PROJECT SILVAFLUX

Capstone Project

Big Data Computing and Interface for Tropical Forest Regeneration

By Team Clean Carbon

Meet the Team

Frontend team:

Curtis McHone - Team Lead
Justin Stouffer
Jonathan Bloom

Backend team:

Richard McCue
Shayne Sellner

Team Sponsor:

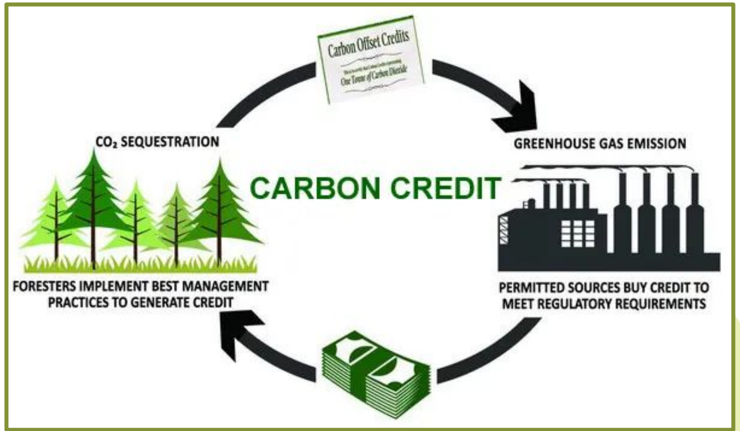
Allie (Alexander) Shenkin

Team Mentor:

Vahid Nikoonejad Fard

What are carbon credits?

- Carbon credits are purchasable credits that landowners and project developers can sell
- These carbon credits are directly correlated to the amount of carbon dioxide a certain plot of land takes in
- Developers and landowners can then sell these credits to help businesses or corporations offset their CO2 emissions
- The value of the carbon market has seen an exponential increase as climate change continues to become more of a pressing issue for our society
  - Value of carbon market in 2021
    ~ 2 billion dollars
  - Expected value of carbon market in 2030
    ~ 50 billion dollars


Carbon Offset Credits
CO₂ SEQUESTRATION
GREENHOUSE GAS EMISSION
CARBON CREDIT
FORESTERS IMPLEMENT BEST MANAGEMENT PRACTICES TO GENERATE CREDIT
PERMITTED SOURCES BUY CREDIT TO MEET REGULATORY REQUIREMENTS

Project Introduction

- Our sponsor Allie (Alexander) Shenkin and his team have discovered a new climate cooling process that allows for 30% more carbon credits to be sold for a designated plot of land

- We have been asked to create an application that is able to calculate the amount of carbon dioxide a certain area will uptake, using this new discovery

- As a team we hope that our final application makes buying and selling carbon credits more profitable and accessible to the average person as well as revolutionize the way carbon credits are sold and predicted

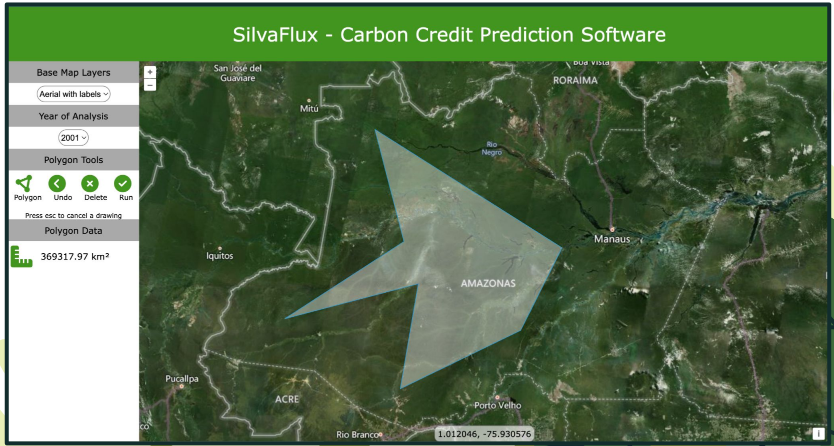
Problem Statement

- There is not currently a way to accurately predict the amount of CO2 uptake for a plot of land.
- Because of this land developers cannot predict how much money they are going to make or if the project is even going to be worth their time
- Allie's discovery makes investing in reforestation projects much more profitable, helping not only the investor but the planet, but what is the best way to implement this
- The current software prototype that is used to calculate the CO2 prediction is simply too slow, inefficient, and not user friendly

