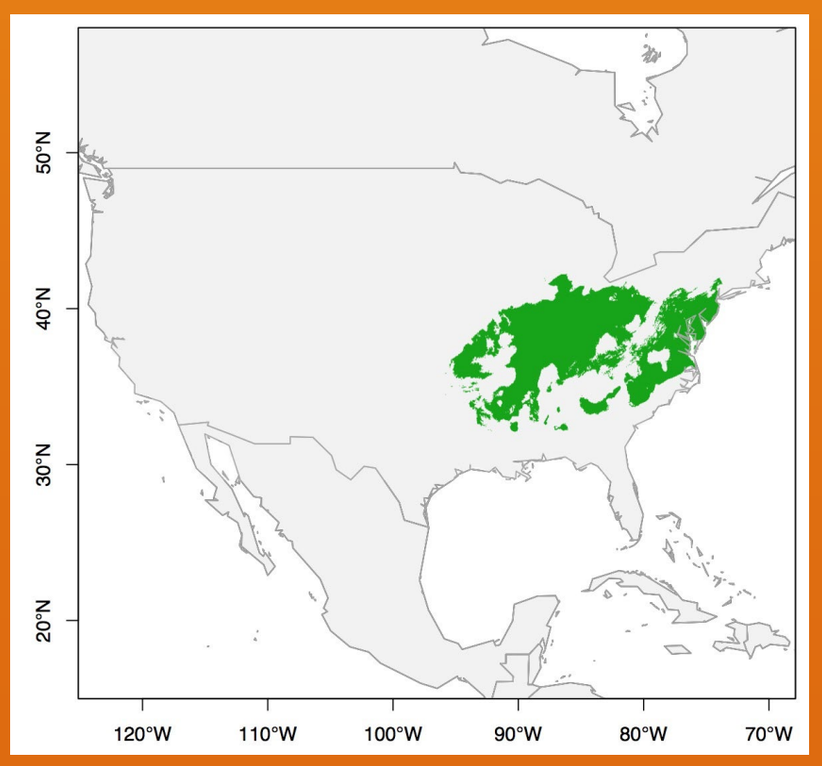
Eurytides marcellus



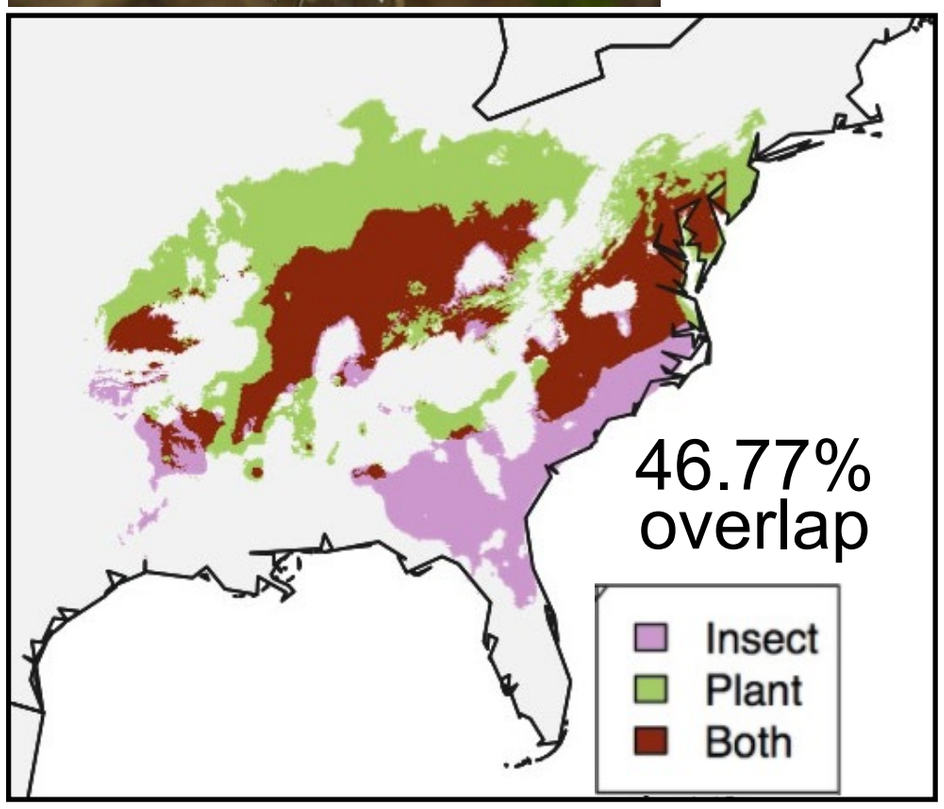
Asimina triloba







Class 2



Generate Species Distribution Model Maps

+

Natural History Information

BAMONA

Observations

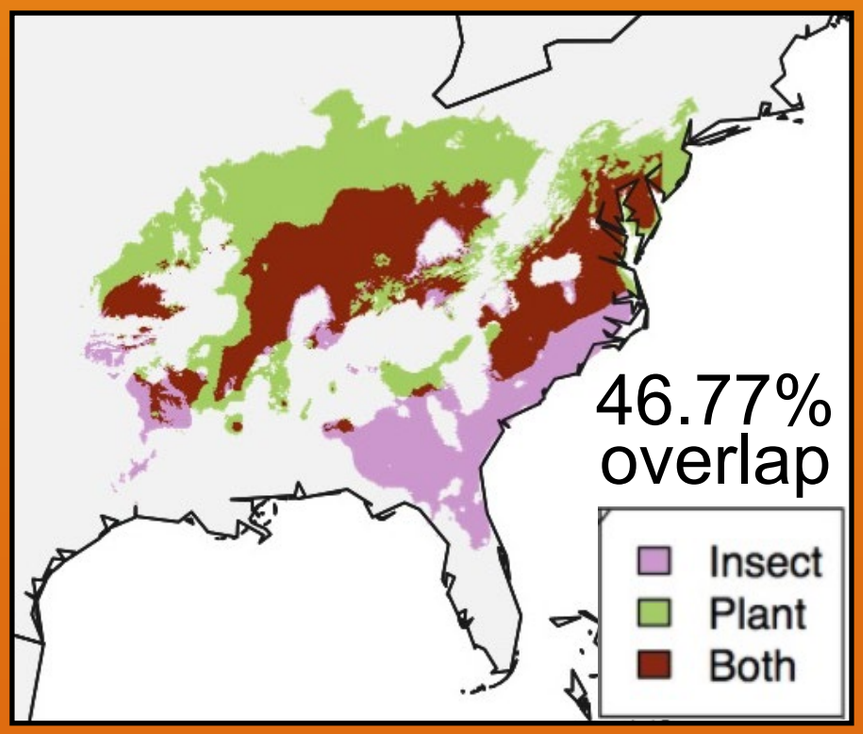
Hypothesis

Learning Goal: Use research computing tools to study a butterfly-host plant interaction

Hypothesis

