

NORTHWEST NAZARENE UNIVERSITY

Mapping of Surface Fire in Forested Biomes from  
Hyperspatial Imagery using Machine Learning

THESIS

Submitted to the Department of Mathematics and Computer Science  
in partial fulfillment of the requirements  
for the degree of  
BACHELOR OF ARTS

Alexander T. Drinnon  
2019

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## Abstract

Mapping of Surface Fire in Forested Biomes from Hyperspatial Imagery using Machine Learning.

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Over the past decade, wildland fires have continued to increase in severity with wildfires burning an average of five to ten million acres in the United States a year. This elevated activity increases the costs of fighting them, with the 2017 season costing \$2.9 billion in wildland-fire suppression. For the past three years, NNU's Fire Monitoring and Assessment Platform (FireMAP) team has been using Small Unmanned Aircraft Systems (sUAS) to capture hyperspatial imagery to map post-fire effects. The purpose of this project was to add capabilities to the existing FireMAP analytic tools and refine and document the process used to gather hyperspatial imagery with sUAS. The analytic tools were improved by adding the ability to identify crown underburn, which is defined by an unburned crown being surrounded contiguously with burned surface vegetation. As tree canopy blocks the drones view from capturing the ground for classification, other methods need to be used to infer this information. The Denoise tool was used to detect pixels that are crown underburn and reclassify them as burned. This improvement allowed for more accurate classification of burned surface vegetation which is obstructed by unburned crown vegetation in forested environments.

## **Acknowledgments**

I want to thank Dr. Dale Hamilton for the opportunity to work on this project and Dr. Barry Myers for his continual feedback and willingness to help me succeed. I also want to thank the other students who have worked as part of the FireMAP team and their help with challenges I encountered as well as the other students that laid the ground work for this project. Last, but not least, I would like to thank my mother for helping edit my thesis. This research was supported through funding from NNU FireMAP.

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## Overview

This project included documenting and improving image acquisition procedures as well as expanding on current FireMAP tools to identify crown underburn. Over the past decade, wildland fires have continued to increase in severity with wildfires burning an average of five to ten million acres in the United States per year. This elevated activity increases the costs of fighting them, with the 2017 season costing \$2.9 billion in wildland-fire suppression.

(*SuppCosts.pdf*, n.d.) For the past three years, Northwest Nazarene University's Fire Monitoring and Assessment Platform (FireMAP) team has been using Small Unmanned Aircraft Systems (sUAS) to capture hyperspatial imagery to map post-fire effects.

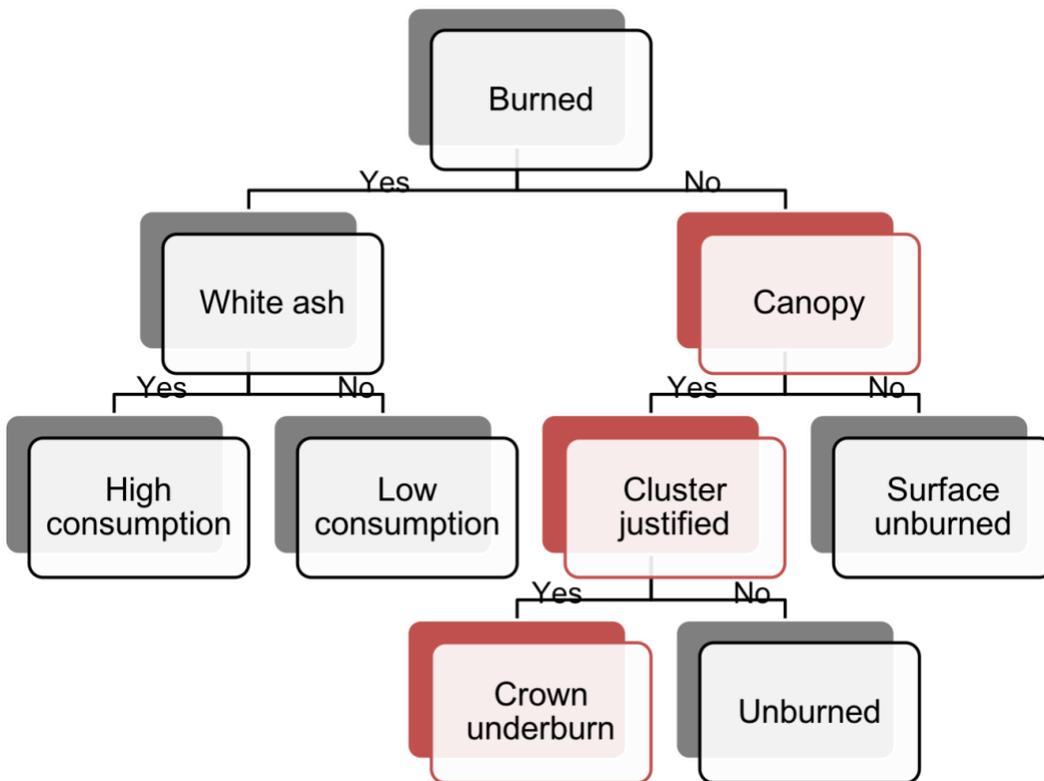
## Background

This summer research project was part of a larger ongoing effort at Northwest Nazarene University (NNU) called FireMAP, whose goal is to give fire managers a better way to survey post-fire effects. This is done using Small Unmanned Aircraft Systems (sUAS), commonly called drones, to obtain hyperspatial imagery of wildland fires. This imagery is then loaded into photogrammetry software, which will be explained in detail below. The output of the software can then be classified using the support vector machine (SVM) and other FireMAP tools.

The work done on FireMAP tools by previous research teams has focused on the burned parts of the imagery, identifying both burn extent and burn severity. Burn extent classifies burned versus unburned whereas burn severity classifies

high and low biomass consumption. White ash represents the hot parts of a fire with high biomass consumption, and black ash represents the parts of a fire with lower biomass consumption.

This project expanded on the previous classifications to include an additional one referred to as crown underburn. Figure 1 below shows the classification from prior research in gray and the added classification in red.



*Figure 1 – FireMAP Classification Hierarchy*

This project was in partnership with the Boise National Forest (BNF) where data acquisition trips were taken every Tuesday and Thursday during the summer of 2018. Drones were used to map mine tailings, rail grades, and other archaeology sites, such as an old Chinese mining camp.

## Terms

To have a clear understanding of this project some key terms must be defined.

- An orthomosaic is a 2D map. Each point contains X, Y, and color information. The orthomosaic has uniform scale and can be used for 2D measurements (distance, surface). It corrects the following problems of the input images: perspective of the camera and different scale based on the distance that each point of the object/ground has from the camera. (“What is an orthomosaic?,” n.d.)
- Small Unmanned Aircraft Systems (sUAS) are small unmanned aircraft (UA) and their associated elements, including communication links and the components that control the small UA, that are required for the safe and efficient operation of the small UA in the National Airspace System (NAS). (*AC\_107-2.pdf*, n.d.)
- Crown underburn is defined by an unburned crown being surrounded contiguously with burned surface vegetation.

## Image Acquisition and Processing

One aspect of this project was focused on refining and documenting the process of acquiring images and preparing data for processing. This encompasses several steps.

