Comparison of Hyperspectral Gray Pine Classification to Lidar Derived Elevation and Slope

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Abstract

The gray pine (GP) tree has been identified as a high fire risk tree in California. This project attempts to contribute to a greater understanding of common terrain types associated with GP. In particular, remote sensing tools are implemented in an effort to compare GP counts to changes in elevation and slope. The study area is limited to a transect line which starts east of Merced and crosses the Sierra foothills toward Hetch Hetchy reservoir. 2017 high resolution Lidar data, 0.5m 111-band VNIR hyperspectral flightlines, and a field collected tree species inventory are for the study. From the lidar dataset, a highest hit raster, bare earth raster, and intensities are used. Using a Digital Elevation Model (DEM), a slope raster is created. The intensities are used as a ground reference to pick tie points, which are used to project the hyperspectral flightlines onto the DEM. Masks created from a feature height raster above 3m and an NDVI raster above 0.4 are combined and used to eliminate non-tree pixels from the scene. The tree species inventory is used to train and validate a Support Vector Machine (SVM) classification. Gray Pine results are isolated from the classification. A buffered and segmented polygon shapefile is used to track changes in gray pine pixel count, average elevation, and average slope across the study area. Comparing gray pine count to changes in elevation, little correlation between the two is observed. Some correlation is observed between areas of high slope and gray pine count.

Keywords: Gray Pine, Species Classification, Lidar, Hyperspectral, Elevation, Slope.

Gray Pine and its Terrain

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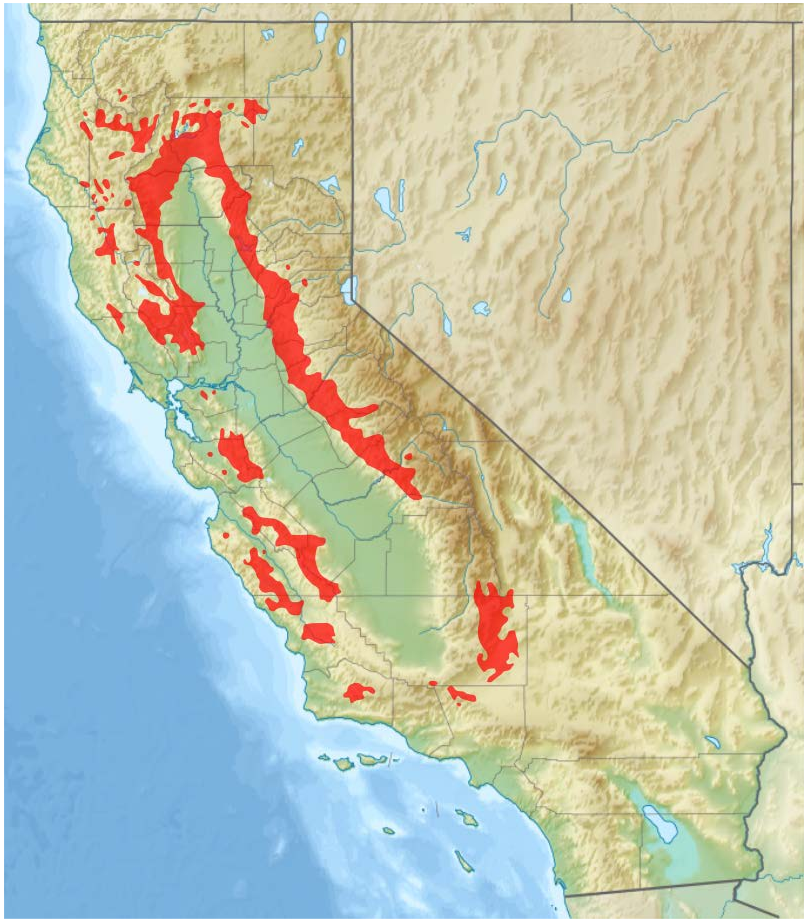
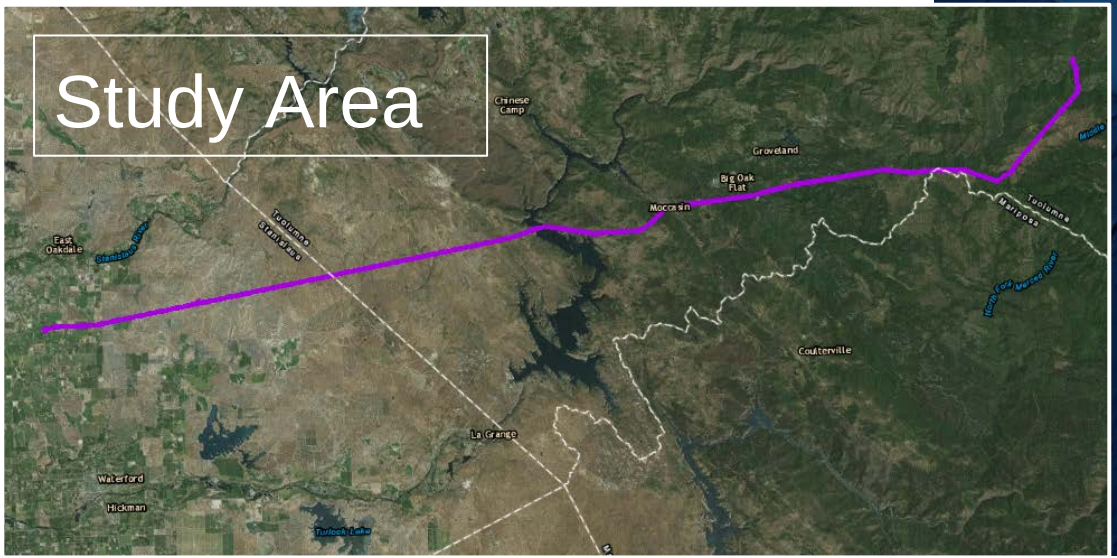
Why Gray Pine (Pinus sabiniana)?

