LARIAC Case Study

Optimizing the Planning and Management of Los Angeles County's Urban Forest

Funders + Advisors + Collaborators
Justin Robertson, AICP, LA County DPH
Steven J. Steinberg, PhD, MPA, GISP, LA County ISD
Thomas W. Gillespie, PhD, UCLA Geography
Elsa M. Ordway, PhD, UCLA EEB
Bo Zhou, PhD, UCLA Geography
Corey DeLisle, UCLA Geography
Kristi Le, UCLA CASB

Presenter
Jonathan Pando Ocón
PhD ABD, UCLA Geography
jonocon@g.ucla.edu

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Urban Forest Planning & Management

Los Angeles County faces public health challenges due to:

- Changing climate,
- Increased drought, and
- Natural disasters like fire.

Optimizing the planning and management of the urban forest using remote sensing can help determine which species are responding better to these challenges.

There are eight County departments responsible for public trees, and traditional methods for conducting tree inventories are resource-intensive.

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Project Goals

Identify individual urban tree species from aerial imagery and derive canopy metrics over time across our pilot sites

- Using these results, determining the tree's health status becomes a welcomed future application

Assist stakeholders, who are manage urban forest stock manually, to deploy their expertise more efficiently and save time

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Stakeholder Engagement

To ensure our project goals are met, we sought input from stakeholders in early 2021 to identify the needs and priorities of those that will be using our product in day-to-day operations:

- **Stakeholder Advisory Group**
    - Users from within and outside the County
- **Technical Advisory Group**
    - A small group of field experts to advise on the technical aspects

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Review of Stakeholder Objectives

In order to prioritize the workflow of our model, stakeholder input is a crucial step needed to identify existing operational issues in regional urban forest management and set the top priorities for our pilot project:

- **Individual tree species identification**
- **Canopy cover metrics**
- **Health assessment**

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Selected 11 target species/Genera:
- Four native
- Seven non-native

- Potential planting sites

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Review of Stakeholder Objectives

Selected tree species/Genera chosen for our pilot sites:

Non-native

Orange (*Citrus* spp)

Crepe Myrtle (*Lagerstroemia* spp)

Eucalyptus (*Eucalyptus* spp)

Jacaranda (*Jacaranda mimosifolia*)

Pines (*Pinus* spp)

Figs (*Ficus* spp)

Palms (*Washingtonia* spp)

Native

Coast Live Oak (*Quercus agrifolia*)

California Sycamore (*Platanus racemosa*)

Coast Redwood (*Sequoia sempervirens*)

California Walnut (*Juglans californica*)

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- **Individual tree species identification**
- **Canopy cover metrics**
- **Health assessment**

Metrics shared that are important for user's day-to-day operations:

- Crown area per species / individual trees
- Crown spread
- Canopy change over time

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COUNTY OF LOS ANGELES CALIFORNIA

Review of Stakeholder Objectives

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- **Individual tree species identification**
- **Canopy cover metrics**
- **Health assessment**

Metrics that are important for user's day-to-day operations:

- Tree condition

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Pilot Sites

Prior to scaling to the entire county, we plan to test our models across three diverse, unincorporated areas in urban LA County. We chose these locations due to their diversity in tree species, demographics, and management approaches:

1. **Marina del Rey**
2. **East Los Angeles**
3. **Altadena**

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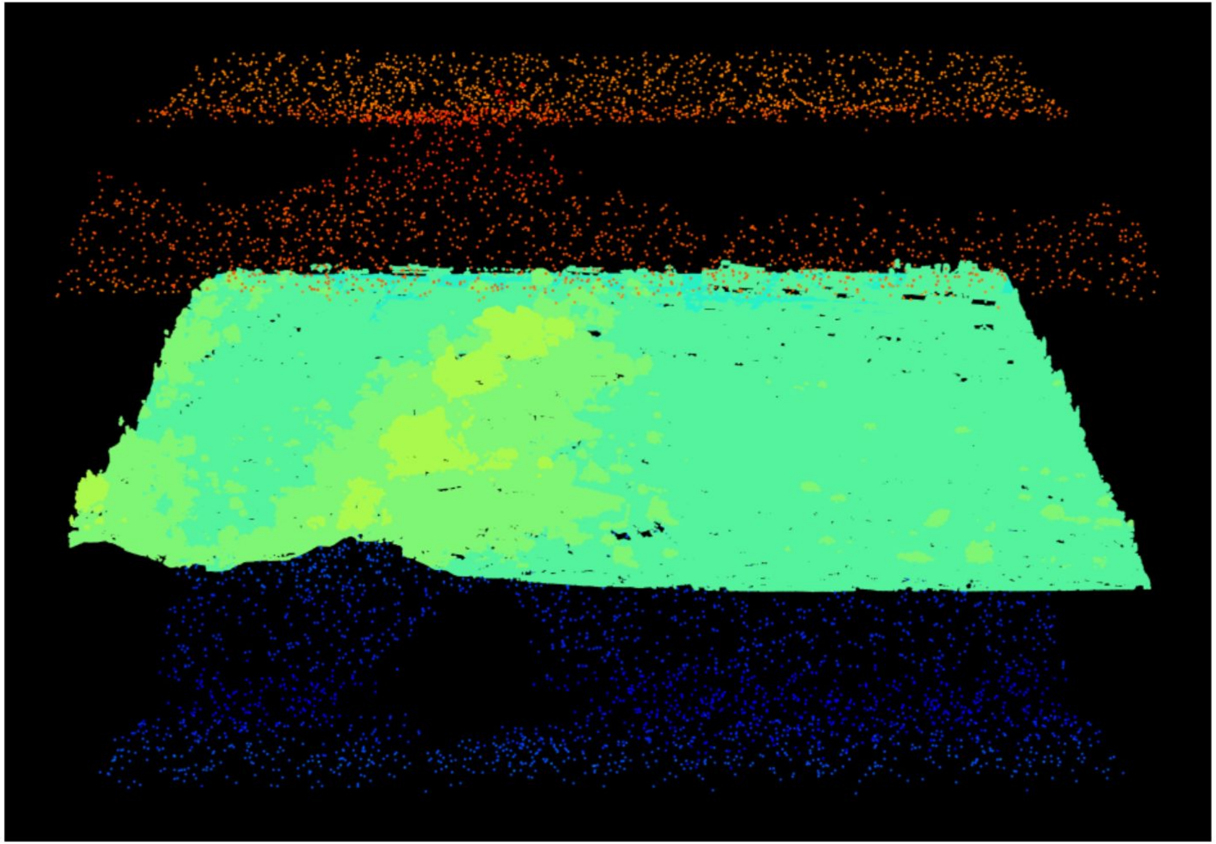
COUNTY OF LOS ANGELES CALIFORNIA

Data Processing:
Processing tile-by-tile.



Raw version of LARIAC 4 tile with below- and above-ground noise and topography.

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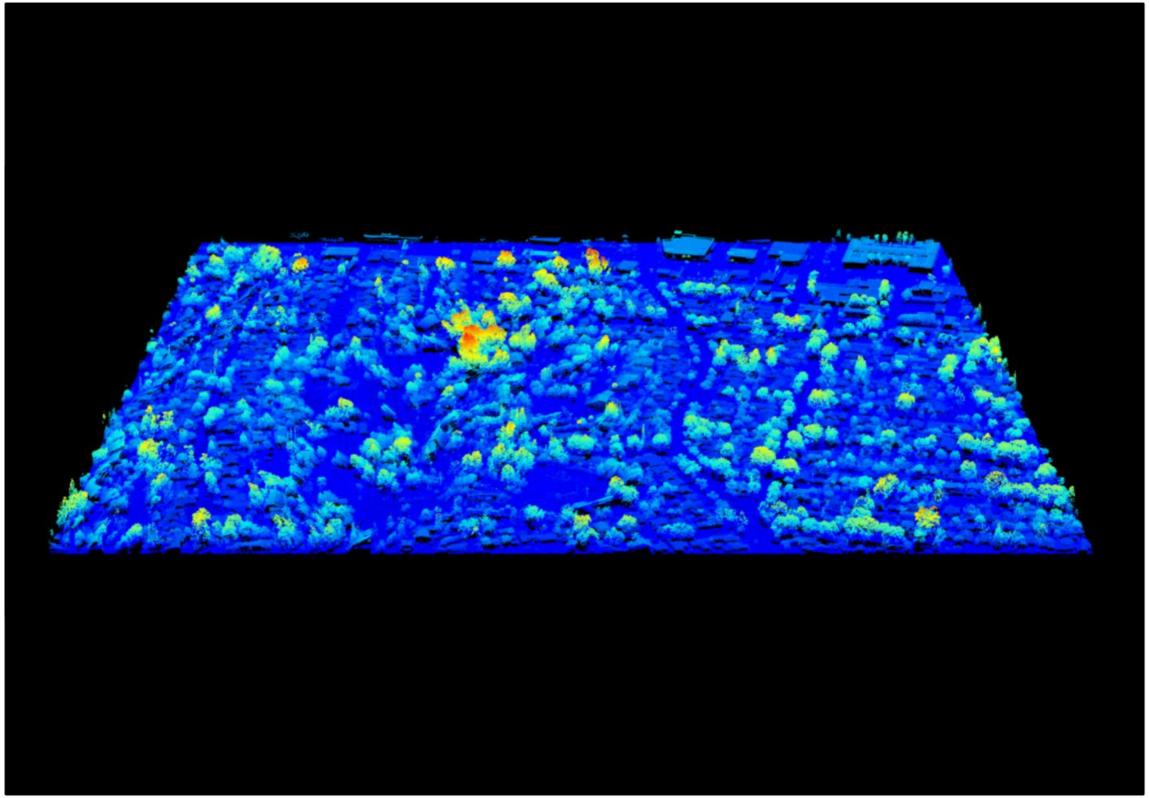
Data Processing:

Processing tile-by-tile.