## Initial Setup

The file structure used to store data and related material for an image acquisition project is important in providing data integrity and ease of use. Four major parts to this file structure are: an Avenza folder, an imagery folder, a Pix4D folder, and a flight observations document. This file structure as well as the documents contained in it follow a strict naming scheme. The Avenza folder contains both the boundary shape file for the specific project and the two GeoPDFs created using this shape file. One

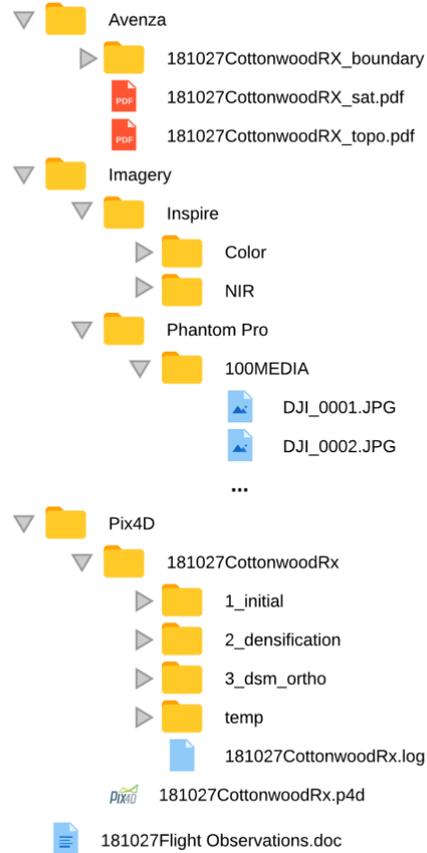


Figure 2 – Example File Structure

GeoPDF contains the shape file layered on top of the satellite basemap. The other GeoPDF contains the shape file layered on top of the topographical basemap. The imagery folder contains one folder per drone used to acquire imagery. Inside this folder are subfolders for each type of camera used or the raw jpeg files from the drone. Going through the media folder and removing any unwanted images that would not aid in processing is an essential step to avoid skewing final results. The last folder in this file structure is the Pix4D folder. It contains the entire output folder of Pix4D and the .p4d file, which will be covered in detail later. Figure 2

shows a sample file structure from the Cottonwood Fire after post processing has been completed.

## Preprocessing

After a project area has been identified and the initial file structure has been created, the next step to be taken for image acquisition is preprocessing. This includes coordinating with any outside entities, gathering supplies, creating and loading Avenza maps onto devices, and setting up Pix4Dcapture. Because this project was done in collaboration with the BNF, the project boundaries were defined by them. Communicating with the BNF and the team flying on exact flight times was necessary so everyone involved could arrive on time as travel distance was a factor. The supplies used on a regular basis can be seen in Table 1 below.

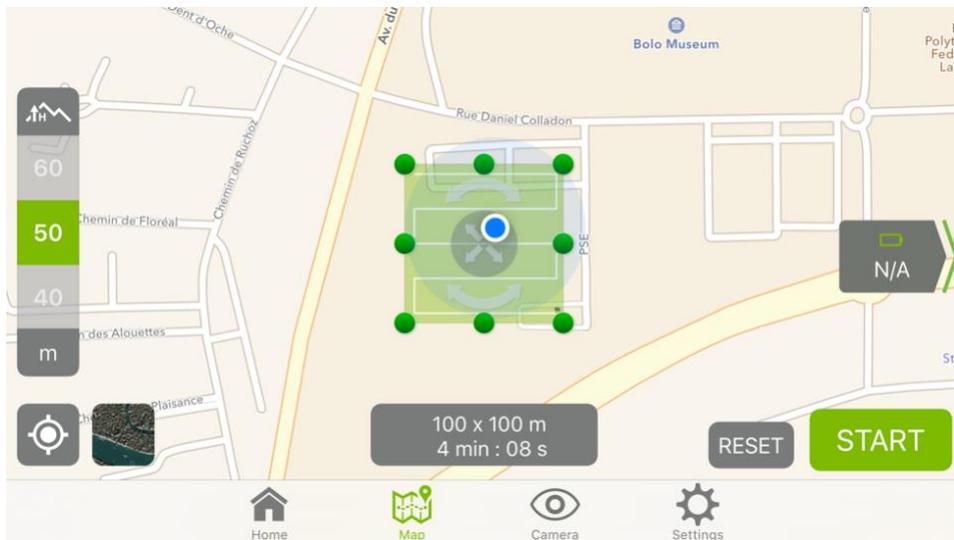
*Table 1 – Flight Supplies Checklist*

<b>For the Groups</b>	<b>For each Person</b>
Drones and their associated equipment	Jeans
Plexi-glass for drone take-off	Boots
Hard hats (6)	Hat
Safety vests (6)	Sun glasses
Radios (6)	Water bottle
First aid kit	Cell phone (w/ Avenza installed)
Sun glasses	
Leather gloves	
5-gallon jug	

Another important aspect of preprocessing was pre-downloading the basemaps in the Pix4Dcapture app as this allows the ability to see both the topographical and satellite maps while flying and not connected to the internet. This was often the case when working with the BNF as there was rarely cell coverage available in the area, thus making the ability to download maps on location impossible. If it was decided in advance that a grid mission would be used for flying, this also required set up in the Pix4Dcapture app. Figure 3 below shows the Pix4Dcapture app home screen. A sample grid mission setup can be seen below in Figure 4.



*Figure 3 – Pix4D Home screen*



*Figure 4 – Grid Mission Setup*

Once the determination is made as to whether a free flight mission or grid mission will be used, the next process in image acquisition is flying.

## **Flying**

Before describing this process, three more terms need to be defined. The pilot, having a FAA Part 107 Remote Pilot Certification, is the person flying the drone, holding the controller, moving the joysticks, and/or monitoring the progress of the preprogrammed flight. The coordinating visual observer (CVO) works with the pilot to communicate with the team. This person is often standing next to the pilot. The visual observers are the people spread among the project area helping the pilot and CVO track the drone.

Before takeoff and mapping can begin, several important steps must be completed. First, all radios should be turned on and a radio test done. This works best by having each person do a name check. For example, a team member named Alex would say, “Alex Check.” The CVO is responsible for making sure everybody’s radio check came through. Second, the team would do a quick

preflight briefing to become familiar with the topography of the flight plan and where to best position visual observers. In order to provide the visual observers with the best opportunity of seeing the drone, they should be positioned on high points of the landscape with low canopy cover. Third, the pilot and CVO should set up the drone at an optimal clearing for takeoff. As a side note, if flying with the near infrared (NIR) camera see Appendix B – below. Once the preflight check has been completed, the steps for flying the mission can be carried out. The most important aspect during image acquisition is communication—one can never communicate too much!

Once all team members are in their designated places, the following proceeds:

1. The CVO will radio for every team member's position.
2. The CVO will communicate the flight plan to all team members:
  - a. From where the drone is taking off
  - b. Which cardinal direction the flight will start and which visual observer (VO) will expect to see it first, second, third, and so on.
  - c. Which pattern the drone will fly (ex., north and south, working its way east to west)
3. The CVO will indicate when the drone is taking off as well as when the drone reaches the altitude at which imagery will be acquired.
  - a. When the drone reaches acquisition altitude, the pilot points the camera up (horizontal) and takes a “marker” image. This will make

it easier to identify the beginning of flight images that are at the acquisition altitude.