Globally increasing temperatures will result in a larger overlap between the distributions of *Eurytides marcellus* and its host plant *Asimina triloba*, due to a greater migration of *E. marcellus* northward than that of *A. triloba* over the 53 year time period.

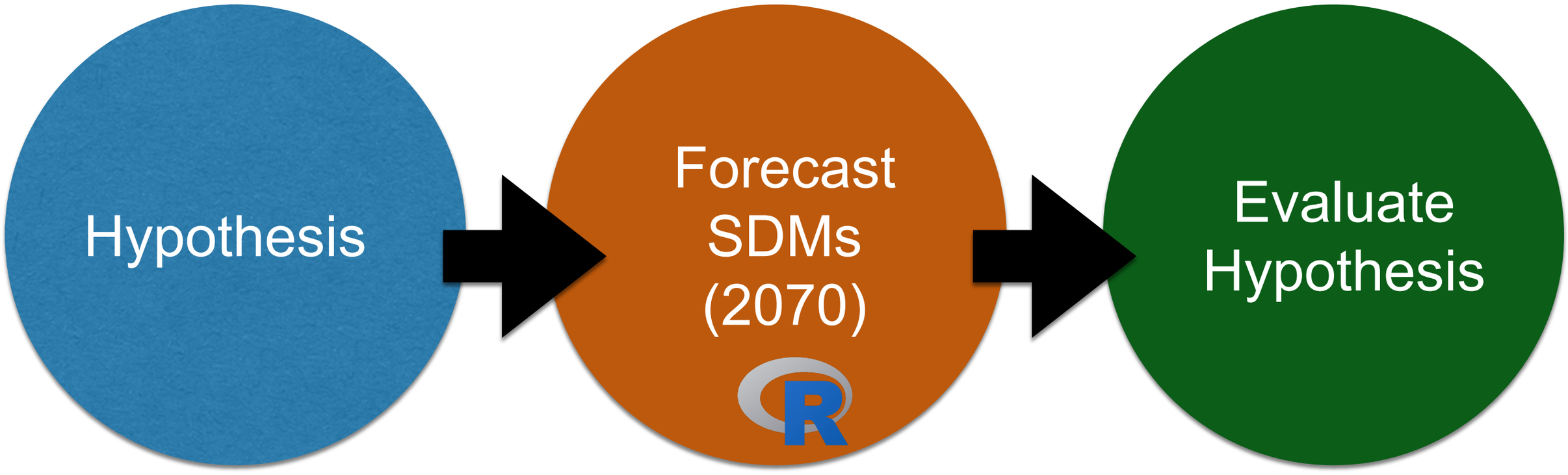
Eurytides marcellus



Asimina triloba

Class 3 - Forecast SDMs

Learning Goal 2: Use research computing tools to study a butterfly-host plant interaction