Solution Overview

Front End

- Web interface
  - Django Web Framework
  - Utilizes the OpenLayers javascript library
  - Easy to use map interface
    - Bing Maps API base maps
    - Ability to Zoom, Pan, Scale
- User friendly and responsive
- Ability to draw a polygon
- Measure area
- Sends the polygon to the prediction script


SilvaFlux - Carbon Credit Prediction Software

Base Map Layers: Aerial with labels

Year of Analysis: 2001

Polygon Tools

Press esc to cancel a drawing

Polygon Data

369317.97 km²

Solution Overview

<u>Back End</u>

- High performance linux based server
- Python based prediction system
  - Static raster simulation
- Raster layer storage
- Send results to front end

<u>Database</u>

- PostgreSQL database
- Stores user login information
- User access control
- Expandability for user query storage

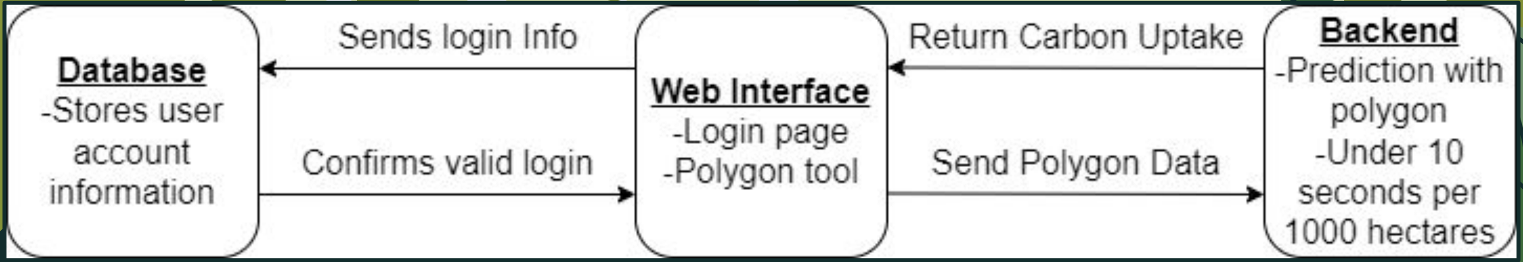
Requirement/Architecture Overview

Requirements Acquisition

- Weekly client meetings
- Initial project description and overview
- External research & sponsor recommendations

Requirements

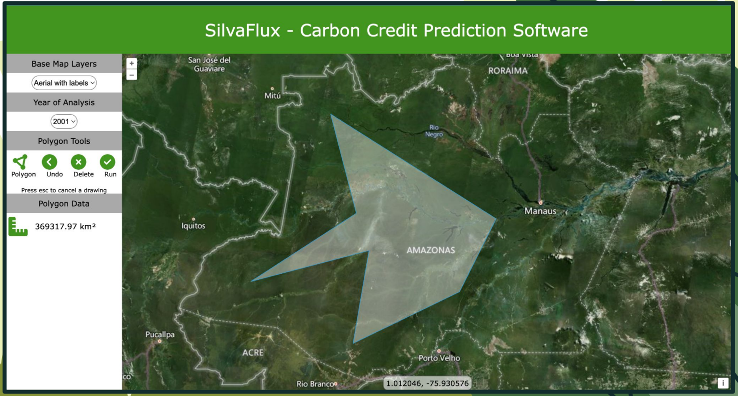
- Simple web interface with an interactable map
- Send polygon to backend
- Computationally efficient backend that computes carbon uptake
- Database with encryption to store user account information



Architecture/Implementation Overview

Front End

- Django Framework
- OpenLayers map using bing maps baselayers
- Communicates with Django Postgres database to verify login information
- Polygon tool on map built into OpenLayers
- Calls backend script with polygon coordinates and year selected


SilvaFlux - Carbon Credit Prediction Software

Base Map Layers: Aerial with labels

Year of Analysis: 2001

Polygon Data: 369317.97 km²

1.012046, -75.930576

What are rasters?