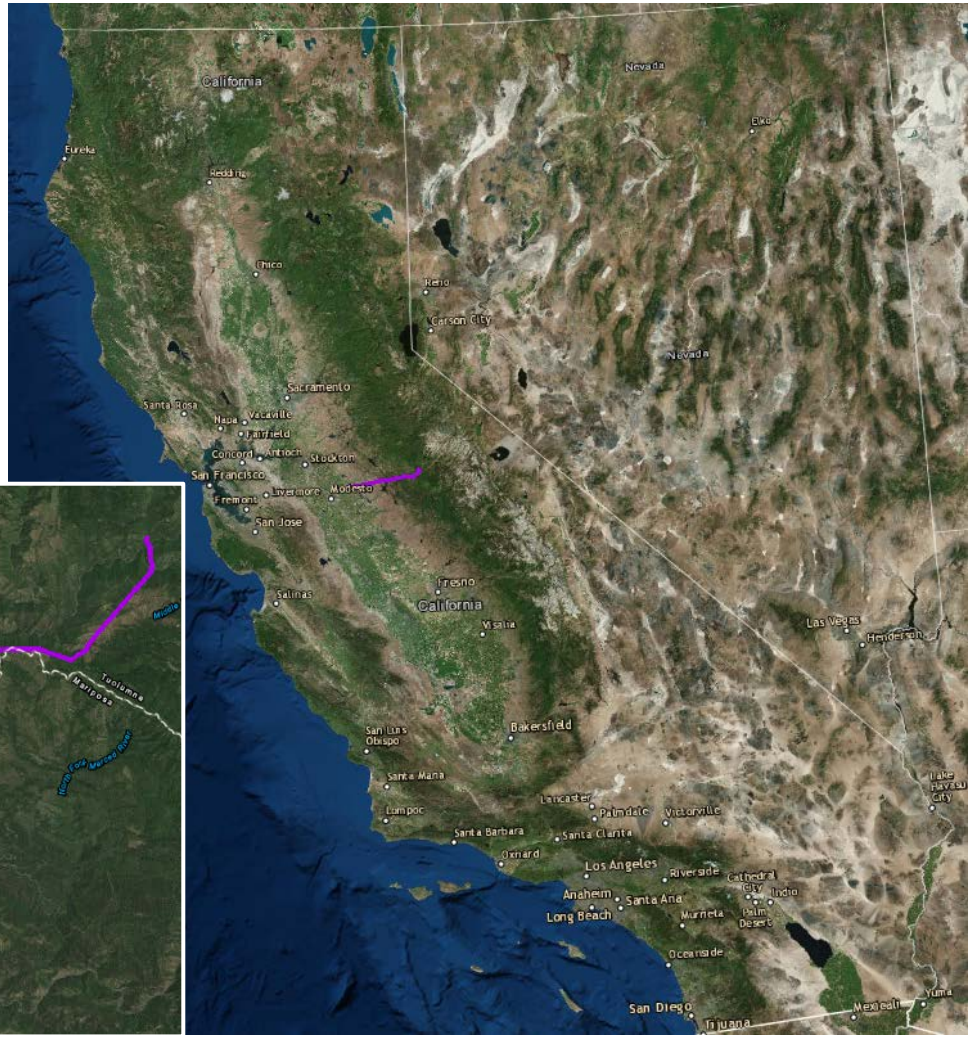
- Distributed throughout CA foothills.
- Tree crown visible in aerial imagery.
- Associated with starting wildfires.
    - 2015 Butte Fire and others large fires



What terrain (Elevation and Slope) do Gray Pines commonly grow in?

Hyperspectral Imagery is used to classify tree species distributions. Lidar Data is used to compare a derived grey pine distribution map to related terrain.