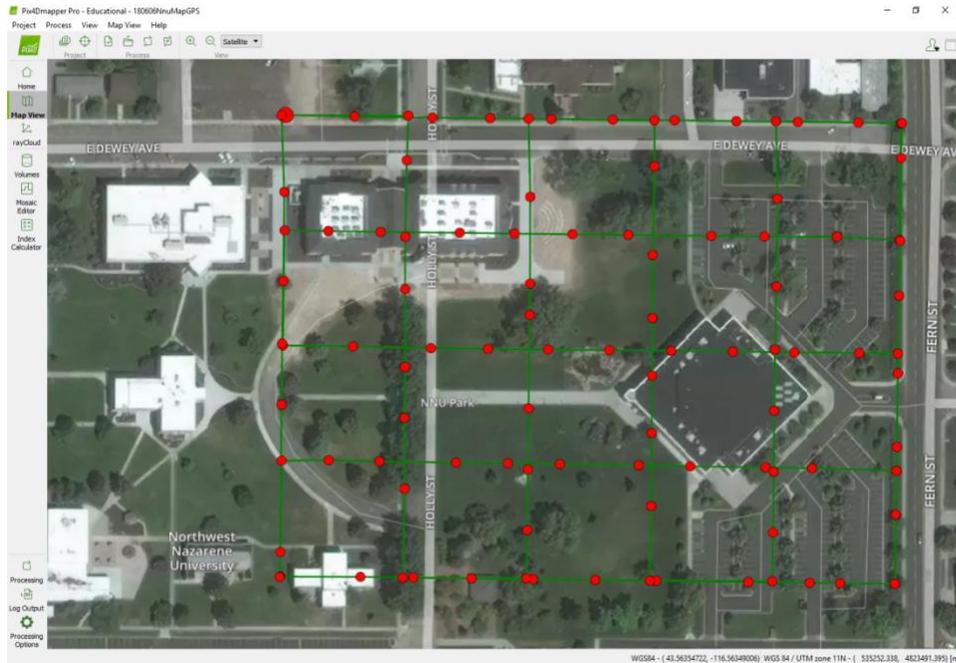
- b. Taking a marker image will also assist with separating sets of flight images for post processing.
4. As soon as a VO sees the drone, he/she will let the team know over radio. For example, "Dale has eyes on."
5. VOs should have visual contact with the drone at all times and will say over the radio every time the drone is in their view. If they are about to lose sight of the drone, they need to let the team know so the CVO can tell the pilot. As an example, "Dale lost eyes."
6. The CVO can ask that all VOs check in with observation status by saying, "Who has eyes on?"
7. The CVO will let the team know when the flight is about to finish and when the drone has landed.
8. When the drone has landed, the CVO will call the team back to a meeting spot unless another flight in the same area will be done.

Once all flights have been carried out for a given project, the imagery is downloaded and filed in the appropriate subfolder previously created and mentioned above.

## **Post Processing**

After all the imagery has been acquired, it must be loaded into the photogrammetry software called Pix4D to create an orthomosaic. For a detailed view of this process, see Appendix A –. A screen shot from this process can be

seen in Figure 5, which shows an example of a flight that has been flown. Each red dot represents an image taken. Because the images were taken with a drone that has GPS, each red dot also represents a place in 3D space around the world.



*Figure 5 – Pix4D Map View*

Processing time can vary depending on the number of photographs acquired by the drone. A small project with about 150 photos would take about an hour of processing time whereas a large project with over 1,000 photos could upwards of 24 hours. After processing is completed, the software outputs a georeferenced orthomosaic that looks similar to what is shown in Figure 6. The entire Pix4D output folder and the accompanying .p4d file are uploaded to the file structure in the appropriate folder. If both of these are not saved and additional processing is subsequently needed, the photogrammetry processing would have to be completely started from scratch. This step of saving all output data can alone save valuable time and frustration.



*Figure 6 – NNU Orthomosaic*

Using orthomosaics for classification is crucial as it gives a true top-down perspective on which machine learning algorithms can classify. If orthomosaics are not used for classification, then the results cannot be as easily related to the real world without error due to perspective.

## **Denoise Tool**

For this project, the SVM was used along with the denoise tool. Because the SVM is a supervised classifier, the computer has to be trained so it can understand what is being classified. The creation of training data is done with a program called the Training Data Selector built by a previous computer science graduate Greg Smith (2018). It allows parts of an image to be selected to train the algorithms.

For this project, the Deer Flat Fire was used for training. For this research effort, the Hoodoo, Cottonwood, and Mesa Fires were classified.

Initially, an approach based on color was taken to identify crown underburn solely using the SVM by trying to separate green pixels of the surface from green pixels of the canopy, which as seen in Figure 7 was difficult. Instead, the denoise tool was used because it works not based on pixel color but on pixel size. Because tree canopy blocks the drone's view from capturing the ground for classification, other methods were replied upon to infer information about crown underburn.

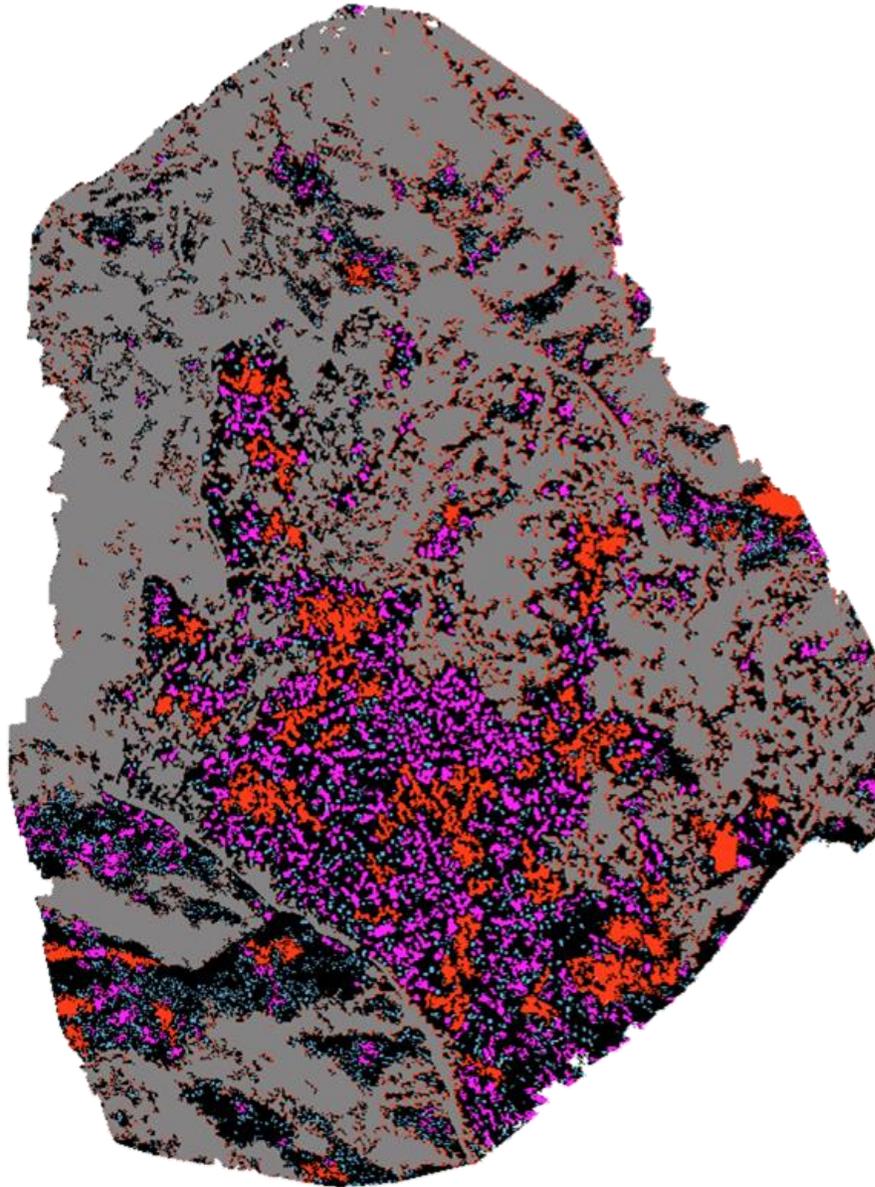


*Figure 7 – Green Canopy vs. Green Surface*

The denoise tool takes the output of the SVM as its input. It has the ability to adjust the parameters for the cluster size of pixels (representing crown underburn) being looked for. For this project, different cluster sizes were tested: 1,000 pixels, 10,000 pixels, 100,000 pixels, and 1,000,000 pixels.