- Students modify and run scripts to generate predictive models of species distribution for the year 2070
- Use the GFDL-ESM2G model with a 4.5 increase in CO2
  - GFDL - Geophysical Fluid Dynamics Laboratory
  - ESM - Earth System Model which models a variety of atmospheric variables and cycles

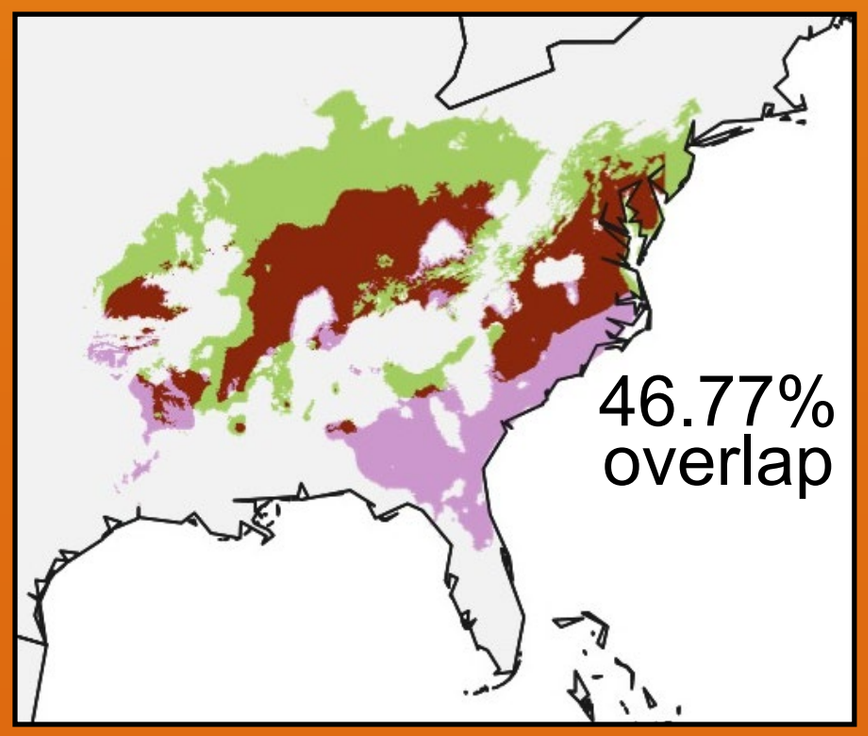
Class 3

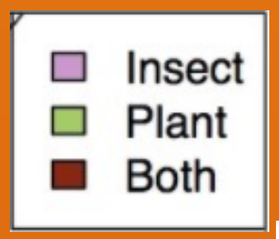
Learning Goal 2: Use research computing tools to study a butterfly-host plant interaction

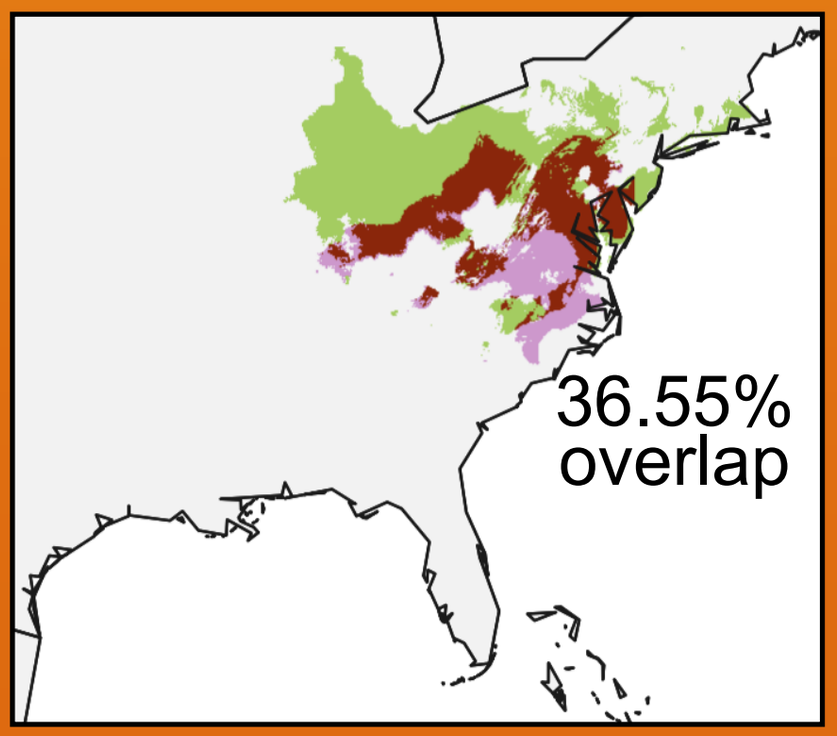
Hypothesis

Forecast SDMs (2070)