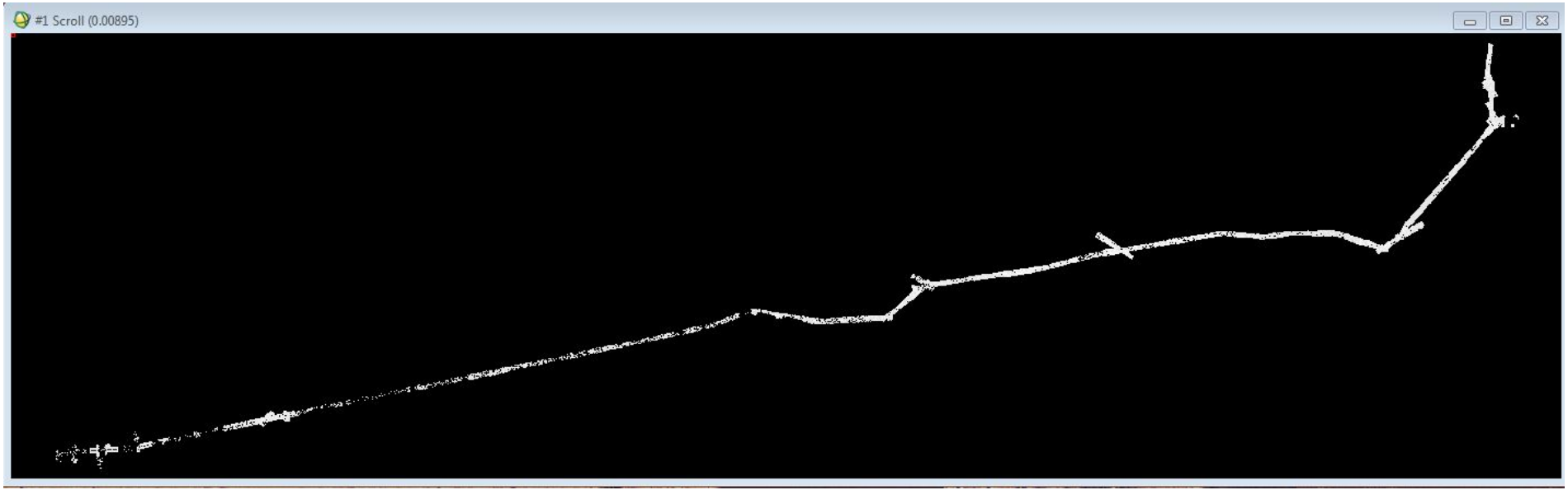


Project Data

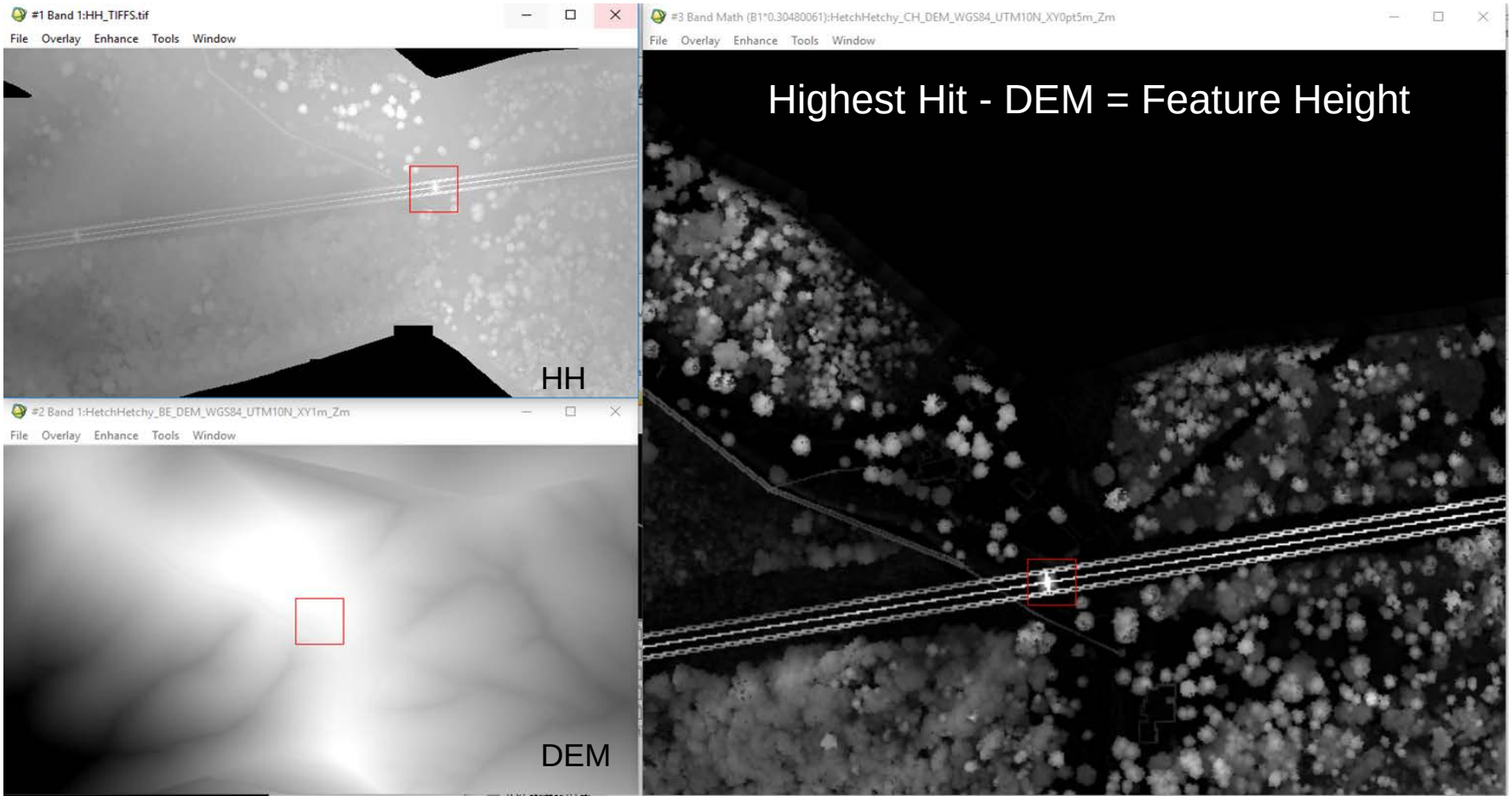
- Hyperspectral Imagery
  - Headwall Photonics VNIR System mounted on Fixed Wing Aircraft
  - Imagery Collected Sept. 6 & 7 2017. Season: Leaf On
  - 22 flightlines collected
  - 111 Spectral Bands from 400 to 1100nm.
  - 0.5 m Spatial Resolution
- LiDAR Data
  - Leica ALS80 LiDAR system, mounted on Fixed Wing Aircraft
  - Data Collected Aug. 30 2017
  - 1.0 MHz Pulse Rate
- Species Field Collection
  - Tablet and Google Earth used to collect field data
  - 605 individual trees identified
  - 29 unique tree species identified

Methods. Lidar, 1

- Data calibrated and turned into spatially defined .LAS files.
- Lidar Intensities were output
- .LAS files used to export 0.5m Zm Bare Earth and Highest Hit Mosaic Rasters
    - Used Global Mapper software to export the mosaics