Figure 8 below is the output of the denoise tool from the Cottonwood Fire. Each of the different colors represents a cluster size. Blue represents clusters of

1,000 pixels removed, purple is 10,000 pixels, and red is 100,000 pixels. Gray is unique because it represents what is left after clusters of 1,000,000 pixels are removed.

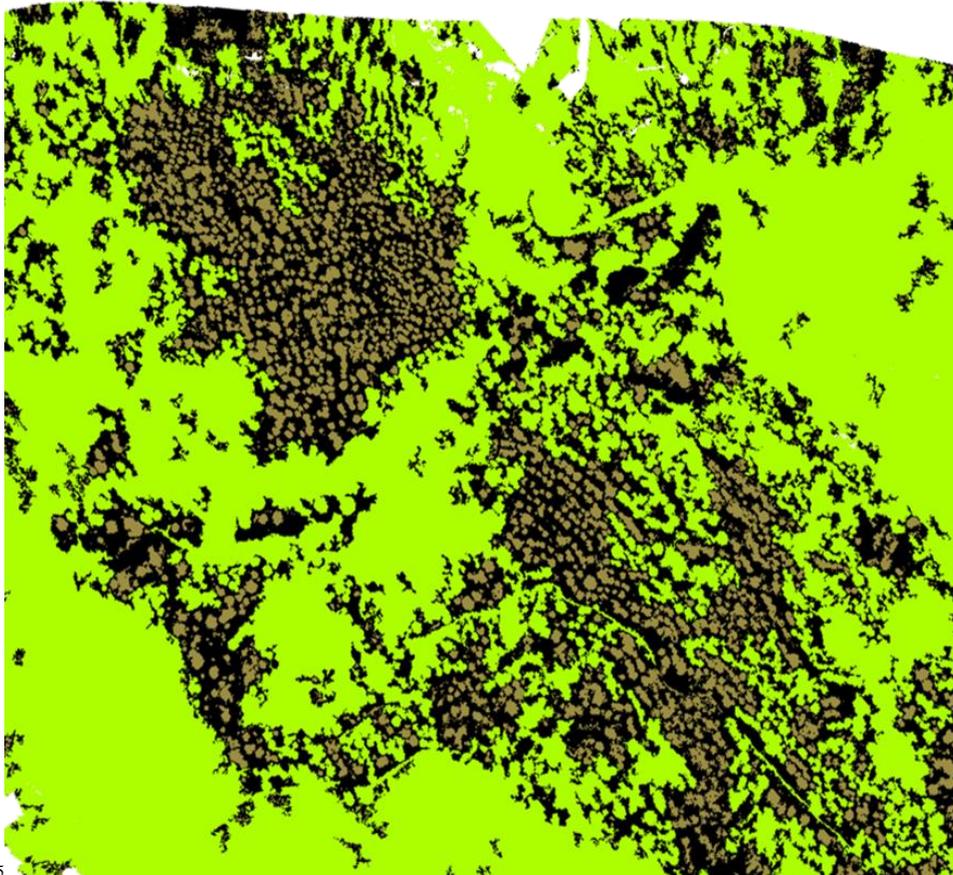


*Figure 8 – Cottonwood Denoise Cluster Size*

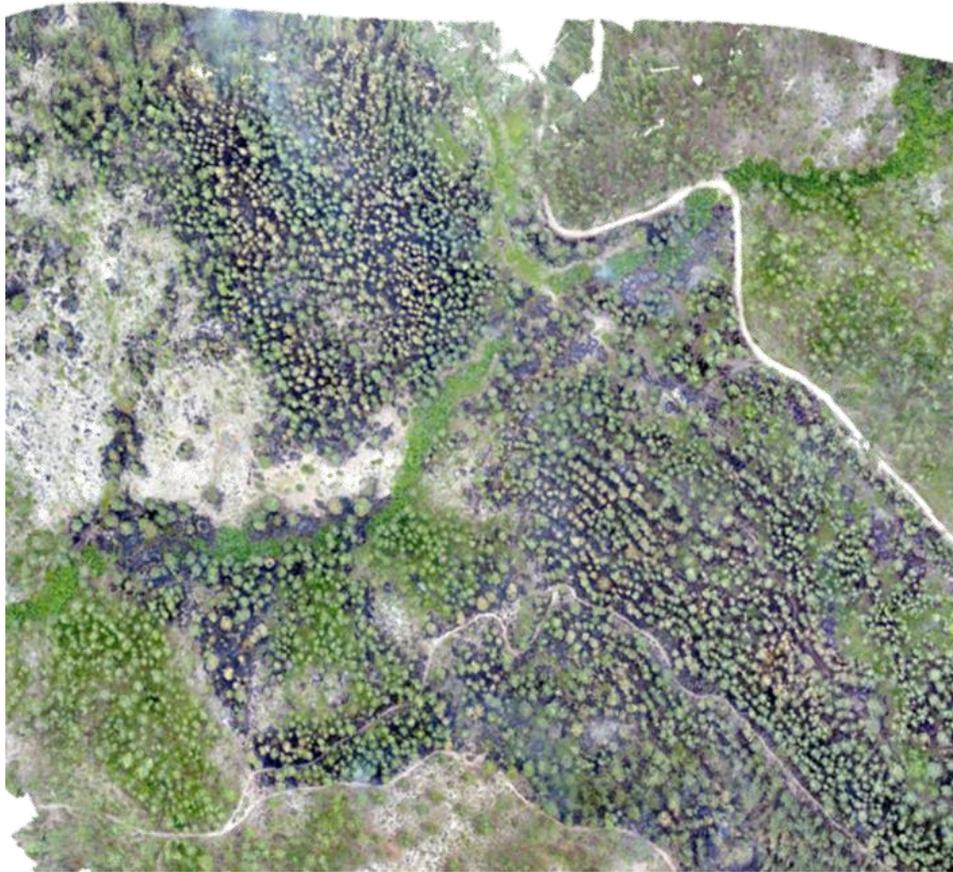
Each one of these clusters represents crown underburn. The denoise tool's capabilities to vary the parameter of cluster sizes provided the ability to test and determine what pixel size works best for most accurately identifying underburn.

## Results

Figure 9 below shows the results for the Hoodoo Fire with 100,000 pixels chosen as the cluster size, where black represents burned, gold represents crown underburn, and green represents unburned. When doing spot checks and comparisons with the orthomosaic, 100,000 pixels showed the best accuracy without overfitting and was thus the size chosen.



*Figure 9 – Crown Underburn Classification*



*Figure 10 – Hoodoo Creek Fire Orthomosaic*

## **Conclusion**

By having crown underburn as an added metric as seen in Figure 1 – FireMAP Classification Hierarchy, a more accurate determination of surface fires in forested environments can be made. Prior to adding the crown underburn category, contiguous vegetation was improperly being classified as unburned when it actually was burned.

Overall, I really enjoyed working on this research project during the summer both. I think my contribution in refining the procedures for acquiring imagery, applying machine learning algorithms, and using the denoise tool to help identify crown underburn will be of benefit to the FireMAP team effort and to fire

managers. I learned so much from this project and have a better understanding of how artificial intelligence and machine learning works. I also appreciated getting to use ArcGIS Pro as part of this project and think that working with drones for GIS mapping might play a role in my future employment.

