Wellpad Feature Extraction of the Piñon Gas Field using OBIA

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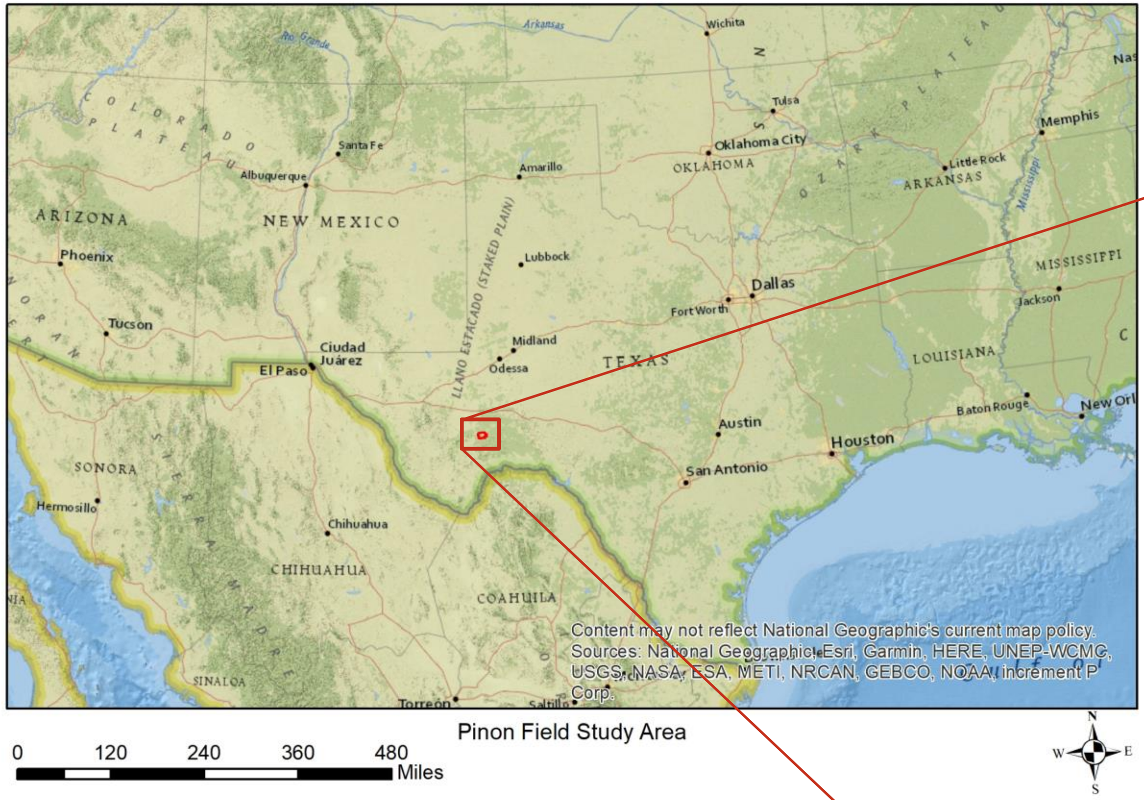
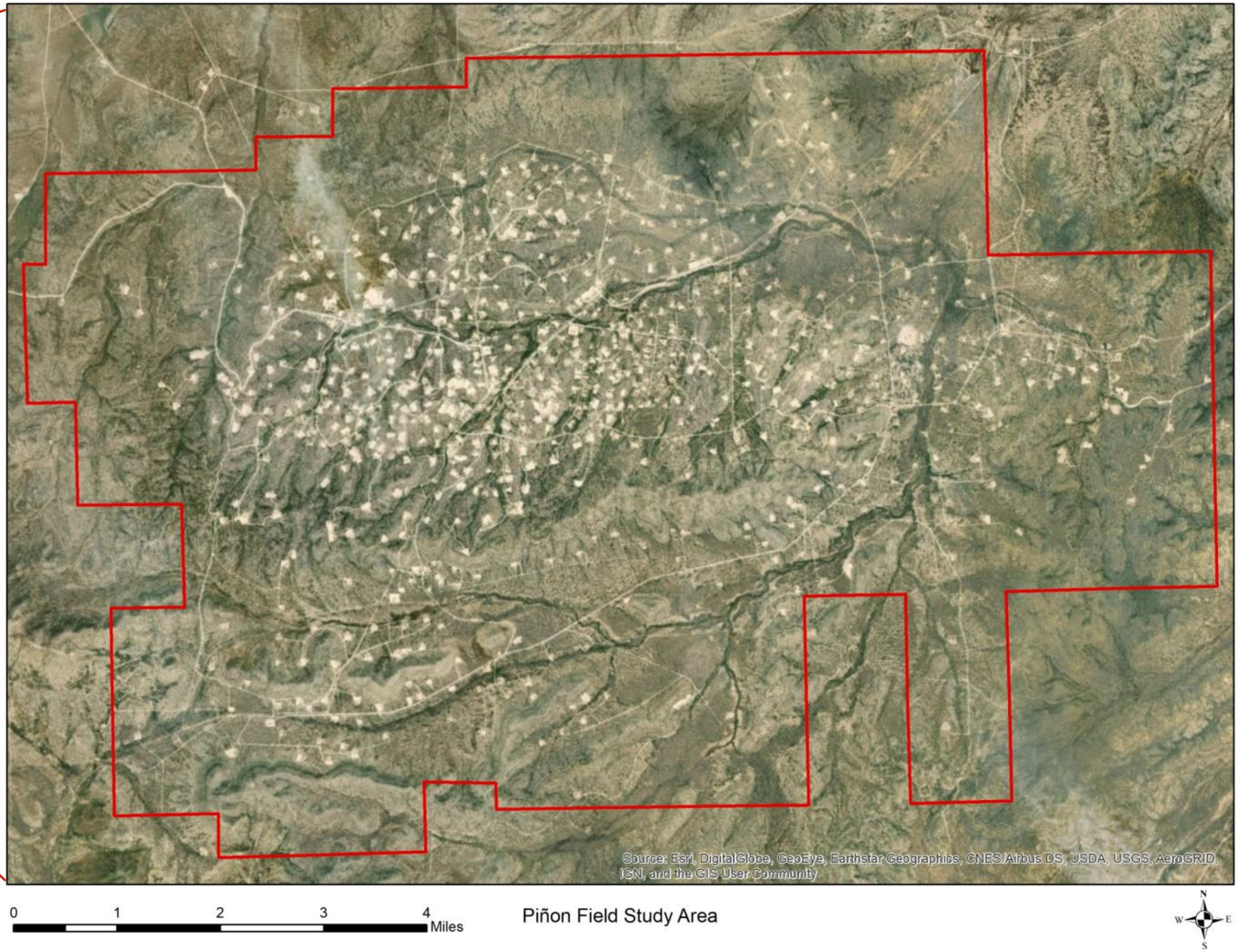
Agenda

