Plume Dynamics of Three Prescribed Fires in Western States

Stephen Drake, PhD, University of Nevada, Reno

Fire and Resource Assessment Program
California Department of Forestry and Fire Protection

Cap and Trade Dollars at Work

Project Participants

- Stephen Drake (PI) – Research Scientist at UNR with background in measuring atmospheric fluxes in forests and snowy environments
- Neil Lareau – Assistant Professor at UNR measuring plume dynamics of wildfires using remote sensing techniques
- Tyler Salas – graduate student in Neil Lareau Lab that participated in the Sycan Marsh Preserve deployments

Examining 3 Prescribed Burns

<u>Sagehen Experimental Forest:</u>
April 29, 2021

<u>Sycan Marsh Preserve:</u>

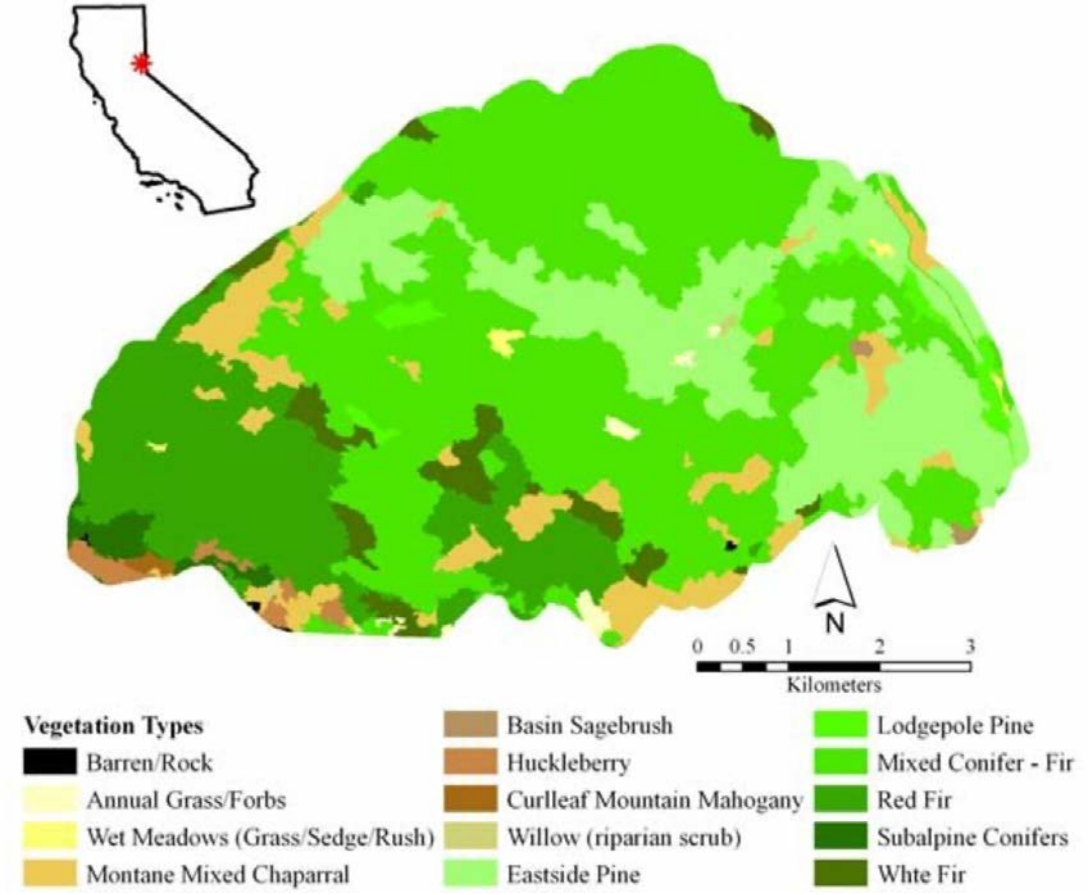
October 25, 2022

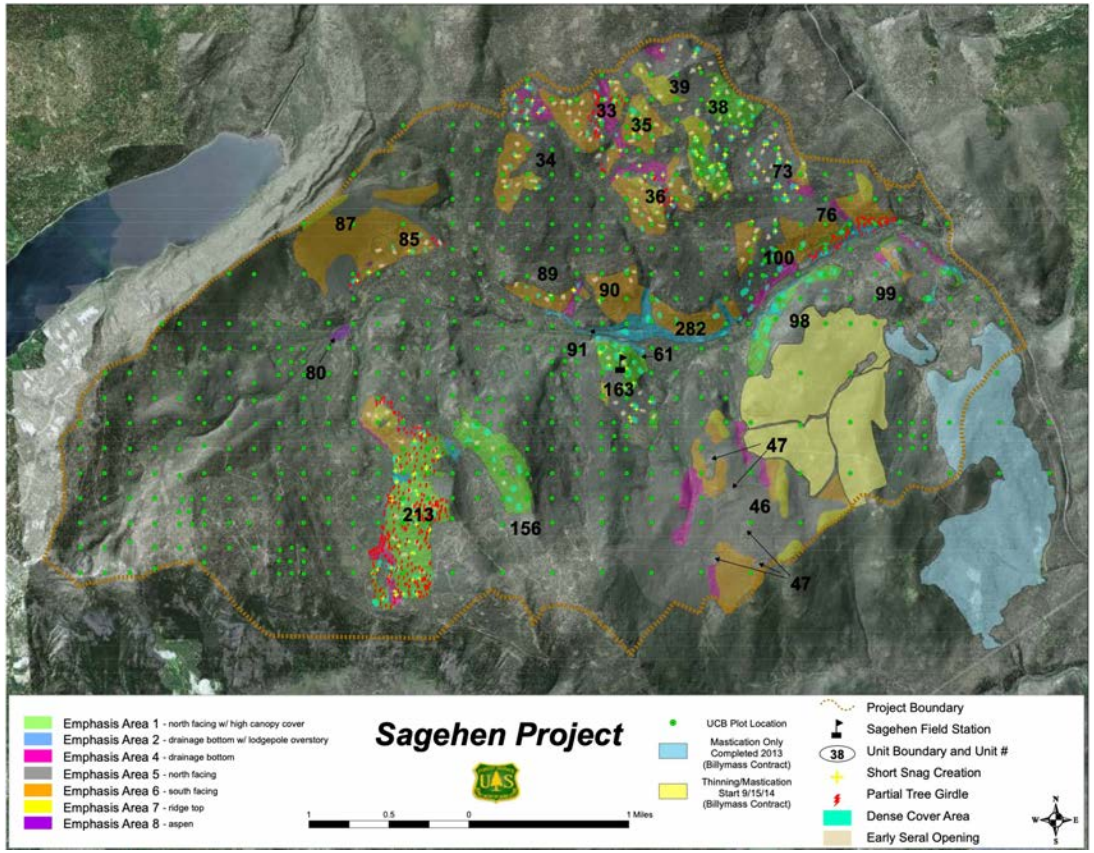
October 26, 2022*

Sagehen Underburn

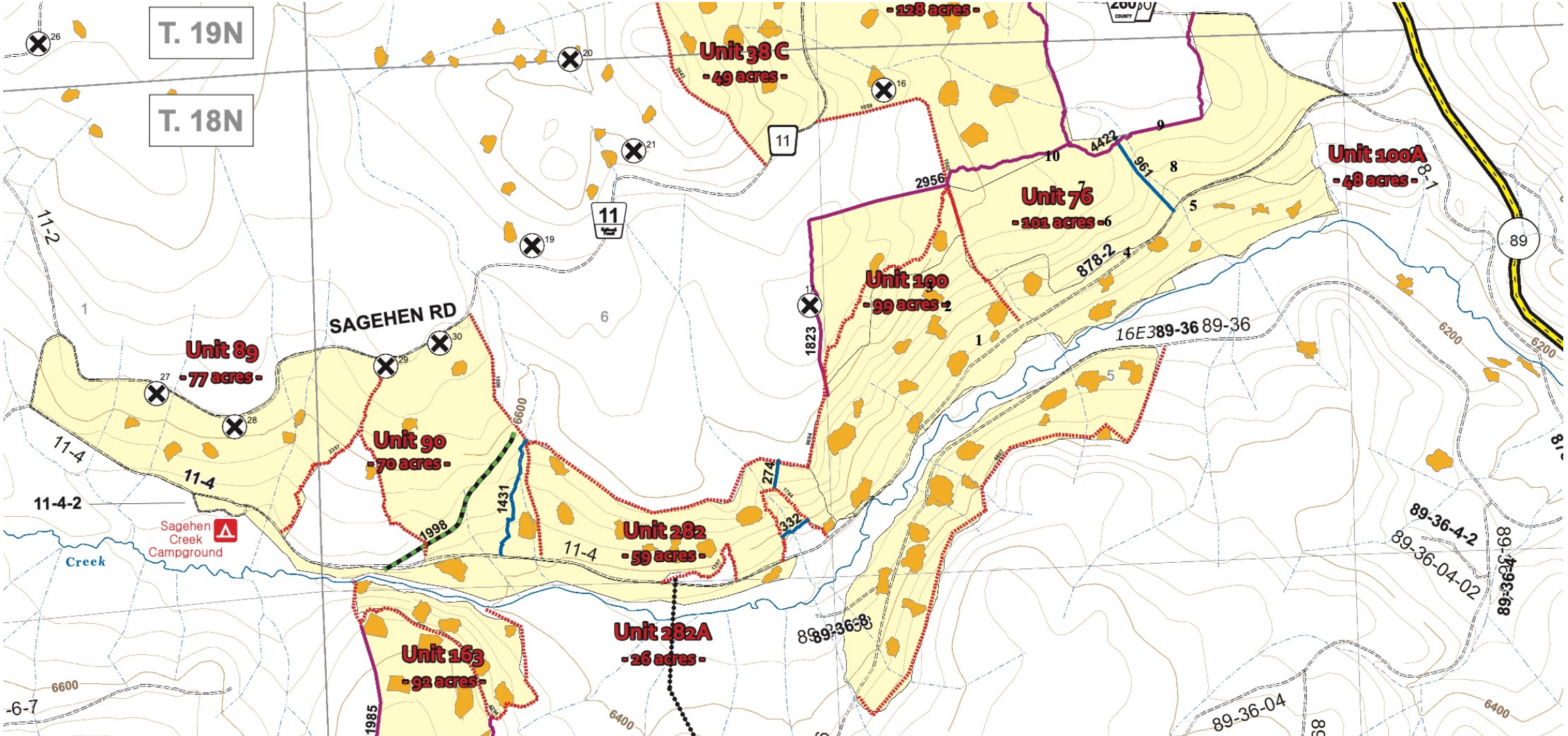
April 29, 2021

Sagehen Vegetation Type



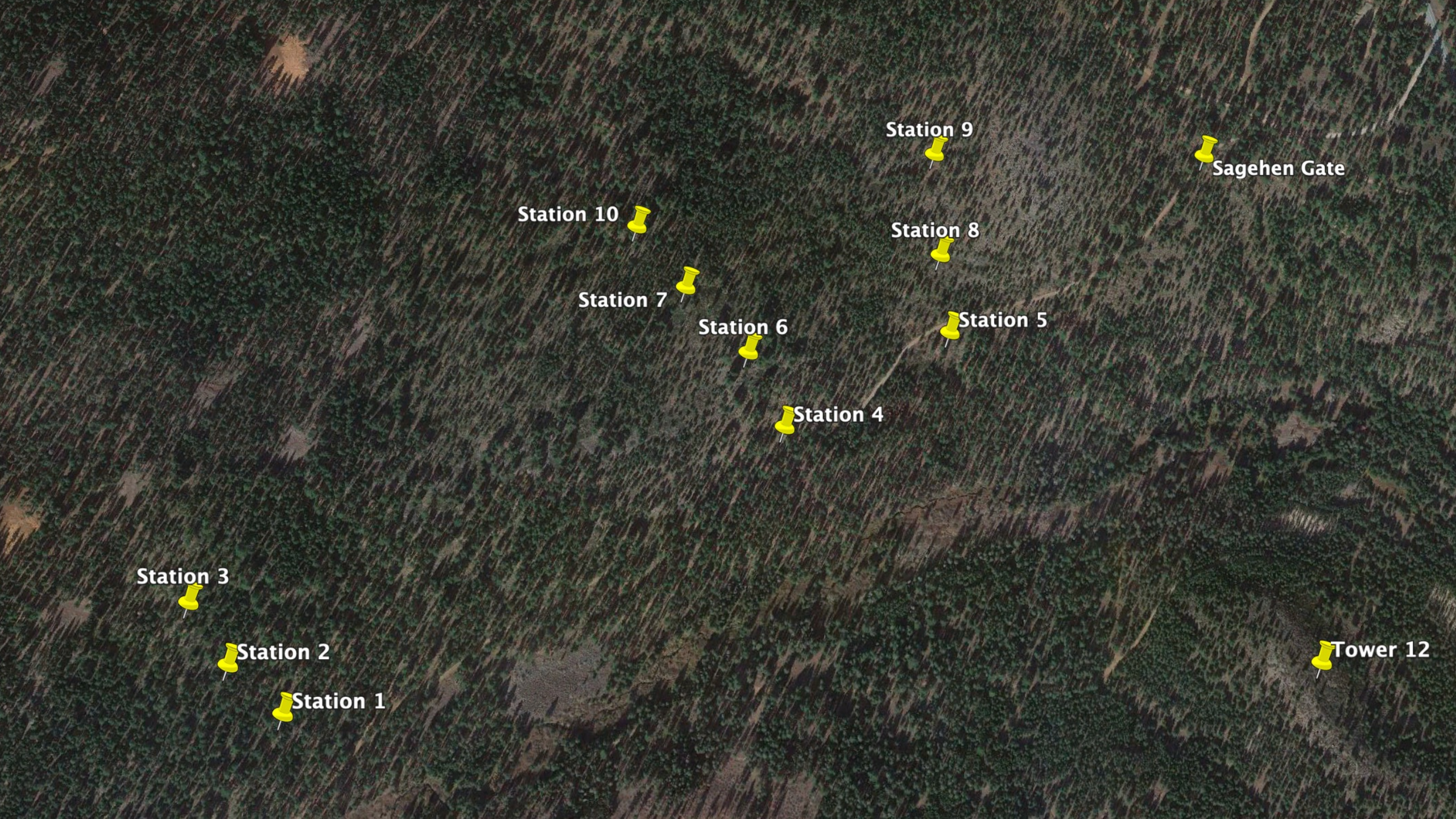


Treatment goal: Units 76, 100



Pile burns of medium/heavy fuels

- Lower extent of Unit 100
- Preparation for underburn
- November 30, 2020


Station 9
Sagehen Gate
Station 10
Station 8
Station 7
Station 6
Station 5
Station 4
Station 3
Station 2
Station 1
Tower 12

Subcanopy Stations

Station 9 – high frequency

Station 8 – low frequency

April 29, 2021

East Zone
Tahoe National Forest
Prescribed Fire Organizer
Updated 10/2019

Project:	Sagehen Hills Unit #
Burn Unit:	76
Size:	100
Complexity:	Moderate
Funding Code:	NFHF
Burn Lat/Long:	39° 26.565 x 120° 13.555
Legal Location:	T 19N R16E S32
Burn Boss:	Brian Pimentel (T)
Date:	

Burn Prescription Parameters