## **Future Work**

The future work that would be part of this project would be expanding on the surface vegetation side and using NIR to see if it would help with distinguishing between surface and canopy vegetation easier. The issue of shadows being falsely represented as burned still needs to be resolved. In addition, other metrics, such as texture, fuzzy logic, or object-based detection, could potentially be added to more accurately and better classify crown underburn.

## References

*AC\_107-2.pdf*. (n.d.). Retrieved from

[https://www.faa.gov/documentLibrary/media/Advisory\\_Circular/AC\\_107-2.pdf](https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_107-2.pdf)

Smith, G. (2018). *Training Data Selector* (Unpublished Senior Thesis). Northwest Nazarene University, Nampa, ID, United States.

*SuppCosts.pdf*. (n.d.). Retrieved from

[https://www.nifc.gov/fireInfo/fireInfo\\_documents/SuppCosts.pdf](https://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf)

What is... (a densified point cloud? an orthomosaic? etc.) – Support. (n.d.).

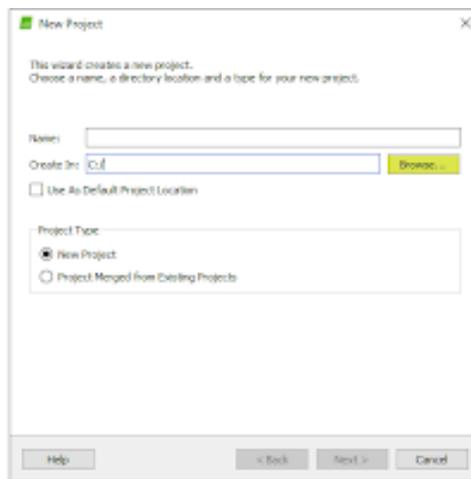
Retrieved May 10, 2019, from <https://support.pix4d.com/hc/en-us/articles/206455126-What-is-a-densified-point-cloud-an-orthomosaic-etc-#label5>

## Appendices

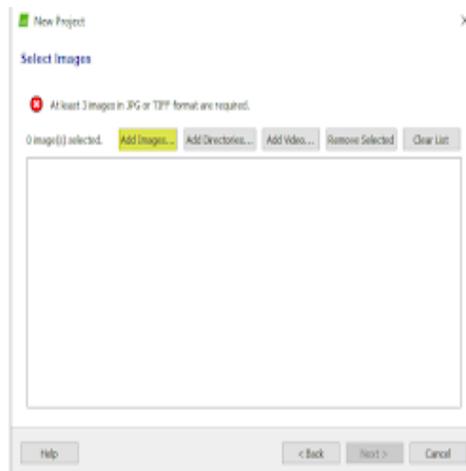
### Appendix A – Pix4D: Creating an Orthomosaic from sUAS Images

All Pix4D projects for summer research should be done on the C drive of AI Workstation under the research user.

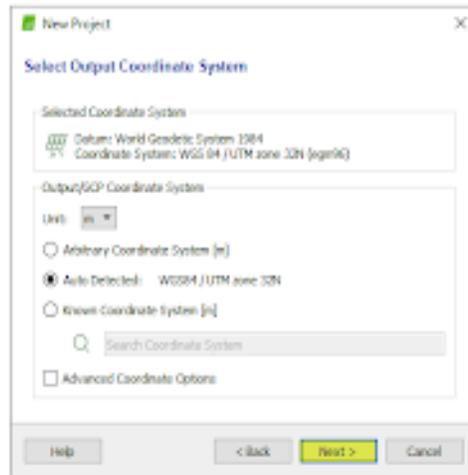
1. Before creating a new project, save all images for the project to the C Drive, under a Pix4D images folder.
2. Open the Pix4Dmapper desktop application
  - a. Click on new project, and rename and save under C:/Pix4Dprojects
    - i. Rename according to naming protocols naming protocols if part of summer research
    - ii. Click next



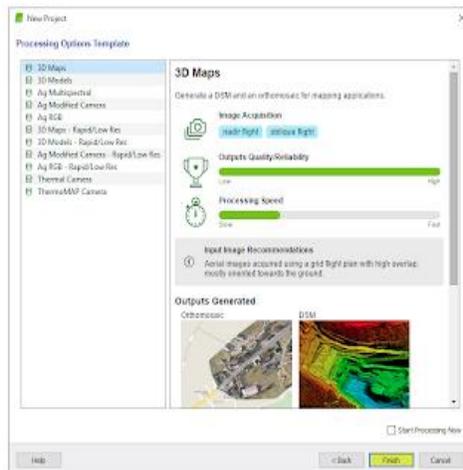
3. A Select Images screen will appear. Click on Add Images... Drag and drop or upload all images for the project.
  - a. Click next, and the screen will take a couple of minutes to upload the images.



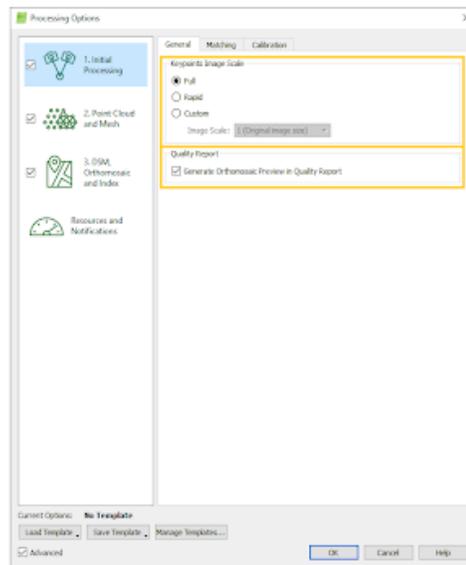
4. A Select Input Coordinate System screen will appear.
  - a. Do not change anything in the box, and click next
5. A Select Output Coordinate System screen will appear. Select the option for Known Coordinate System [m]
  - a. If for the Boise National Forest, search for and select NAD 83 UTM Zone 11.
  - b. If for own project, select the preferred coordinate system.
    - i. Click next



6. A Processing Options Template screen will appear.
  - a. Select **3d Maps** for an Orthomosaic, DSM, and 3d model output
  - b. Do not click the start processing now button in the lower right-hand corner if you want to customize or be more specific with the processing
    - i. All summer projects for the Boise National Forest need to have the processing options configured, so the start process now button should not be clicked.
  - c. Click finish



7. The project screen now appears. If already clicked Start Processing Now on the previous screen, then creating the project is done. If not, continue with these steps
  - a. In the top left corner, click Menu Process > Processing Options
    - i. > 1. Initial Processing, 2. Point Cloud and Mesh, 3. DSM, Orthomosaic and Index, Resources and Notifications should all be listed
      1. On the Processing images screen, click **Load Template** on the bottom left-hand side of the screen, and select **FireMAP Template**.
        - a. The FireMAP template was created on Hoth, Kashyyyk, and AI Workstation under the research user



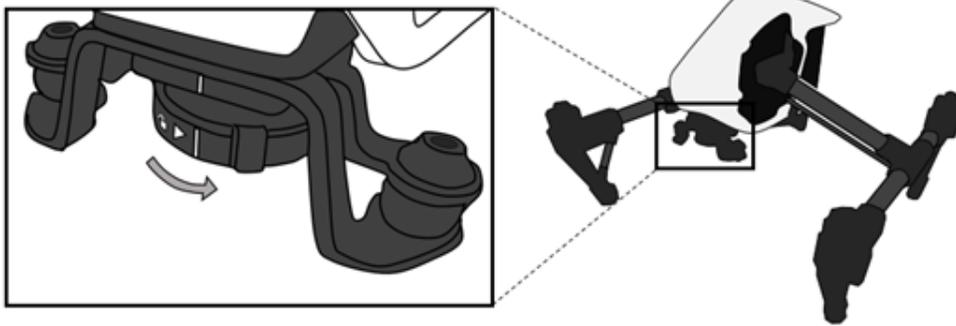
8. Once back to the main project screen, click **Start** processing button at the bottom left-hand corner of the screen.