- Project Location and Background
- Wellpad Features and Development Cycle
- Project Goals
- Data and Software Requirements
- Object Based Image Analysis (OBIA) Overview and Methodology
- Accuracy Assessment
- Challenges
- Logistics and Timeline
- Potential Presentation Venues

Where is the Piñon gas field?

- Southern Pecos County, West Texas
- On a large ranch with a single landowner





- Project AOI of 42,764 Acres (66.8 mi^2)
- Contains ~ 900 wells

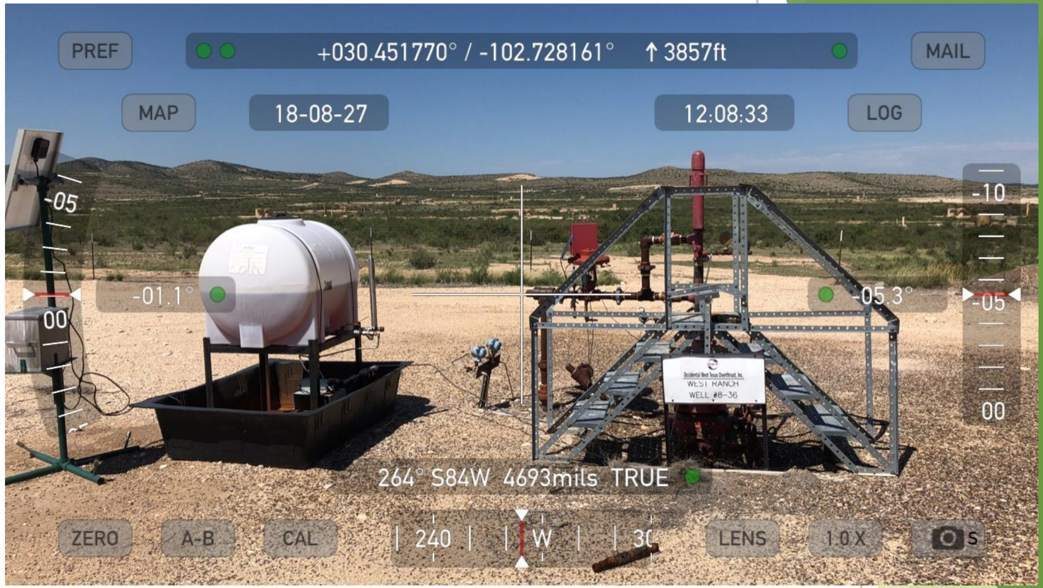
What is a well pad?

- A cleared, level site used for oil and gas operations, production, storage or processing.
- Usually has a wellhead, some production tanks, and some processing facilities.

What features are on a wellpad?