1. Normalizing the topography, a.k.a. setting the ground to '0'
2. Filtering for height: $0 \leq Z < 220$ ft (corrects for below-ground noise)
3. Selecting points inside the 90th percentile of height (corrects for above-ground noise)

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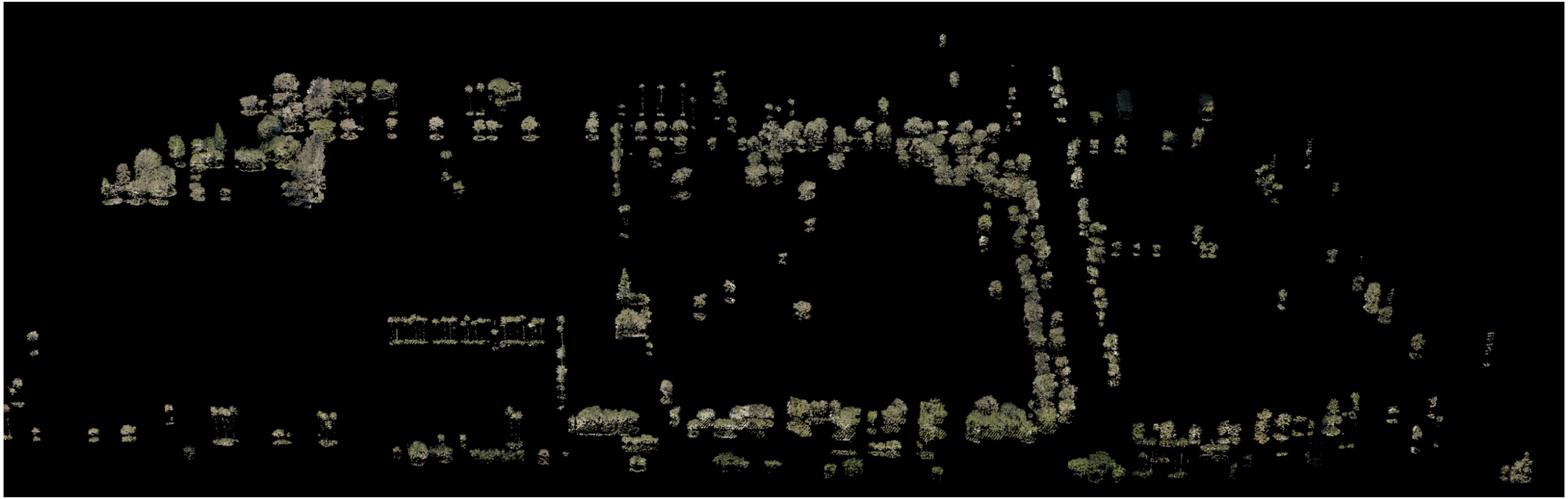
Data Processing:

Processing tile-by-tile.

Merging (draping) NAIP digital numbers with point-cloud.

Tree Mask



Tree Canopy Layer derived from LARIAC Land Cover (2016) - Example from Marina del Rey

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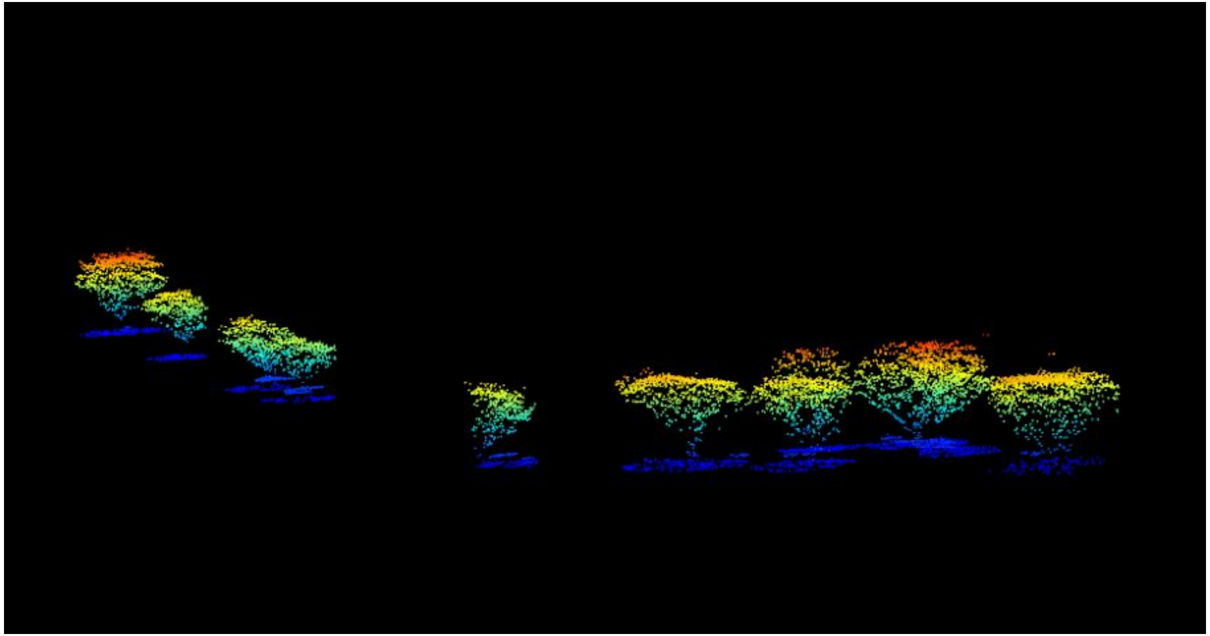
COUNTY OF LOS ANGELES CALIFORNIA

Tree Segmentation



Erythrina caffra (not a target species) from Marina del Rey.