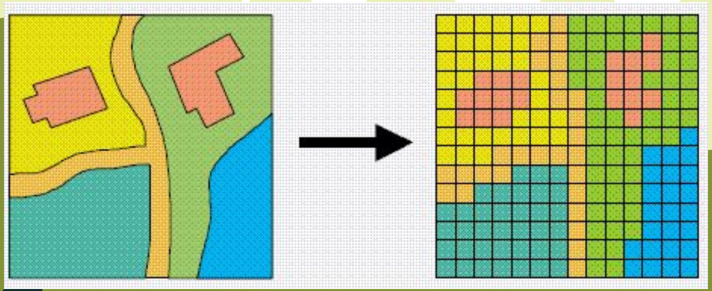
- Rasters are digital images made up of a grid of pixels, representing a unit of space

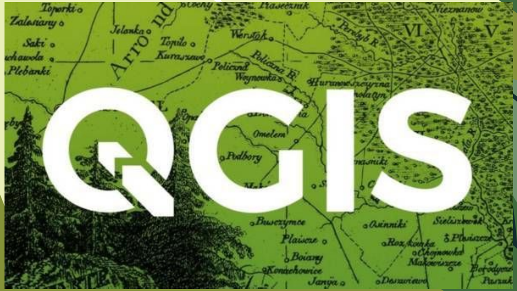
What they represent

- Geospatial data: Elevation, land cover, temperature, precipitation, and etc

Why are they useful?

- They can be used for mapping, land use planning, environmental monitoring, and natural resource management
- Geographic Information System (GIS) software can manipulate rasters to analyse and visualize geospatial data
- Due to their format they can be easily shared with others and manipulated for your specific purpose





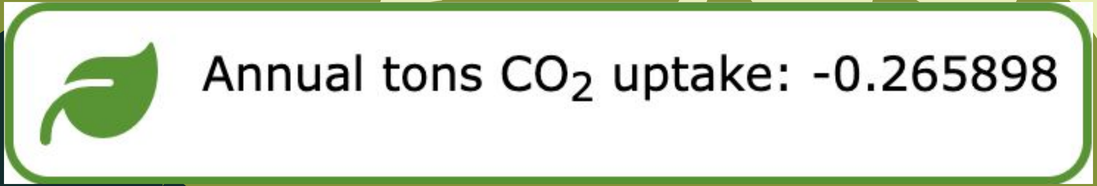
Architecture/Implementation Overview

Backend

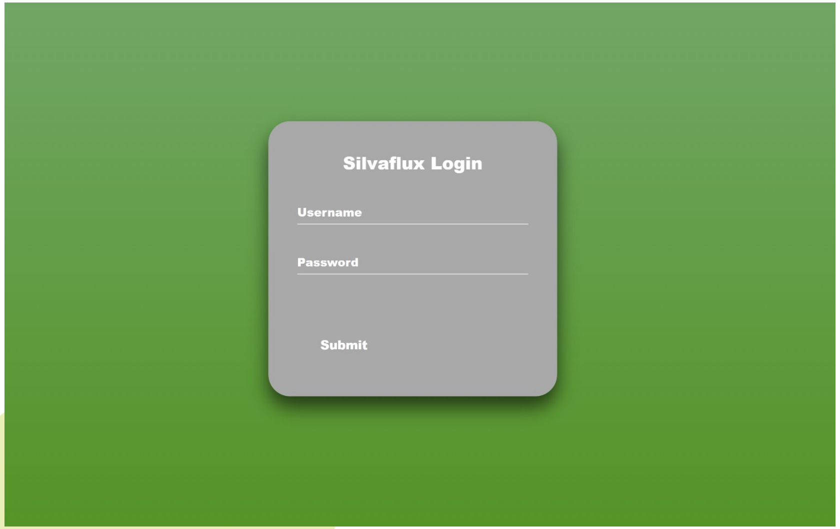
- Precomputed rasters for years 2014-2021 for global prediction
- Python script to compute the carbon uptake on the polygons plot of land
- Return carbon uptake back to front end