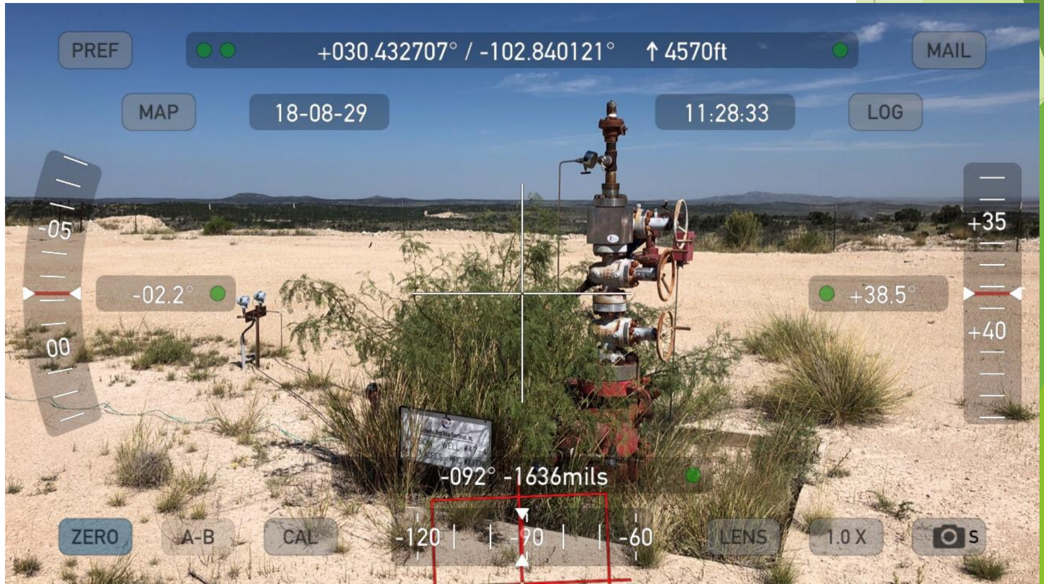
Production Tanks

Wellhead, Chemical Tanks and Meters



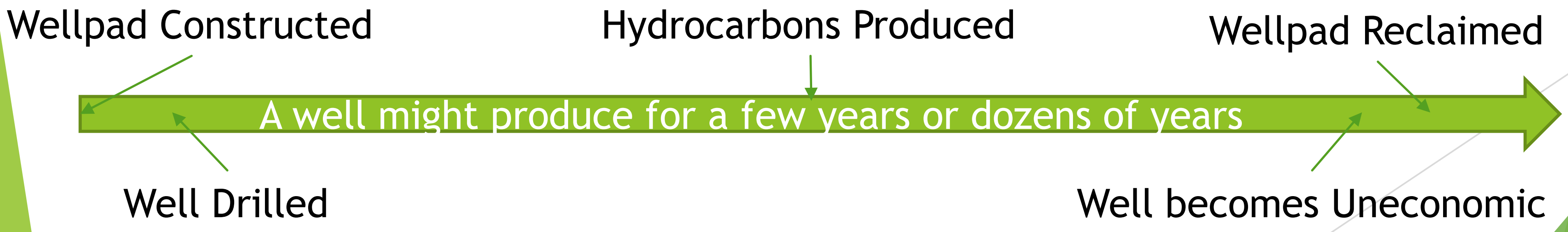
Heater Treater and Separator

Wellhead



Wellpad Development cycle

- Site constructed. Might require some cut and fill.
- A drilling rig is set up on the wellpad and a well is drilled.
- Production facilities and storage tanks are placed on the pad, or it is connected to a pipeline gathering system to bring the hydrocarbons to a central processing facility.
- The well might be dry (no hyrdocarbons in economic amounts) or might produce hydrocarbons for many years.
- Eventually the production will drop, and the well will become uneconomic. When this happens, the well is plugged, and the facilities are removed from the pad.
- The wellpad is eventually reclaimed and restored to it's original land cover.



Wellpad Reclamation – Before and After

Why use OBIA to identify wellpads and the features on the pad?

- A large area can be classified in a short amount of time.
- The process is repeatable and can be used to track changes.
- The well operator is responsible to eventually reclaim the location, the OBIA can be used to estimate the liability to reclaim the wellsite.
- This analysis could be replicated on other oil and gas fields.
- Reclamation liability is a major issue for the oil and gas industry, this analysis could improve the quality and speed to assess the cost of reclamation.
- This analysis could be done as part of the divestment or acquisition of oil and gas assets, adding a level of business intelligence to the process.

Literature Review

- Dacre et al, High-resolution satellite imagery applied to monitoring revegetation of oil-sands exploration well pads.
  - This is a very detailed article about using OBIA to track the reclamation of oil sands well sites in Alberta. It has good methods for ground truthing the findings and tracking reclamation, which my analysis could be used for.
- Brodrick et al, Application of machine learning techniques for well pad identification in the Bakken oil field.
  - The paper tries to identify wellpads in North Dakota for purpose of estimating volume of emissions from the oilfield. It has useful information about the parameters for the multi-resolution segmentation algorithm. Also has information about errors in the analysis.
- A wide variety of OBIA papers that can influence the analysis.

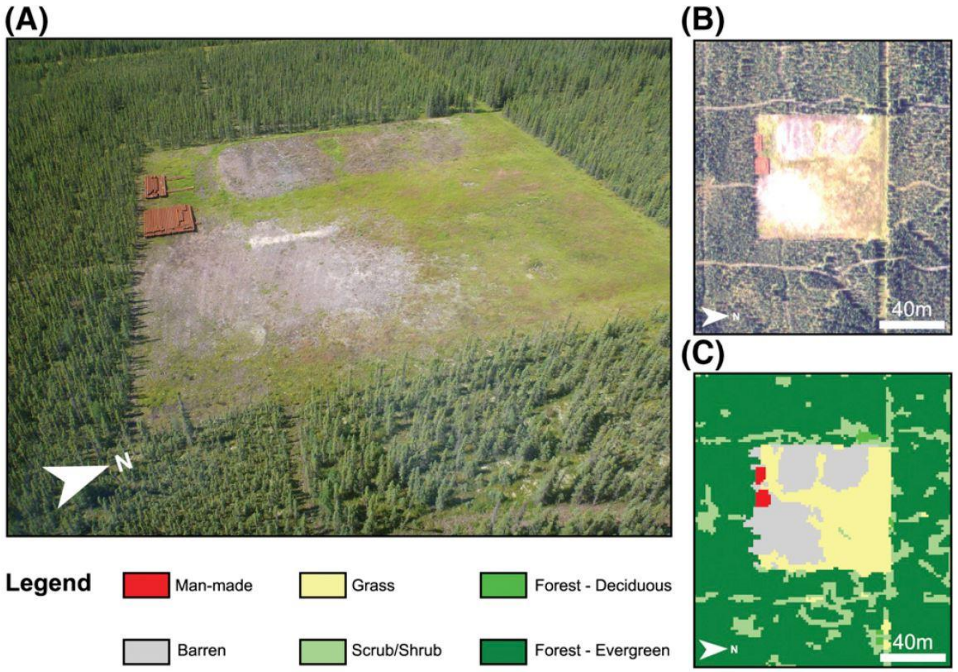
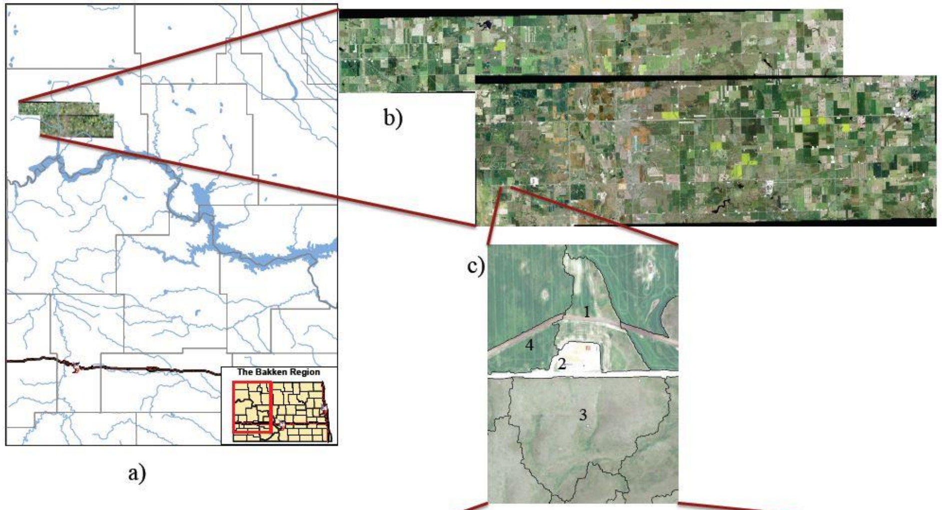