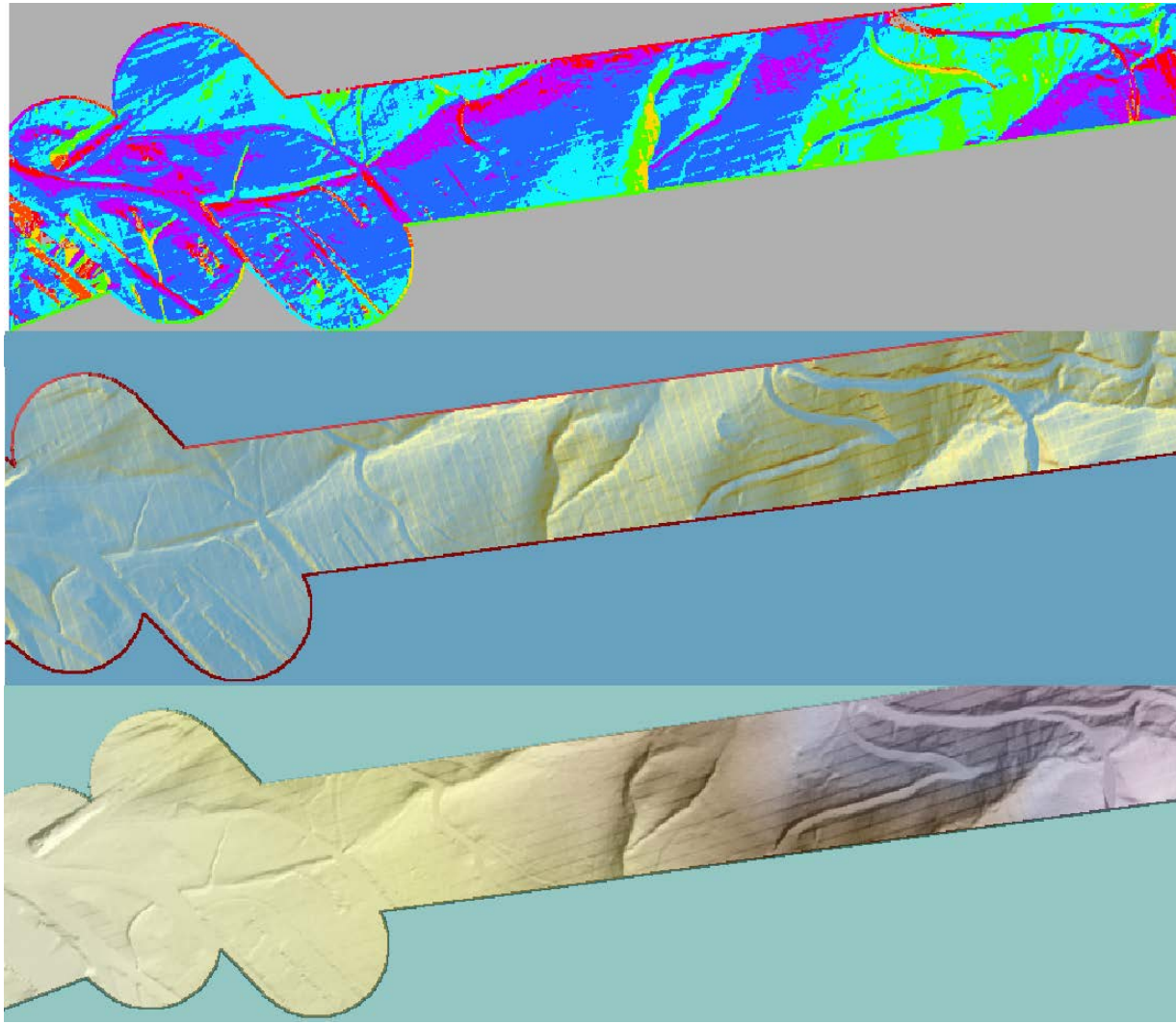


Methods. Lidar, 2



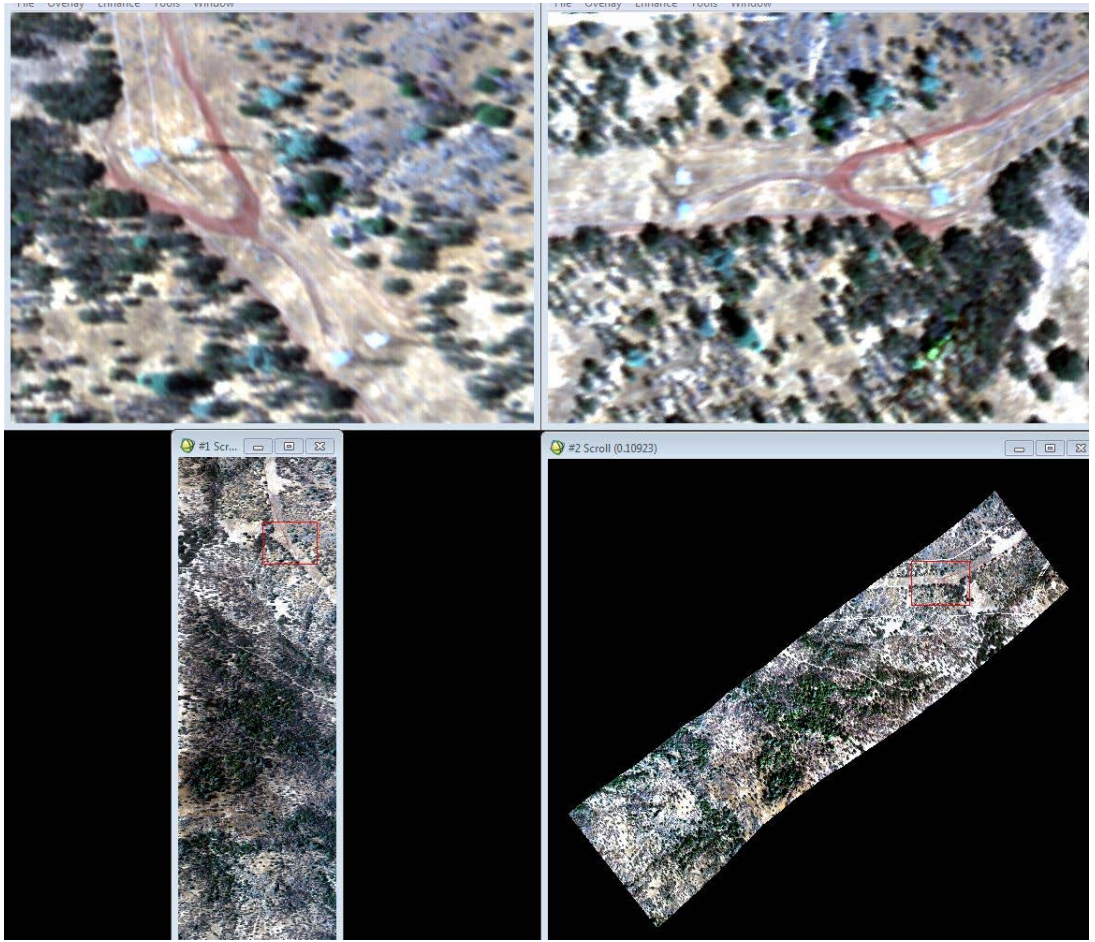
Methods. Lidar, 3

- DEM Raster used to create
  - Used ArcGIS
    - Aspect Raster
    - Slope Raster
    - Elevation Information



