2022 MAS-GIS Capstone Proposal

Christopher Harris 2021

Group 6

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Introduction

The Cactus Fire of 2017 burned over 800 acres of riparian and Sonoran Desert habitat along the Lower Salt River northeast of Mesa, Arizona. The presence of invasive plant species such as salt cedar (*Tamarix chinensis*) which was well established for decades in the area allowed the fire to burn at a greater severity and carry faster than what is typically expected in a desert riparian landscape (“Management Objectives’’). Following the fire nonnative species such as stinknet (*Oncosiphon piluliferum*) emerged within the burn scar and giant reed (*Arundo donax*), which was already present, spread to new territories. The presence of these nonnative species poses a significant threat to the biodiversity of the area by changing fuel properties, which can in turn affect fire intensity and extent (Brooks et al., 2004). In response to the Cactus Fire and the need to reduce the presence of invasive plant species, the Lower Salt River Restoration Project (LSRRP) was established in 2018. The LSRRP has a long-term goal of restoring eleven miles of the Lower Salt River Recreation Area from Stewart Mountain Dam to Granite Reef Dam. From an ecological perspective, LSRRP’s objectives are to reduce the presence of invasive plant species, increase native plant abundance, reduce the risk of wildfire, and improve riparian habitat for wildlife species (“Management Objectives’’). To monitor the 400-acre LSRRP site Unmanned Aircraft Systems(UAS), more commonly known as drones, are used. Aerial imagery collected via UAS is then utilized to aid in the continuation of the restoration project through vegetation classification and analyses.

Operating under the umbrella of LSRRP is Green Drone AZ (GDAZ), which is a collaboration between Northern Arizona University (NAU), EcoCulture, the Tonto National Forest, Arizona State University (ASU), the National Forest Foundation, The Boeing Company, Society for Science, and the Arconic Foundation. GDAZ is a Science, Technology, Engineering,

and Mathematics (STEM) educational outreach program. This program is designed to expose middle and high school students to the applications of Geographic Information Systems (GIS) and drones in natural resource management.

Project Purpose

GIS has been a vital piece of LSRRP since its establishment in 2018. This capstone will build upon the efforts of four previous MAS-GIS capstone projects related to work on the Lower Salt River. The first Capstone was completed by Justin Eddinger in 2018 in which he created an initial inventory of invasive and native vegetation communities along the Lower Salt River. This inventory was used to help facilitate restoration management efforts of the LSRRP. Following the creation of GDAZ in 2020, the first cohort of MAS-GIS interns produced two capstone projects working on vegetation analysis and classification. However, one group's overall classification of invasive and native vegetation species did not produce statistically significant results. In an effort to increase the classification's accuracy the second group added structural data such as a canopy height model (CHM) and digital terrain model (DTM) which increased the accuracy percentage into the mid '90s (Kedia et al. 2020). Their success led to the publication of the journal article "An integrated spectral–structural workflow for invasive vegetation mapping in an arid region using drones" in *Drones*. Building upon the methods used in 2020, the interns of 2021 sought to improve vegetation classification accuracy within the project area of phases one through three (Figure 2). Their end results proved to be highly accurate at 91% and 96%. Along with vegetation classification, the interns also produced outreach applications to assist GDAZ staff in recruiting teachers for their

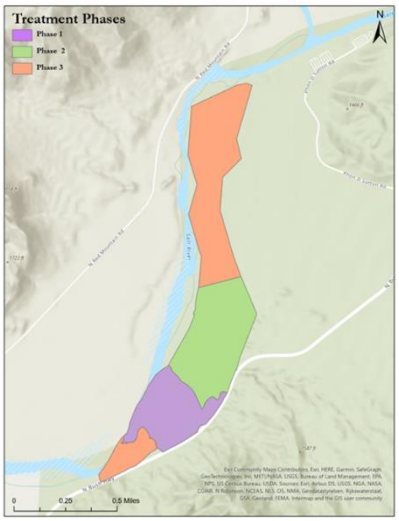

Figure 2. Phases 1 through 3 of the LSRRP project site.