Figure 4. A comparison of a 2011 helicopter-collected image (A), WorldView-2 (WV2) imagery from 2011 (B; © 2011 Digital-Globe, Inc.), and land-cover results from the WV2 image (C) for well pad 12-24-93-7 within the Aspen area of interest (Figure 1). Legend is for land cover provided in panel C.



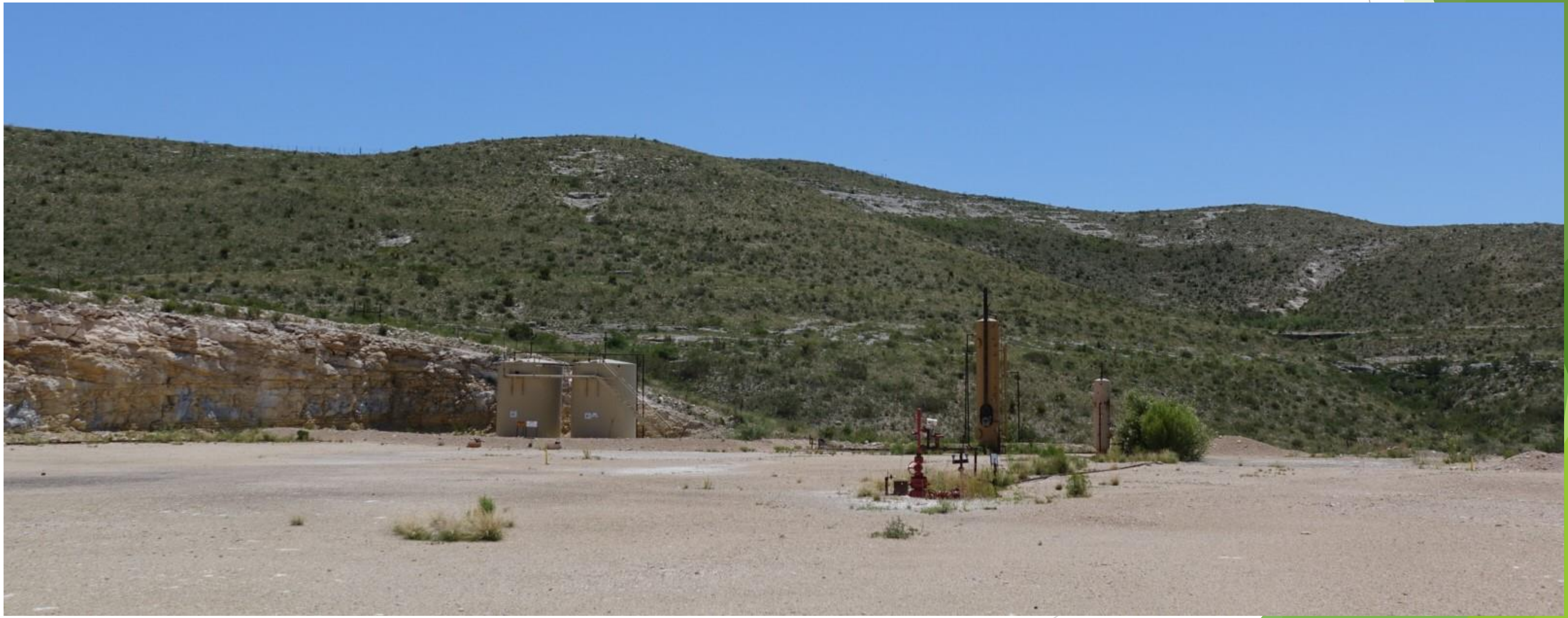
d)

Segment	NDVI mean	Brightness	Area (pixels)	Roundness	GLCM Entropy
1	0.10	151.01	51652	1.16	6.91
2	-0.08	196.97	31473	2.05	6.67
3	0.06	143.45	137819	0.71	5.60
4	0.24	134.44	27498	0.70	6.11

Figure 1: Schematic for input data: a) project study area within the context of the Bakken region and North Dakota, b) Close up image of study area, c) example of segmented image, d) example of data exported from segmentation

Project Goals

- The primary goal is to identify all wellpads and access roads in the field along their sizes. This will provide a GIS based inventory of all wellpads and roads in order to track reclamation.
- The secondary goal is to identify the features on the wellpad. The storage tanks, heater/treaters, separators and potentially the wellheads.