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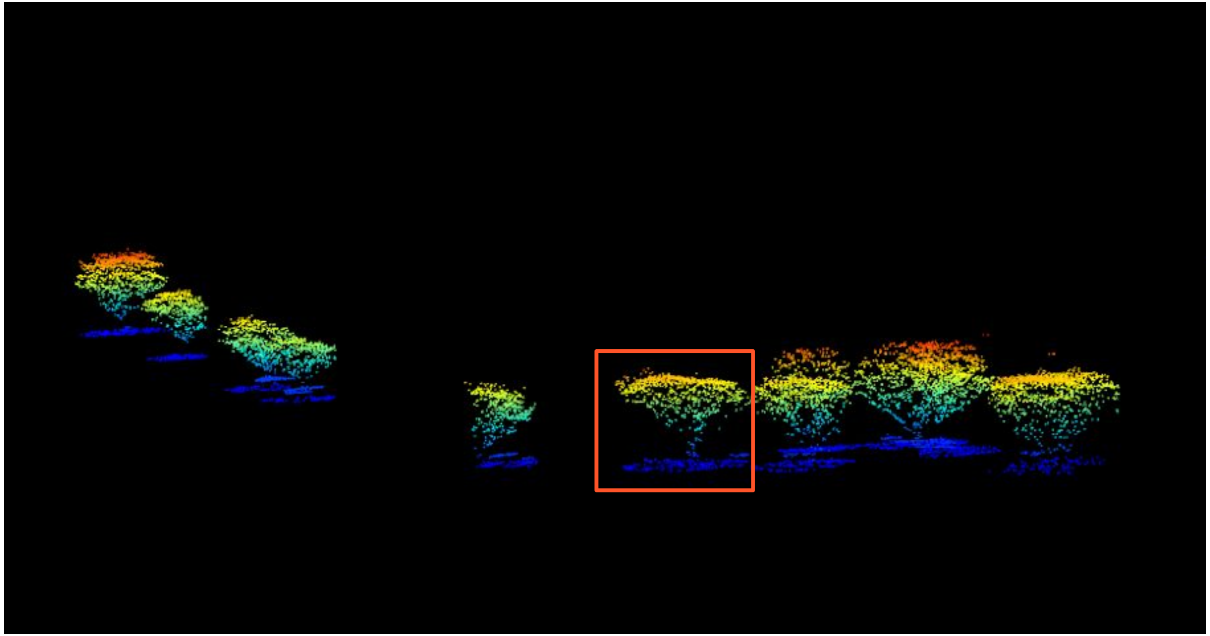
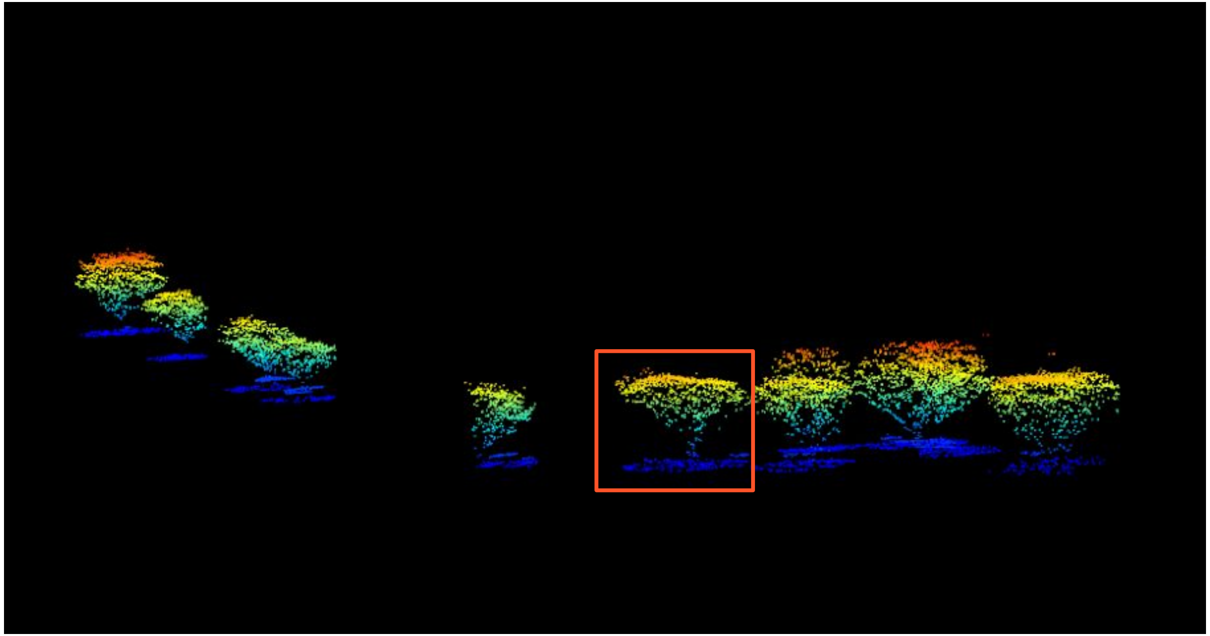
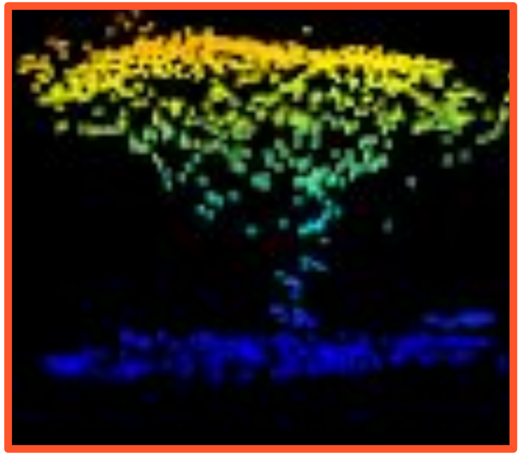
Single Tree ID



Erythrina caffra (not a target species) from Marina del Rey.

Single Tree Segmentation





Erythrina caffra (not a target species) from Marina del Rey.

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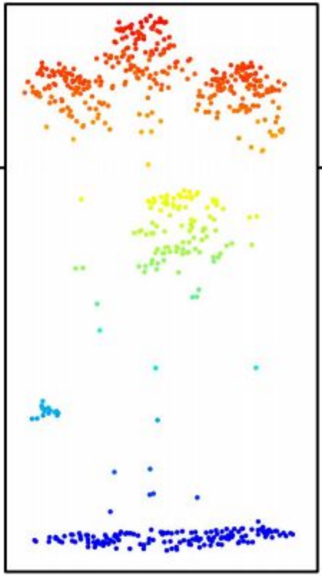
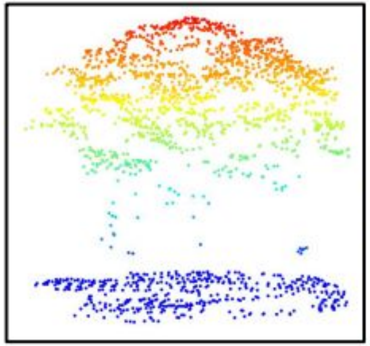
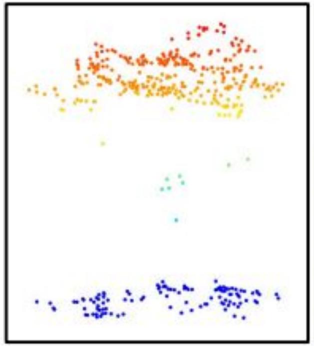
Washingtonia robusta



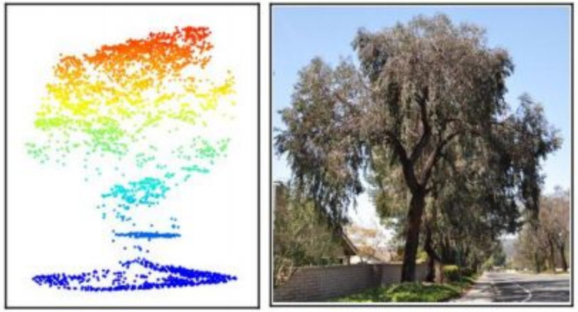
Ficus spp.



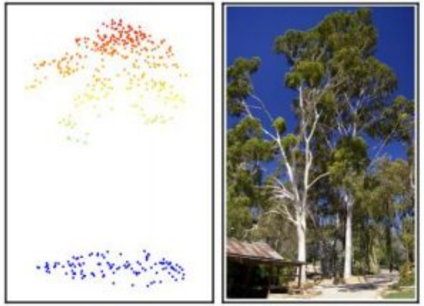
Ficus rubiginosa



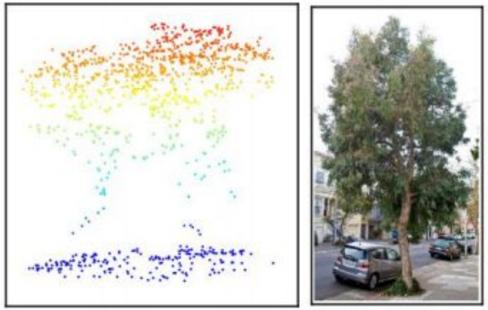
Ficus microcarpa ‘nitida’



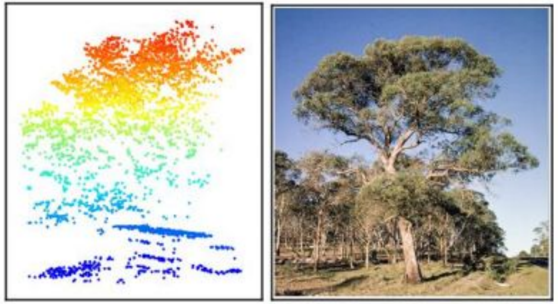
Eucalyptus sideroxylon



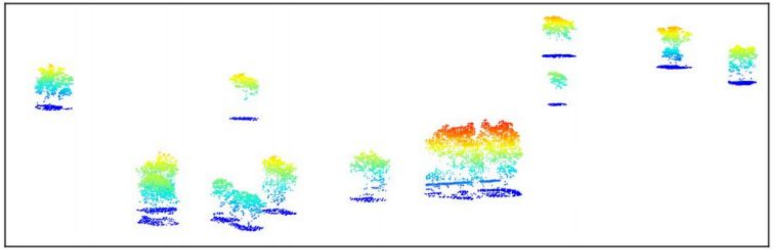
Eucalyptus citriodora



Eucalyptus polyanthemos



Eucalyptus nicholii



Eucalyptus spp.