Evaluate Hypothesis







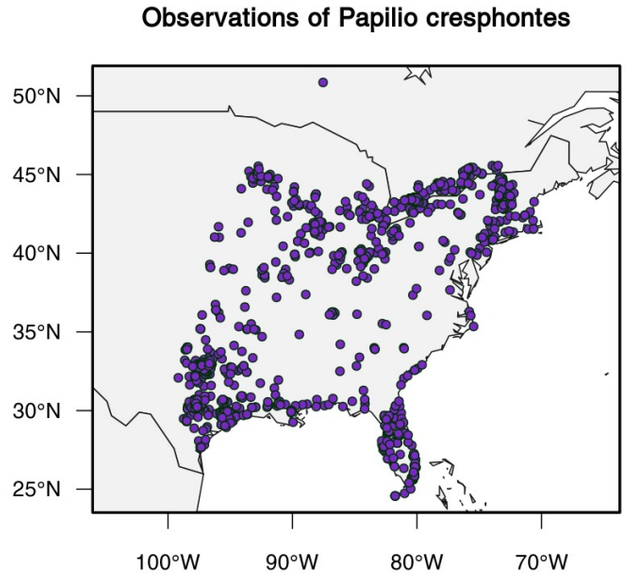
Class 4

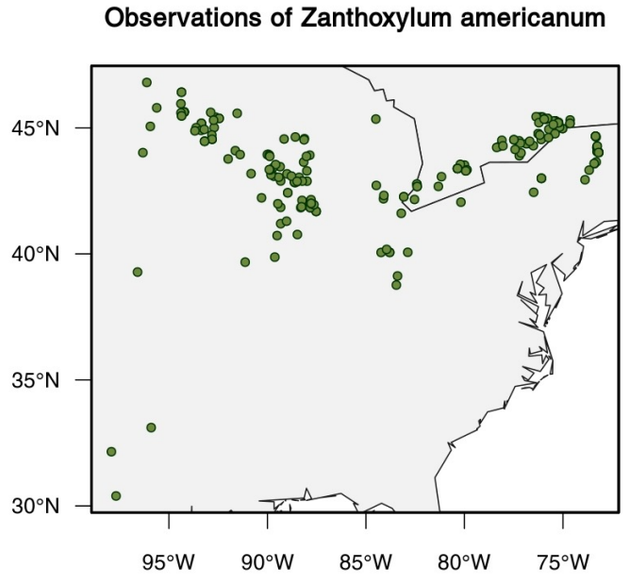
Learning Goals:

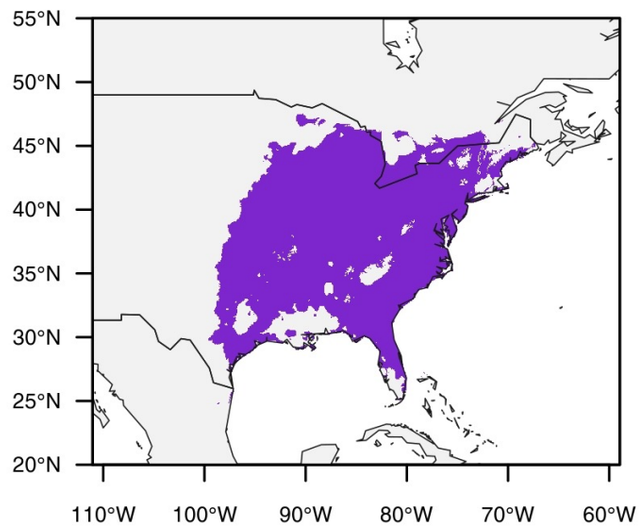
3. Communicate findings in the form of an oral presentation
4. Synthesize potential outcomes of the effects of climate change on plant-insect interactions