Data requirements

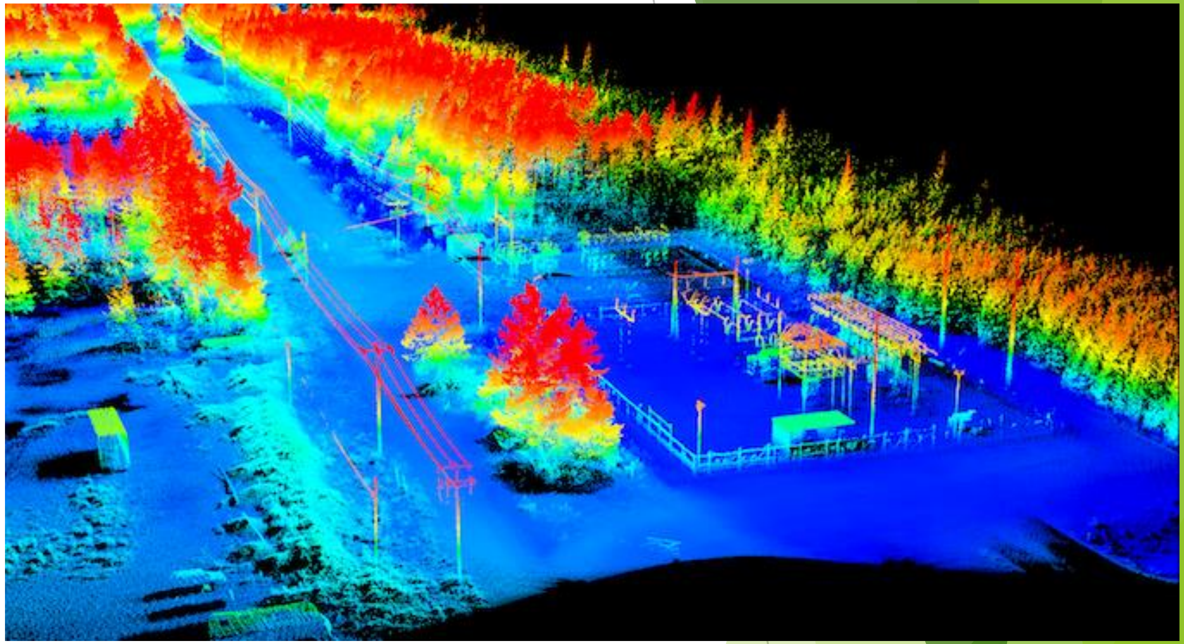
- Multi-spectral imagery
  - Air Photo Mosaic
  - Satellite
- Elevation data
  - Lidar
  - Satellite Radar
- IHS well data
- Road networks
- Parcel data

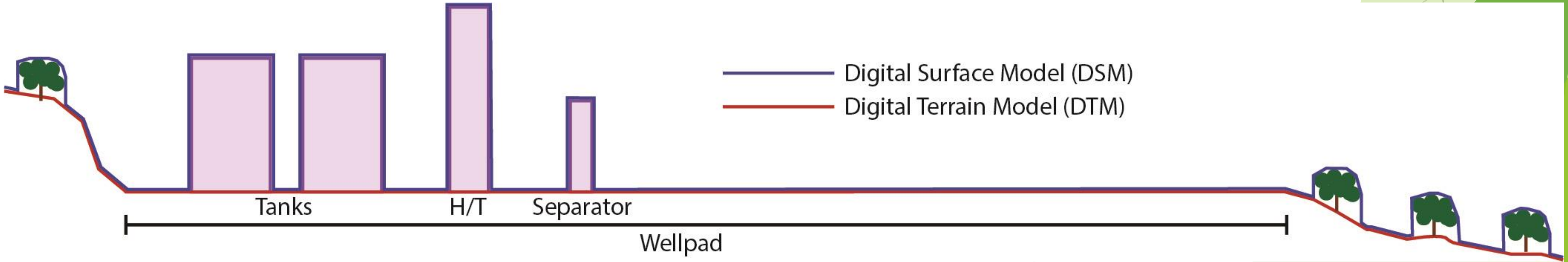
Multi-Spectral Imagery

- 2016 4-band NAIP (National Agriculture Imagery Program) at 50 cm resolution.
  - Free
  - 3 years old.
  - 50 cm is not high enough resolution to identify small objects on the wellpads.
  - 4 bands are Red, Green, Blue and Infra-Red.
- Newer Satellite data.
  - There will be a cost associated but could work out a partnership will the vendor.
  - Better vintage, the more recent the better.
  - Can be a higher resolution, up to 15 cm.
  - Can have more than 4 bands increasing the quality of the segmentation. Potentially have thermal, NIR, FIR, UV.
- New air photo acquisition.
  - Likely the most expensive.
  - Lidar data could be acquired at the same time.
  - 10 cm resolution is possible.
  - Could potentially be acquired through drone flights.

Elevation Data

- Lidar is ideal but could be cost-prohibitive for a large AOI (66.8 mi^2).
  - It can be processed to provide a digital surface model. (DSM)
  - The DSM can be used to identify features on the wellpad.
- Wellpads are flat. Slope would be calculated and incorporated into the multi-resolution segmentation to help in the classification of wellpad objects.
- Potentially use a satellite-based elevation product, such as radar.