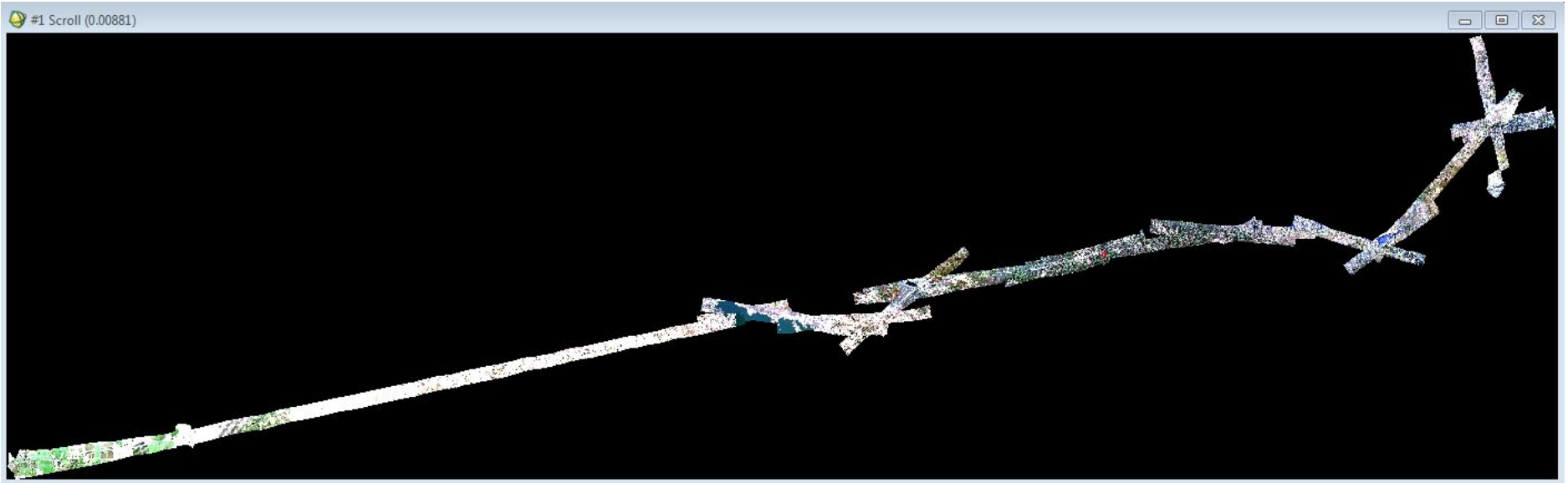
Methods. Hyperspec, 1

- Image Conversion.
  - Raw to Radiance
  - Radiance to Reflectance
    - Atmospherically Corrected
    - Used ATOCR4 ATM model
- Tie Points were picked using Lidar Intensities and ground reference.
  - Used ArcGIS
- Flightlines projected to DEM from tie points.
  - Used Parge projection software



Method. Hyerspec, 2

Hyperspectral Imagery flightlines were mosaicked to create a VNIR Mosaic Raster of the project area.



Tree Species Classification. - Training

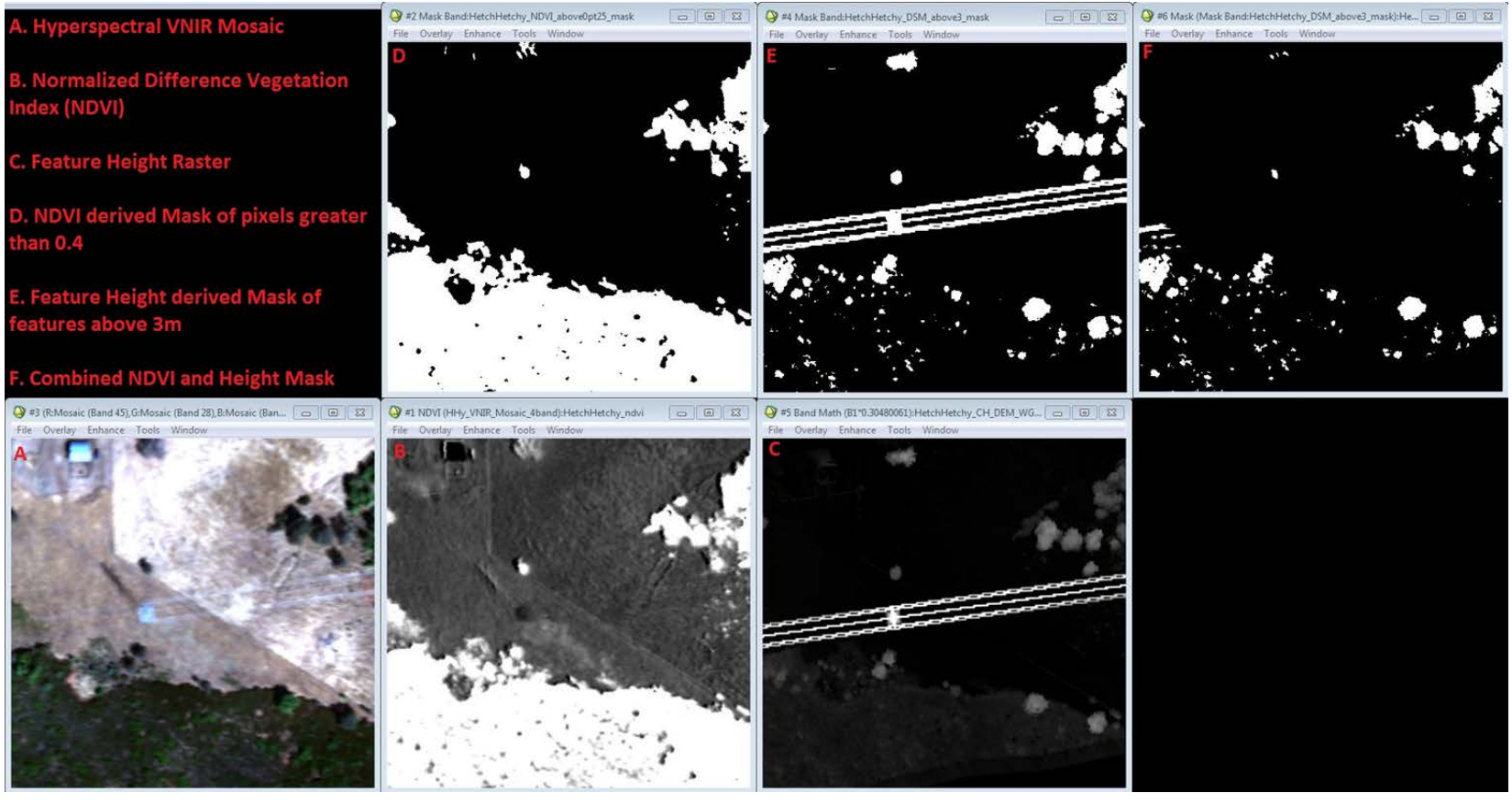
- Supervised Classification - Support Vector Machine
  - Field tree data used as Classification training and validation.
  - VNIR hypercube used as input imagery.
  - Mask used to eliminate non-tree related pixels.
    - Combined NDVI and Feature Height masks combined.
  - Species included
    - Almond, Incense Cedar, Black Oak, Blue Oak, Live Oak, Gray Pine, Ponderosa Pine, Sugar Pine, and Other Class