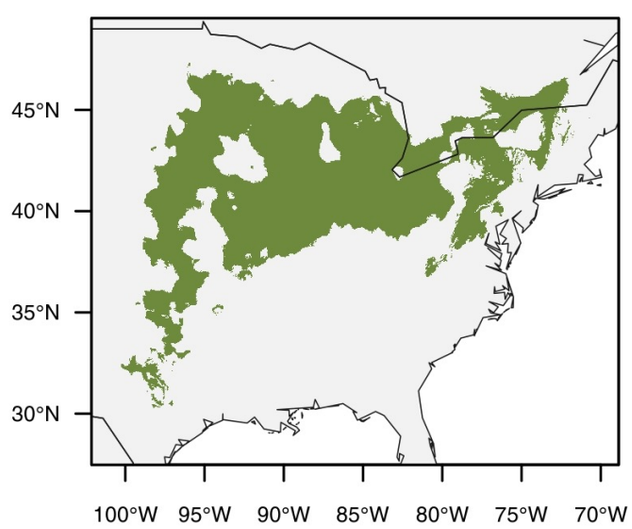
Takeaways

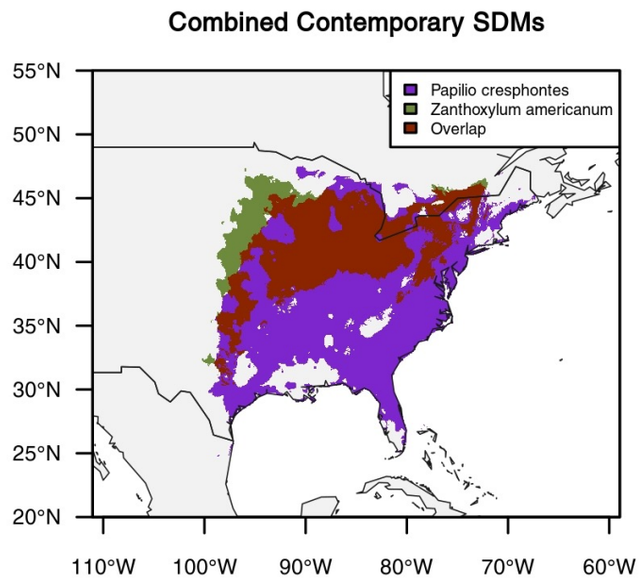
- Introduction to R and big data
- Generate a hypothesis based on observations
- Evaluate the hypothesis based on their data analysis
- Communicate scientific results
- Examine effects of climate change in their lifetime