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Sample of Crown Metrics

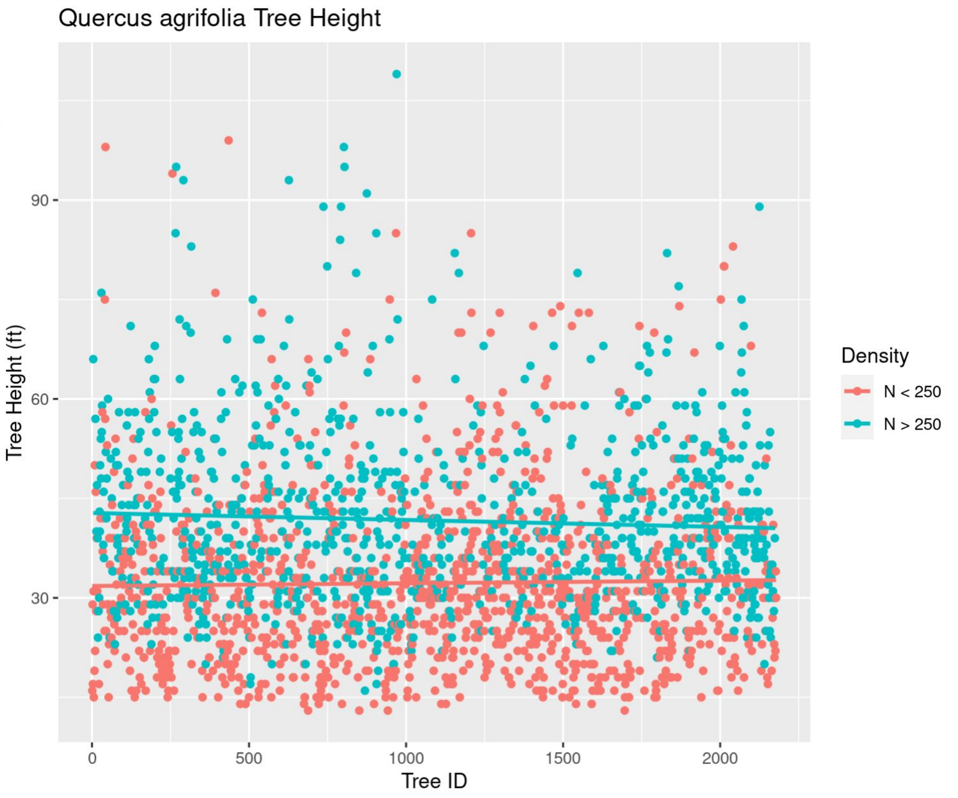
Group	Num of Crowns	Mean Density (N pts)	Mean Height (ft)	Mean Area (sq ft)	Mean Perim (ft)
Citrus spp	506	209.68	28.59	879.96	102.16
Eucalyptus spp	3713	362.01	43.06	1170.66	118.5
Ficus spp	**8707**	**460.84**	32.94	**1479.86**	**130.7**
Jacaranda mimosifolia	2504	399.16	33.38	1277.15	122.79
Juglans californica	330	219.53	35.95	1008.08	110.18
Lagerstroemia spp	**10558**	151.53	23.91	707.15	90.28
Pinus spp	**9952**	248.04	**55.83**	937.32	105.44
Platanus racemosa	1518	341.21	46.99	1017.41	109.95
Quercus agrifolia	2165	**407.52**	36.94	**1442.74**	**130.73**
Sequoia sempervirens	330	216.81	**54.03**	799.23	97.69
Washingtonia spp	**9152**	184.87	**60.41**	664.34	89.06

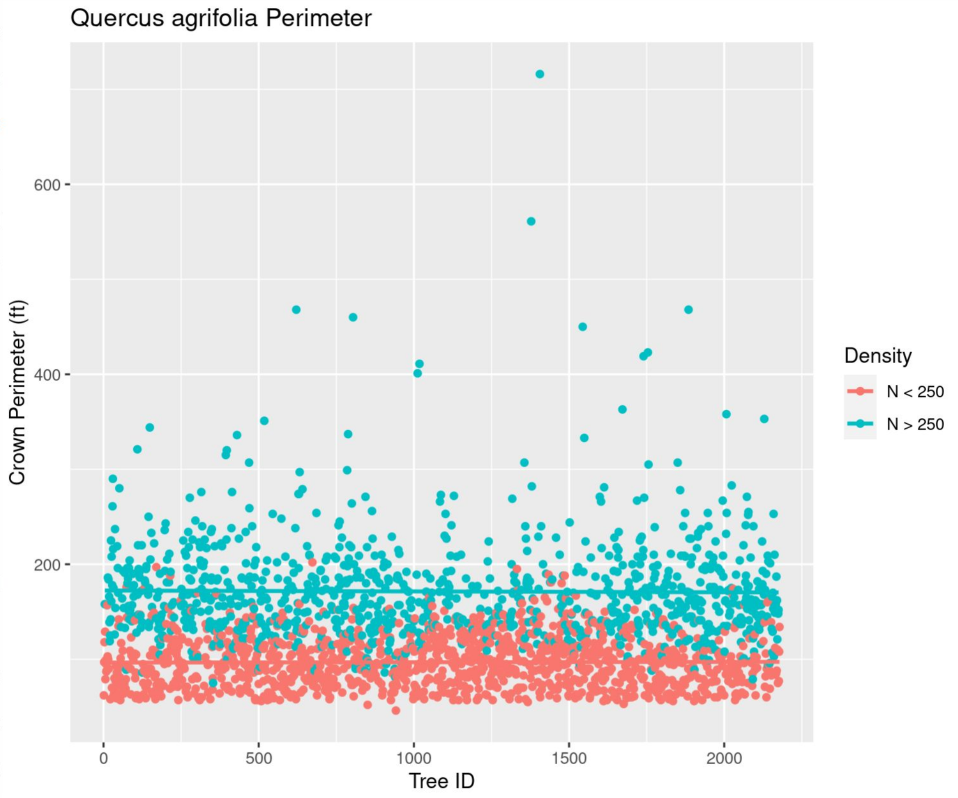
Species Highlight: California Natives

Black walnut *Juglans californica*	Coastal live oak *Quercus agrifolia*	Coastal redwood *Sequoia sempervirens*	California sycamore *Platanus racemosa*
Deciduous	Deciduous	Conifer	Deciduous
			

Table produced by Kristi Le

Crown Metrics: *Quercus agrifolia*





Proxy Health Assessment: Satellite NDVI

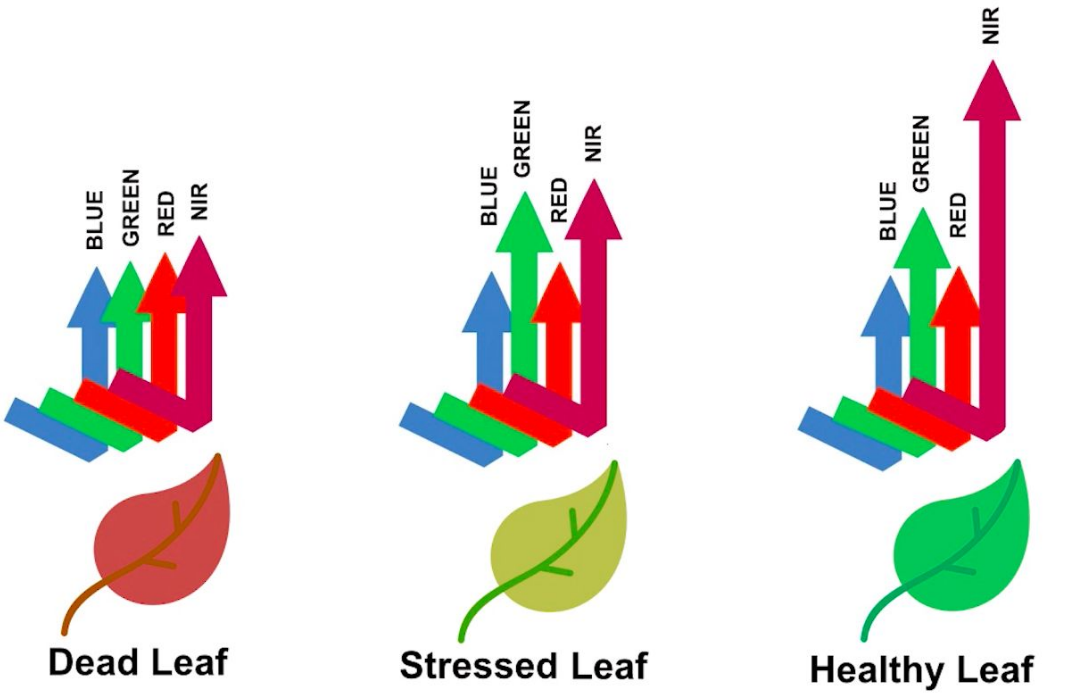


Image source: *regrow*

$$\text{NDVI} = \frac{\text{NIR} - \text{R}}{\text{NIR} + \text{R}}$$

Sentinel-2 satellite constellation
Repeat observations every 5 days
Image source: *European Space Agency*