STEM outreach program. With these past capstones in mind, this year's goals are to organize data collected from 2020, 2021, and 2022 into a final geodatabase, develop a model in ArcPro to run vegetation classification, review three years of data collection to determine the best parameters for drone flights, create a public web app and story map guiding visitors through the LSRRP site, and improve upon educational outreach within Arizona.

Project Objectives

Objective 1: Vegetation Classification and Analysis

The first objective of this project is to organize all data collected over phases one through three of the project site (Figure 2) from 2020, 2021, and 2022 into a final geodatabase. Following the collection of this year's imagery, a supervised pixel-based image classification will be done in ArcPro to create classified rasters for vegetation classification and analysis. In addition to this, we will develop a model in ArcPro to run a vegetation classification analysis on imagery collected in 2020, 2021, and 2022.

Objective 2: LSRRP Web App & Story Map

The second objective is directed toward creating geospatial content for the public in the form of a web app and story map. The story map will serve as a guided tour that can be explored remotely covering the 400-acre extent of the project through maps and text. It will feature project objectives, treatment strategies, before and after pictures, plant information on native and nonnative species, invasive weeds, details on project phases, and ecological facts about the area. The accompanying web app will serve as a "semi-guided tour" through the site. The app will allow visitors to interact with the area by following trail layers with pop-ups at certain points detailing a variety of topics. These topics will include the project phase the visitor is currently in, before and

after pictures, native and nonnative plant information, historical sites, and designated vegetation communities.

Objective 3: Educational Outreach

The third objective of this project is to assist in improving educational outreach. Arizona's public Title 1 middle and high schools are the focus of outreach since they are typically in underserved communities. To assist in finding these schools, we will be adding teacher contact information to GDAZ's master teacher directory. The updated directory information will be added to GDAZ's STEM Equity Dashboard. This information will be used to assist in reaching out to new schools not enrolled in GDAZ's education program. GDAZ's outreach program is an online-based curriculum to expose middle school and high school students to GIS technology and drones. To keep students engaged, we will create a modified version of the web app tour mentioned in objective two, which students can access at any point to learn about the site. This version will be designed to engage students in GIS technology by allowing students to locate points of interest. These points of interest will be spread throughout the project site, once the student clicks on one the pop up will share educational information on the point. This web app will be supplementary to the course modules.

Data

Data	Data Type	Data	Data Type
Title I Schools	Excel Table	Plant Species Inventory	Feature Layer
Master Teacher Directory	Excel Table	Plant Classification Adjusted	Service Definition
Coon Bluff Point Cloud	Scene Layer	Spectral Aerial Photo	Raster Feature Class
RGB aerial photo	Raster Feature Class		

Methodology

Data Collection

Data collection for this capstone project will be done in conjunction with GDAZ utilizing aerial imagery captured by drones across 400-acres of the LSRRP site. The drones will fly transects over the project site according to a preprogrammed route while capturing photos in timed intervals. Highly accurate ground control point (GCP) data is collected utilizing the Trimble DA2 GNSS receiver, which achieves an overall spatial resolution of 5-8 cm. The GCPs are used for aerial photo geo-referencing and calibration for synthesis. The location information recorded by GNSS receivers and drones is based on WGS84, which will be converted to NAD 1983 UTM Zone 12N in a later step. All RGB and multispectral imagery collected over the site will be georeferenced and processed using the photogrammetry software, Pix4D, resulting in outputs of orthomosaics, point clouds, and digital elevation models (DEMs).

Data collected for teacher outreach will come from a pre-prepared list of Arizona school districts. For each independent school district, we will collect information on STEM and career and technical education (CTE) teachers from school websites. Teacher information (teacher name, subject, email address, and phone number) will be imported into subtables representing each school district.