Element	hot	cold	spot wx forecast/predicted
Temp	75	55	75-77
RH%			48
Wind Speed (MFWS)	8	6.2	5-9
Wind Direction			Santa
10hr TL fuel stick	5	13	7
Probability of Ignition (PIG)	71	20	
Predicted Fire Behavior	max	min	
Rate of spread (ROS) ch/hr	12.9	1.3	
Flame length (FL) feet	5.2	1.7	

Contingency

Contingency Level Determination will be completed prior to starting burn using Appendix F of the Rx Burn Plan. This section is for quick reference.

Fire Prescription Level	[redacted]	2		
Contingency Level	[redacted]	2		
Required Resources (#)	Engines 2	Crew	WT	Patrols

Resources Identified/Assigned **note if resource is onsite

1 - Type 3 Contract engine
1 - Type 2 15 person crew
2 - Type 3 Forest Service engines E-371 E-361

1

Area Forecast Discussion

Issued by NWS Reno, NV

849
FXUS65 KREV 291016
AFDREV

Area Forecast Discussion
National Weather Service Reno NV
316 AM PDT Thu Apr 29 2021

.SYNOPSIS...

The drying and warming trend continues into Friday, with many lower valleys reaching into the 80s each afternoon. Temperatures cool but remain above average Saturday through the middle of next week. Increased afternoon and evening breezes are expected Friday into the weekend. Precipitation chances look meager through the first few days of May.

&&

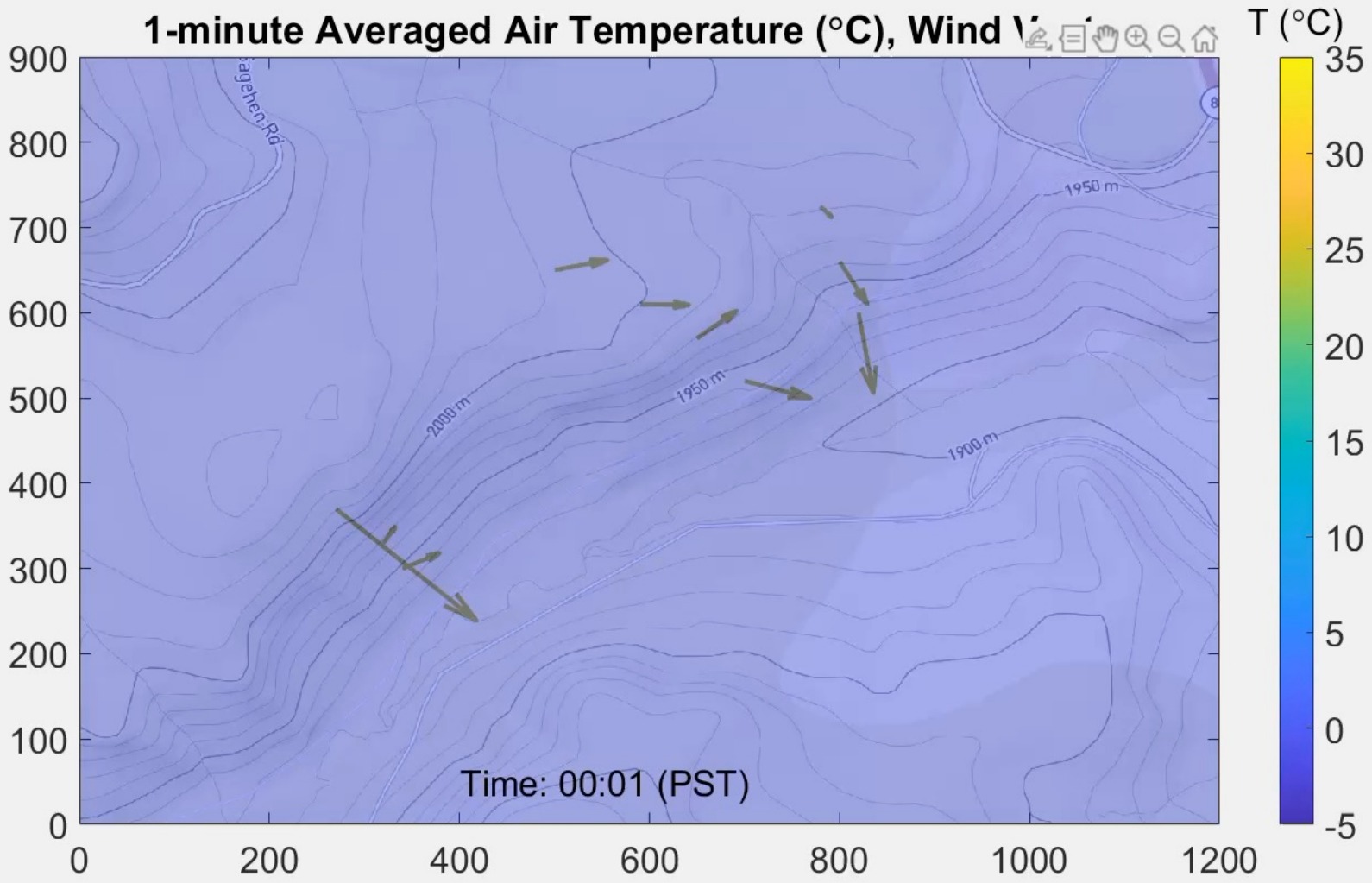
.SHORT TERM...

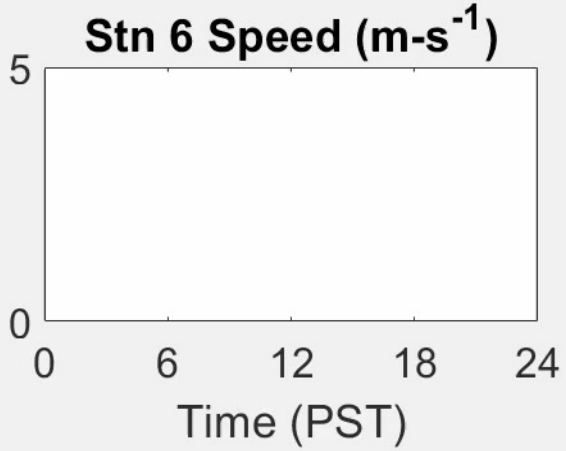
A strong area of high pressure continues to build over the region into Friday, before drifting east and weakening this weekend as a trough of low pressure passes by to our north and east. High pressure looks to rebuild into the region by early-to-mid next week.

