

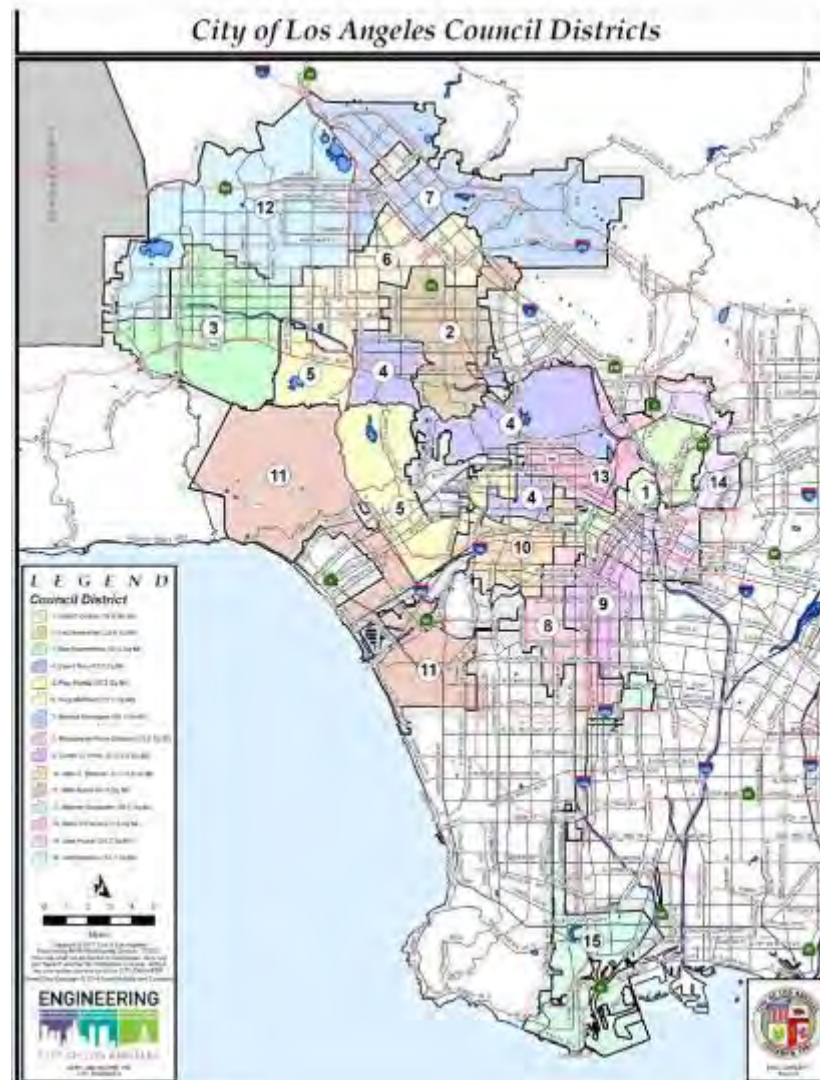
# DRONE ANALYSIS OF THE URBAN FOREST



**PARKPROUDLA**

# CITY OF LOS ANGELES

- ▶ Population over 4,000,000
- ▶ 469 square miles
- ▶ 15 council districts
- ▶ 2<sup>nd</sup> most populous city in the US
- ▶ Historical home of the Gabrieleno, Gabrielino, Tongva and Kizh
- ▶ Claimed for Spain in 1542
- ▶ Founded in 1781 under Spanish governor Felipe de Neve



# DEPARTMENT OF RECREATION AND PARKS

- ▶ Over 16,000 Acres Of Park Land
- ▶ ~551 Parks & Sections Of Parks
- ▶ 187 Recreation Centers
- ▶ Cabrillo Aquarium, Beaches And Lakes
- ▶ Campgrounds
- ▶ Child Care Centers
- ▶ Sleep Over & Day Camps
- ▶ Dog Parks





# DEPARTMENT OF RECREATION AND PARKS

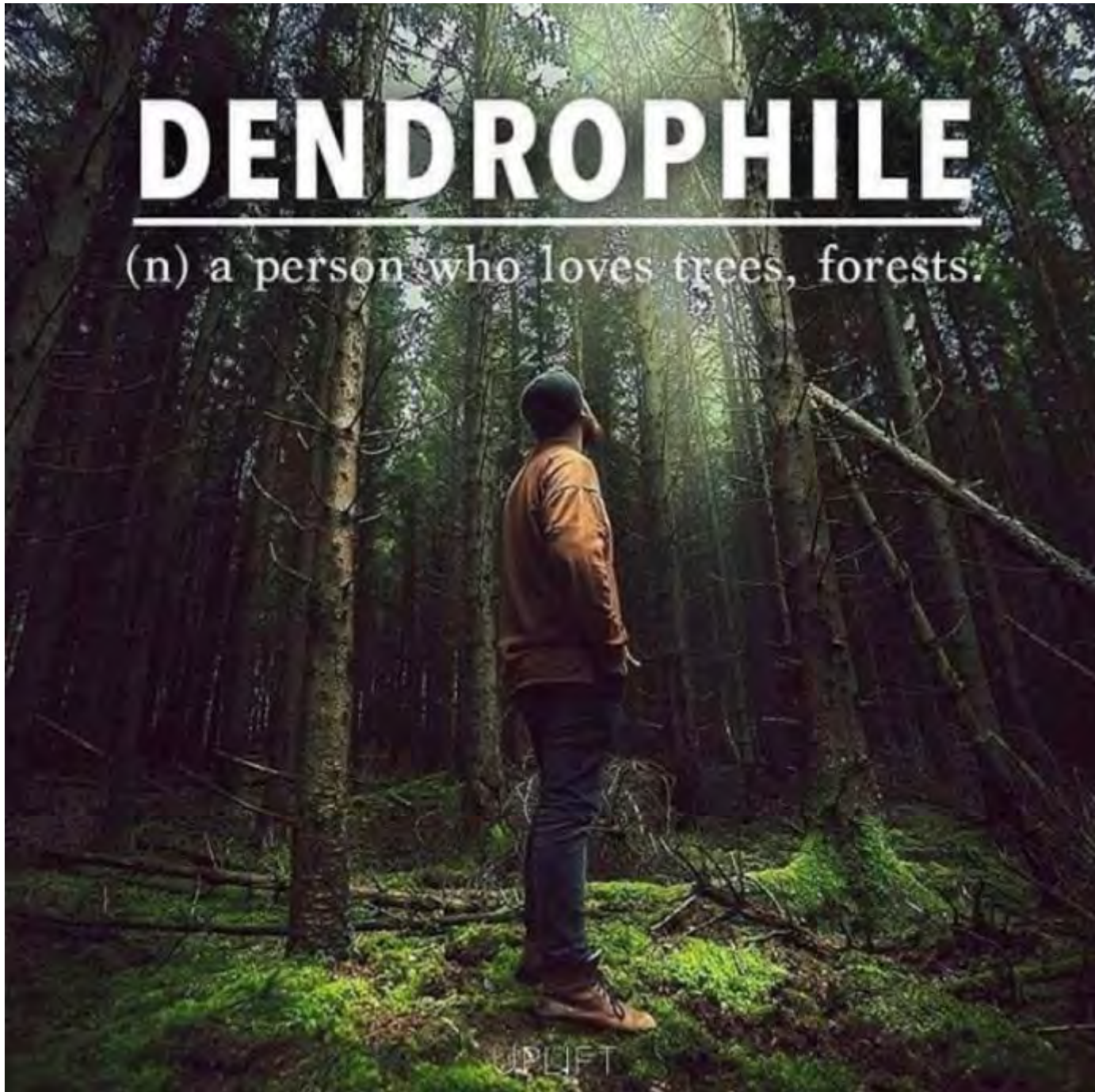
- ▶ 11 Golf Courses
- ▶ Griffith Observatory
- ▶ Greek Theater
- ▶ Historical Sites
- ▶ Museums
- ▶ Senior Citizen Centers
- ▶ Skate Parks
- ▶ Swimming Pools
- ▶ Universal Access Playgrounds