Modeling

To georeference the collected images, GDAZ staff will upload these photos to Pix4D. Import aerial imagery, then use pre-set ground control points (GCP) to help georeference the imagery to represent locations on the ground. Pix4D will use this data to georeference point clouds created using triangulation. It then uses the point cloud to georeference the orthomosaic and create ground models, including digital surface models (DSMs) and digital terrain models

(DTMs). The collected spectral layer will be used as the basis for plant classification: a rough classification of surface plants in aerial photos based on the different spectra exhibited by different plants. At the same time, the layer will be gridded according to a certain size, and the main plants in each grid will be used as the final displayed cells. The point cloud data will be presented in the form of an ArcGIS Scene Layer and point clouds containing plant information (such as canopy and shrubs) will be the basis for generating DEMs. Spectral data and RGB data will compose the layers of the raster data. A tile layer will be created to serve as a base map for plant classification and analysis. For the classification process the spectral data and structural data (DSM, CHM) are used to create a "raster stack" used as a reference dataset in the classification process. This raster stack utilizing spectral and structural data is the basis of our classification protocol. The process of segmentation groups like pixels to create a less complex, data heavy raster data set used for classification. Training samples representing ground referenced plant species types are then fed into the model. We will be developing a model in ArcPro to run the vegetation classification analysis established protocol from previous years on aerial imagery collected in 2020, 2021, and 2022. The newly developed model will then be used for future vegetation data processing by GDAZ. This is important to do so the data is the product of one protocol instead of three different protocols used in the previous capstones. Any changes in vegetation will be compared and tracked throughout all three years of collected data to try and determine the best flight altitude based on results.

Geodatabase

A final geodatabase (GDB) will be created that includes all vector and raster data collected over phases one through three of the project site from 2020, 2021, and 2022. The GDB will contain all orthomosaics, digital elevation models (DEM), canopy height models (CHM),

digital surface models (DSM), digital terrain models (DTM), point clouds, vegetation classifications, feature classes, and created metadata. The coordinate system used for all feature classes will be NAD 1983 UTM Zone 12N. The final GDB will then be given to GDAZ to use on future projects.

Story Map and Web App

An ArcGIS story map will be created to serve as a remotely guided tour of the LSRRP site. Background information on the Cactus Fire, LSRRP, and restoration efforts will be included along with a guided map tour through the project site. The viewer will be "walked" through the phases of the LSRRP site each featuring different points of interest. The points of interest will range from information on the Lower Salt River vegetation to LSRRP and its objectives. An accompanying web app built on ArcGIS Online will be created to serve as a "semi-guided tour" throughout the site. The web app will contain different layers that visitors can interact with, for example, a trails layer or a project phases layer. The app will also include the points of interest as seen in the story map. Visitors will be able to zoom in and out of the map, toggle layers, and click on point features to read their accompanying information. The story map and web app will both be available to the public with visitors of the Lower Salt River being the main target audience.

Educational Outreach

To assist with outreach, we will maintain and update existing records based on the Arizona teacher directory used in the public GDAZ STEM Equity Dashboard. The dashboard is an extensive directory of STEM teachers in Arizona middle and high schools. The purpose of

this custom dashboard is to serve as both a recruitment and metric tracking tool for schools enrolled in the GDAZ educational program. Any changes in STEM teachers will be identified by independently collecting data for each school. The collected data will be manually updated in the teacher directory which is in Excel. Each school district has a separate sub-table and records all teacher contact information including first and last name, e-mail, subject taught, and phone number. After the data maintenance is complete, the STEM Equity Dashboard will be updated. The interactive dashboard provides quick query functions to improve ease of use which helps public users that do not necessarily have a strong GIS background. In addition to assisting in outreach, a modified version of the web app created for visitors of the Lower Salt River will be made. This app will include the same information and data points, but students will also be shown congratulatory messages or “fun facts” upon reaching sites and clicking a point feature. The purpose of this app is to encourage students to go explore the area with the app in hand.