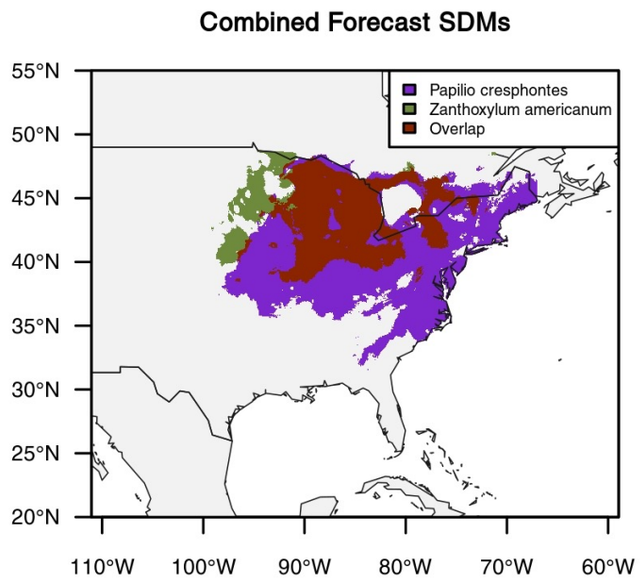








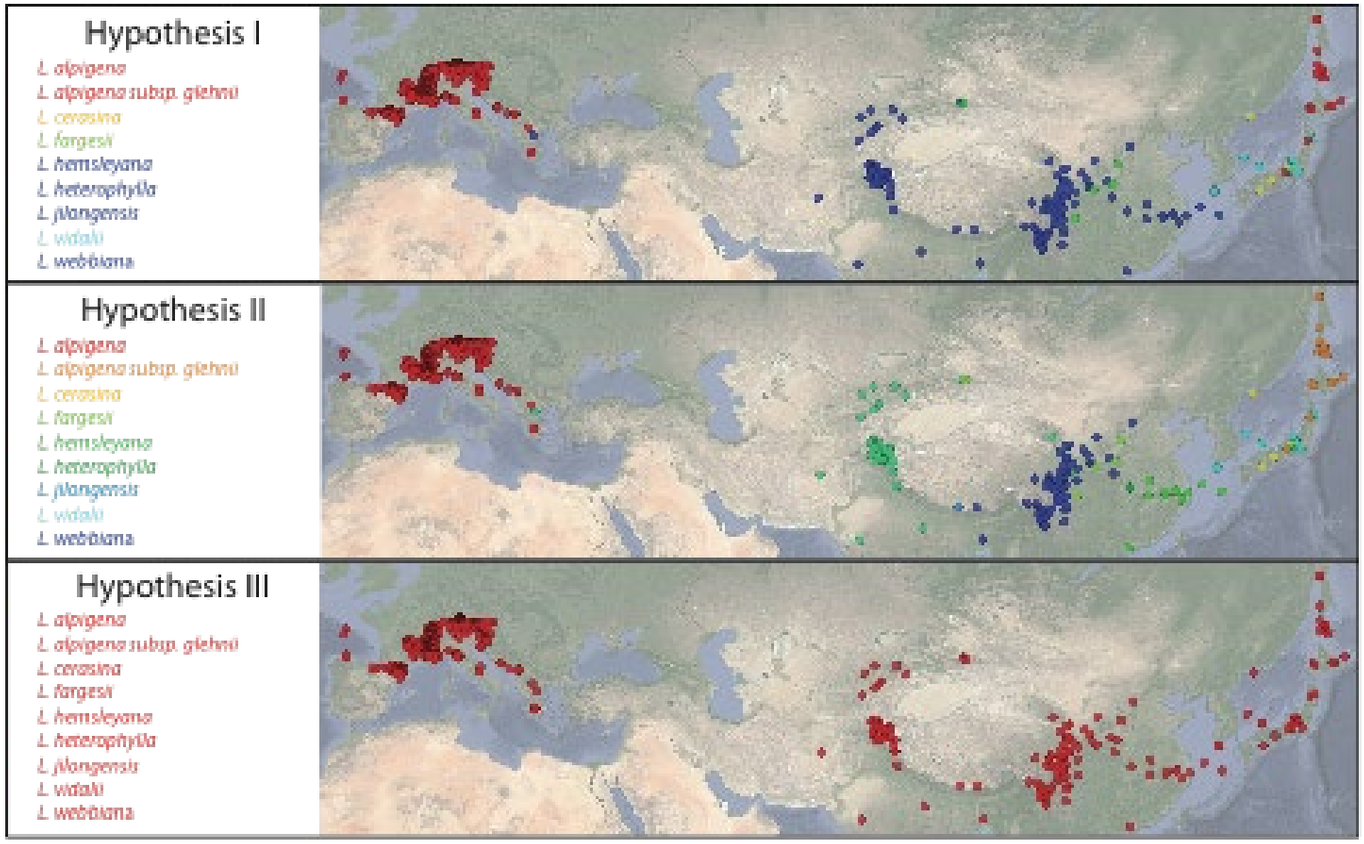


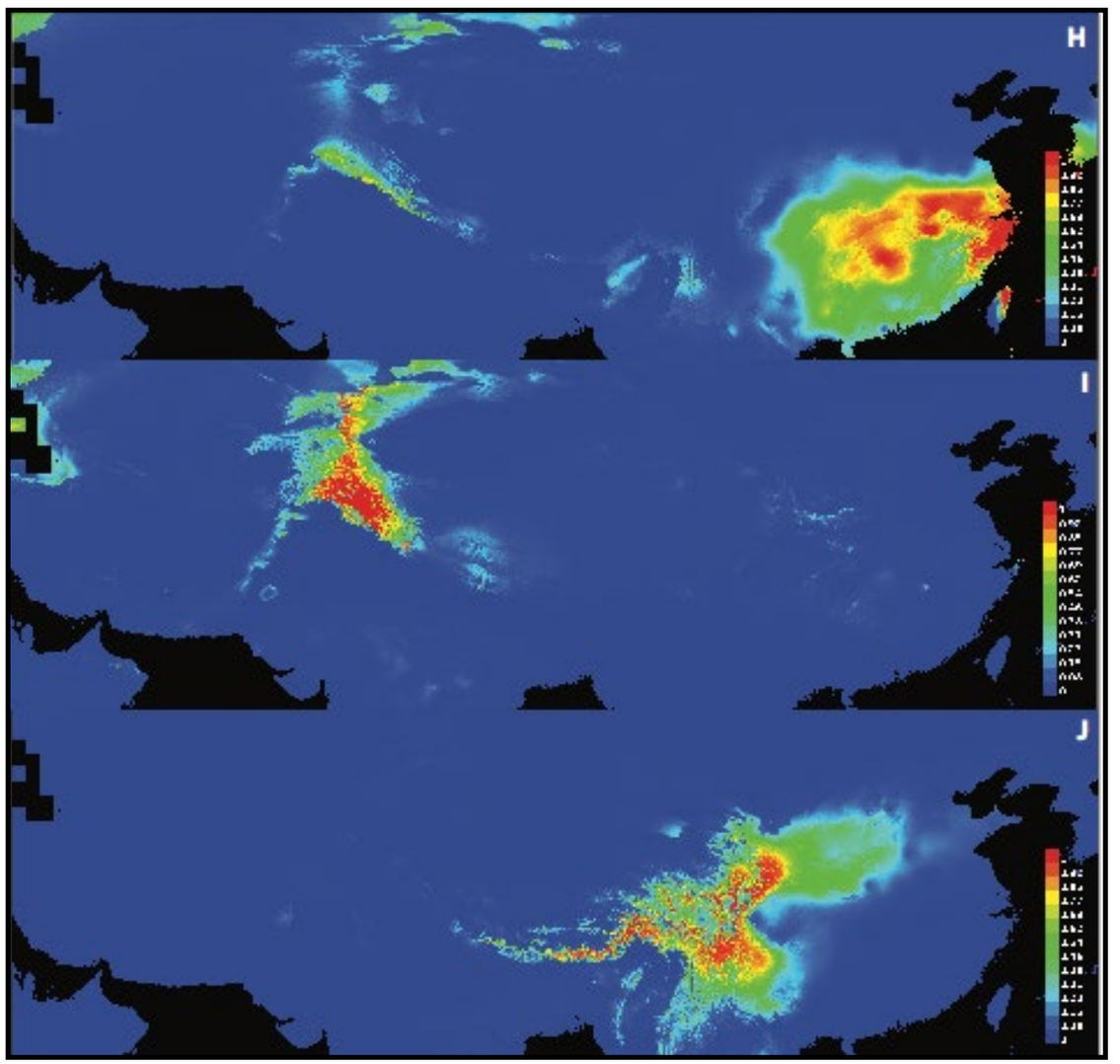


Applications to Independent Research

Using SDM to examine the role of species distribution and climate in assessing species boundaries in a species complex of honeysuckles