Thematic Data Sources

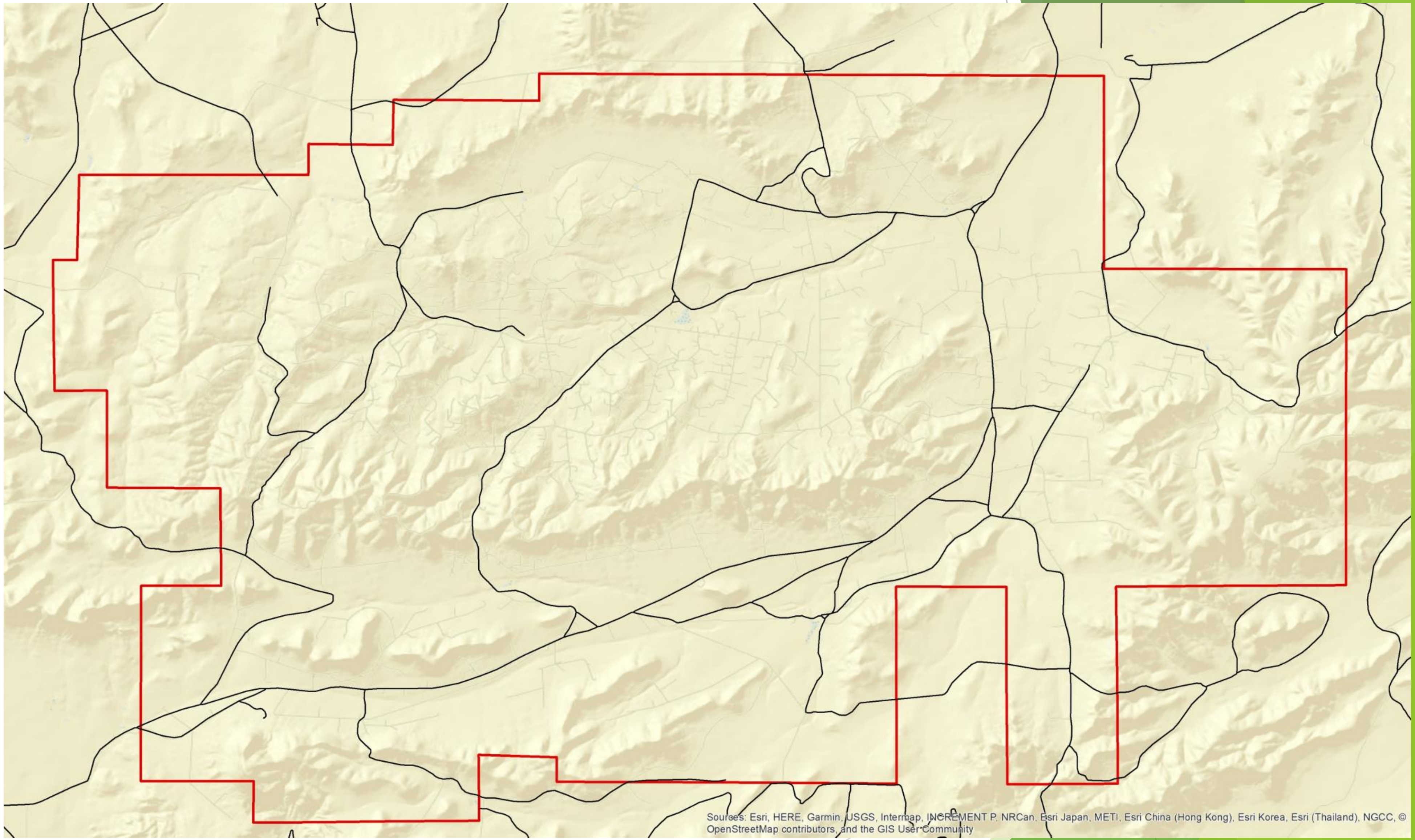
- IHS well database.
  - This contains the location and detail of all the wells in the area. It would be used to provide attribute data to the well pads and facilities.
  - The location of this data will need to be QC'ed to remove positional errors.
- Road data.
  - This would be used to limit the area of the of the access road segmentation and classification.
- Texas land survey grid
  - This data was used to generate the AOI.

Existing Well Data

- IHS well data has issues. It needs to be spatially corrected before it can be used.
  - The location of many of the wells is incorrect. These locations will need to be corrected prior to them being used in a spatial join to the wellpad features.
  - It will most likely be a manual revision.