Prevalence of Clouds - Sentinel-2 NDVI

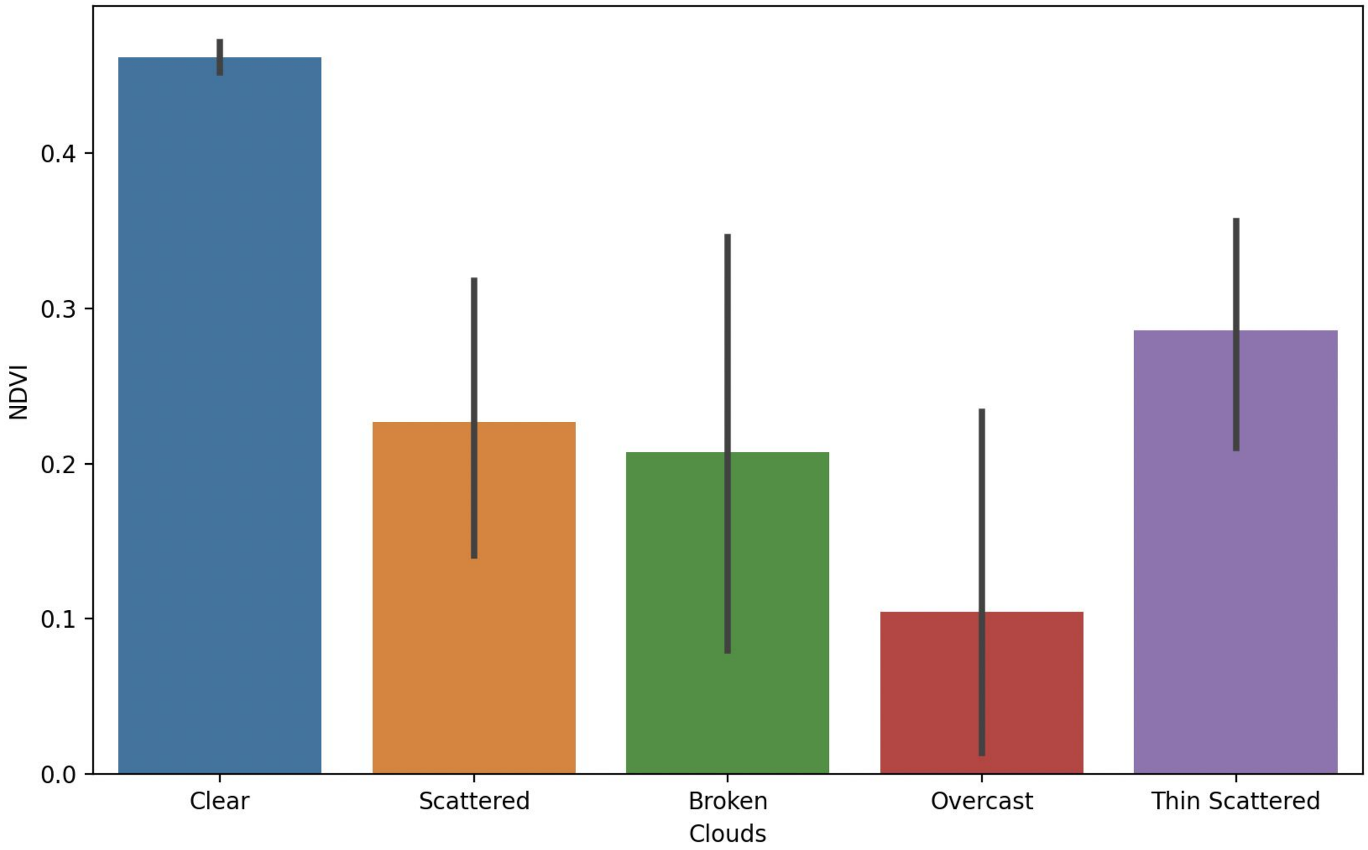


Chart produced by Kristi Le

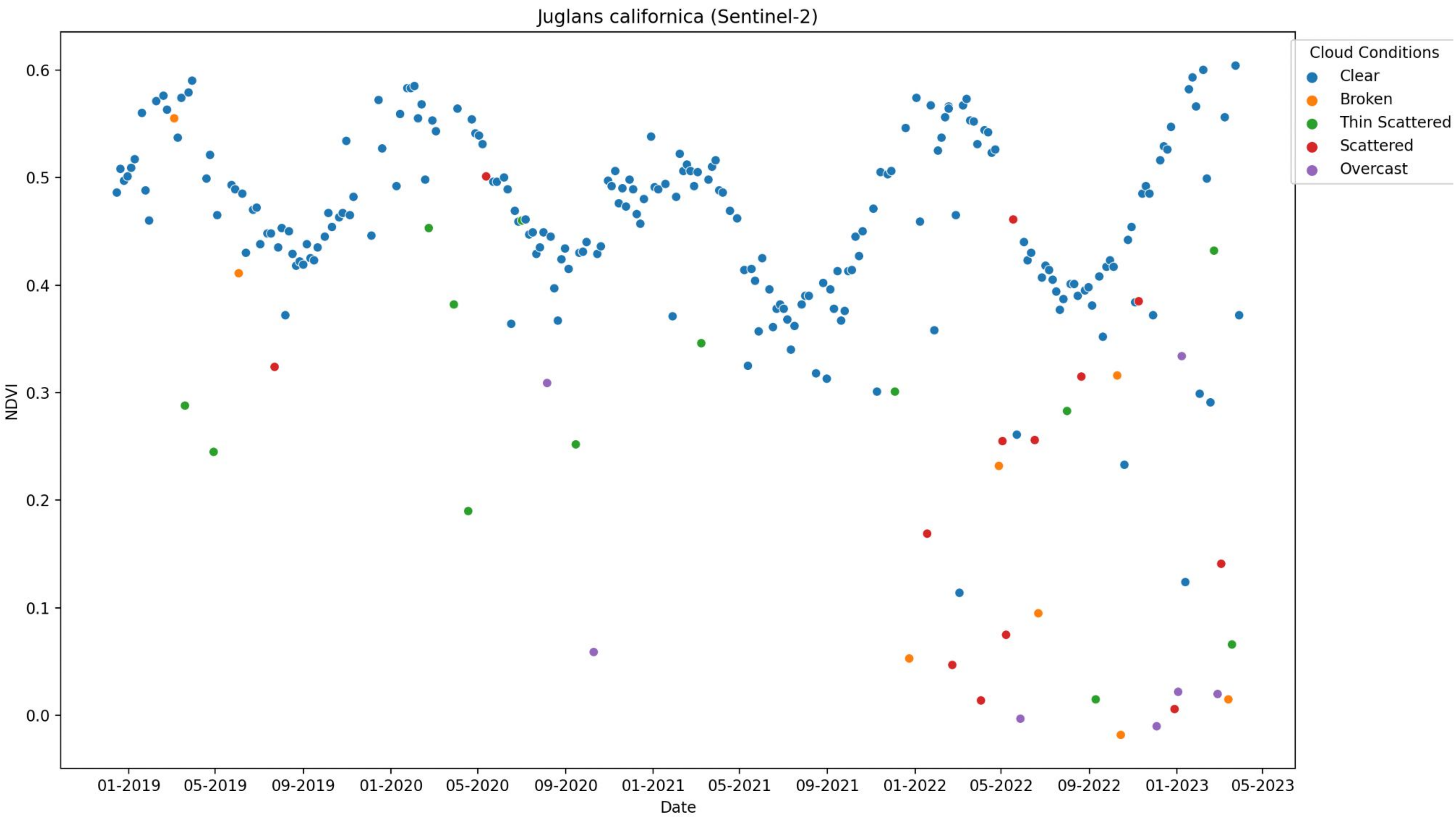
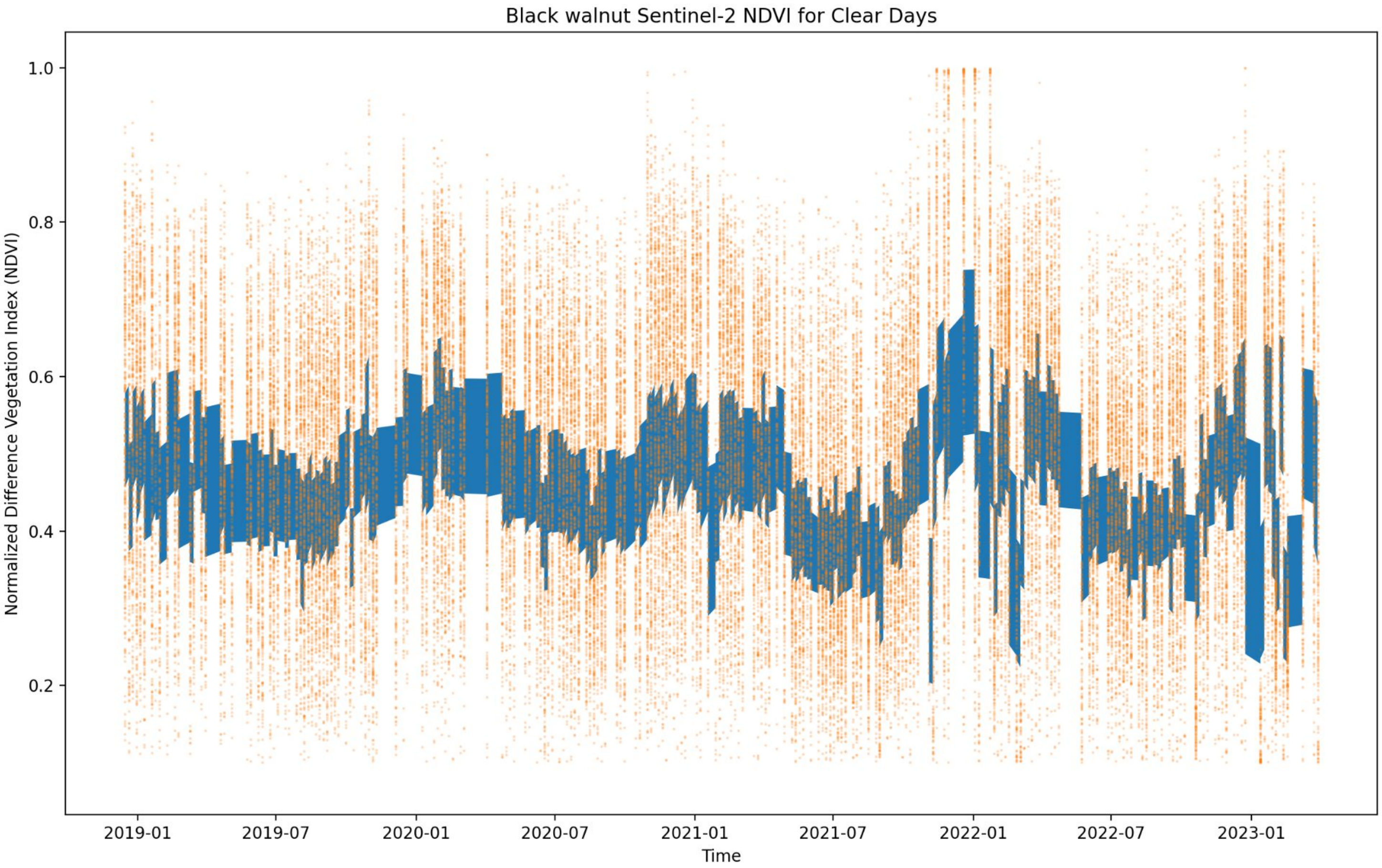