Nicole Tineo, ‘19



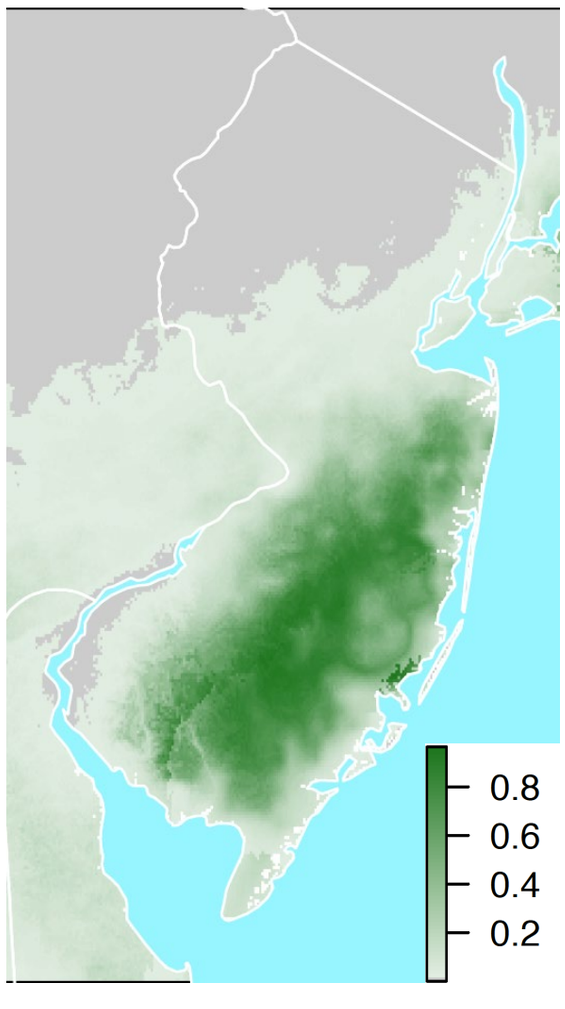


Applications to Independent Research

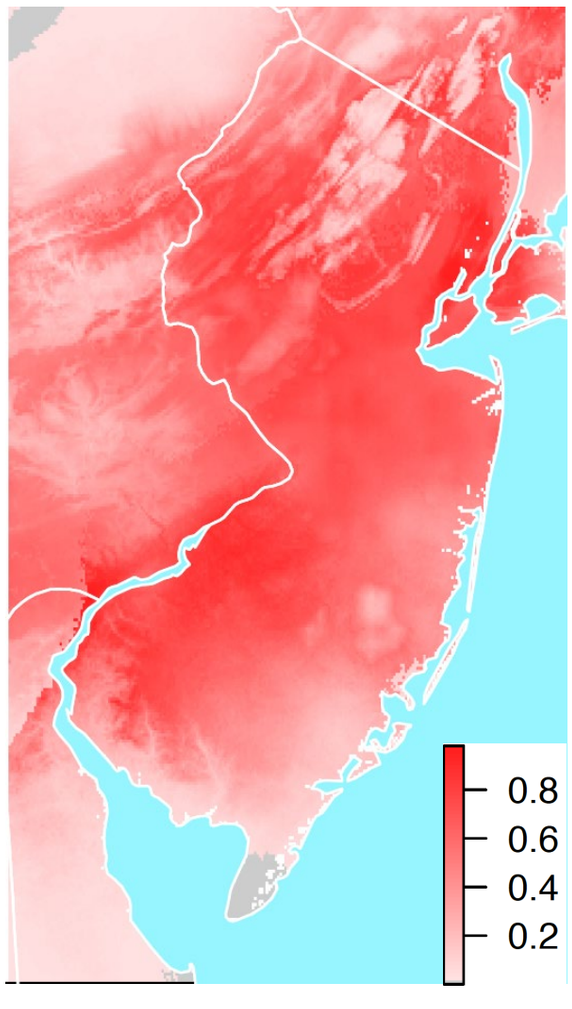
Using SDM to examine impacts of climate changes on species distribution and phenology over the past 150 years in NJ Pine Barrens