## Appendix B – NIR Camera Installation for Inspire 1

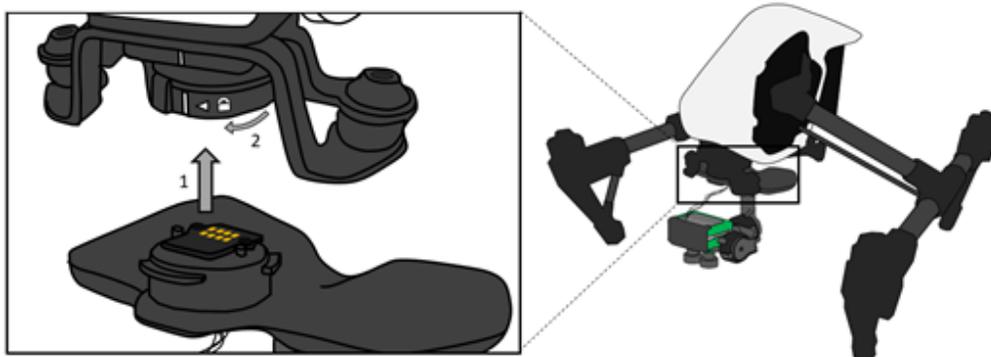
1. Turn on Inspire and Inspire remote controller (press the button on the battery once, and then press and hold for two seconds).
  - a. To exit travel mode use joystick and flick switch up and down 10 times.



- b. Turn off Inspire to install the NIR camera.
2. Locate the locking mount on the front of the Inspire 1 and position into the unlocked position as shown below.



3. Insert the Multispectral 4K Inspire Gimbal into the Inspire locking mount (1) and rotate the locking mount into the locked position (2).
  - a. Ensure proper engagement by confirming gimbal is not loose.



4. Place the Inspire on a stable surface and turn on with the standard method (press the button on the battery once, and then press and hold for two

seconds). Once powered, do not touch until the camera stabilizes to point downward.

- a. The camera contains two LED indicators, one for Power and one for Status (see below).



- b. The camera has the following states:

#### Initialization

**Operation:** The camera is initializing its components and performing startup functions.

**State Time:** Camera initialization can take up to 60 seconds.

**Transition:** The camera transitions to the idle state immediately after initialization of all camera components are completed.

**Status Indicator:** Off or flashing red.

#### Idle

**Operation:** The camera is waiting to start a session. Criteria for starting a session are based on configuration setting – see section Operation Modes.

**State Time:** The state occurs indefinitely until criteria are met for starting the session.

**Transition:** The camera transitions to the active state once a session is started. The transition from the idle to active state can take up to 20 seconds.

**Status Indicator:** Solid green.

#### Active

**Operation:** The camera is able to take pictures and log these pictures along with metadata to the SD card. This state cannot be entered if the SD card is missing or corrupt.

**State Time:** This state occurs indefinitely until criteria is met for closing the session.

**Transition:** Transition to the idle state occurs if the session is closed.

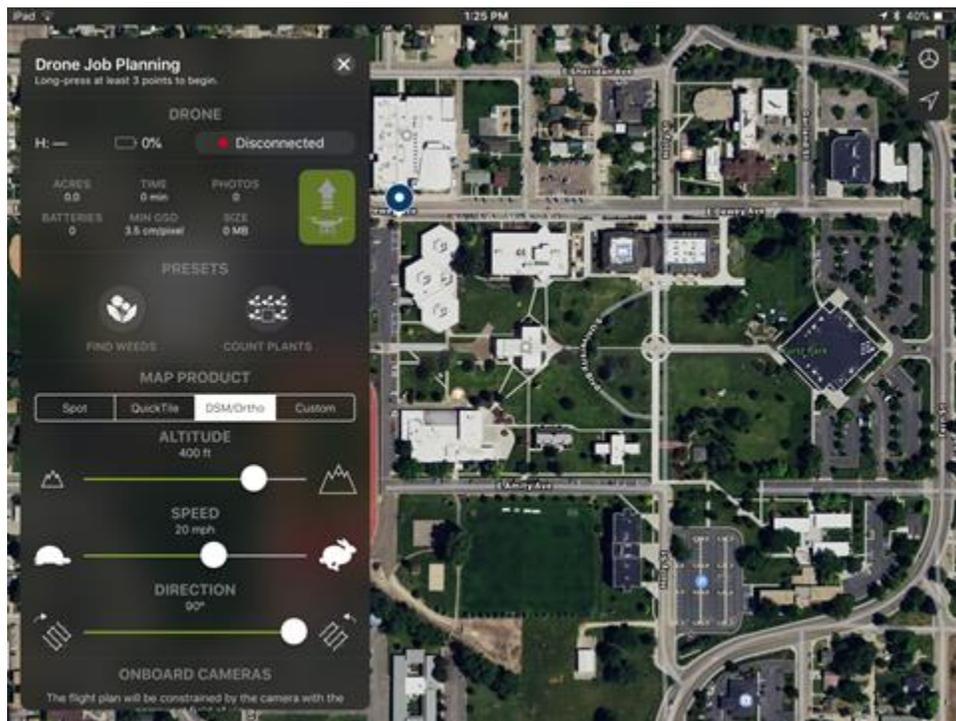
**Status Indicator:** Flashing green.

**IN ORDER FOR THE CAMERA TO WORK AND TAKE PICTURES THE SD card MUST BE IN FAT32 FORMAT.**

5. To fly the inspire with a preprogrammed mission use the FieldAgent app.
  - a. Select Mission area.



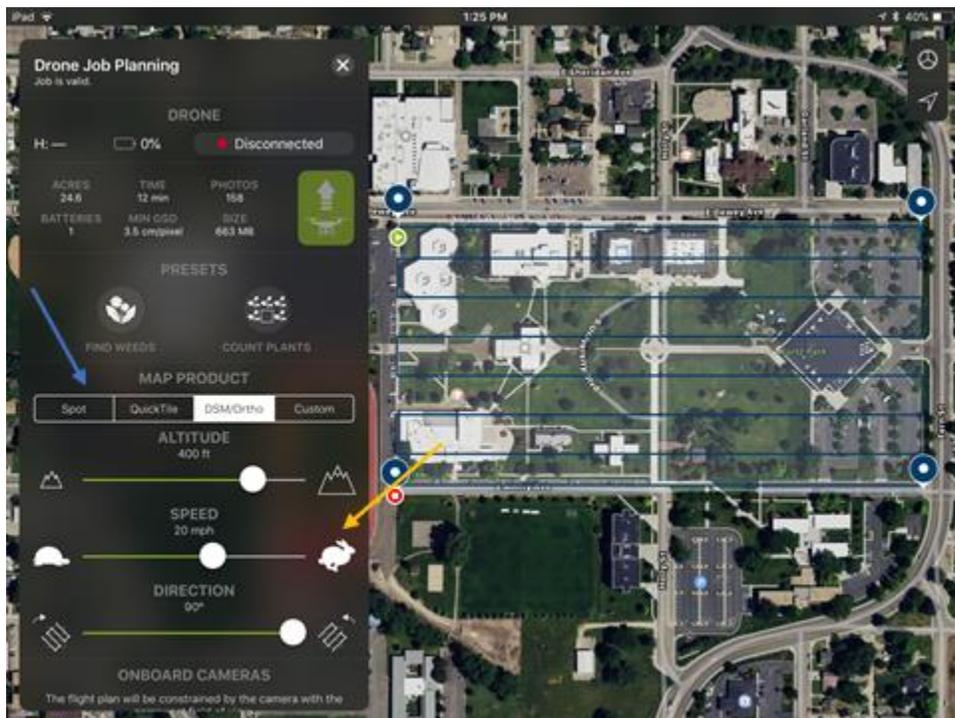
- b. Add points by long pressing.  
(To delete points, press and then press and hold)



c. Once the Shape is defined the mission is ready to fly.



d. The amount of overlap and distance between passes can be configured by selecting Spot, QuickTile, DSM/Ortho, or Custom (blue arrow). The Altitude, Speed, and Direction of passes can be configured using the sliders on the left. The default is 400 ft, 20 MPH, and 90 ° (yellow arrow).