Chart produced by Kristi Le



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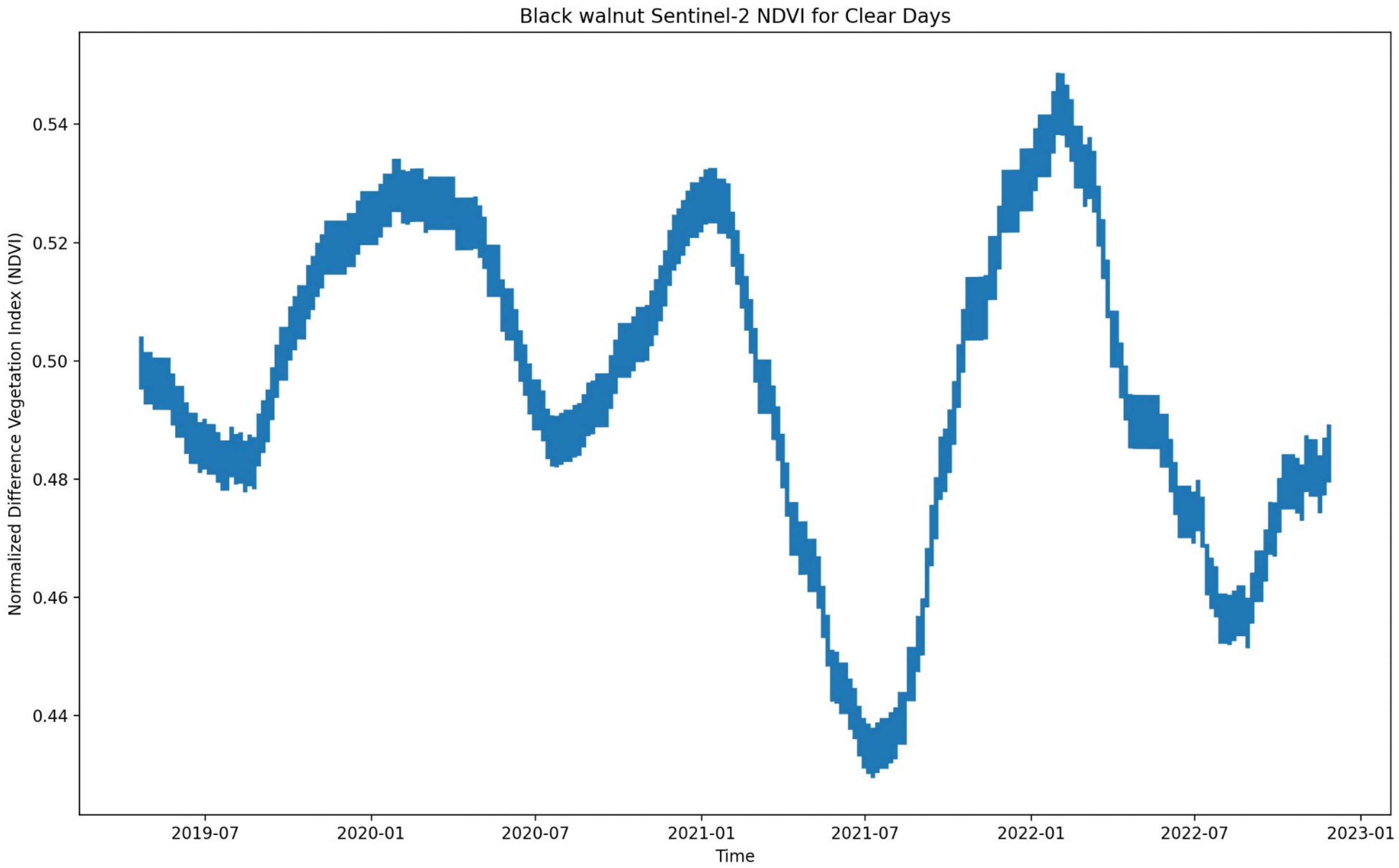