**PARK PROUD LA**

# DENDROPHILE

(n) a person who loves trees, forests.



**PARK PROUD LA**

# TREES PROVIDE MANY BENEFITS



**Trees Are  
THE ANSWER**



**PARK PROUD LA**



# BENEFITS OF A TREE INVENTORY

- ▶ Data driven management
- ▶ Reduce risk and liability & increase public safety
- ▶ Justify budgets
- ▶ Improve tree health
- ▶ Increased efficiency
- ▶ Facilitate short-term and long-term planning
- ▶ Determine value of urban forest
- ▶ Analyze environmental benefits



# TREE INVENTORY

MANAGE IT

YOU NEED TO KNOW WHAT YOU HAVE BEFORE YOU CAN



**PARK PROUD LA**



# RECREATION & PARKS INVENTORY

- ▶ Started in 2004 with a Trimble backpack collection unit
- ▶ Collected limited data
- ▶ Heavy and cumbersome
- ▶ Completed ~8,400 sites
- ▶ Focused on “special tree”



**PARK PROUD LA**

# RECREATION & PARKS INVENTORY

- ▶ ~2008 we acquired Davey Resource Group's TreeKeeper 7
- ▶ Both a tree (or asset) inventory and work management software
- ▶ In 2012 we were awarded a Cal Fire grant totaling \$275,000
- ▶ Added another ~53,000 sites to the inventory
- ▶ Currently using TreeKeeper 8





# TREEKEEPER 8

- ▶ PROACTIVE
- ▶ Adjustable user permissions
- ▶ Work planning
- ▶ Call tracking
- ▶ Comprehensive reporting
- ▶ Calculate ecosystem benefits





# TREEKEEPER 8

- ▶ MOBILE
- ▶ Manage all data in the field
- ▶ Coordinate field work
- ▶ Attach photos
- ▶ Location-aware interface
- ▶ Mobile device friendly



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# CAL FIRE GRANTS

- ▶ California Climate Investments Urban Forestry Program
- ▶ Grants are funded through the states effort to offset greenhouse gases (GHGs)
- ▶ Projects must result in a net GHG benefit
- ▶ Provide environmental services
- ▶ Cost effective solutions to the needs of urban communities



# CAL FIRE GRANTS

- ▶ Net GHG benefits include, but are not limited to:
- ▶ Increased water supply
- ▶ Clean air and water
- ▶ Reduced energy use
- ▶ Flood and stormwater management
- ▶ Recreation
- ▶ Urban revitalization
- ▶ Improved public health
- ▶ Producing useful products such as bio-fuel, clean energy, high quality wood



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# CAL FIRE GRANTS

- ▶ Common projects include:
- ▶ Tree inventories
- ▶ Urban forest management plans
- ▶ Tree planting projects
- ▶ Urban wood recycling and reuse
- ▶ Workforce development
- ▶ Canopy cover surveys



## CAL FIRE Urban and Community Forestry Grant Awards

2021/22	40	\$29.9M	14 Awards \$12,964,475	13 Awards \$12,434,035	13 Awards \$4,509,820	37,159	171,789	172,967	17
GRANT PERIOD	AWARDS	TOTAL FUNDING	URBAN FOREST EXPANSION AND IMPROVEMENT	EDUCATION AND WORKFORCE DEVELOPMENT	URBAN FOREST MANAGEMENT ACTIVITIES	TOTAL TREES	CARBON STORED (MT)	NET GHG BENEFIT (MT)	COUNTIES SERVED



**PARK PROUD LA**

# CAL FIRE GRANT FOR INVENTORY

- ▶ 2017/2018 CALIFORNIA CLIMATE INVESTMENTS URBAN FORESTRY PROGRAM
- ▶ In the end of 2017 we started our application for a grant to complete our tree inventory
- ▶ Concept proposals were due on February 26, 2018
- ▶ We were invited back for the full proposal
- ▶ Besides completing our inventory we proposed to:
- ▶ Plant 680 trees in disadvantaged communities
- ▶ Hold trainings on inventory and structural pruning
- ▶ Hold volunteer tree planting and tree care events
- ▶ Produce reports and outreach material