The main message continues to be the increasing temperatures as the 500-hPa ridge axis begins to come overhead today. Mid-afternoon to early evening temperatures today and Friday will push into the 80s for the lower valleys of western Nevada and 70s for Sierra valleys. Winds today will remain light with modest afternoon breezes, while afternoon breezes will pick up Friday (25-30 mph) as southwesterly flow increases with the ridge axis moving east over the Great Basin. Today, we will have a better shot at tying/breaking the maximum temperature at Reno-Tahoe International Airport of 86 degrees with NBM guidance having a 50% chance of this occurring. For Friday, cirrus coverage increases, which will lower our chances to 9% of breaking or tying a relatively stout record of 89 degrees. These rather warm afternoon temperatures will help to melt snow, which will increase flows on streams and rivers in and away from the Sierra. Stay mindful and be careful near these waters as they are running cold this time of year.

As the ridge slides east Saturday, a weak cold front will move through cooling temperatures and increasing afternoon gusts into the 30-35 mph range, with some amplified winds in prone areas along the Sierra Front (gusts up to 40 mph). Winds Saturday will be from the west-northwest and will veer from the north Sunday. Although it will

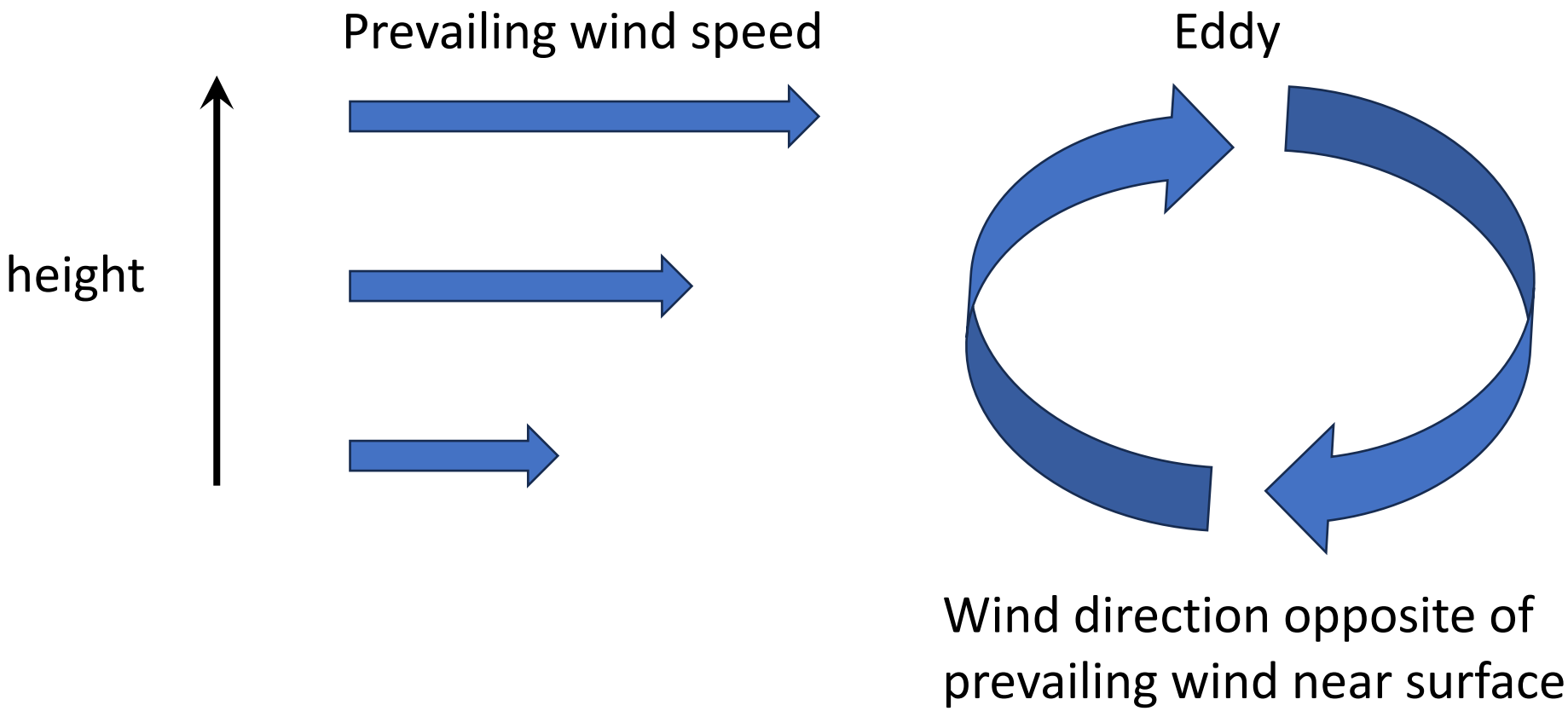
April 29, 2021

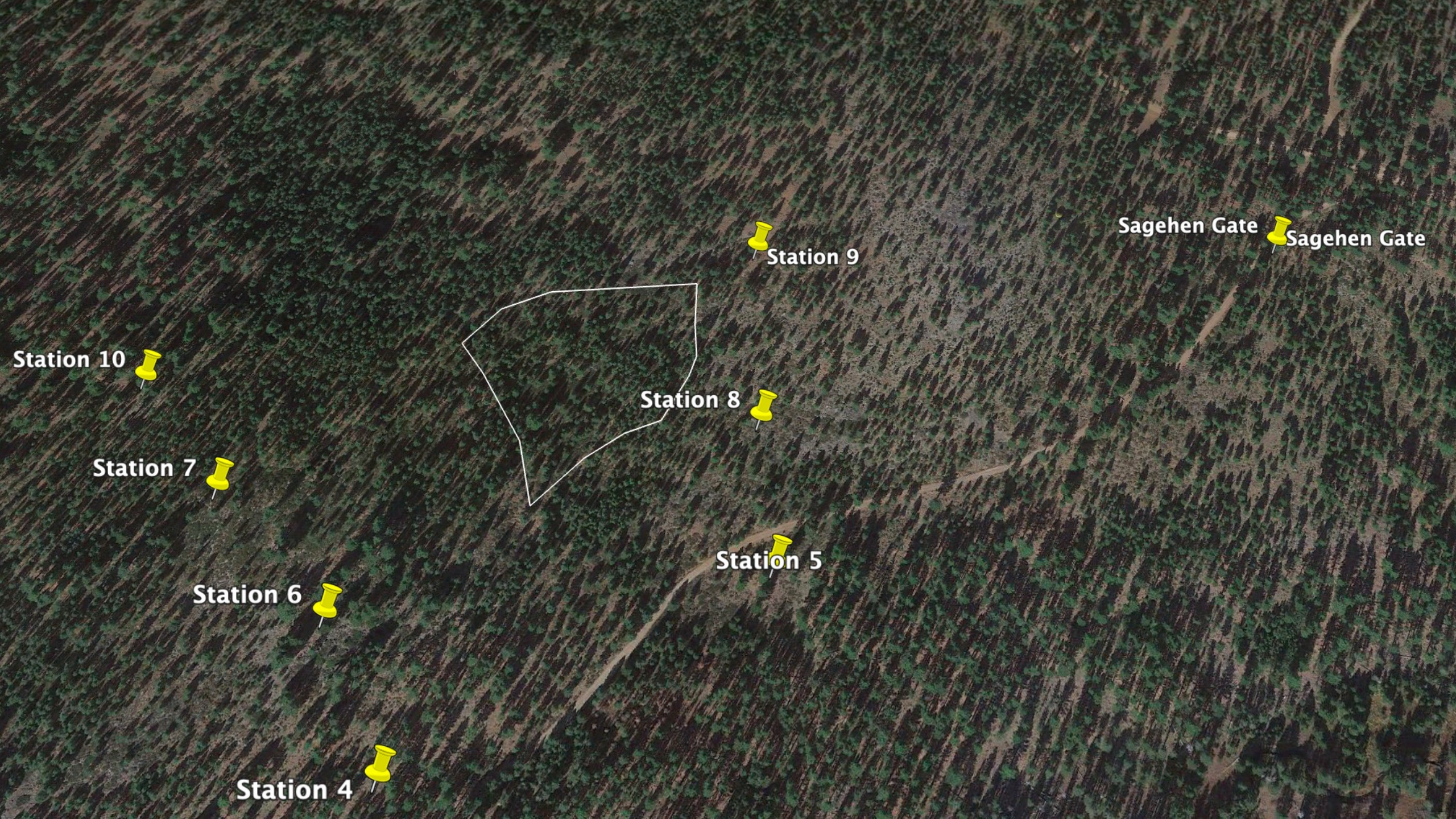




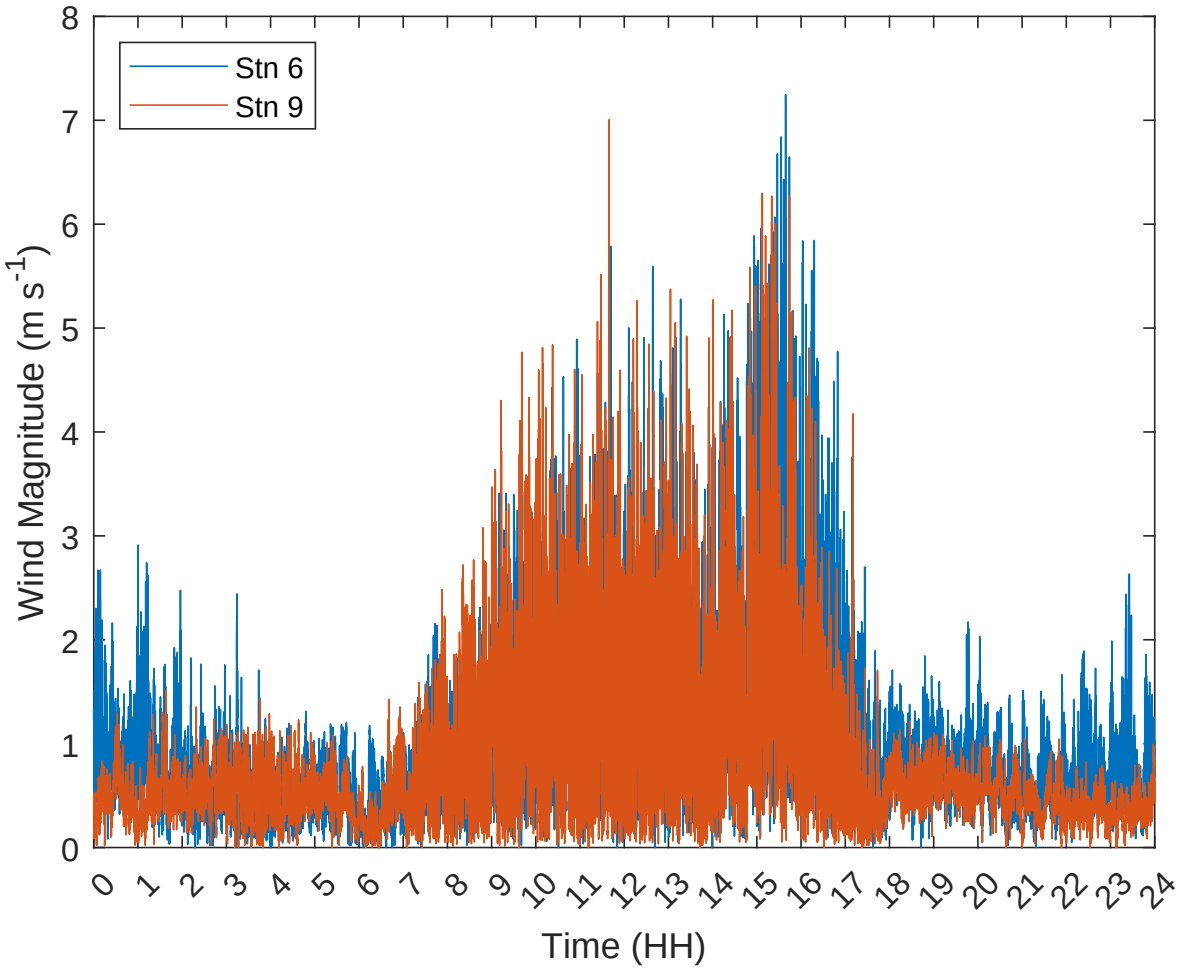

Meidase
39 °C / 102 °F
04/29/2021 14:00:45

Idealized Eddy



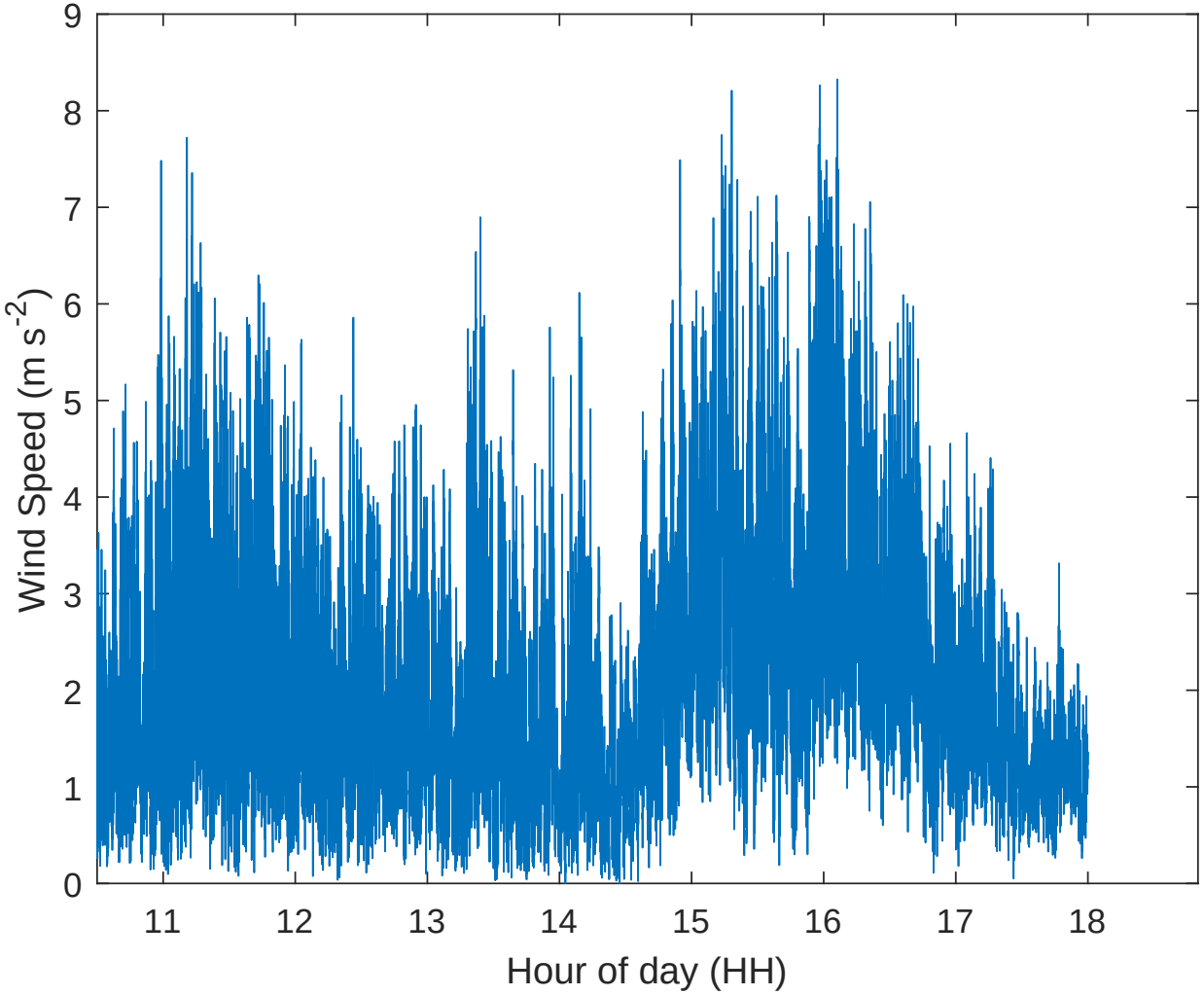

Station 9
Sagehen Gate
Sagehen Gate
Station 10
Station 8
Station 7
Station 5
Station 6
Station 4

Wind Magnitude (3D wind speed)



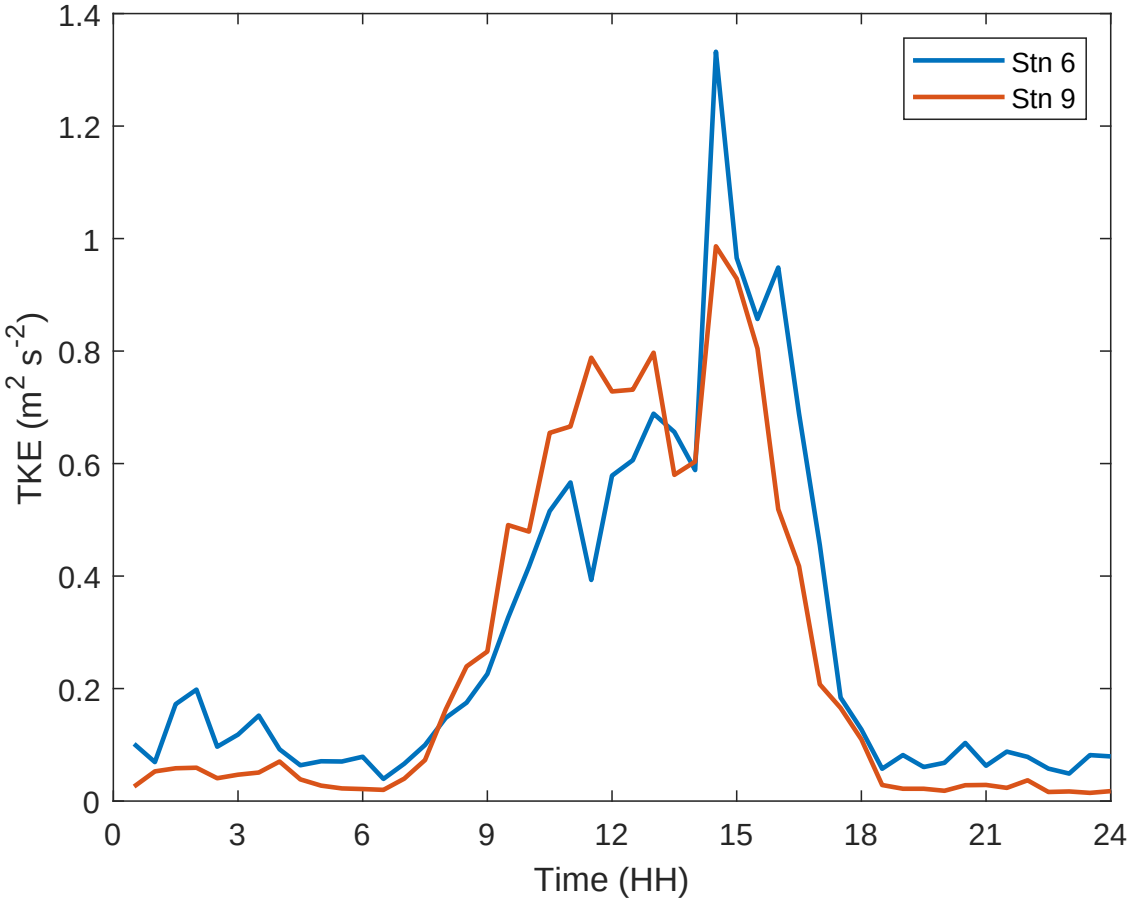
- 10 Hz wind magnitude
- Wind speed increases due to daytime heating
- Afternoon spike in wind speed (between 2:30-4:30PM)

Wind Magnitude (Tower 12)



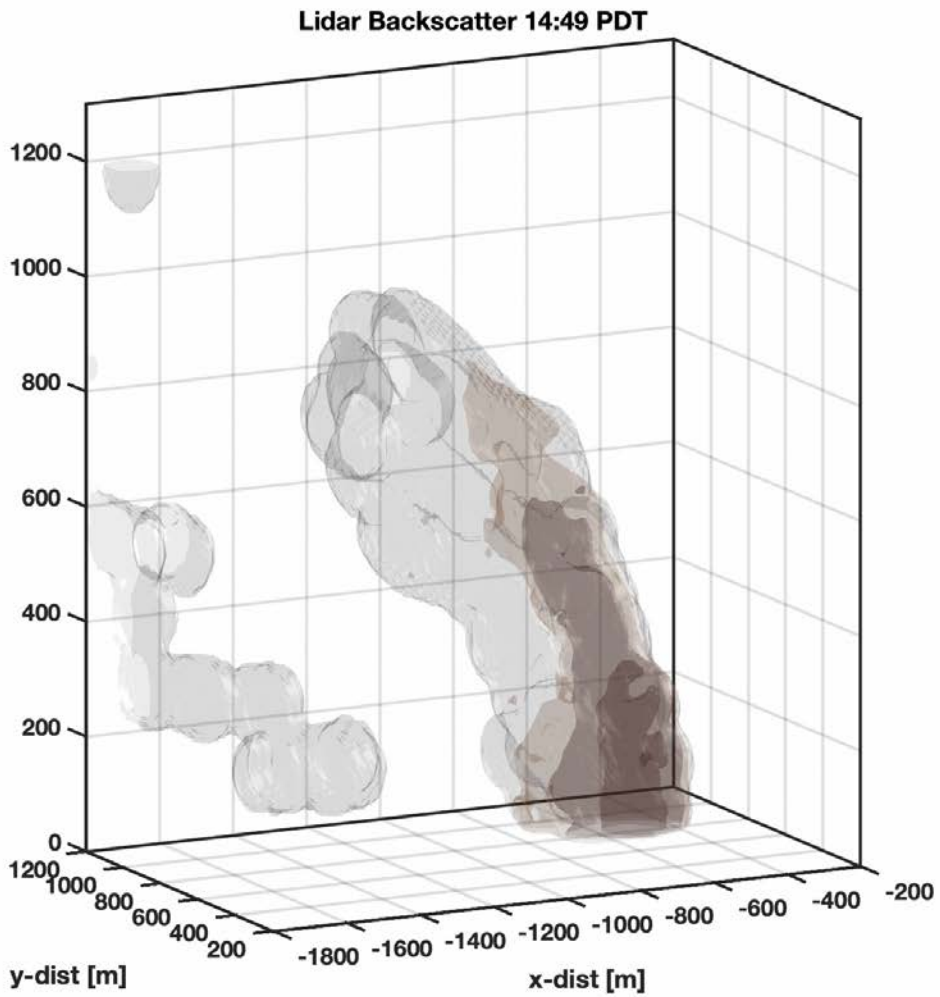
- 10 Hz wind magnitude
- Background wind speed increase in the afternoon
- Afternoon spike in wind speed (between 2:30-4:30PM)