Database

- Stores user login information utilizing encryption


Annual tons CO_2 uptake: -0.265898

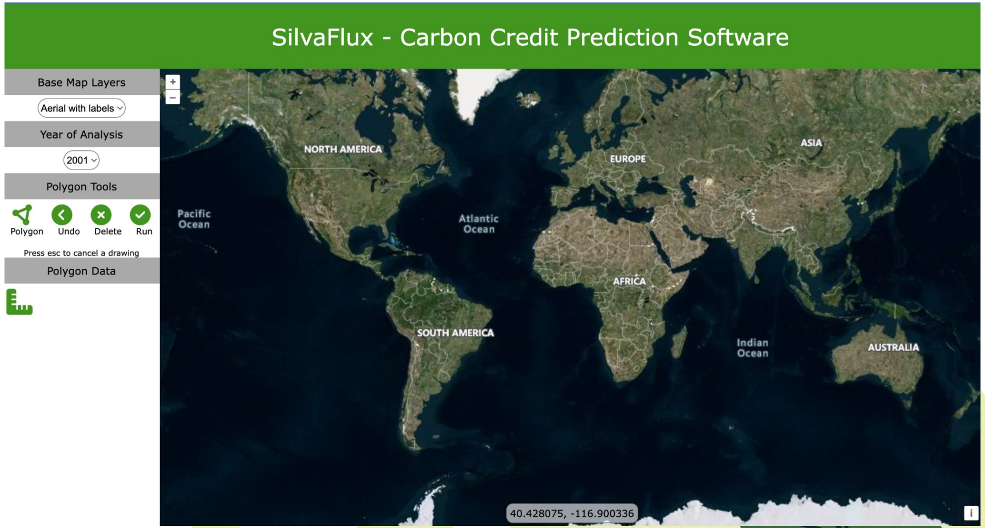
Prototype


Silvaflux Login

Username

Password

Submit


SilvaFlux - Carbon Credit Prediction Software

Base Map Layers: Aerial with labels

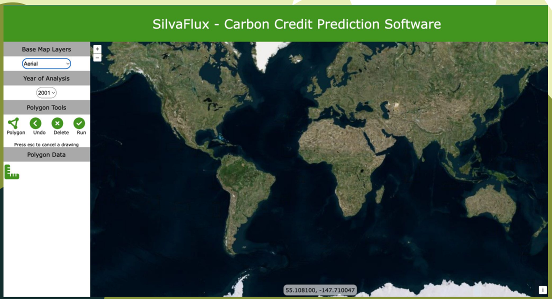
Year of Analysis: 2001

Polygon Tools

Press esc to cancel a drawing

Polygon Data

40.428075, -116.900336


SilvaFlux - Carbon Credit Prediction Software

Base Map Layers: Aerial

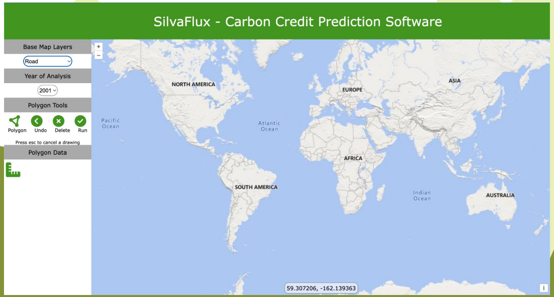
Year of Analysis: 2001

Polygon Tools

Press esc to cancel a drawing

Polygon Data

55.108100, -147.710047


SilvaFlux - Carbon Credit Prediction Software

Base Map Layers: Road

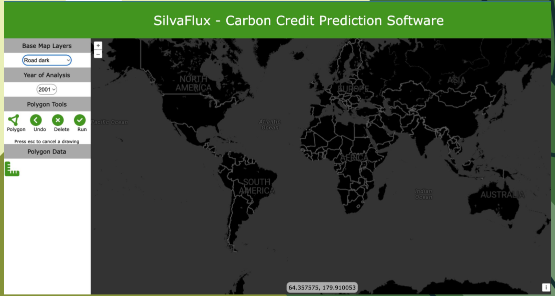
Year of Analysis: 2001

Polygon Tools