Chart produced by Kristi Le

NDVI Ranges for individual *Juglans californica*

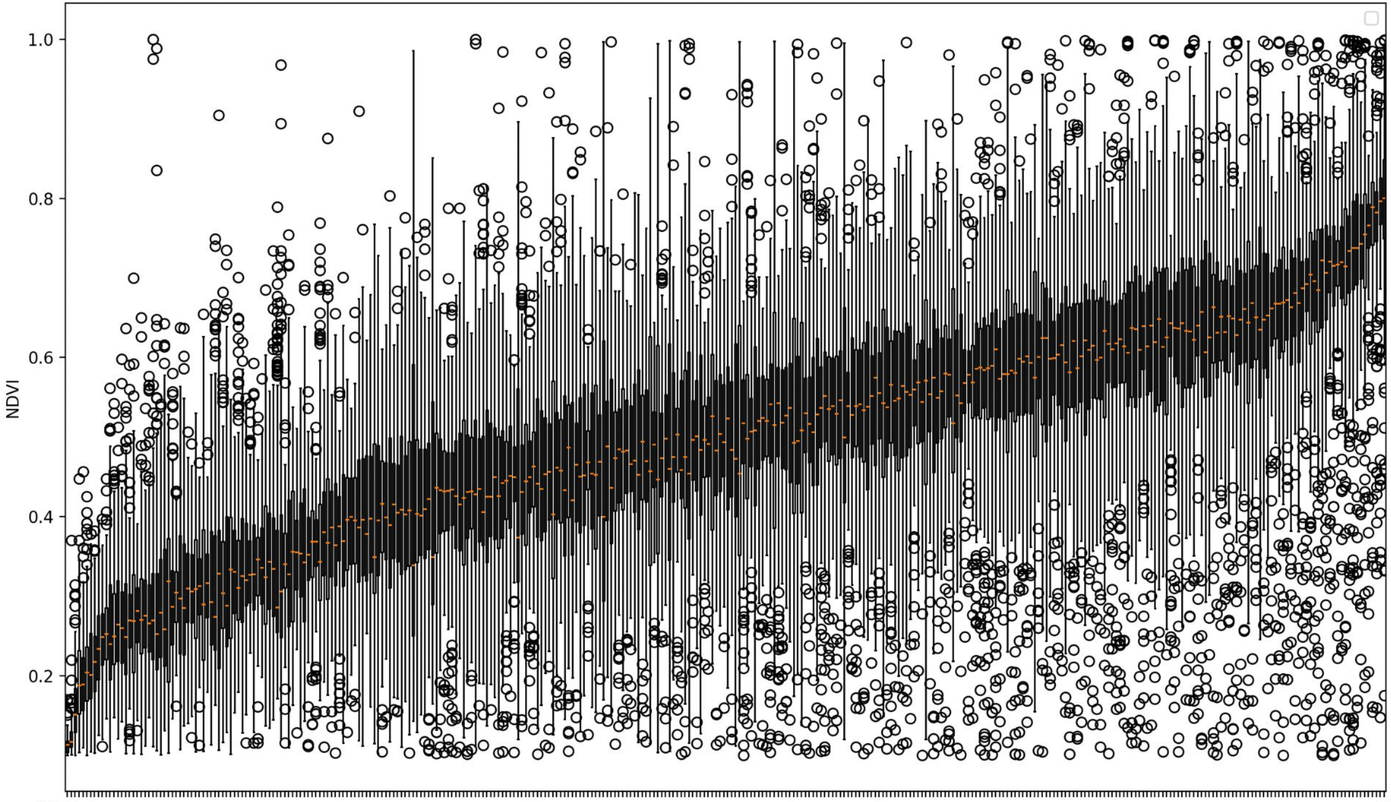
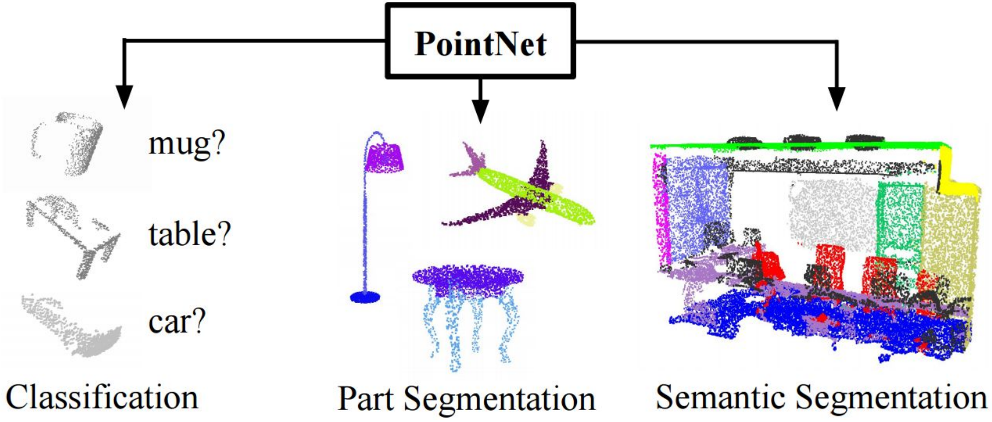


Chart produced by Kristi Le

3D Fully Convolutional Neural Network

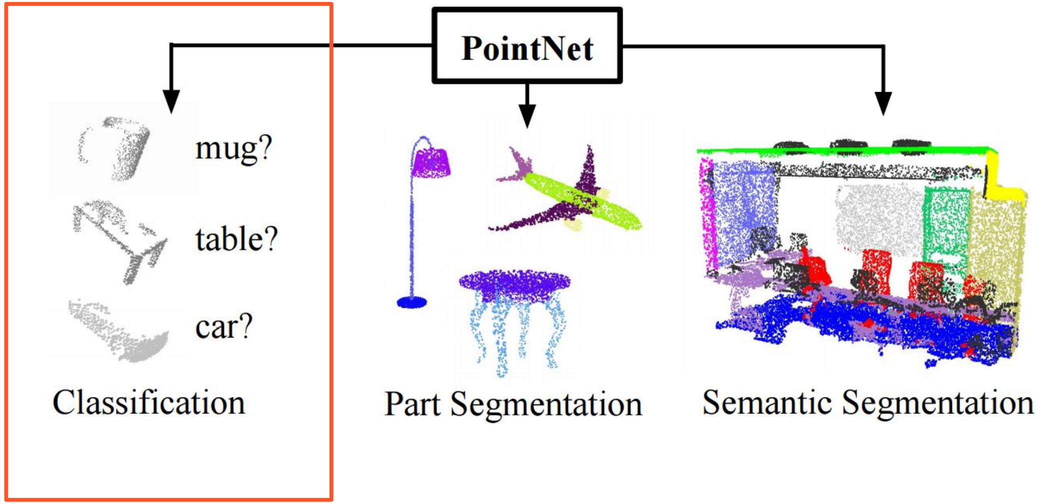


Originally made to classify and segments objects of interest in 3-D point clouds.

We engage in transfer learning to apply to tree species classification using aerial LiDAR.

Figure source: Qi et al. 2017

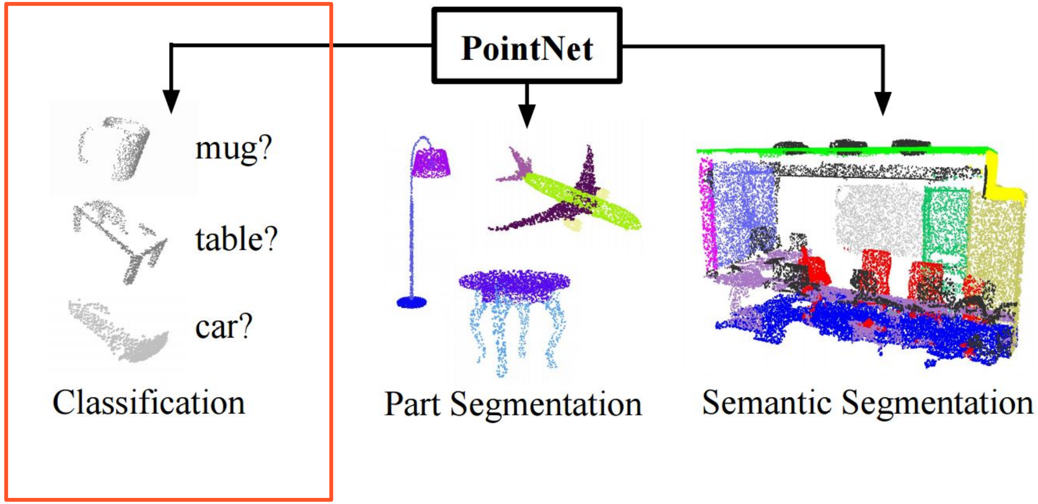
3D Fully Convolutional Neural Network



Randomly select 128 points per tree to create a uniform object to input into the PointNet architecture.