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# TREE INVENTORY

## MINIMUM DATA COLLECTION FROM CAL FIRE

- ▶ Species, geo-location (gps), site id, height, DBH
- ▶ Overall condition, maintenance needs, clearance requirements
- ▶ Hardscape damage, overhead utilities
- ▶ Growth space type, space size, any additional notes
- ▶ Rap also collects: foliage and wood condition
- ▶ Primary defect/observation, secondary maintenance task
- ▶ Pest/pathogen, ISHB, further inspection
- ▶ Protected, heritage, historic



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# CAL FIRE GRANT FOR INVENTORY

- We were awarded the grant in the summer of 2018



# CAL FIRE GRANT FOR INVENTORY

- ▶ Cal fire awarded us \$1,312,500.00
- ▶ Our match was \$450,000.00
- ▶ We assumed we had ~300,000 trees to inventory based on trees per acre estimates
- ▶ We went out to bid for a contractor to do the inventory
- ▶ Davey Resource Group (DRG) was awarded the contract.
- ▶ Which was fortunate as we use their tree inventory/work management system treekeeper 8
- ▶ Grant was to run through March 2022 with all deliverables due June 2022
- ▶ We extended the grant for 1 year due to Covid 19



# CAL FIRE GRANT FOR INVENTORY

- ▶ We partnered with the Los Angeles Conservation Corps
  - ▶ They oversaw the tree plantings and tree care
  - ▶ All trees received supplemental watering, mulch and repairs to stakes twice a month from June through October for 3 years
- ▶ We also partnered with City Plants, the Mayor's tree planting non-profit to oversee the volunteer tree planting events
  - ▶ 2/3s of our trees were planted by volunteers
  - ▶ We held a Winter Wonderland event, Arbor Day event, Earth Day event, Tu Bishvat/MLK Jr day of service events



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# CAL FIRE GRANT FOR INVENTORY

## Drone Analysis

- Use aerial monitoring (i.e., drone) in hard to access parts of parks to assess species diversity and vegetative health and to help reduce the risk of wildfire and locate invasive species, pests, or disease.



# Drone Data Collection Process in Elysian Park



**PARK PROUD LA**



# CAL FIRE GRANT FOR INVENTORY

## Drone Analysis

- ▶ A drone was flown over areas of Elysian and Griffith Parks to collect aerial imagery where physical access was limited by terrain and other conditions.
- ▶ Using a multispectral camera, the drone captured infrared, red-edge aerial imagery.
- ▶ Analysis of the imagery, specifically the differences in light reflectance, illustrates variations and reductions in the plant pigment chlorophyll, which cannot be seen by the human eye.