HHy_TV_Polygons_join_export

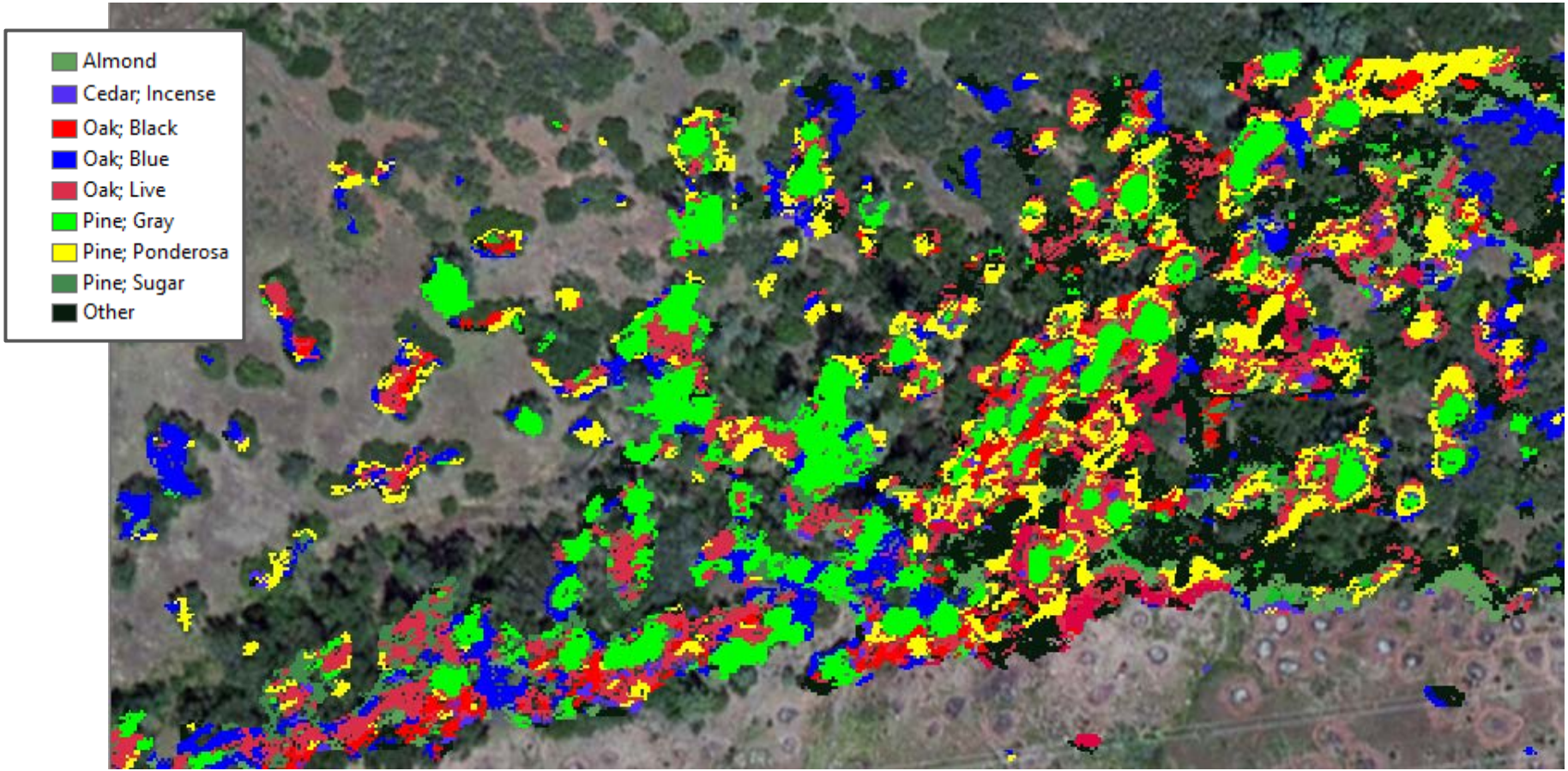
FID	Shape	Id	Name
210	Polygon ZM	210	Gray Pine
211	Polygon ZM	211	Blue Oak
212	Polygon ZM	212	Live Oak
213	Polygon ZM	213	Live Oak
214	Polygon ZM	214	Live Oak
215	Polygon ZM	215	Gray Pine
216	Polygon ZM	216	Gray Pine
217	Polygon ZM	217	Live Oak
218	Polygon ZM	218	Live Oak
219	Polygon ZM	219	London Planetree
220	Polygon ZM	220	London Planetree
221	Polygon ZM	221	Live Oak
222	Polygon ZM	222	Cypress
223	Polygon ZM	223	Redwood
224	Polygon ZM	224	Eucalyptus
225	Polygon ZM	225	Gray Pine
226	Polygon ZM	226	London Planetree
227	Polygon ZM	227	Cypress
228	Polygon ZM	228	Incense Cedar
229	Polygon ZM	229	Blue Oak
230	Polygon ZM	230	Blue Oak
231	Polygon ZM	231	Blue Oak
232	Polygon ZM	232	Incense Cedar

Tree Species Classification - Mask Creation

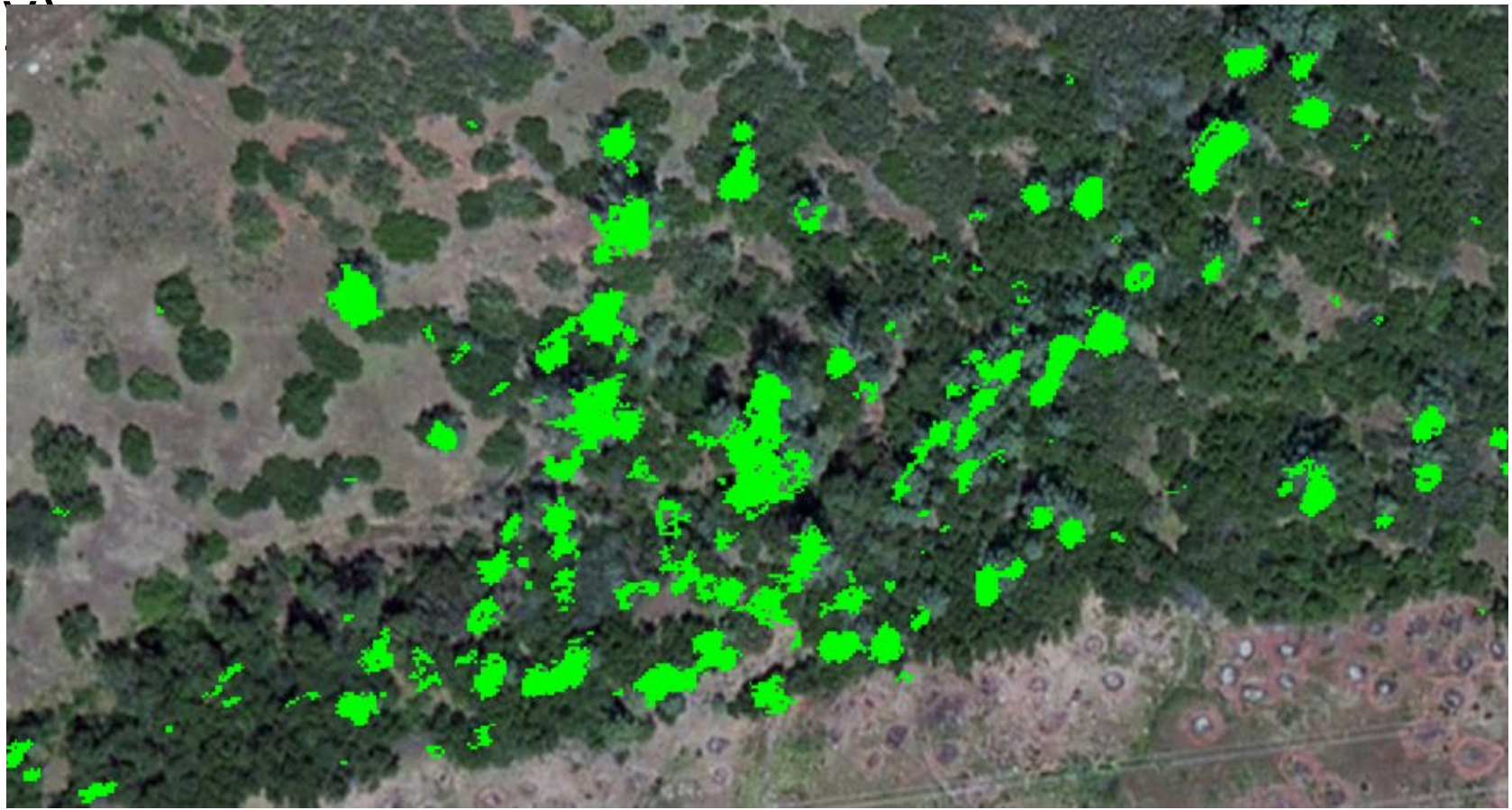
Feature Height and NDVI combined to create a Tree-Only Mask.