Classification based on structure (X, Y, Z) and reflectance (NIR, R, G)

Point Cloud Classification



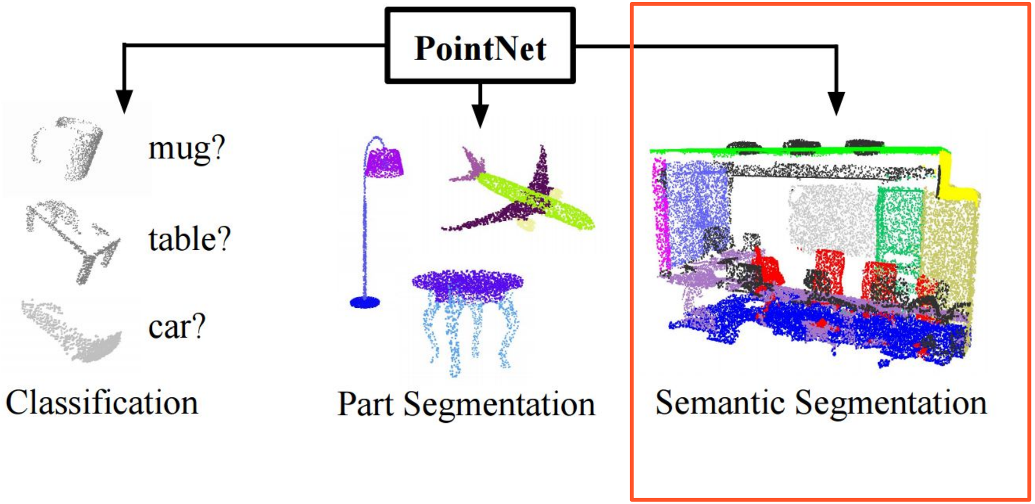
Results for our target species were not ideal:

~20% accuracy for individual species

~40% accuracy when grouped by structural similarity

~60% accuracy when grouped by structural & reflective similarity

3D Fully Convolutional Neural Network



Feeding the model entire LiDAR scenes (¼ - ½ mile grids), and segmenting for target trees based on previously classified scenes.

Classification is still based on structure (X, Y, Z) and reflectance (NIR, R, G)

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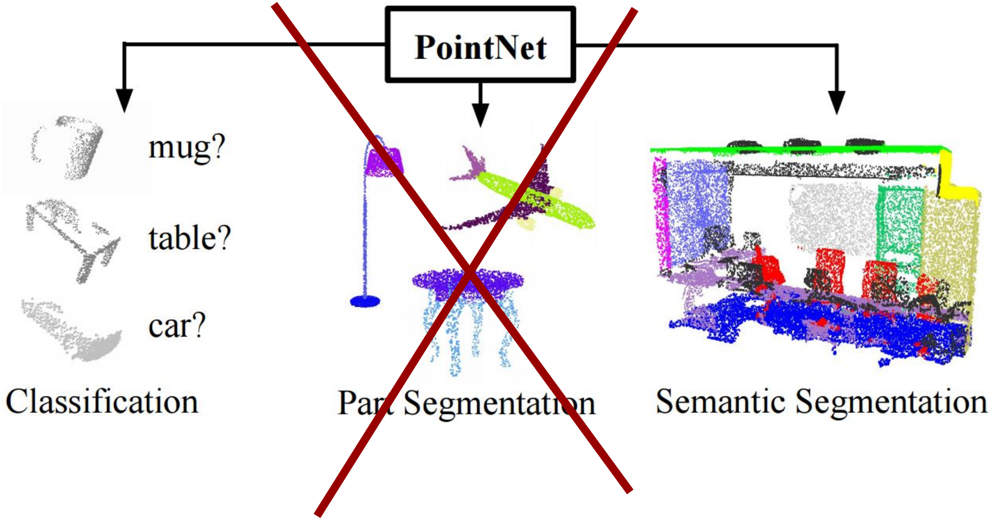
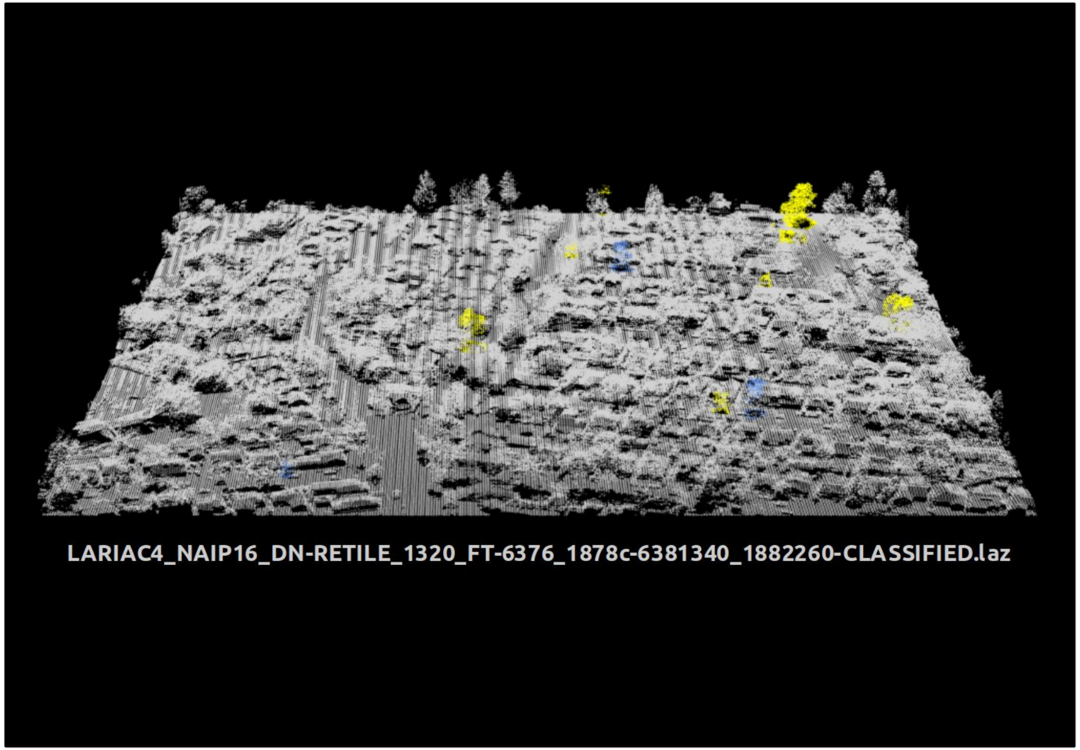
3D Fully Convolutional Neural Network



We do not need PointNet's part segmentation, since we are not looking to separate our target species into parts (i.e. branch, canopy, stem, etc.)

Data Processing:
Processing gridded scenes for semantic parsing.



Grid-naming Scheme:
LARIAC4_NAIP16_DN-RETILE_1320_FT-6376_1878c-6381340_1882260-CLASSIFIED.laz

LiDAR & Optical Data	Grid Size	Tile	Center X, Y	Classified
LARIAC4_NAIP16_DN	RETILE_1320_FT	6376_1878c	6381340_1882260	CLASSIFIED.laz

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Data Structure:

Attributes used in scene semantic parsing.

las	S4 [743476 x 20] (lidR::LAS)	S4 object of class LAS
data	list [743476 x 20] (S3: data.t	A data.table with 743476 rows and 20 columns
X	double [743476]	6363520 6363520 6363520 6363520 6363520 6363520 ...
Y	double [743476]	1898704 1898705 1898712 1898712 1898727 1898734 ...
Z	double [743476]	18.9 19.1 22.5 22.7 20.8 17.5 ...
gpstime	double [743476]	0 0 0 0 0 0 ...
Intensity	integer [743476]	0 0 0 0 0 0 ...
ReturnNumber	integer [743476]	1 1 1 1 1 1 ...
NumberOfReturns	integer [743476]	1 1 1 1 1 1 ...
ScanDirectionFlag	integer [743476]	0 0 0 0 0 0 ...
EdgeOfFlightline	integer [743476]	0 0 0 0 0 0 ...
Classification	integer [743476]	0 0 0 0 0 0 ...
Synthetic_flag	logical [743476]	FALSE FALSE FALSE FALSE FALSE FALSE ...
Keypoint_flag	logical [743476]	FALSE FALSE FALSE FALSE FALSE FALSE ...
Withheld_flag	logical [743476]	FALSE FALSE FALSE FALSE FALSE FALSE ...
ScanAngleRank	integer [743476]	0 0 0 0 0 0 ...
UserData	integer [743476]	0 0 0 0 0 0 ...
PointSourceID	integer [743476]	0 0 0 0 0 0 ...
R	integer [743476]	44461 44461 44461 45232 33924 32125 ...
G	integer [743476]	35723 35723 35466 35980 27499 27242 ...
B	integer [743476]	33667 33667 33410 33667 26985 26471 ...
N	integer [743476]	35209 35209 34952 37008 26471 25186 ...

1. Structure: X, Y, Z
2. Classification: 0, 'No species,' 1 – 31, 'Species name'
3. Spectral: R, G, B, N

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Project Assessment

To best serve the needs of our stakeholders, we have to weigh the processing and computational needs of 3-D point cloud classification vs. other traditional forms of species classification using remote sensing.

Even if the **scene semantic parsing** yields better results than a raster-based classification (2-D), will the results be significant enough to justify the complex workflow?

Next Stakeholder meeting: May, 31

Thank you!

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