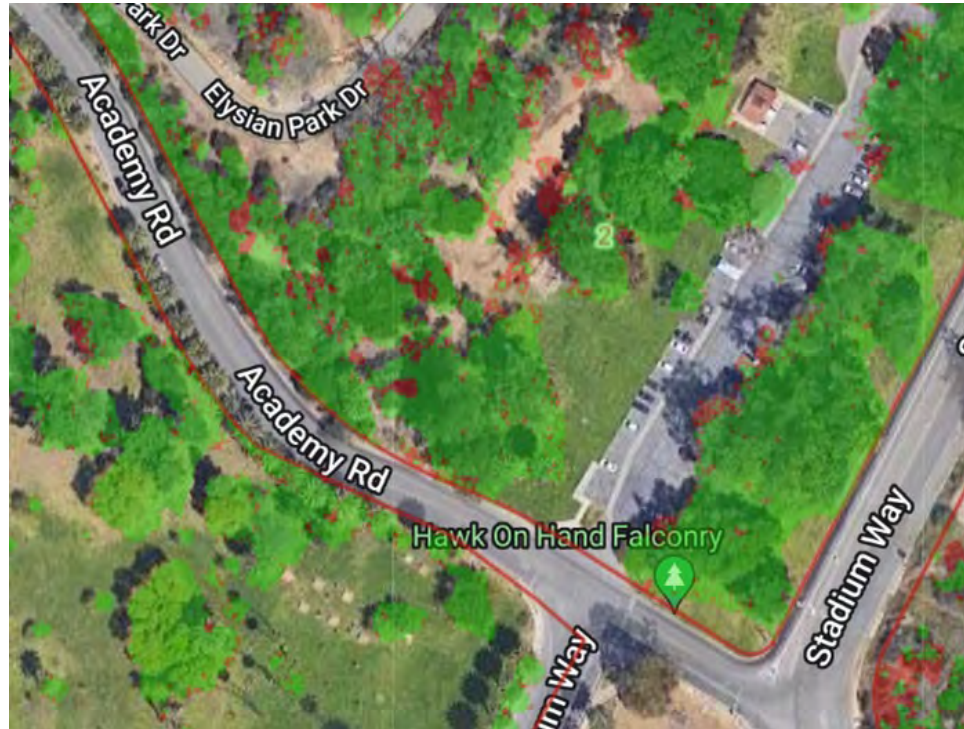




# CAL FIRE GRANT FOR INVENTORY

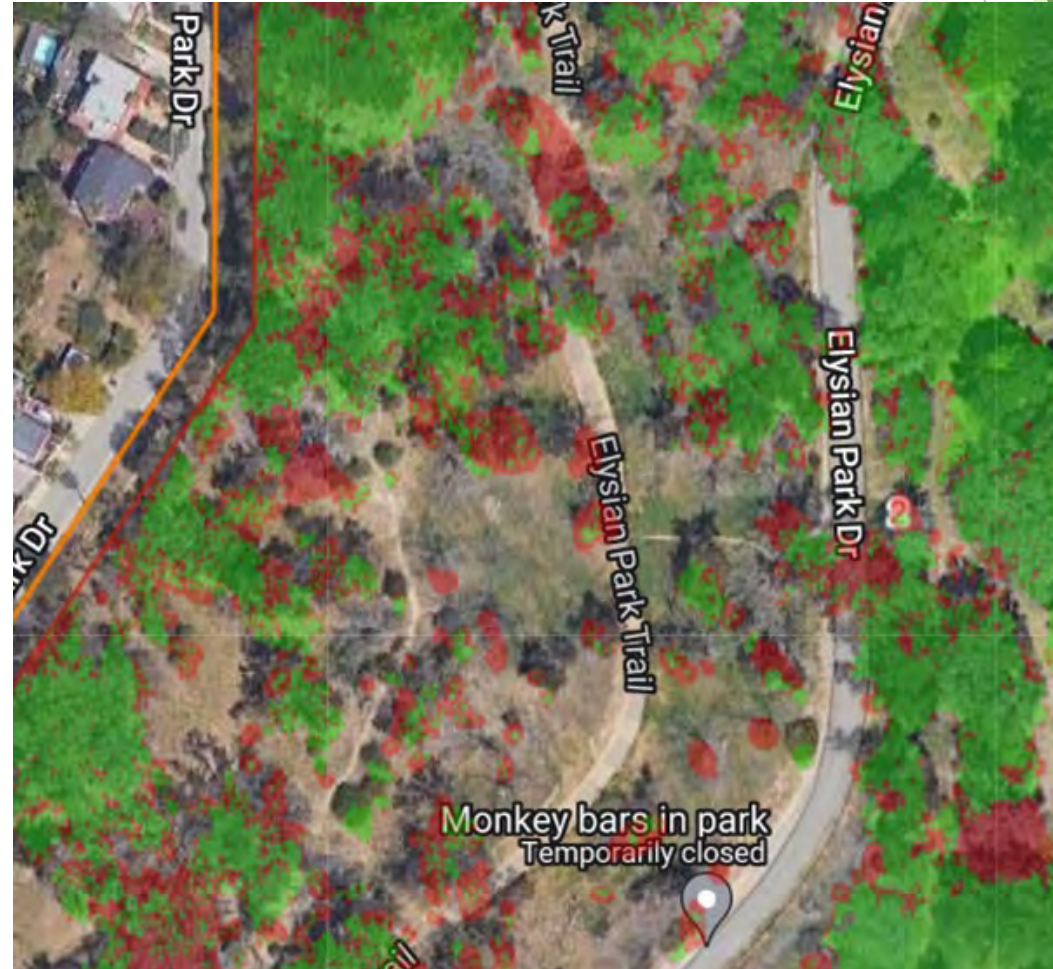
## Drone Analysis

- ▶ The drone assessment is a reflection, quite literally, of **internal plant stress**, while the ground-based data collection is based on the external appearance of the trees.
- ▶ Understandably, these **different methodologies result in variable findings** that should be assumed to be complementary rather than contradictory.
- ▶ A tree that appears healthy to the human eye may still be **experiencing stress**, which can be made visible through infrared, red-edge spectrometry.



# CAL FIRE GRANT FOR INVENTORY Drone Analysis

- ▶ These variations of plant pigment chlorophyll can be correlated with canopy health.
- ▶ Stressors that may result in lower chlorophyll levels include drought, nutrient deficiencies, pest infestations, and disease outbreaks.
- ▶ Infrared, red-edge images produced from the drone flyover provide a snapshot of the current condition of tree and shrub canopy within the flight path.
- ▶ Managers can use the imagery to better understand the condition of trees in inaccessible areas, monitor changes in canopy over time, and to estimate fuel loads and potential fire hazards.





# CAL FIRE GRANT FOR INVENTORY

## Drone Analysis

- ▶ Some species found in the drone study area are highly flammable due to traits that result in large amounts of litter, ladder fuels, peeling bark, and plant oils/resins (e.g. *Acacia* spp. and *Eucalyptus* spp.) (San Diego County, 2004).
- ▶ Locations with significant dead or dying vegetation should be further inspected to estimate the extent and severity of damage that would result from a potential wildfire. In addition to fuel loads, factors effecting wildfire severity and outcomes include aspect, terrain, surrounding land cover, structures, and other sources of fuel and combustion.



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# CAL FIRE GRANT FOR INVENTORY

## Drone Analysis

- ▶ Because drone imagery can detect more subtle tree signals, the use of this technology can be a valuable precursor to ground-based inspections.
- ▶ Vegetation health assessment maps can help prioritize tree management activities, including removals, structural pruning, irrigation adjustments, pest control, fertilization, or other alterations in maintenance.



**PARK PROUD LA**

# CAL FIRE GRANT FOR INVENTORY

## Drone Analysis

- ▶ In addition, the imagery and data acquired from the drone assessment can help managers better understand and address fuel loading and fuels management related to wildfire risk.
- ▶ Locations with significant dead or dying vegetation should be further inspected to estimate the extent and severity of damage that would result from a potential wildfire.



**PARK PROUD LA**

# CAL FIRE GRANT FOR INVENTORY

## Elysian Park

- ▶ We started collecting in Elysian Park, 3<sup>rd</sup> largest and one of the oldest parks in the City.
- ▶ Elysian means: relating to or characteristic of heaven or paradise.
- ▶ Also has Chavez Ravine Arboretum, oldest in the City of Angels.
- ▶ Home of Dodger Stadium.





# CAL FIRE GRANT FOR INVENTORY

## Elysian Park Drone Analysis

- ▶ Many of these areas are difficult to access due to steep slopes and and/or thick brush.
- ▶ The areas are largely unmaintained and less than 85% of trees are provided with supplemental irrigation.
- ▶ The areas are characterized as a naturalized habitat, dominated mostly by non-native species such as *Acacia*, *Eucalyptus*, and *Ailanthus*.
- ▶ Prolonged periods of drought have resulted in a decline in tree and vegetation health.



# CAL FIRE GRANT FOR INVENTORY

## Elysian Park Drone Analysis

- ▶ The drone data indicates that **approximately 26%** (22 acres) of all above-ground vegetated cover (including trees, shrubs, and low-lying vegetation) is in a dead or dying state.
- ▶ Data from the **ground-based inventory**, taken within the drone study area, identified **9.2% of trees to be in critical condition or dead**.
- ▶ Therefore, the drone data indicates a higher percentage of vegetation in a dead or dying state when compared to the ground-based data.