Turbulence Kinetic Energy (TKE)



- TKE is noisy so use 15-minute time average
- Large spike in TKE starting at 2:45 PM at both stations
- Corresponds to timing of wind shift in earlier video

Lidar Measurement of Plume Load



- Lidar backscatter image levels are in $\log_{10}$ intervals
- With height, particulate concentration is quasi-linear in a log scale
- Smaller high-concentration footprint -> volume average of particulate concentration decreases faster with height

April 29, 2021 5:43 PM

- Fire crowning due to ladder fuels
- Treatment is stopped
- Fire is suppressed

May 1, 2021
(2 days later)

May 1, 2021
(2 days later)

1 year later

April 7, 2022 vs September 27, 2023

(1 year later) (2 years later)

April 7, 2022 vs September 27, 2023

(1 year later) (2 years later)

September 27, 2023

Outreach: Truckee Community Center Exhibit

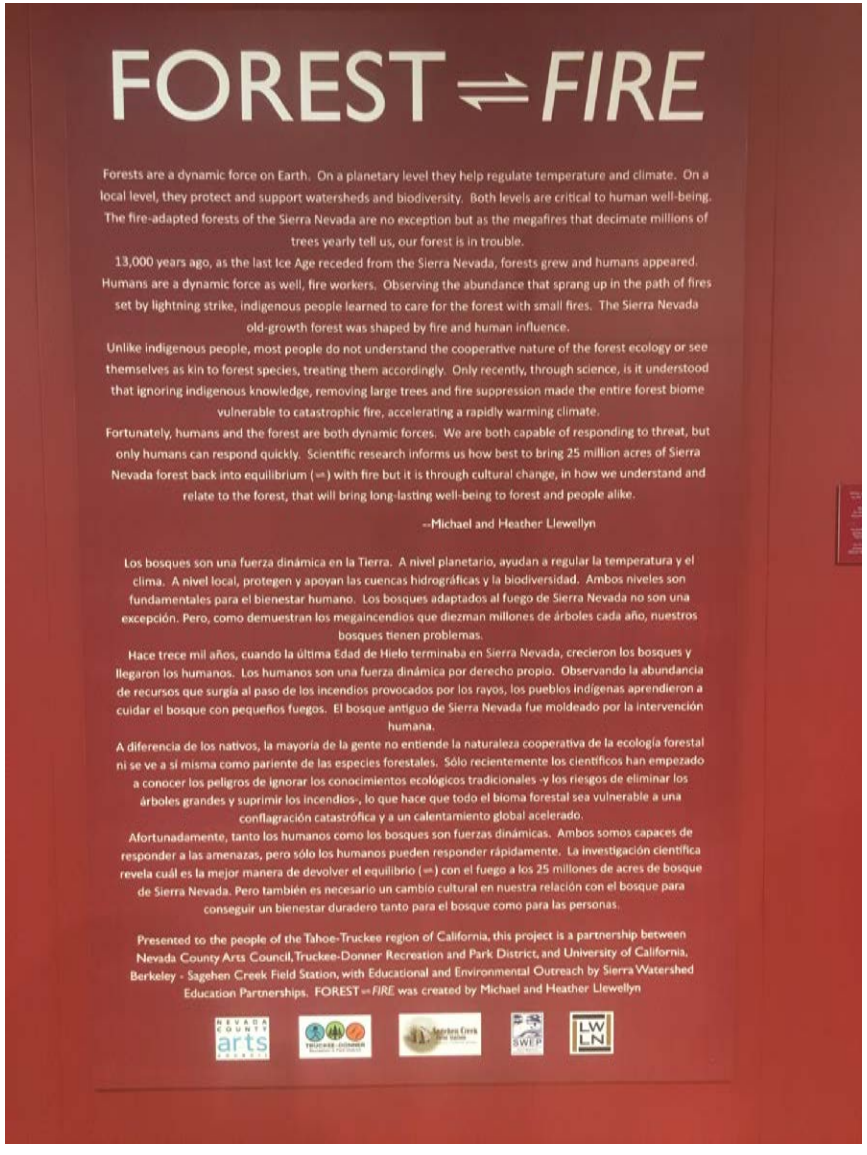


Exhibit: https://www.forestandfire.org/about-the-exhibition
PBS: https://watch.pbsreno.org/video/local-feature-episode-716-lziz1s/