Press esc to cancel a drawing

Polygon Data

59.307206, -162.139363


SilvaFlux - Carbon Credit Prediction Software

Base Map Layers: Road dark

Year of Analysis: 2001

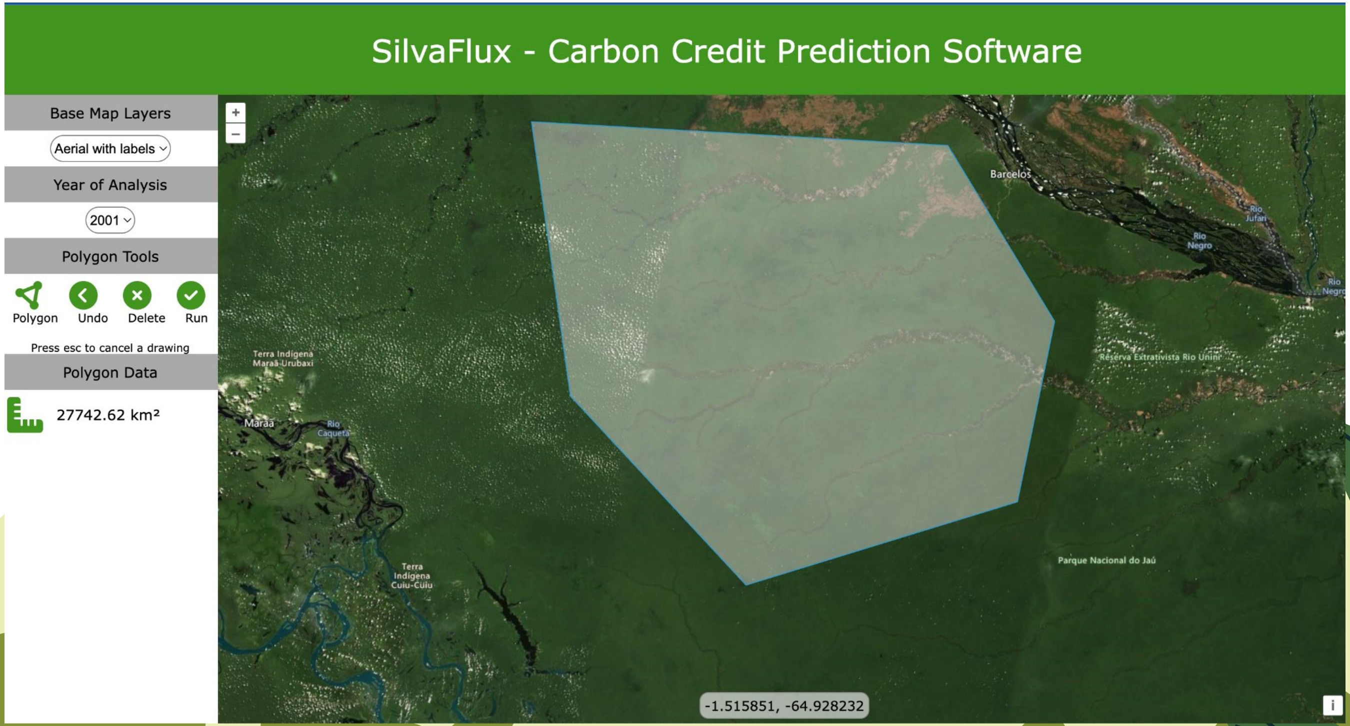
Polygon Tools

Press esc to cancel a drawing

Polygon Data

64.357575, 179.910053

Prototype



SilvaFlux - Carbon Credit Prediction Software

Base Map Layers

Aerial with labels

Year of Analysis

2001

Polygon Tools

Polygon Undo Delete Run

Press esc to cancel a drawing

Polygon Data

27742.62 km²

Annual tons CO_2 uptake: -0.323998

Challenges

Backend

Raster storage:

- Our rasters are up to ~45GB in size, up to 21 rasters
- 45GB x 21 rasters = ~945GB total storage needed

Runtime:

- Takes very long to read the raster into memory

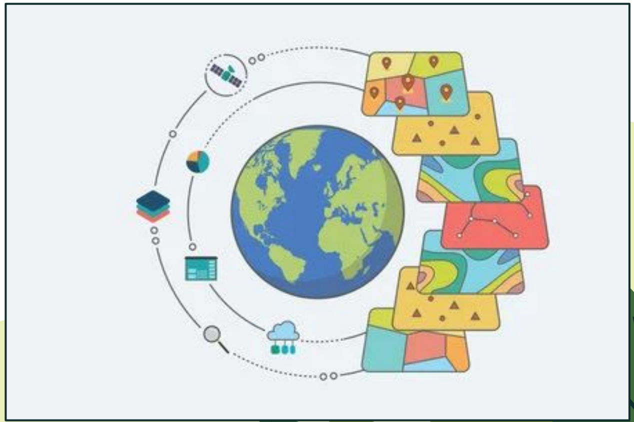
Frontend

Local CSS:

- CSS for OpenLayers is not working locally

Django:

- Could not start up the web server



Resolutions

Backend

Storage Solutions:

- Increase our AWS storage size
- Support less rasters

Runtime Solutions:

- Reading only sections of the raster into memory

Frontend

CSS and Django Solutions:

- More research
  - On static CSS files and linking
  - On Django file architecture and server startup

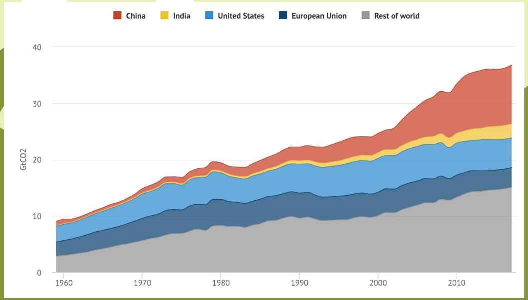
Future Work

Version 2.0 would include:

- More carbon uptake visualizations / future predictions
- ArcGIS plugin, Monsoon module
- Usage based billing
- Ability to change forest baselayers / real time raster computation
- More feedback to the user regarding the results
- Support for all of the available years
- Further performance upgrades

Example of a carbon uptake graph:

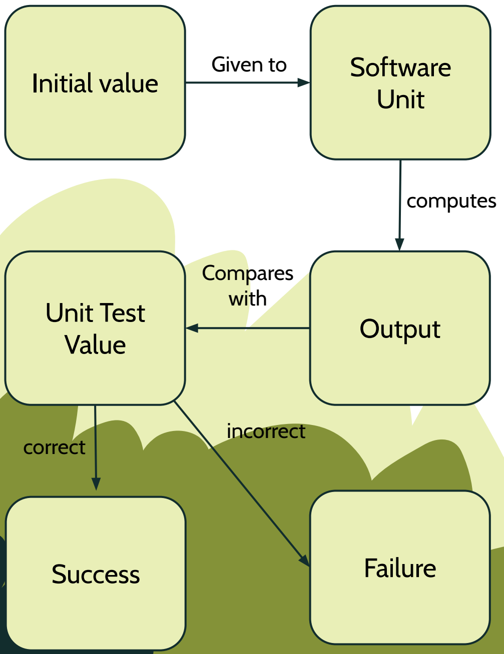
Source: carbonbreif.org



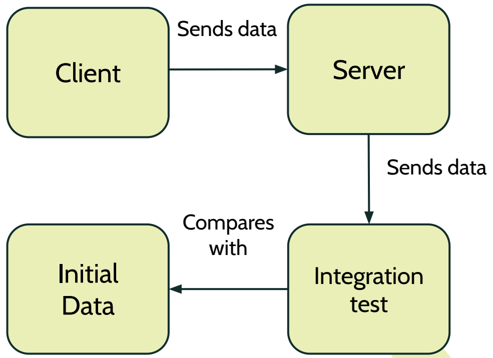
ArcGIS

Testing Plan

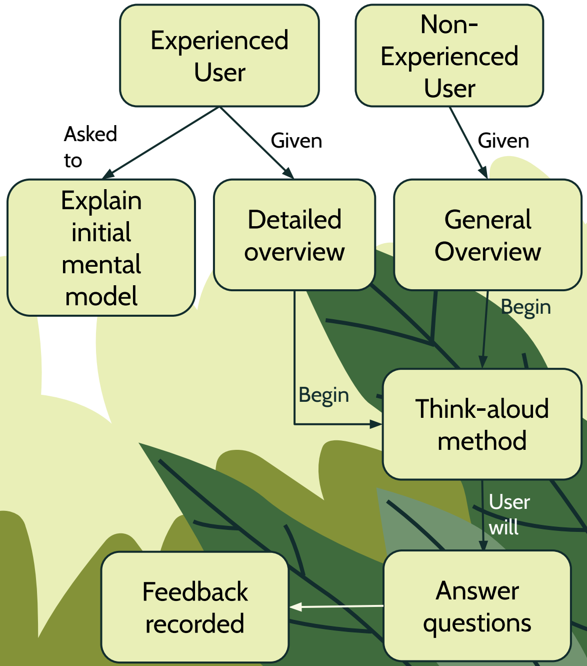
Unit testing



Integration testing



Usability testing



Testing Plan

Unit testing

Ensures our software and code is accurate and reliable
Tested Units:

- Correct coordinates
- Map projection
- CO2 uptake amount
- Year of prediction selection

Once Unit testing is complete, our team will know exactly which functions/isolated pieces of software work correctly

Integration testing

Four different tests:

- Query results are correctly sent over to postgres from Django
- Logout function restricts access to home page
- Prediction page vulnerabilities
- Frontend coordinates correctly sent and match to backend coordinates

Once Integration testing is complete, our team will know exactly which software systems are correctly communicating with one another