# CAL FIRE GRANT FOR INVENTORY

## Elysian Park Drone Analysis

- ▶ Additional information collected during the ground-based inventory provides a more detailed assessment of these areas, including:
- ▶ 69.4% of trees exhibit structural problems
- ▶ 8.1% show general stress or low vigor not attributed to pests or disease
- ▶ 3.6% show signs of disease (e.g. cankers, decay, fruiting bodies, etc.)
- ▶ 1.2% show symptoms of polyphagous shot hole borer infestation (<1% show current borer activity)
- ▶ Evidence of other pests, including sucking insects, woodborers, and defoliators



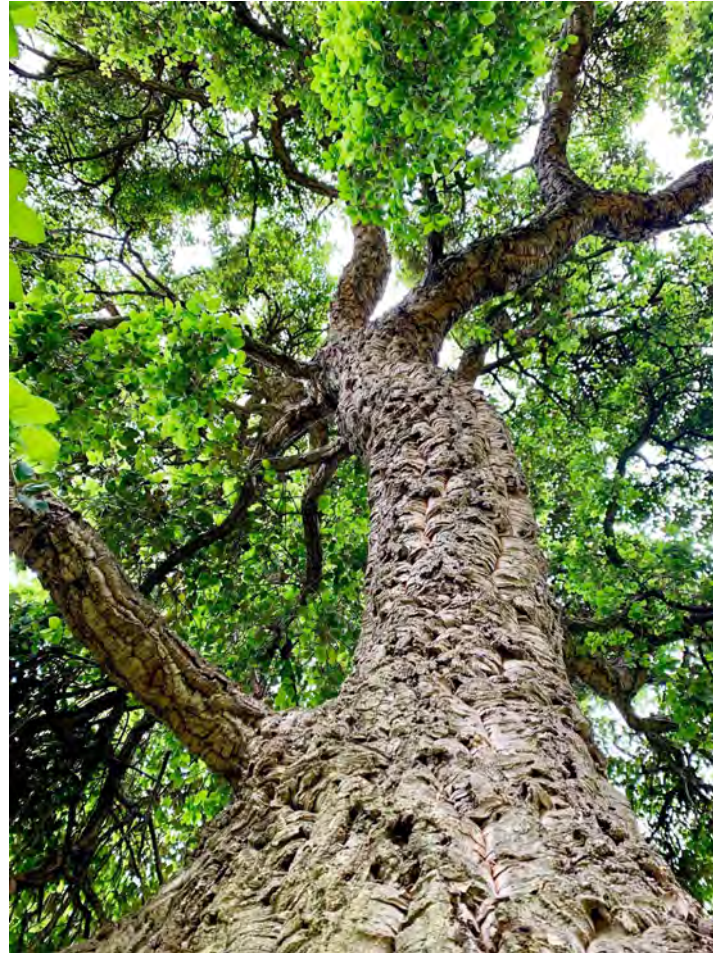
**PARK PROUD LA**



# CAL FIRE GRANT FOR INVENTORY

## Elysian Park Drone Analysis

- ▶ Based on condition ratings alone, 71% of the data collected by the ground-based inventory agreed with the drone acquired assessment.
- ▶ But when visual observations of structural defects, signs of pests and diseases, and signs of stress (a total of 81.2% of trees) collected during the ground-based assessment were reviewed, approximately 85% of the drone findings was corroborated by the ground-based inventory.



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# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK

- ▶ One of the largest municipally-owned parks in the US covering over 4,300 acres.
- ▶ Much of the land donated by the infamous Griffith J. Griffith in 1896.
- ▶ As part of the eastern Santa Monica Mountain range, Griffith Park has rugged terrain and natural areas consisting of chaparral, oak and black walnut woodlands, canyons, and caves.



**PARK PROUD LA**



# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK

- ▶ The park is home to the Griffith Observatory; the Los Angeles Zoo, the Greek Theater and the world famous Hollywood Sign.
- ▶ The park boasts many hiking and equestrian trails through rugged terrain.
- ▶ As well, Griffith Park has golf courses, merry-go-round, train and pony rides, sports fields, tennis courts, picnic areas and children's play areas.





# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK

- ▶ Many of these areas are difficult to access due to steep slopes and/or thick brush.
- ▶ The areas are largely unmaintained with vegetation that consists of 44.2% grass / low lying vegetation, 39.6% shrubs, and 16.1% trees.



# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK



**PARK PROUD LA**

# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS



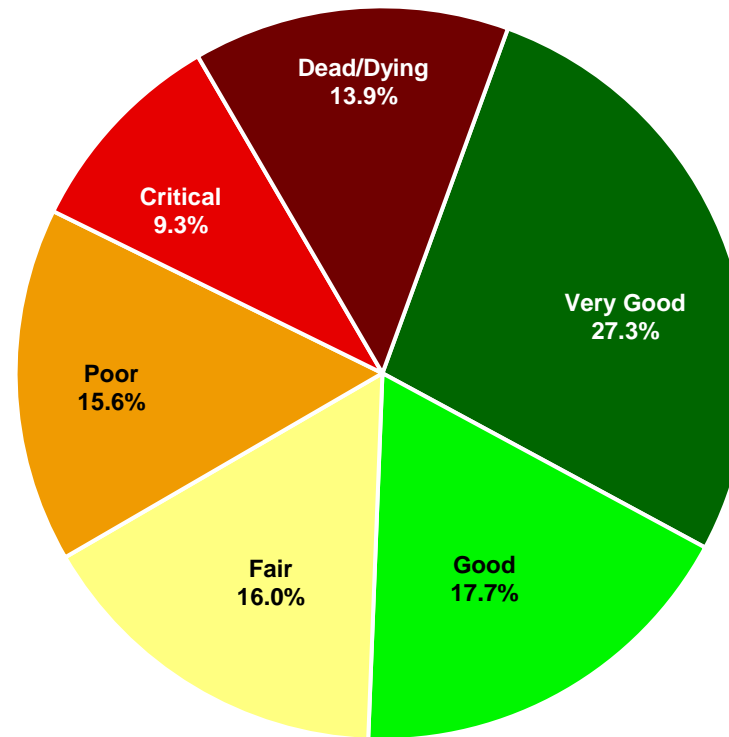
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# CAL FIRE GRANT FOR INVENTORY

## GRIFFITH PARK DRONE ANALYSIS

- ▶ 13.9% (154.3 acres) of all above-ground vegetated cover (including trees, shrubs, and low-lying vegetation) is in a dead or dying state.
- ▶ Data from the ground-based inventory, taken within the drone study area, identified 12.1% of trees to be in critical condition or dead.
- ▶ Therefore, the drone data indicates a higher percentage of vegetation in a dead or dying state when compared to the ground-based data.