- e. To start the mission, press the green launch button (orange arrow). (Make sure launch area is clear as Inspire will take off on its own)



- f. Inspire will then take off to set Altitude and then fly to start point. When the inspire completes the mission it will then return to home and land.
6. To fly the inspire in free flight mode one of the following apps can be used: DJI Go, Pix4D Capture, FieldAgent.
    - a. To fly with the DJI Go app launch the Inspire like regular keeping in mind there is no image feedback. The camera will begin taking pictures once above the altitude set in the Config.yml file.
    - b. To fly with the Pix4D Capture app launch the Inspire like regular keeping in mind there is no image feedback, and the map will not show tracks as no mission has been started. The camera will begin taking pictures once above the altitude set in the Config.yml file.
    - c. To fly with the FieldAgent app launch the Inspire like regular keeping in mind there is no image feedback, and the map will not show tracks as no mission has been started. The camera will begin taking pictures once above the altitude set in the Config.yml file.

See Double 4k Quickstart guide for more information.

<https://sentera.freshdesk.com/support/solutions/articles/19000054367-double-4k-quickstart-guide>

Camera installation instructions from:

<https://sentera.freshdesk.com/support/solutions/articles/19000058891-double-4k-for-inspire-1-gimbal-installation>

## Appendix C – Denoise Batch Files

Hoodoo

```
SET
img="T:\UserProfileData\adrinnon\Desktop\SeniorProject
\Hoodoo\Hoodoo_170601.tif"
SET
imgClip="T:\UserProfileData\adrinnon\Desktop\SeniorPro
ject\Hoodoo\Hoodoo_c.tif"
SET
outFldr="T:\UserProfileData\adrinnon\Desktop\SeniorPro
ject\Hoodoo\CanOut"
SET
imgCanSvm="T:\UserProfileData\adrinnon\Desktop\SeniorP
roject\Hoodoo\CanOut\hoodoo_svm_can_out_alex.tif"
SET svm="C:\FireMAP\Gitlab\burnclassifier-
svm\SvmBurnClassifier\x64\Release\SvmBurnClassifier.ex
e"
SET key="C:\FireMAP\SVM\SVM_Test\key.csv"

SET
importSpatRef="T:\UserProfileData\adrinnon\Desktop\Sen
iorProject\importSR3.py"

rem canopy classification

SET coordSel="C:\NNU\FireMAP\Portal\FireMAP Coordinate
Selector\Release\FireMAPCoordinateSelector.exe"

del %outFldr%\*.*" /Q
mkdir %outFldr%

rem SET pxCoordList="C:\Data\Hoodoo\Canopy\Hoodoo-
c_45_trainTraining.csv"

rem ***** Run SVM on just color *****
rem %svm% %img% %imgCanSvm% %key% -p -ti %imgClip% -tp
%pxCoordList% -linear
```

```

rem **** run SVM w/ burn ext as an input ****
set
dfImg="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat.jpg"
rem set
dfExtTrnGeomFile="C:\Data\DeerFlat\deerFlat_BSmall_train.csv"
rem %coordSel% %dfExtTrnGeomFile% 0 5 1

SET
dfExtPxCoordList="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat_BSmall_trainTraining.csv"
set
imgExtOut="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\HoodooS_Ext_alex.tif"

%svm% %img% %imgExtOut% %key% -p -ti %dfImg% -tp
%dfExtPxCoordList% -linear

set denoise="C:\FireMAP\Code\Denoise_4-23-18\Denoise_v1.4\x64\Release\Denoise_v1.4.exe"
%denoise% %imgExtOut% -pf 1 10000 1000

rem -p -> -pf will flip the mat.
rem denoise appears to flip both ext and cons by default, need to use -pf for both.
rem 2nd numeric cmd ln arg controls size of unburned that goes away.
rem needs to see what additional "unburned" is removed, and label it as burned (not hi/lo cons)

set
burnExt="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\burnExt.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\3 Islandless Burn Area.tif" %burnExt%

```

```

rem *** working with thinning here
%denoise% %imgExtOut% -pf 1 10000 1000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\burnExt_Thinned_3.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\3 Islandless Burn Area.tif" %burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 10000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\burnExt_Thinned_4.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\3 Islandless Burn Area.tif" %burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 100000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\burnExt_Thinned_5.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\3 Islandless Burn Area.tif" %burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 1000000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\burnExt_Thinned_6.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut\3 Islandless Burn Area.tif" %burnExtThin%

"%PROGRAMFILES%\ArcGIS\Pro\bin\Python\Scripts\propy"
%importSpatRef%
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\CanOut
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Hoodoo\Hoodoo_170601.tif

```

Cottonwood

```
SET
img="T:\UserProfileData\adrinnon\Desktop\SeniorProject
\Cottonwood\CottonwoodRx_transparent_mosaic_group1.tif
"
SET imgClip=""
SET
outFldr="T:\UserProfileData\adrinnon\Desktop\SeniorPro
ject\Cottonwood\CanOut"
SET
imgCanSvm="T:\UserProfileData\adrinnon\Desktop\SeniorP
roject\Cottonwood\CanOut\cottonwood_svm_can_out_alex.t
if"
SET svm="C:\FireMAP\Gitlab\burnclassifier-
svm\SvmBurnClassifier\x64\Release\SvmBurnClassifier.ex
e"
SET key="C:\FireMAP\SVM\SVM_Test\key.csv"

SET
importSpatRef="T:\UserProfileData\adrinnon\Desktop\Sen
iorProject\importSR3.py"

rem canopy classification

SET coordSel="C:\NNU\FireMAP\Portal\FireMAP Coordinate
Selector\Release\FireMAPCoordinateSelector.exe"

del %outFldr%\*.*" /Q
mkdir %outFldr%

rem SET pxCoordList="C:\Data\Hoodoo\Canopy\Hoodoo-
c_45_trainTraining.csv"

rem ***** Run SVM on just color *****
rem %svm% %img% %imgCanSvm% %key% -p -ti %imgClip% -tp
%pxCoordList% -linear
```

```

rem **** run SVM w/ burn ext as an input ****
set
dfImg="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat.jpg"
rem set
dfExtTrnGeomFile="C:\Data\DeerFlat\deerFlat_BSmall_train.csv"
rem %coordSel% %dfExtTrnGeomFile% 0 5 1

SET
dfExtPxCoordList="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat_BSmall_trainTraining.csv"
set
imgExtOut="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\CottonwoodS_Ext_alex.tif"

%svm% %img% %imgExtOut% %key% -p -ti %dfImg% -tp
%dfExtPxCoordList% -linear

set denoise="C:\FireMAP\Code\Denoise_4-23-18\Denoise_v1.4\x64\Release\Denoise_v1.4.exe"
%denoise% %imgExtOut% -pf 1 10000 1000

rem -p -> -pf will flip the mat.
rem denoise appears to flip both ext and cons by default, need to use -pf for both.
rem 2nd numeric cmd ln arg controls size of unburned that goes away.
rem needs to see what additional "unburned" is removed, and label it as burned (not hi/lo cons)

set
burnExt="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\burnExt.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\3 Islandless Burn Area.tif" %burnExt%

rem *** working with thinning here
%denoise% %imgExtOut% -pf 1 10000 1000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\burnExt_Thinned_3.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cot