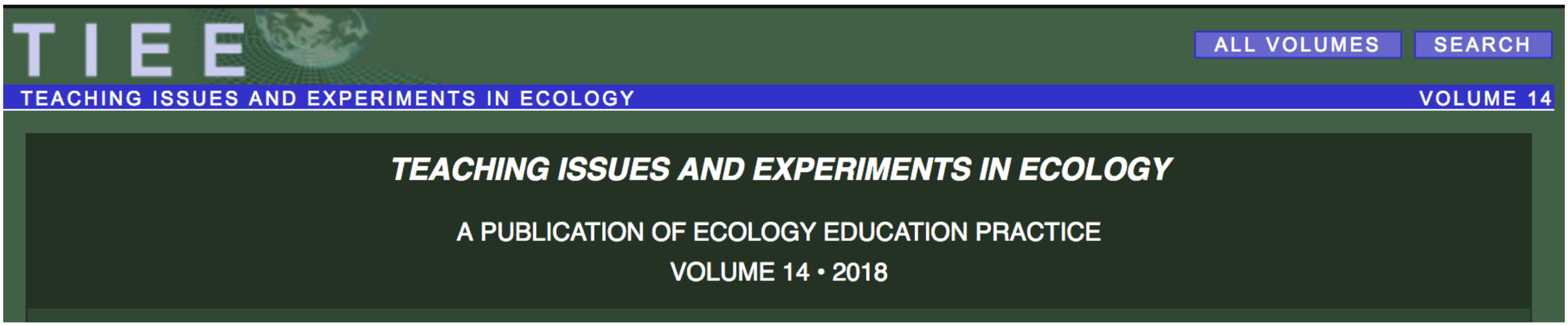
Matt Fertakos, ‘19

Eupatorum resinosum



Eupatorum perfoliatum





e will impact plant-insect distributions and interactions using open

Wendy L. Clement, Kathleen L. Prudic, Jeffrey C. Oliver

- Class slides
- Pre-class assignments
- Class plans (instructions)
- Five assignments with rubrics and answer keys
- Deep dive questions

- ~~Butterfly-host plant suggestions~~ with key natural history information
- Student instructions for downloading software & running SDMs in R
- R scripts, code explanations, trouble shooting information

Download Bundle (78 MB)

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Exploring how climate will impact plant-insect distributions and interactions using open data and informatics

By Wendy Clement[1], Kathleen Prudic[2], Jeffrey Oliver[3]

1. The College of New Jersey 2. University of Arizona 3. University of Arizona Libraries

qubeshub.org

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- Jeff Oliver, Katy Prudic
- TCNJ Plant-Insect Interactions students
- TCNJ School of Science
- Citizen science projects & Citizen scientists

Questions?

Colias eurytheme

Nathalis iole

Battus philenor

Limenitis arthemis astyanax

Epargyreus clarus

Lycaena helloides

Nymphalis antiopa

Papilio cresphontes

Vanessa cardui

Danaus plexippus

Junonia coenia

Asterocampa celtis

FLOWER POWER

STUDENTS FROM THE 1800s
PRESERVED PLANTS FOR
THEIR 21ST-CENTURY COUNTERPARTS

Roughly a century and a quarter ago, three students at TCNJ's first incarnation, the New Jersey State Normal School, collected about 450 plant specimens from the Trenton area. With care and precision, Sarah Kandle, Nelson Pepper, and Margaret Todd assembled them into herbarium books, bound libraries used to study biodiversity and ecology.

But at some point, the books fell off the radar until the STEM Building's construction in 2017 prompted a deep dive into storage in a botany lab.

"These books are a fun find," says biology professor Wendy Clement. "They are snapshots in time of the plant diversity in the region." In fact, one book traveled to the 1893 World's Fair in Chicago, included, one guesses, because the students' professor Austin Craig Apgar, vice principal of the Normal School and member of the Class of 1862, was a well-known botanist.

Since the rediscovery, Clement's research students have compiled the plants' classification information, digitized the specimens, and registered TCNJ as an herbarium with the Index Herbariorum at the New York Botanical Garden.

The continuing importance of the books hit home for Matthew Fertakos '19, who wrote his senior honors thesis on herbarium collections. "Students can look at individual species," he says, "and study how plants are responding to changes in the environment over the course of 100 years."

—*Kara Pothier*

Leiophyllum buxifolium
Common name: Sand Myrtle

Primarily found in the Pine Barrens of New Jersey, the Coastal Plain of the Carolinas, and in the Blue Ridge Mountains.

Smilacina racemosa

Common name: False Solomon's Seal

This plant was reclassified in the late 20th century as Maianthemum racemosum.

Claytonia Virginica.
Spring Beauty.
Portulacaceæ.
Trenton, Apr. 25. 94.

Original label, 1894, Sarah Kandle