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# CAL FIRE GRANT FOR INVENTORY

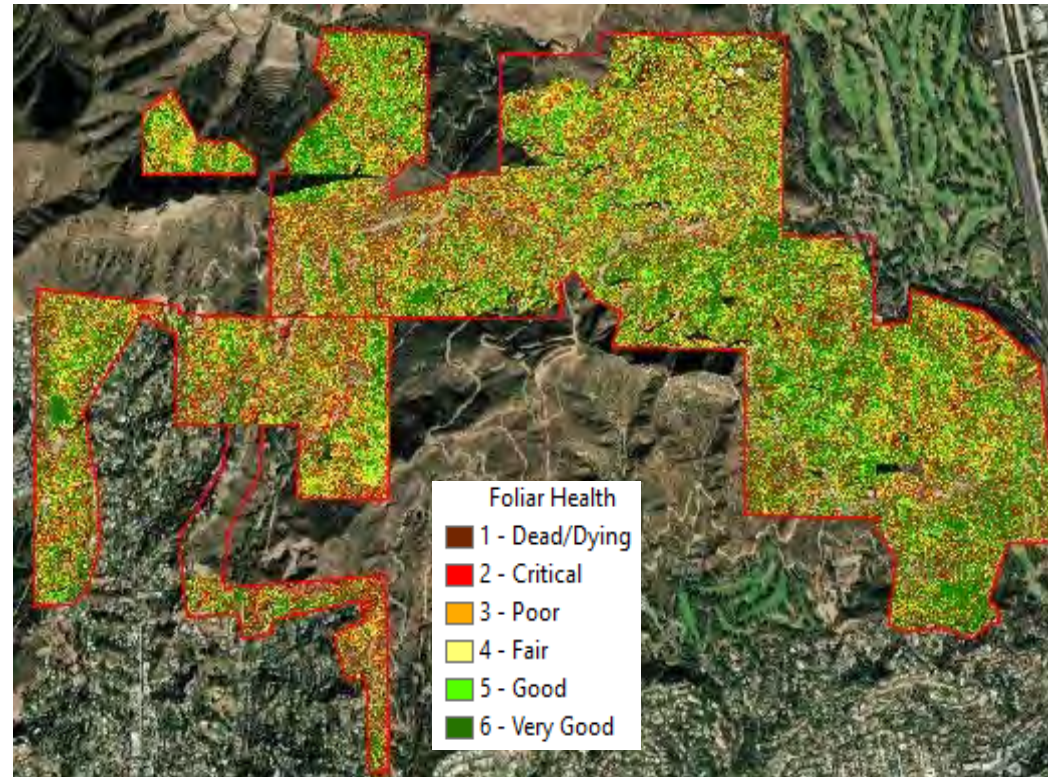
## GRIFFITH PARK DRONE ANALYSIS

- ▶ Additional information collected during the ground-based inventory provides a more detailed assessment of these areas, including:
- ▶ 54.9% of trees exhibit structural problems.
- ▶ 3.7% show general stress or low vigor not attributed to pests or disease 3.2% show signs of disease (e.g., cankers, decay, fruiting bodies).
- ▶ Less than 1% show symptoms of polyphagous shot hole borer infestation.
- ▶ Less than 1% with evidence of other pests, including sucking insects and defoliators.



# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS

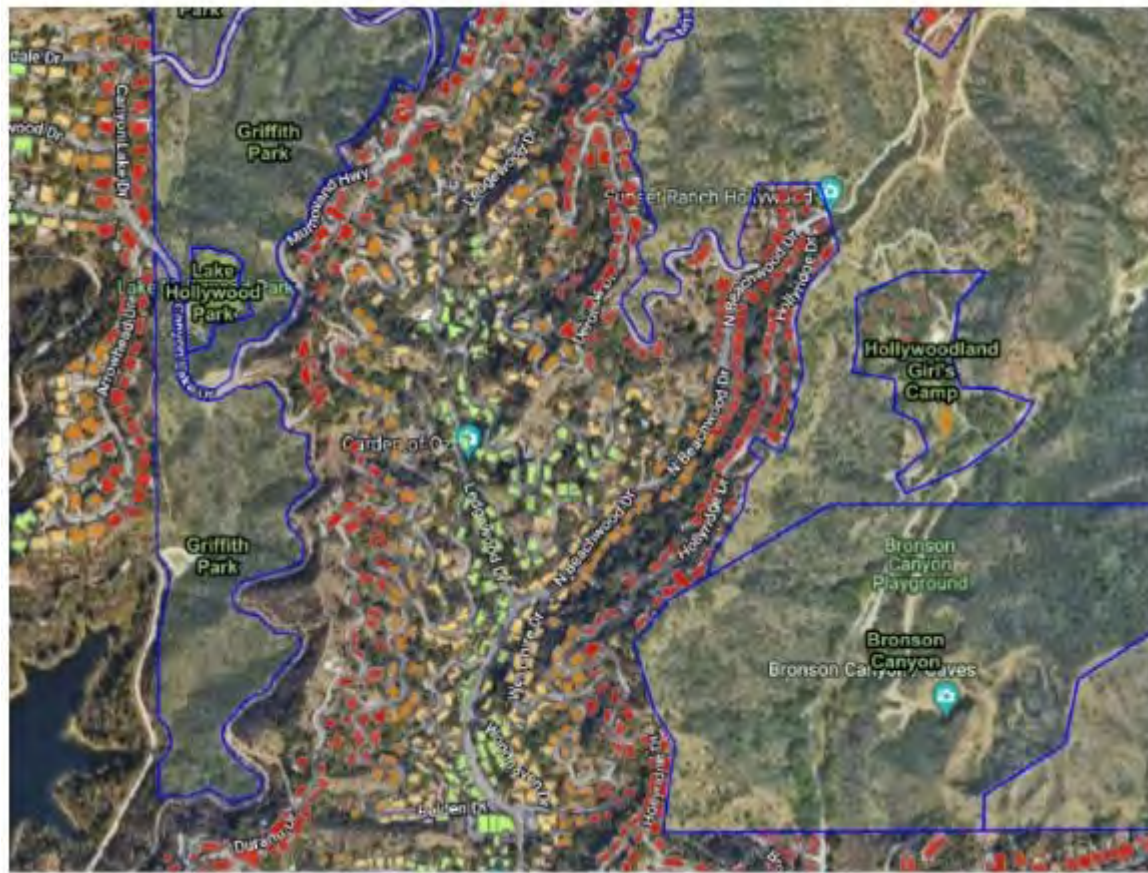
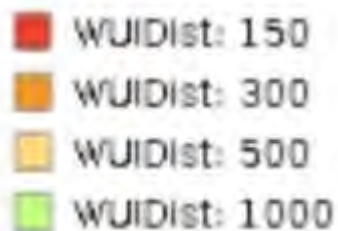
- ▶ A tree that appears healthy to the human eye may still be experiencing stress, which can be made visible through infrared, red-edge spectrometry.
- ▶ Approximately 80% of the drone findings were corroborated by the ground-based inventory.





# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS

- Distance from Buildings



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# CAL FIRE GRANT FOR INVENTORY

## GRIFFITH PARK DRONE ANALYSIS

- ▶ As trees and other vegetation succumb to environmental and physiological stresses, they leave behind highly flammable fuels that can facilitate the rapid spread of small and large fires.
- ▶ The **wildland urban interface (WUI)** is defined as areas where the built environment meets the natural environment and where there is infrastructure adjacent to or within natural areas that exhibit conditions favorable to wildfire.
- ▶ A total of 2,624 buildings are adjacent to Griffith Park's WUI, while 38.3% of buildings are more than 1,000 feet away, 29.4% of structures are within 150 feet.





# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS

## ► Tree Height



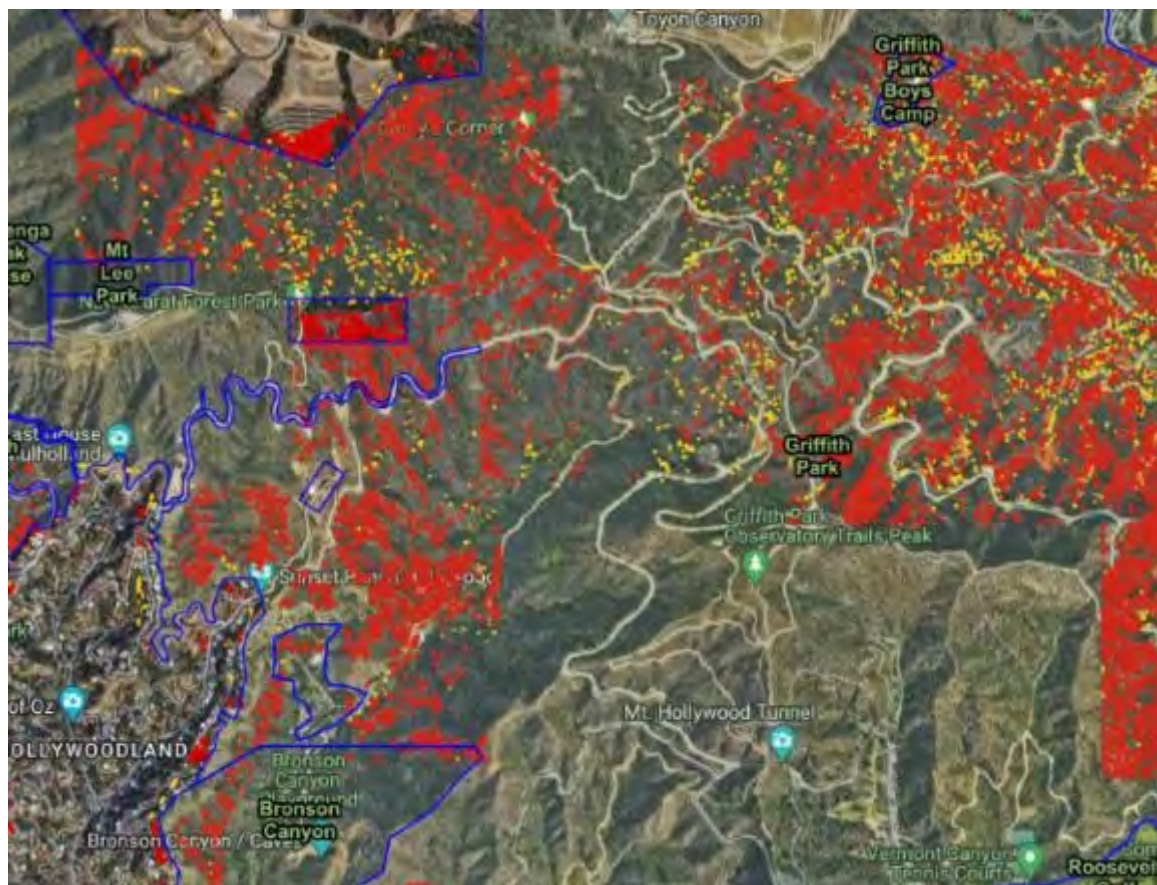


# CAL FIRE GRANT FOR INVENTORY

## GRIFFITH PARK DRONE ANALYSIS

- ▶ Invasive Species
- ▶ *Ricinus communis*
- ▶ *Nicotiana glauca*
- ▶ *Acacia longifolia*
- ▶ *Ailanthus altissima*
- ▶ *Brassica nigra*