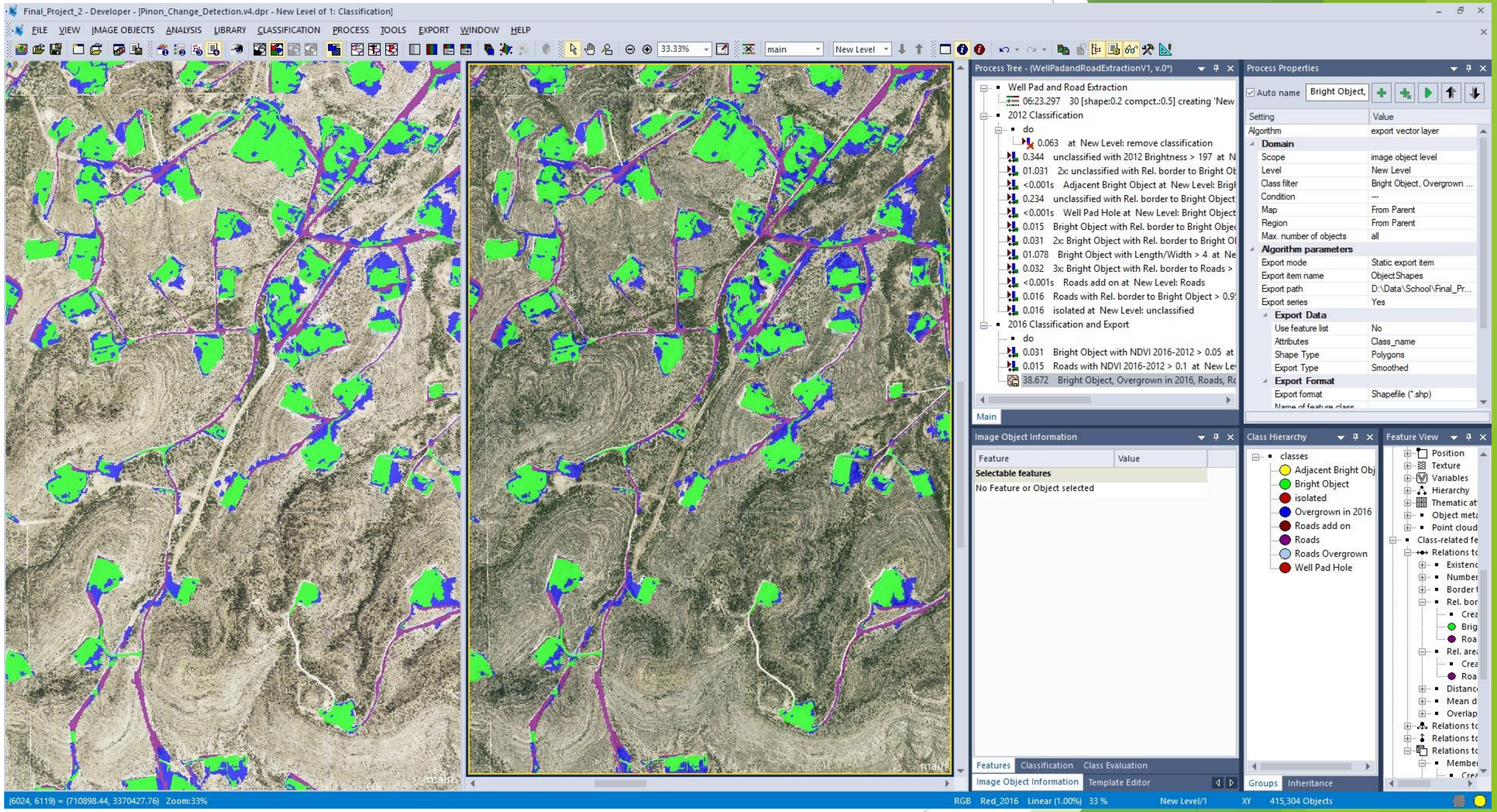
Road Data

- Can use existing road network data to constrain the road segmentation.
- This will allow for a better classification of the road objects.
- Detailed road layer is shown on the ESRI World Street Map basemap. This source data could be found or extracted from the basemap.



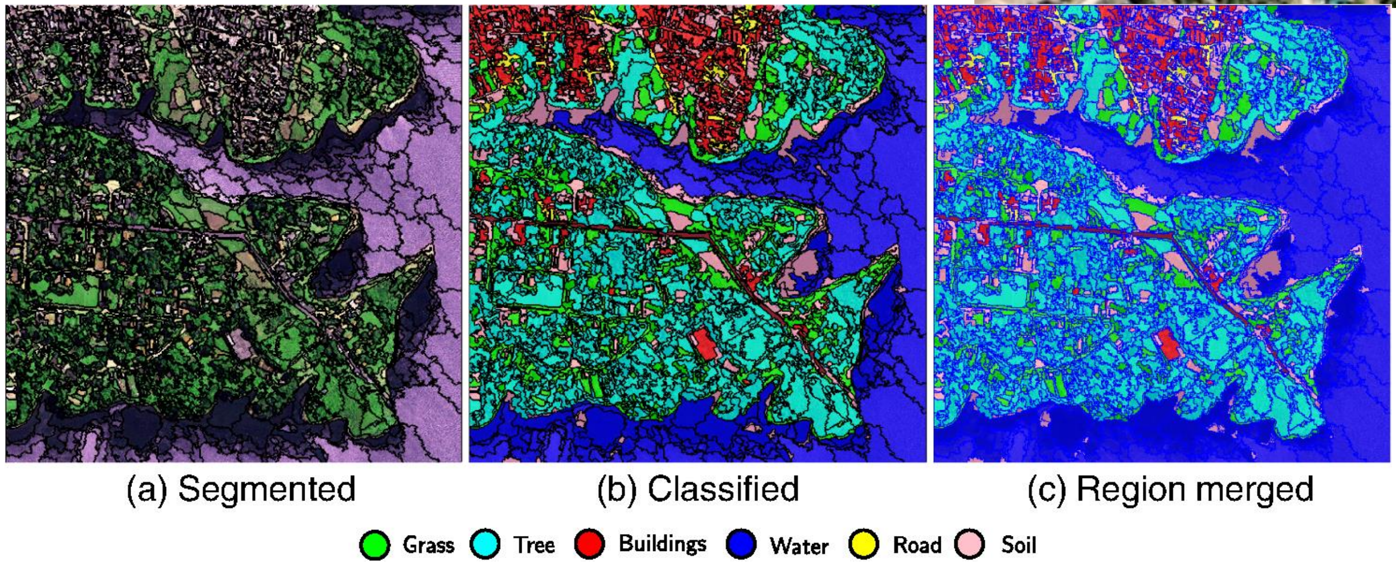
Software Requirements

- Trimble eCognition Developer
  - This software is used for the OBIA.
  - Uses the powerful multi-resolution segmentation algorithm to generate objects.
- ArcGIS
  - Used to pre-process data prior to loading to eCognition and analyze data created by the OBIA.
- ArcGIS Spatial and 3D Analyst
  - Required to generate datasets from the elevation data.