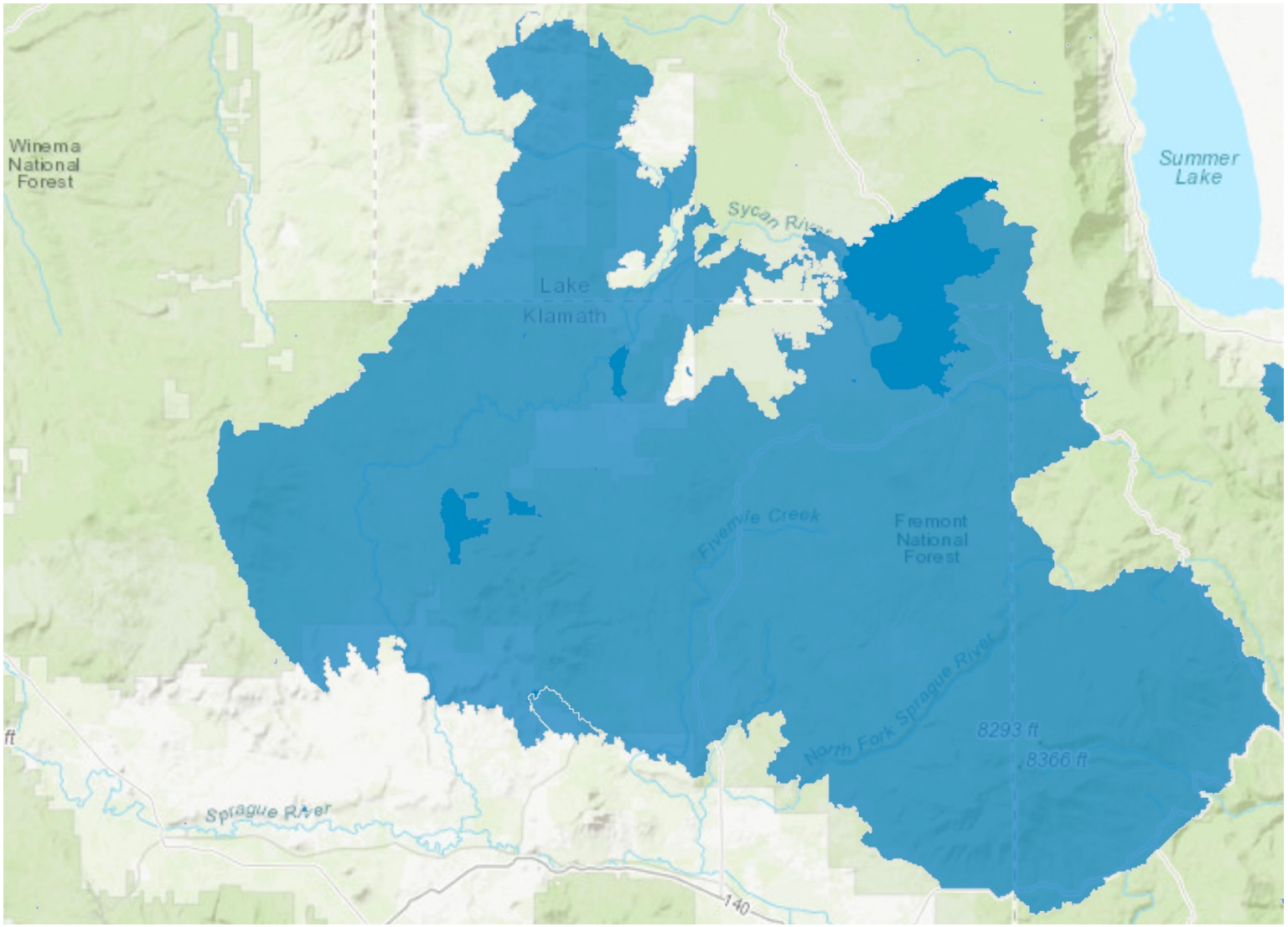
Sycan Marsh Preserve

October 25 – 28, 2022

Sycan Marsh Actors

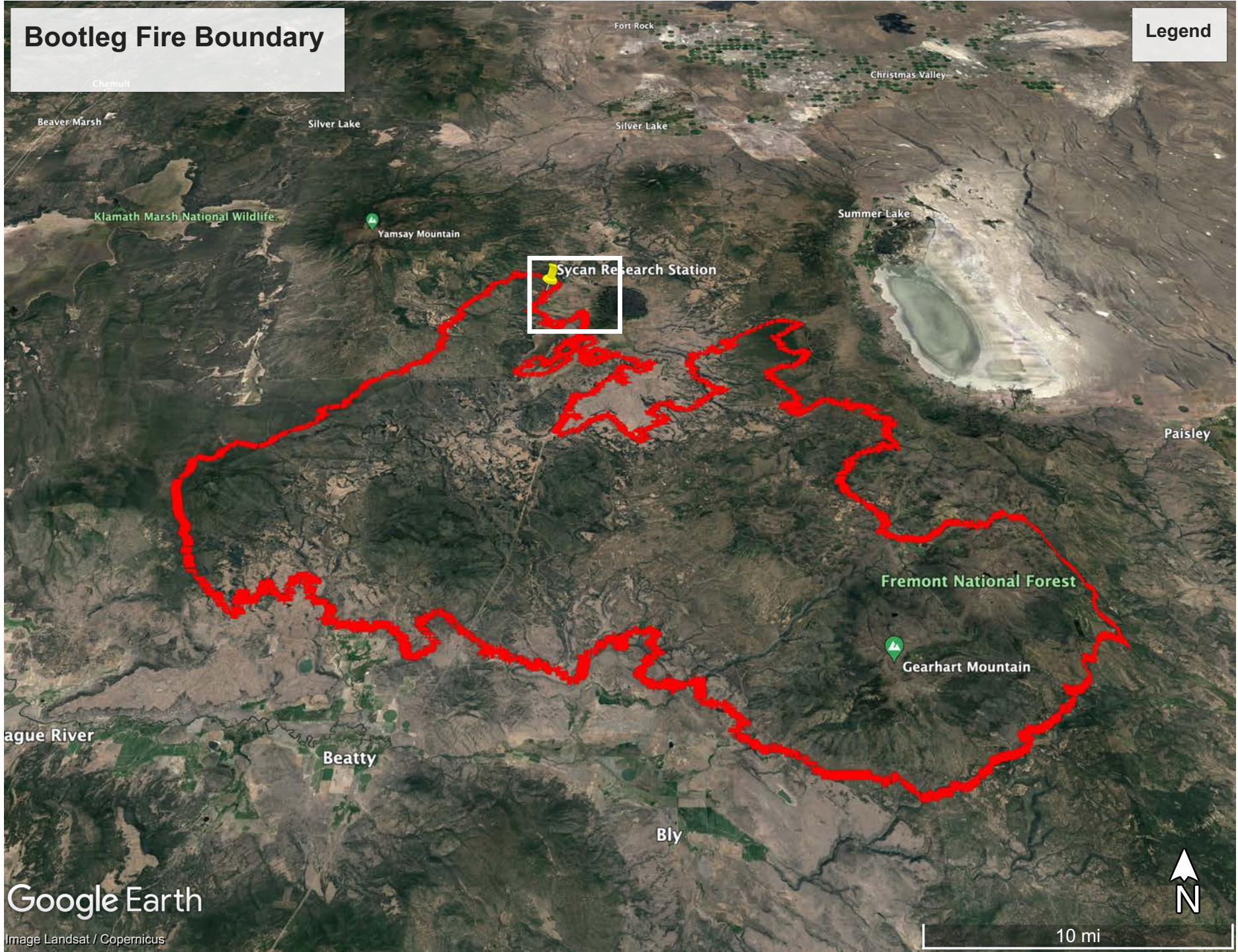
- Katie Sauerbrey – Burn Boss (TNC)
- Russ Parsons – Fire Sciences Laboratory, Missoula
- Andy Hudak – Rocky Mountain Research Station, Moscow
- Adam Watts – Desert Research Institute, Reno

Bootleg Fire, July-August 2021, 647 mi^2

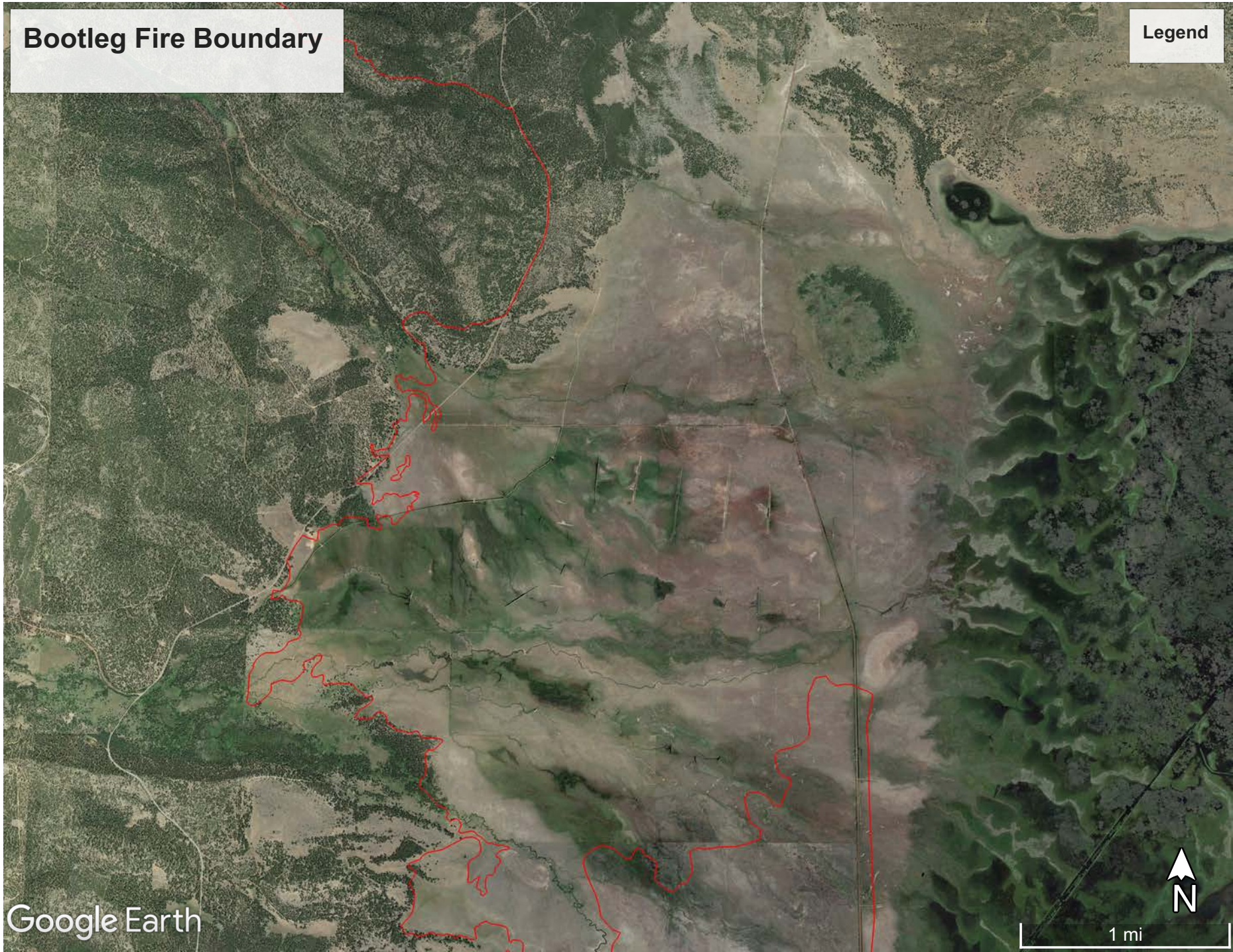


Source:
Interagency Fire Center

https://data-nifc.opendata.arcgis.com/datasets/nifc::wfigs-interagency-fire-perimeters/explore?location=42.648393%2C-121.093482%2C10.63



Bootleg Fire Video:
https://www.youtube.com/watch?v=uhVt1pPFMgI



BICO East 2D Treatments

Lidar

- Halo Photonics Streamline Scanning Lidar

SCIENCE & ENVIRONMENT

An arrest in Oregon worries those who want to prescribe more fire on the land

Every year, land managers intentionally set millions of acres on fire across the United States. Last month, one of those prescribed fires in Eastern Oregon's Grant County had the rare distinction of making news headlines.

On Oct. 19, Grant County Sheriff Todd McKinley arrested Ricky Snodgrass, the leader of a U.S. Forest Service crew conducting a prescribed burn in the Malheur National Forest.

The sheriff charged Snodgrass with reckless burning after the fire crept onto about 20 acres of private land beyond the national forest boundary.

The incident was a potential flash point in a long-simmering conflict between rural Western sheriffs and the federal government. At the same time, some prescribed fire advocates worry the arrest could be another setback in efforts to use more fire in forest management.

"The sheriff felt like he was protecting the community and restoring justice, and I think it's just the opposite," said Timothy Ingalsbee, a fire ecologist and director of Firefighters United for Safety, Ethics and Ecology, or FUSEE. "One of the intentions of that prescribed fire was to make the community safer in the event of a future wildfire."

https://www.opb.org/article/2022/11/20/burn-boss-arrest-oregon-prescribed-fire/

Grant County Sheriff arrests US Forest Service employee after prescribed burn jumps to private property

The leader of a U.S. Forest Service crew conducting a prescribed burn in the Malheur National Forest was arrested Wednesday on charges of reckless burning, according to the Grant County Sheriff's Office.

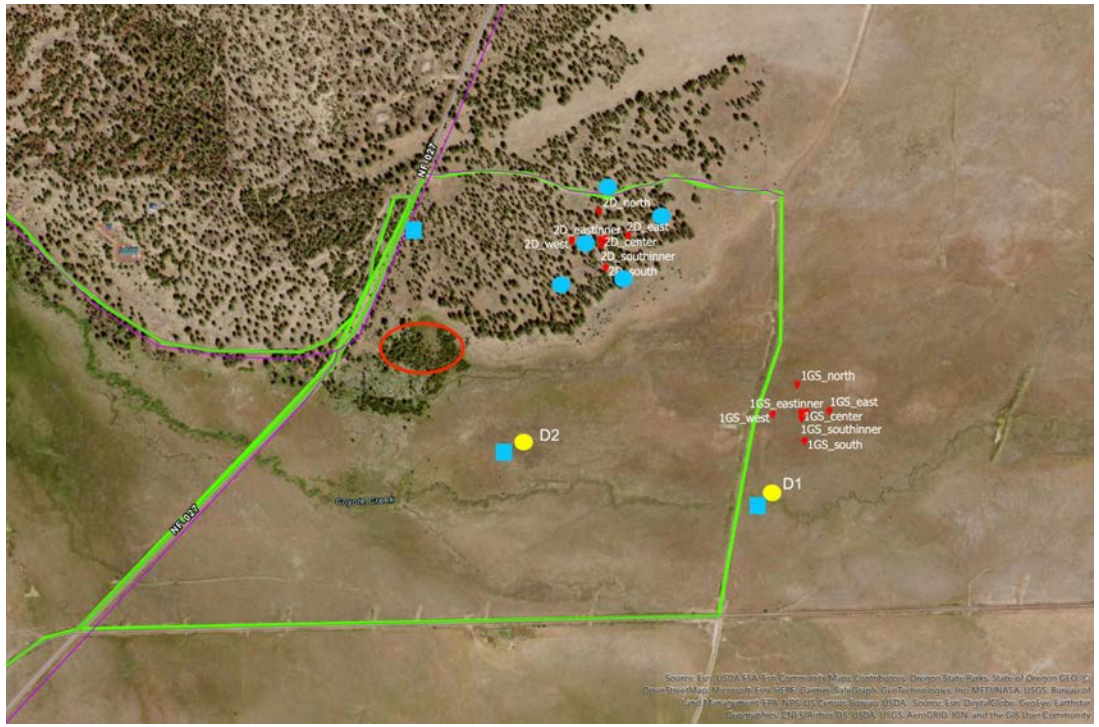
Oct. 20, 2022

Pre-burn meeting at Nature Conservancy Conference Room (Jim Castles Applied Research Station)

- Met each morning to discuss conditions, fire treatment plan for the day
- Coordinate crews