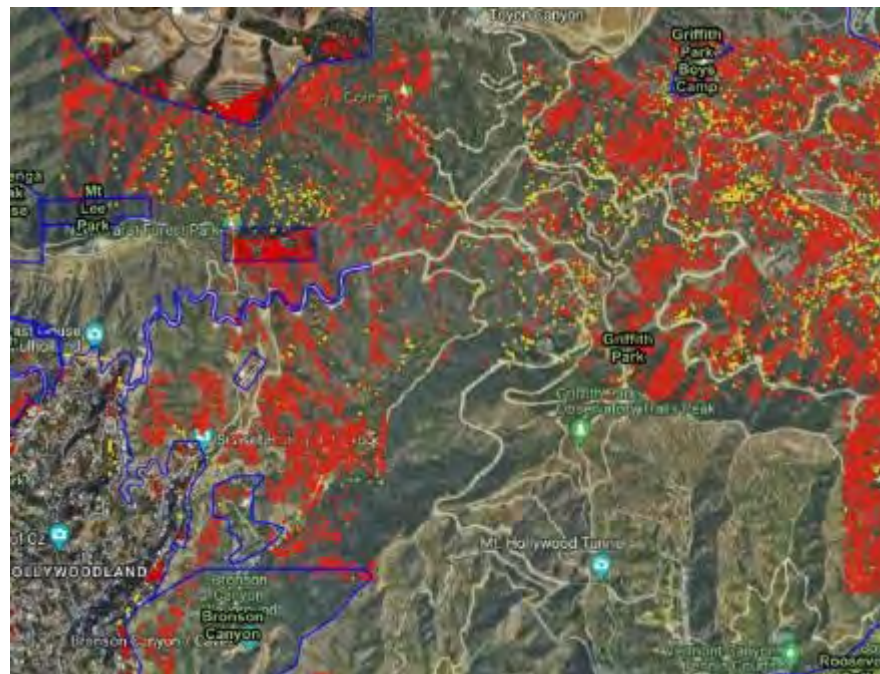
Invasive Species	Predicted Acreage
<i>Ricinus communis</i>	128.40
<i>Nicotiana glauca</i>	23.60
<i>Acacia longifolia</i>	13.60
<i>Ailthanus altissima</i>	2.40
<i>Brassica nigra</i>	0.10
Total	168.10



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# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS

- ▶ Areas consisting of **diverse species**, such as the drone study area, often pose challenging issues for tree species classification.
- ▶ **Species identification** through traditional tree inventories from field surveys can be time consuming and lack the ability to cover large areas in a quick turnaround time.
- ▶ However, the increased availability of very high spatial resolution multispectral imagery coupled with **ground-truthing mechanisms** provide a great opportunity for tree species mapping with levels of greater accuracy.
- ▶ Remote sensing methods, such as the method presented in this report, provide timely and detailed data at a temporal and spatial scale.

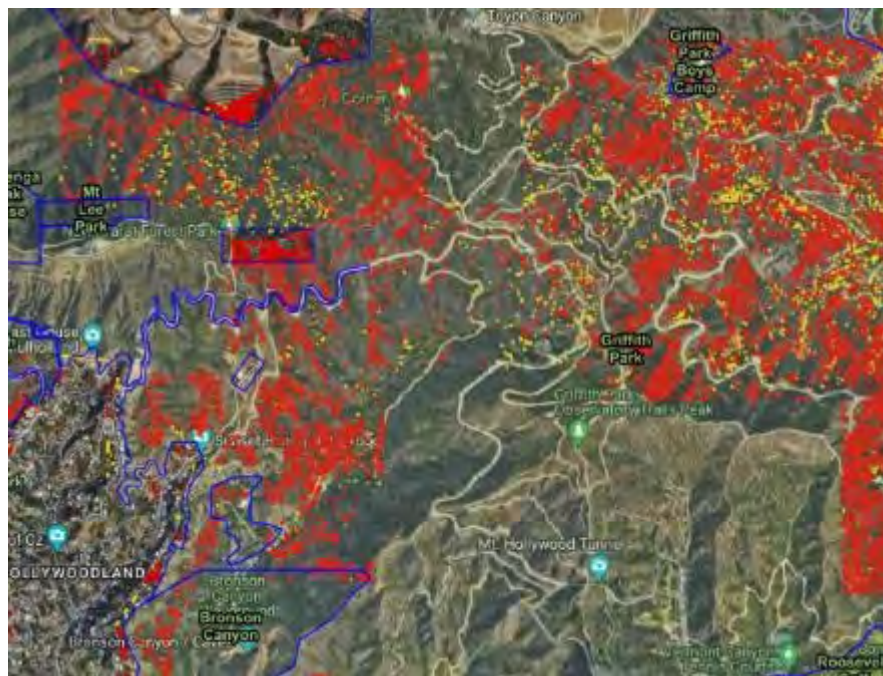


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# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS

- ▶ Overall, 11.7% (168.1 acres) of the land in the drone collection area of Griffith Park could be described as having some predicted infestation of invasive vegetation.
- ▶ When developing goals to combat invasive species, land managers should analyze the types of natural assets currently on the preserve and **prioritize** how much of each cover type in which they want to invest.
- ▶ The **aerial imagery** used as the base layer in the mapping included with this report provides the **baseline data** for future discussions relative to land management objectives.



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# CAL FIRE GRANT FOR INVENTORY GRIFFITH PARK DRONE ANALYSIS

- ▶ Vegetation Type
- ▶ The areas are largely unmaintained with vegetation that consists of 44.2% grass / low lying vegetation, 39.6% shrubs, and 16.1% trees.



# CAL FIRE GRANT FOR INVENTORY

## Obstacles and Success

### Obstacles

- ▶ Terrain, People and Wildlife
- ▶ Flight paths
- ▶ Nesting Birds
- ▶ Technology

### Benefits

- ▶ Determined areas that require further inspected
- ▶ Plan for invasive species eradication
- ▶ Identify and manage fuel loads



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# CAL FIRE GRANT FOR INVENTORY

- ▶ The inventory was finished early and under budget.
- ▶ We conducted a deeper dive into our inventoried trees performing risk assessments, ISHB surveys and inspections of our Heritage trees.
- ▶ We also did specific analyses of our golf courses producing reports and a video.
- ▶ We are also starting to update our Urban Forestry Manual.





# CAL FIRE GRANT FOR INVENTORY

- ▶ In conclusion, City of Los Angeles, Department of Recreation and Parks has a very successful Cal Fire Grant.
- ▶ We formed great partnerships and had much community involvement.



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# CAL FIRE GRANT FOR INVENTORY

- ▶ Completed our inventory.  
Produced meaningful reports based on the best current and accepted scientific methods.
- ▶ Used cutting edge technology (drone analysis) to expand the limits of data and analysis.
- ▶ As the project progressed so did the technology and we cast a wider net gathering more meaningful information.
- ▶ Planted 691 trees



# CONTACT INFO

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