Methodology Flow Chart

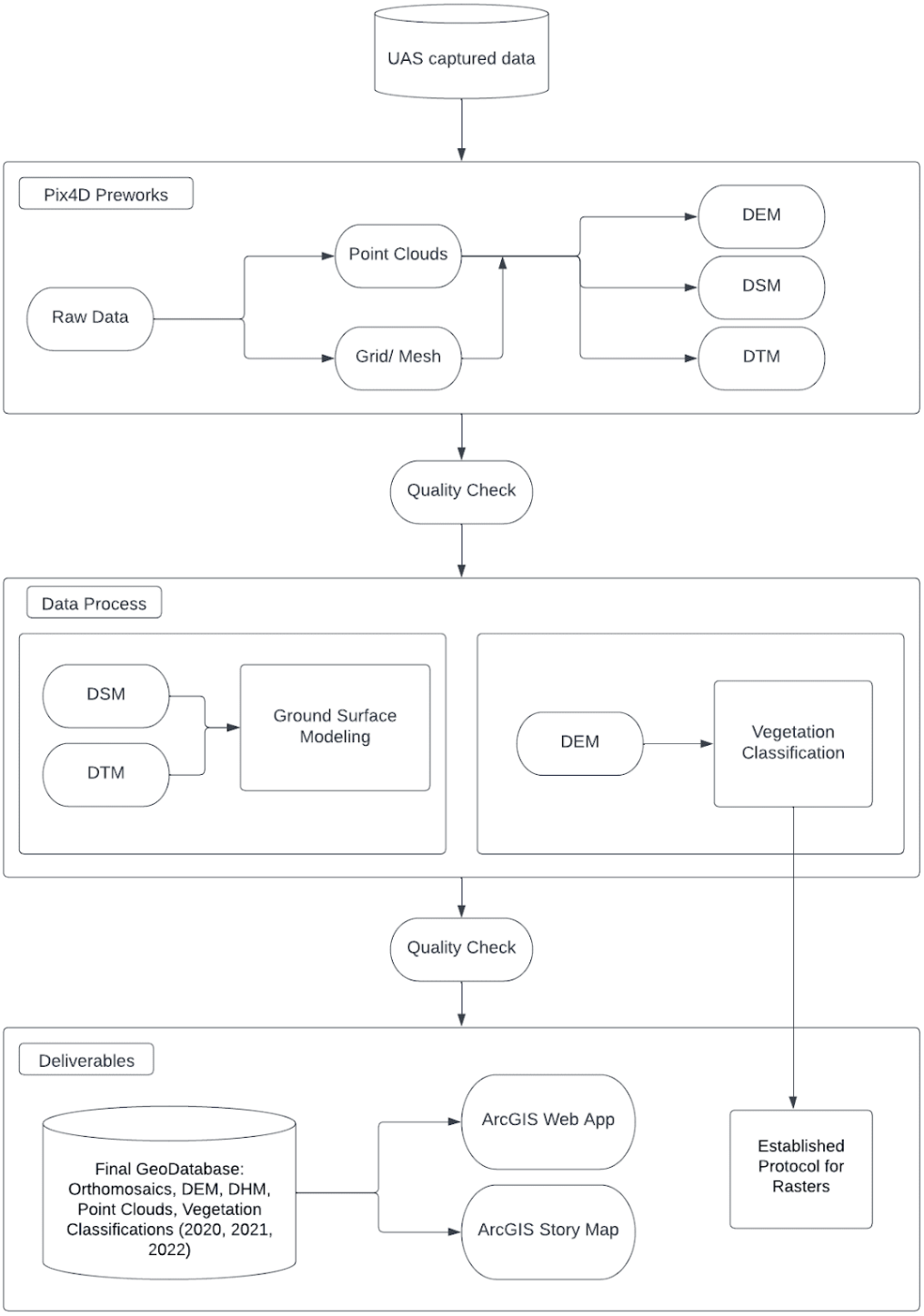

Table of Deliverables

Deliverable	**Description**
Final Geodatabase	Contains orthomosaics, DEMs, CHMs, DSMs, DTMs, point clouds, vegetation classifications, feature classes, and created metadata.
ArcPro Model	Final model for vegetation classification established in ArcPro model builder.
Story Map	Story map of the project site created to act as a remote guided tour for the public.
Web App	Semi-guided tour of the project site created for the public to use once on site.

References

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