Unit 2D burn, October 25

- Lidar at location D1 (yellow dot)
- High frequency stations (blue dots)
- Low frequency stations (blue squares)
- Subcanopy stations placed to study fire/plume in forested area
- Fire did not carry in fine fuels (grass)
- Burn was stopped after ~ 2hrs



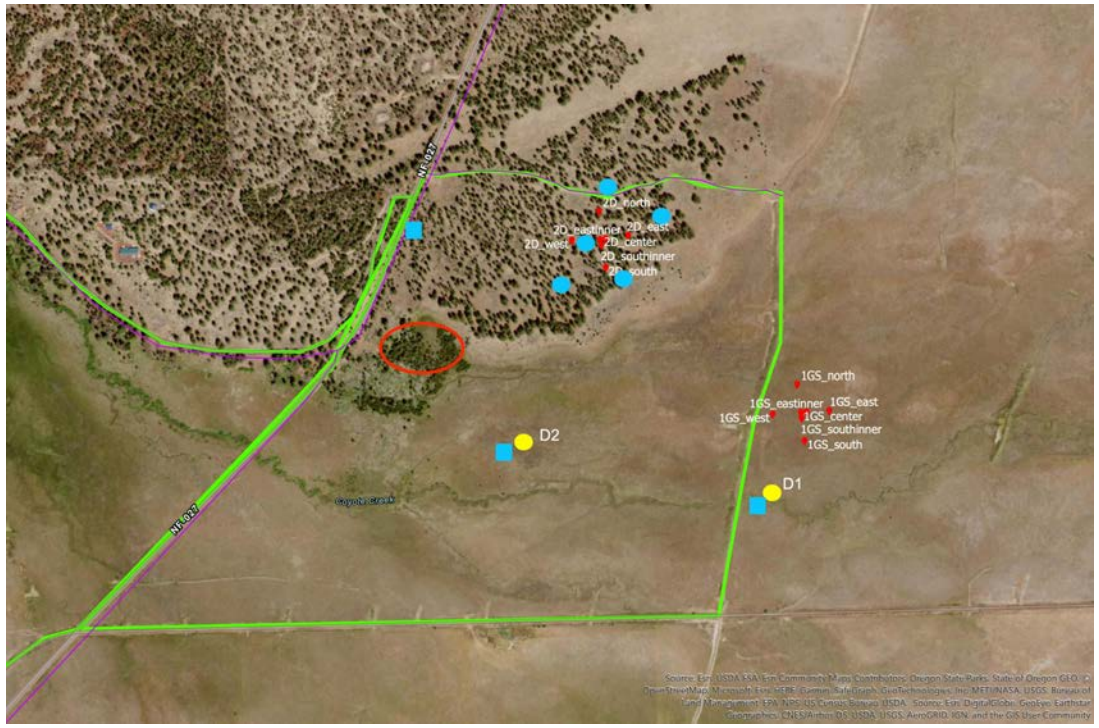
October 25 Treatment

1:19 PM

2:07 PM

Unit 2D burn, October 26

- Decision to burn the area in the red ellipse was too late to relocate subcanopy stations in burn area
- Lidar at location D2 (yellow dot)
- Low frequency station (blue square)
- Fire did carry in heavy fuels (red ellipse, October 26)



Localized heavy fuels burn

October 26, 2022 4:18 PM

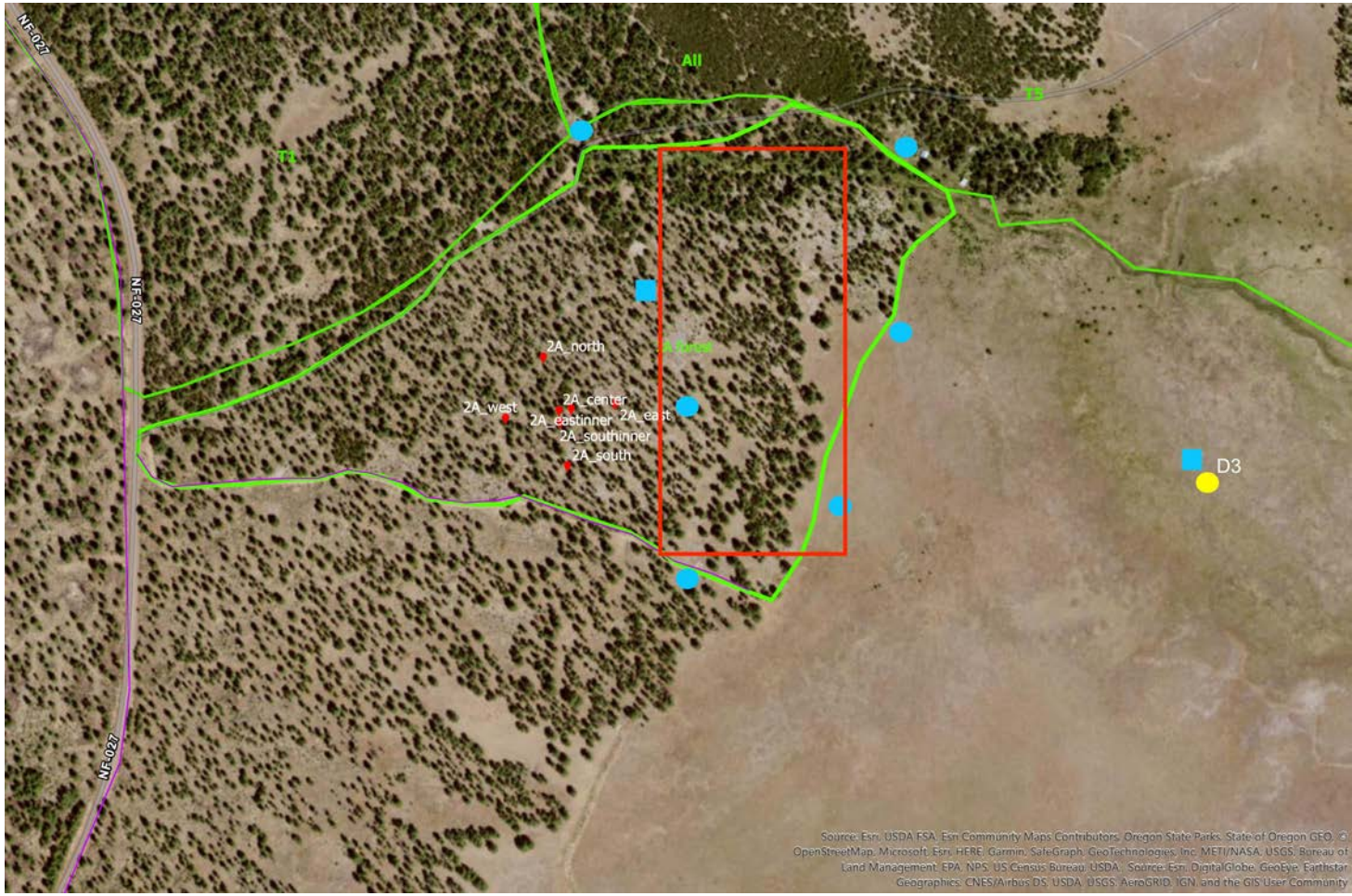
October 26, 2022 5:18 PM

Post-burn landscape

- Heavier fuels carried fire
- Fine fuels then dried and burned

Unit 2A

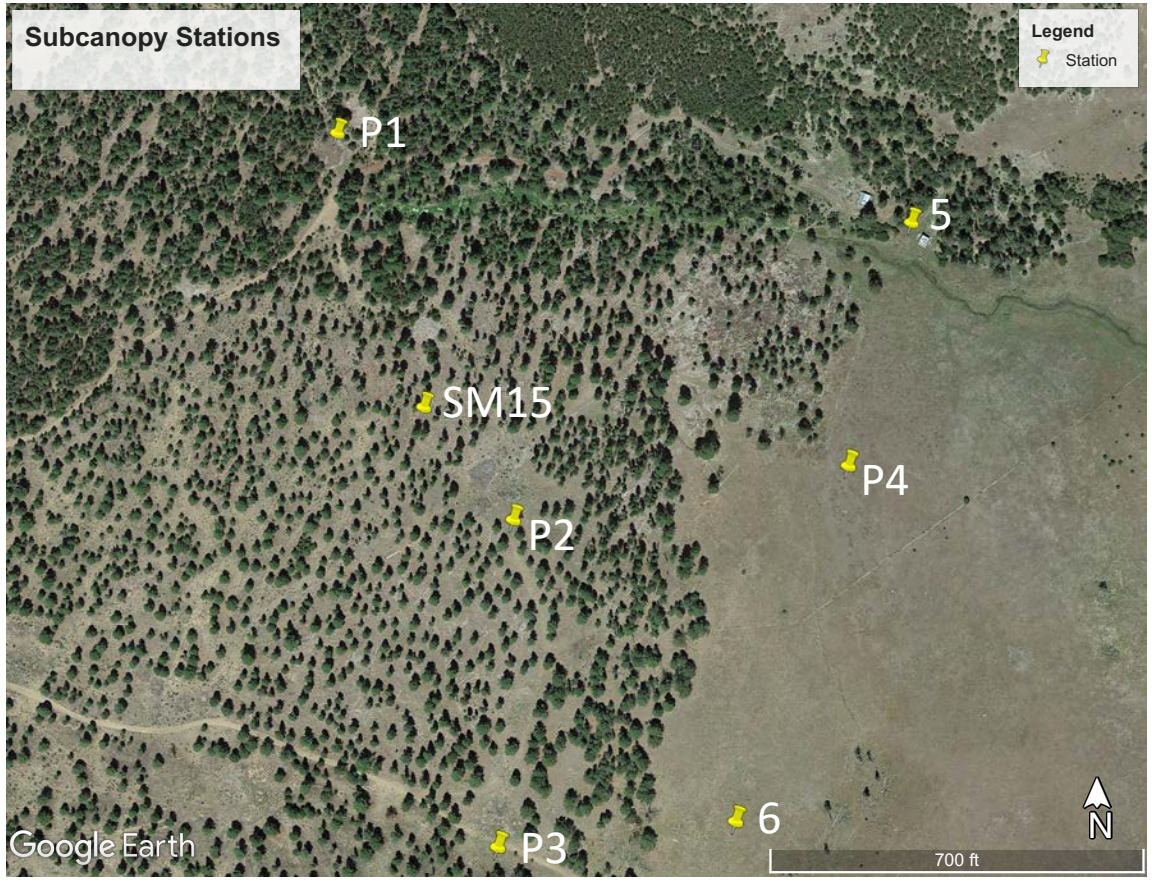
- Lidar at location D3 at yellow dot
- High frequency stations at blue dots
- Low frequency stations at blue squares