```

```

tonwood\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 10000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\burnExt_Thinned_4.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 100000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\burnExt_Thinned_5.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 1000000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\burnExt_Thinned_6.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

"%PROGRAMFILES%\ArcGIS\Pro\bin\Python\Scripts\propy"
%importSpatRef%
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CanOut
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Cottonwood\CottonwoodRx_transparent_mosaic_group1.tif

```

Mesa 0908

```
SET
img="T:\UserProfileData\adrinnon\Desktop\SeniorProject
\Mesa0908\MesaFireOrtho0908.tif"
SET imgClip=""
SET
outFldr="T:\UserProfileData\adrinnon\Desktop\SeniorPro
ject\Mesa0908\CanOut"
SET
imgCanSvm="T:\UserProfileData\adrinnon\Desktop\SeniorP
roject\Mesa0908\CanOut\Mesa0908_svm_can_out_alex.tif"
SET svm="C:\FireMAP\Gitlab\burnclassifier-
svm\SvmBurnClassifier\x64\Release\SvmBurnClassifier.ex
e"
SET key="C:\FireMAP\SVM\SVM_Test\key.csv"

SET
importSpatRef="T:\UserProfileData\adrinnon\Desktop\Sen
iorProject\importSR3.py"

rem canopy classification

SET coordSel="C:\NNU\FireMAP\Portal\FireMAP Coordinate
Selector\Release\FireMAPCoordinateSelector.exe"

del %outFldr%\*.*" /Qcmd
mkdir %outFldr%

rem SET pxCoordList="C:\Data\Hoodoo\Canopy\Hoodoo-
c_45_trainTraining.csv"

rem ***** Run SVM on just color *****
rem %svm% %img% %imgCanSvm% %key% -p -ti %imgClip% -tp
%pxCoordList% -linear
```

```

rem **** run SVM w/ burn ext as an input ****
set
dfImg="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat.jpg"
rem set
dfExtTrnGeomFile="C:\Data\DeerFlat\deerFlat_BSmall_train.csv"
rem %coordSel% %dfExtTrnGeomFile% 0 5 1

SET
dfExtPxCoordList="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat_BSmall_trainTraining.csv"
set
imgExtOut="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\Mesa0908S_Ext_alex.tif"

%svm% %img% %imgExtOut% %key% -p -ti %dfImg% -tp
%dfExtPxCoordList% -linear

set denoise="C:\FireMAP\Code\Denoise_4-23-18\Denoise_v1.4\x64\Release\Denoise_v1.4.exe"
%denoise% %imgExtOut% -pf 1 10000 1000

rem -p -> -pf will flip the mat.
rem denoise appears to flip both ext and cons by default, need to use -pf for both.
rem 2nd numeric cmd ln arg controls size of unburned that goes away.
rem needs to see what additional "unburned" is removed, and label it as burned (not hi/lo cons)

set
burnExt="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\burnExt.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\3 Islandless Burn Area.tif" %burnExt%

```

```

rem *** working with thinning here
%denoise% %imgExtOut% -pf 1 10000 1000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\burnExt_Thinned_3.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 10000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\burnExt_Thinned_4.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 100000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\burnExt_Thinned_5.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 1000000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\burnExt_Thinned_6.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

"%PROGRAMFILES%\ArcGIS\Pro\bin\Python\Scripts\propy"
%importSpatRef%
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\CanOut
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa0908\180908MesaFireOrtho.tif

```

Mesa 1117

```
SET
img="T:\UserProfileData\adrinnon\Desktop\SeniorProject
\Mesa1117\MesaFireOrtho1117.tif"
SET imgClip=""
SET
outFldr="T:\UserProfileData\adrinnon\Desktop\SeniorPro
ject\Mesa1117\CanOut"
SET
imgCanSvm="T:\UserProfileData\adrinnon\Desktop\SeniorP
roject\Mesa1117\CanOut\Mesa1117_svm_can_out_alex.tif"
SET svm="C:\FireMAP\Gitlab\burnclassifier-
svm\SvmBurnClassifier\x64\Release\SvmBurnClassifier.ex
e"
SET key="C:\FireMAP\SVM\SVM_Test\key.csv"

set
importSpatRef="T:\UserProfileData\adrinnon\Desktop\Sen
iorProject\importSR3.py"

rem canopy classification

SET coordSel="C:\NNU\FireMAP\Portal\FireMAP Coordinate
Selector\Release\FireMAPCoordinateSelector.exe"

del %outFldr%\*.*" /Q
mkdir %outFldr%

rem SET pxCoordList="C:\Data\Hoodoo\Canopy\Hoodoo-
c_45_trainTraining.csv"

rem ***** Run SVM on just color *****
rem %svm% %img% %imgCanSvm% %key% -p -ti %imgClip% -tp
%pxCoordList% -linear
```

```

rem **** run SVM w/ burn ext as an input ****
set
dfImg="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat.jpg"
rem set
dfExtTrnGeomFile="C:\Data\DeerFlat\deerFlat_BSmall_train.csv"
rem %coordSel% %dfExtTrnGeomFile% 0 5 1

SET
dfExtPxCoordList="T:\UserProfileData\adrinnon\Desktop\SeniorProject\DeerFlat\deerFlat_BSmall_trainTraining.csv"
set
imgExtOut="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\Mesa1117S_Ext_alex.tif"

%svm% %img% %imgExtOut% %key% -p -ti %dfImg% -tp
%dfExtPxCoordList% -linear

set denoise="C:\FireMAP\Code\Denoise_4-23-18\Denoise_v1.4\x64\Release\Denoise_v1.4.exe"
%denoise% %imgExtOut% -pf 1 10000 1000

rem -p -> -pf will flip the mat.
rem denoise appears to flip both ext and cons by default, need to use -pf for both.
rem 2nd numeric cmd ln arg controls size of unburned that goes away.
rem needs to see what additional "unburned" is removed, and label it as burned (not hi/lo cons)

set
burnExt="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\burnExt.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\3 Islandless Burn Area.tif" %burnExt%

```

```

rem *** working with thinning here
%denoise% %imgExtOut% -pf 1 10000 1000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\burnExt_Thinned_3.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

%denoise% %imgExtOut% -pf 1 10000 10000
set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\burnExt_Thinned_4.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%
%denoise% %imgExtOut% -pf 1 10000 100000

set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\burnExt_Thinned_5.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%
%denoise% %imgExtOut% -pf 1 10000 1000000

set
burnExtThin="T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\burnExt_Thinned_6.tif"
copy
"T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut\3 Islandless Burn Area.tif"
%burnExtThin%

"%PROGRAMFILES%\ArcGIS\Pro\bin\Python\Scripts\propy"
%importSpatRef%
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\CanOut
T:\UserProfileData\adrinnon\Desktop\SeniorProject\Mesa1117\181117MesaFireOrtho.tif

```