Tree Species Classification - Results



Tree Species Classification - Results (gray pine only)



Tree Species Classification -Results

Confusion Matrix

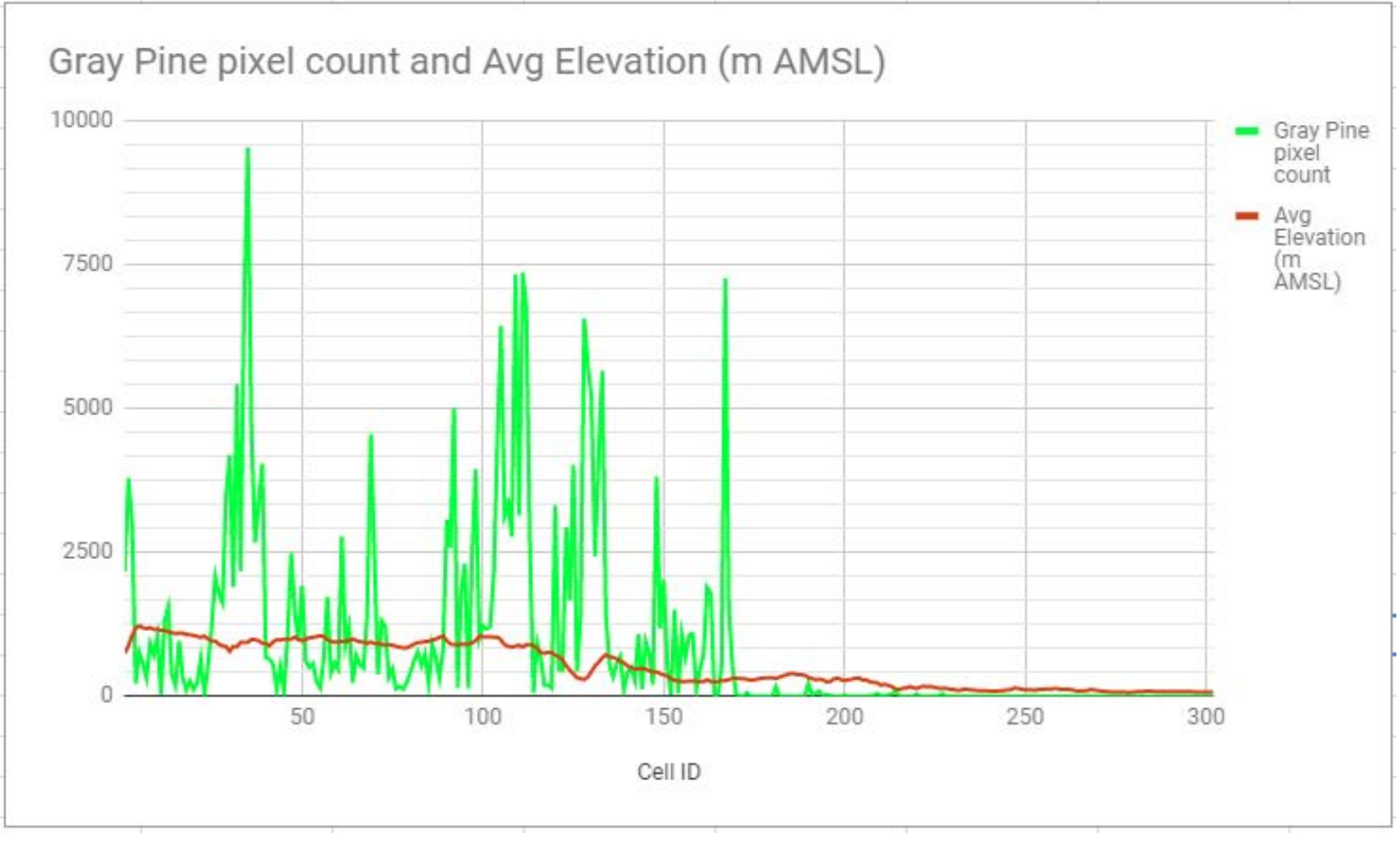
	Almond	Incense	Black	Blue	Live	Gray	Pondero	Sugar	Other		Column Total	User's Accuracy
Almond	**21**	0	0	0	0	0	1	0	3		25	84
Cedar; Incense	0	**8**	0	0	1	0	0	0	0		9	88.9
Oak; Black	0	1	**5**	0	1	0	0	2	4		13	38.5
Oak; Blue	1	1	0	**47**	0	0	1	0	2		52	90.4
Oak; Live	0	0	5	1	**21**	0	1	0	5		33	63.6
Pine; Gray	0	0	0	1	0	**38**	0	1	1		41	**92.7**
Pine; Ponderosa	1	3	3	0	6	0	**35**	0	2		50	70
Pine; Sugar	0	0	0	0	1	0	1	**11**	0		13	84.6
Other	2	2	1	0	5	2	5	0	**45**		62	72.6
Row Total	25	15	14	49	35	40	44	14	62			**Total Accuracy**
Producer's Accuracy	84	53.3	35.7	95.9	60	**95**	79.5	78.6	72.6			**77.52%**