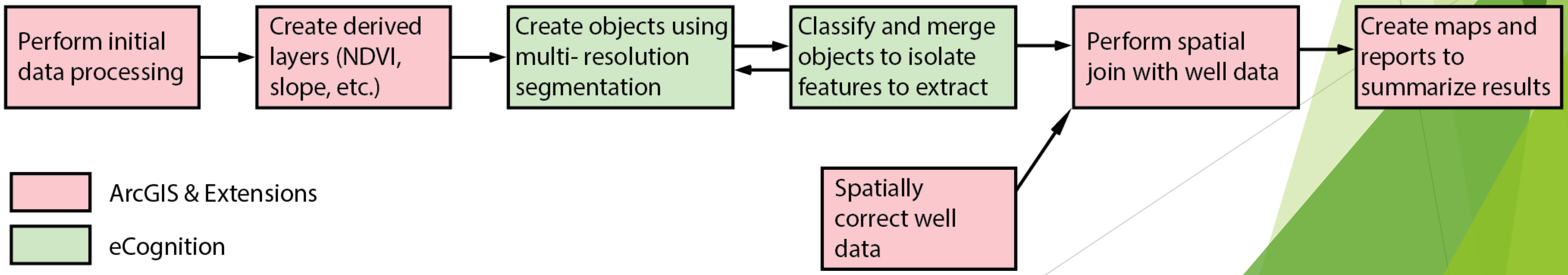
What is OBIA?

- The raster data sources are analyzed and segmented into objects.
- These objects are then classified into unique classes.
- The classes are then exported as GIS data to be used in further analysis.



OBIA Methodology

- Assuming all data sources have been acquired, the first step is to generate derived layers. Such as normalized difference vegetation index (NDVI), slope, normalized difference surface model (nDSM), etc.
- These derived layers, along with the bands from the high-resolution imagery and elevation are then loaded into eCognition for the multi-resolution segmentation.
- The multi-resolution segmentation create objects from all the raster data sources.
- The objects are then classified into features: roads, wellpads and other.
- The features on the wellpad are then classified into production tanks, separators, and heater treaters. Wellheads, chemical tanks and other facilites will be attempted to be identified if the data allows.
- All features are then exported for spatial joining and report generation in ArcGIS.



Data Processing

- If new high resolution imagery is acquired, it will need to be orthorectified and possibly have the reflectance values converted into absolute scale to remove any atmospheric effects.
- The thermal imagery, if acquired, will likely require processing prior to loading into the multi-resolution segmentation.
- Lidar data, if acquired, will need to be processed by the vendor into return classes. These classes can then be converted into surfaces. These surfaces could then be analyzed to generate slope and nDSM models.
- IHS well data will need to be spatially corrected to the orthorectified high resolution imagery. If it’s possible to extract the wellhead features from the wellpad features, the IHS well data could be snapped to these features.

Accuracy Assessment

- After the analysis has been performed an accuracy assessment will be completed.
- Errors of omission (a wellpad was not identified as a wellpad) and errors of commission (an area was incorrectly identified as a wellpad) with be evaluated by the creation of random sample points within each class. These sample points are analyzed to determine if the classification was correct.
- There will be two assessments.
  - The assessment of wellpads, access roads and other for the primary objective.
  - The assessment of the wellpad features for the secondary objective.
- Could potentially have a ground truthing field visit.

ClassValue	Well Pads	Overgrown Area of Well Pad	Roads	Overgrown Area of Road	Other	Total	User Accuracy
Well Pads	8	2	3	0	2	15	53.33%
Overgrown Wellpad	0	7	2	1	2	12	58.33%
Roads	4	1	3	0	2	10	30.00%
Overgrown Road	0	1	0	7	2	10	70.00%
Other	8	29	5	3	418	463	90.28%
Total	20	40	13	11	426	510	0.00%
Producer Accuracy	40.00%	17.50%	23.08%	63.64%	98.12%	0	86.86%

Challenges

- Properly identifying the wellpads and roads.
  - Often roads will cross over wellpads. This could lead to confusion if it should be a road or pad.
  - Partially overgrown wellpads that are not reclaimed. The flora can encroach on the pad making identification difficult.
  - Partially reclaimed pads. Often the wellpads will be constructed larger for the drilling and completions operations then partially reclaimed and reduced in size for the production phase. The analysis might include the reclaimed part of the pad.
  - There are other features such as gas plants or storage yards in the AOI. These will be classified as other but could be mistakenly included as a wellpad.
  - Pipeline right of way could be mistaken for an access road.
- Proper identification of the wellpad features.
  - The resolution of the data might be insufficient to properly identify the smaller features, such as the wellhead or chemical tanks.
- Well database spatial correction.
  - Some of the pads and wells a very dense. So the correcting of the well location might not be obvious and could be incorrect.

Logistics and Timeline

- Project Planning (4-6 weeks)
  - Collect prices for data sources and secure software licenses. (2-3 weeks)
  - Decide on data sources then build the project budget and execution plan. (2-3 weeks)
- Project Execution (7-15 weeks)
  - Do any required pre-processing of the data. (1-3 weeks)
  - Perform the segmentation and classification of the wellpads, roads and wellpad features. (2-4 weeks)
  - Improve the positional accuracy of the IHS well data. (2-4 weeks)
  - Perform the spatial join and quantify all the features into a usable report. (2-4 weeks)
- Analyze the results (3-7 weeks)
  - Perform the accuracy assessment. (1-3 weeks)
  - Write up the report and create presentation materials. (2-4 weeks)
- Present the results of the analysis at a conference.
- Total time to complete project (14-28 weeks or 3-7 months)

Potential Presentation Venues

- ESRI Petroleum User Group (PUG) Conference – Houston May 2020
- ESRI User Conference – San Diego July 2020
- URISA GIS-Pro – Baltimore September 2020
- URISA GIS/Valuation Technologies Conference – Louisville March 2020
- URISA Caribbean GIS Conference – Port of Spain, Trinidad November 2019
- ASPRS Pecora Conference – 2020 Date and Venue TBD
- GIS in the Rockies – Denver September 2019

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