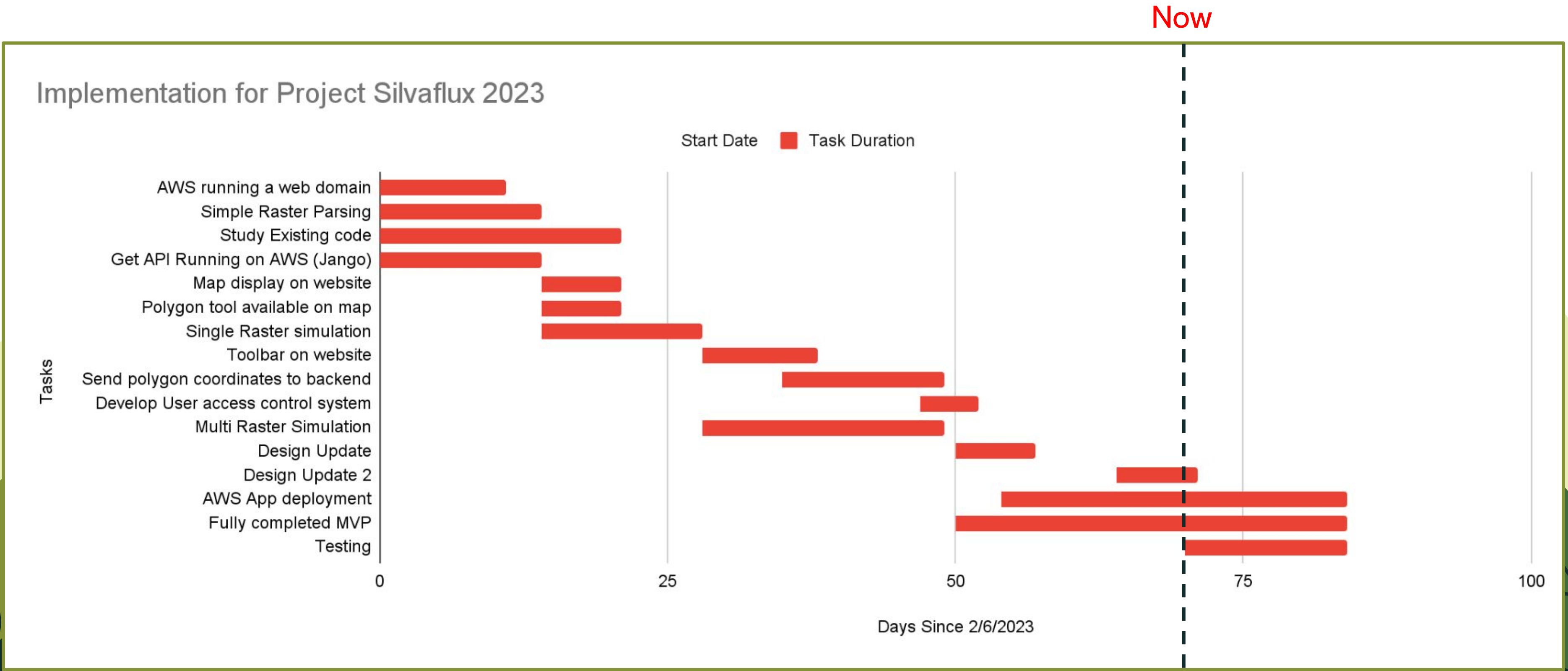
Usability testing

Users will provide feedback on:

- Initial Impressions
- Ease of use, navigation around interface
- Expected functionality of features
- Interpretation of results, useful or redundant data

Once Usability testing is complete, our team will have a better understanding of what users are thinking when using our system, and the different functionalities that they find important

Schedule


Now
Implementation for Project Silvaflux 2023
Start Date
🟥 Task Duration
Tasks
AWS running a web domain
Simple Raster Parsing
Study Existing code
Get API Running on AWS (Jango)
Map display on website
Polygon tool available on map
Single Raster simulation
Toolbar on website
Send polygon coordinates to backend
Develop User access control system
Multi Raster Simulation
Design Update
Design Update 2
AWS App deployment
Fully completed MVP
Testing
0
25
50
75
100
Days Since 2/6/2023

Conclusion

Our current implemented solution includes:

- A responsive and convenient web interface front-end with authenticated user access control system (Django)
- Fast and secure data transmission between our web interface and backend (Django)
- Secure database that holds all of the user access information (PostgreSQL)
- Correct data sent back to the user with additional useful information

Functional Requirements:

Simple web interface with a interactable map, with fast communication with backend

Computationally efficient backend that will run the prediction on a specified plot of land

Database with encryption to store user account information

Conclusion

System Performance

- Instantaneous Login/Logout connection with database
- Under 10 sec runtime for a polygon of 1000 hectares

Architecture Implementation

- Prediction computation located on the backend, implemented in Django framework
- High performance AWS backend server
- PostgreSQL database used to store authenticated user information

Challenges/Resolutions:

- Computational performance was accelerated to meet runtime requirements
- AWS storage was upgraded to hold a larger amount of rasters
- Django and Web front end are up and running with working CSS