Comparing Gray Pine abundance to Terrain. 1

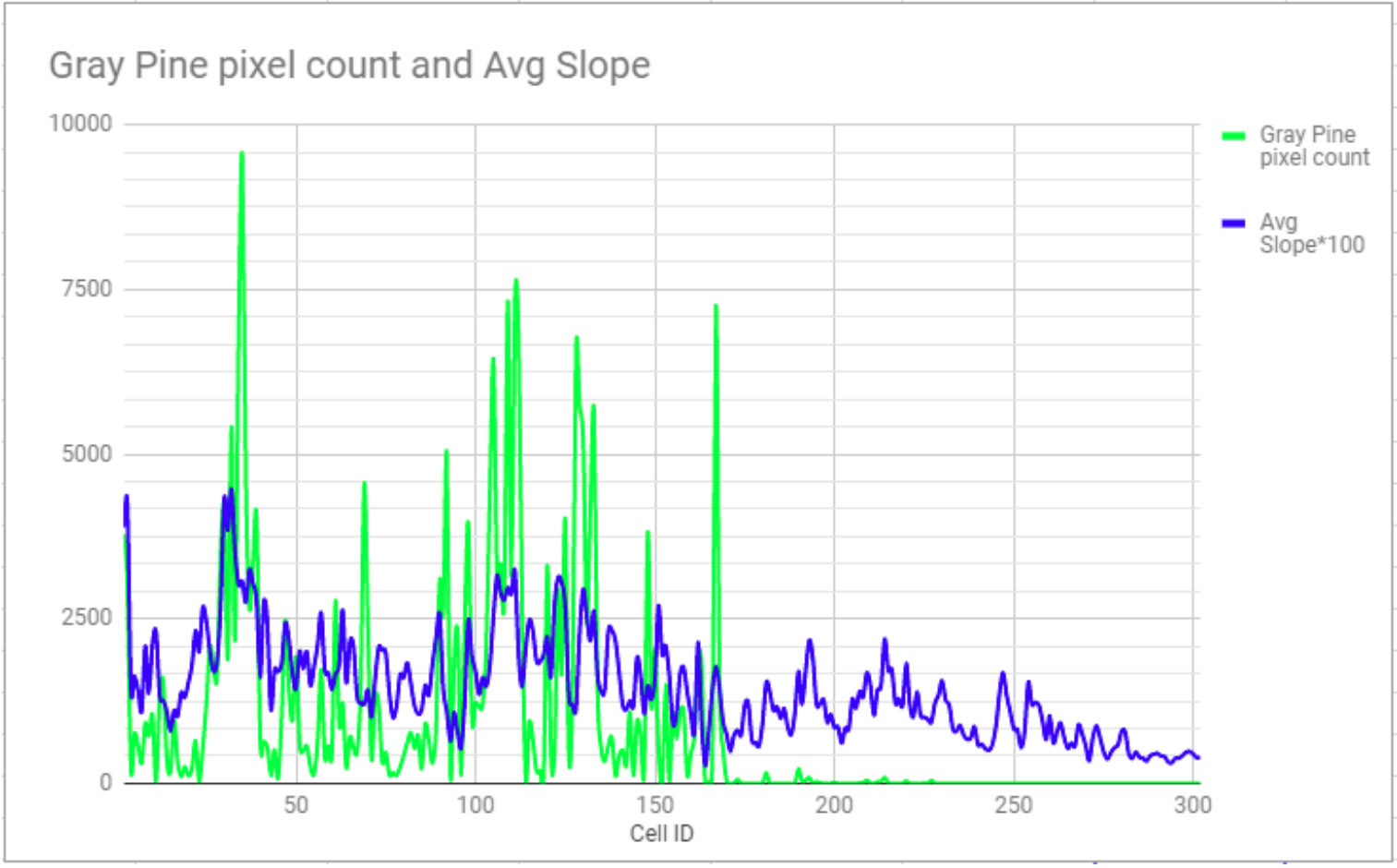
- Create buffered cells along the entire length of the project area.
  - 100 ft buffer
  - 302 total, increasing from ID 1 going west.
- Sum Gray Pine pixel count within each cell.
- Use Zonal Stats tool to calculate average Elevation and Slope for each cell.
  - Did not end up using Aspect

Cell ID	Area	Gray Pine pixel count	Avg Elevation (m AMSL)	Avg Slope
0	38174	2165	748.7179813	29.59873327
1	27655	3784	874.431423	38.81581057
2	27948	2989	1050.392987	42.53129575
3	28092	220	1178.705728	14.5721975
4	27185	754	1222.134539	16.25814052
5	27777	569	1189.164971	14.11426617
6	27398	312	1171.175659	10.97601926
7	27366	914	1188.836149	20.82286159
8	26543	721	1158.810199	13.64627927
9	27132	1036	1163.627387	21.14647022
10	26364	31	1139.041889	23.02927512
11	27010	1307	1139.460355	13.49000476
12	25858	1548	1117.519383	12.55041143
13	25888	372	1098.953632	10.98046199
14	25207	183	1087.417437	7.912403607
15	25081	962	1093.998302	11.0335701
16	24507	330	1091.52038	10.19381542
17	24704	108	1070.939337	13.77617847
18	23962	260	1066.279765	13.07149014
19	23901	117	1053.852345	15.27035671
20	24525	227	1037.079661	17.93074628
21	24528	646	1021.700542	23.17200237
22	24856	28	1043.119949	19.99781727
23	24645	530	995.2260127	26.670581

Results - Gray Pine vs Avg Elevation



Results - Gray Pine vs Avg Slope



- Conclusion
  - Factors such as soil type and water availability are likely contributing more to Gray Pine distribution than elevation.
  - Possible link between elevation and Gray Pine abundance.
- Issues
  - Hyperspectral Imagery was blurry due to internal sensor diffraction issues.
  - Classification was noisy which likely contributed to spikes in Gray Pine pixel count.
  - Study was limited to a narrow corridor
- Future Work
  - Studies focusing on alternative Gray Pine locations and with wider study areas could provide more thorough information on Gray Pine distributes and how they related to surround terrains.

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