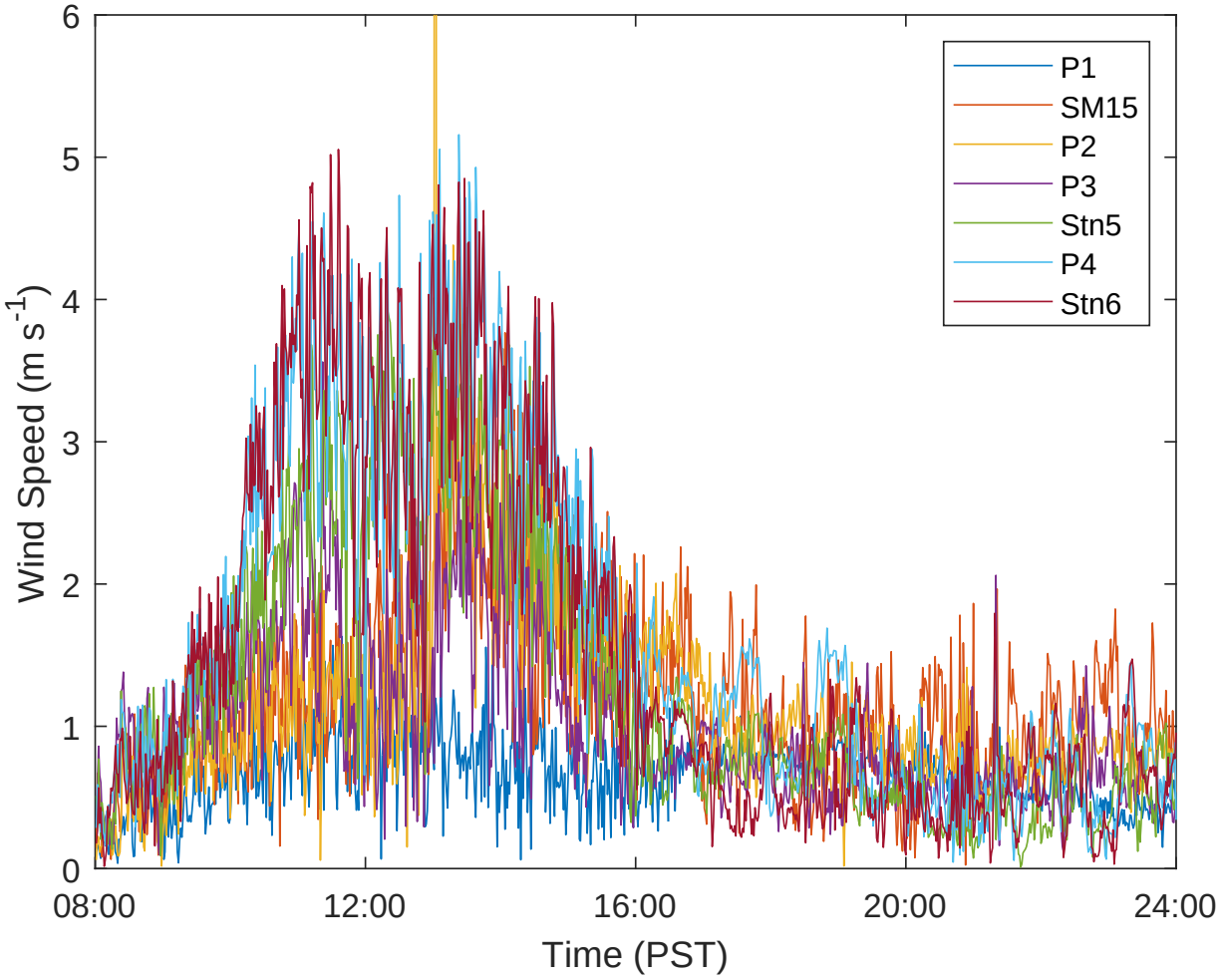



Meidase
12 °C / 53 °F
10/27/2022 11:00:11

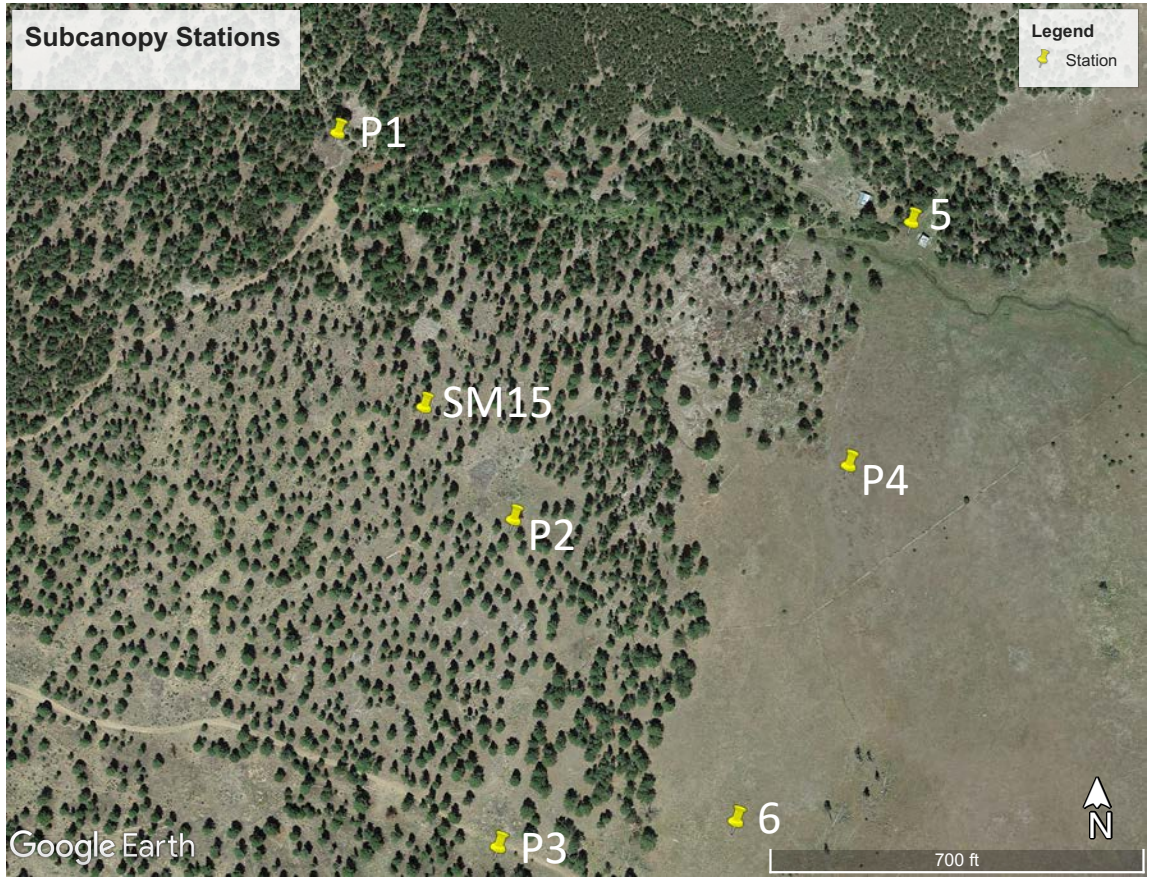
Unit 2A burn, October 27

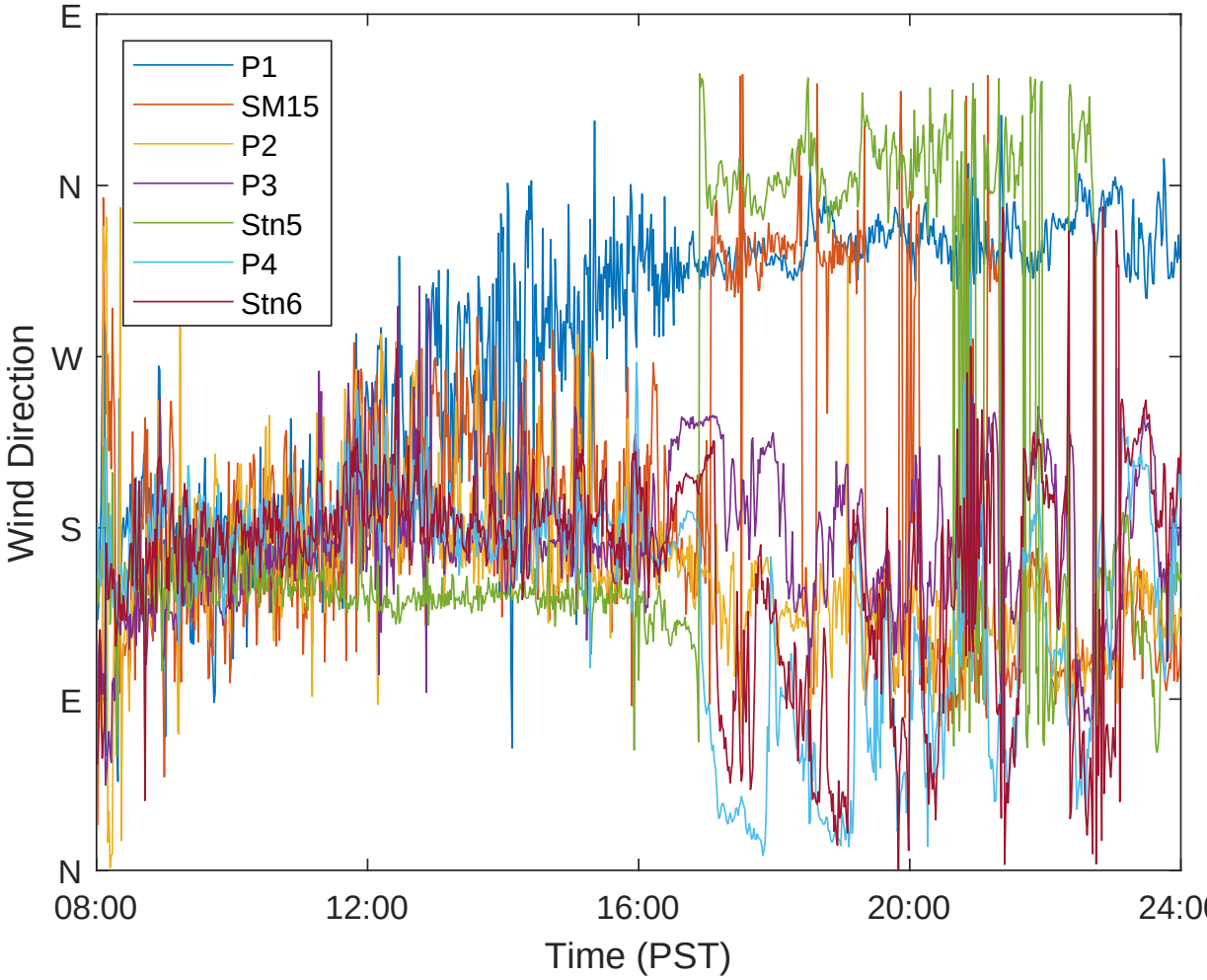
Wind Speed


Subcanopy Stations
Legend
Station
P1
5
SM15
P4
P2
6
P3
Google Earth
700 ft
N

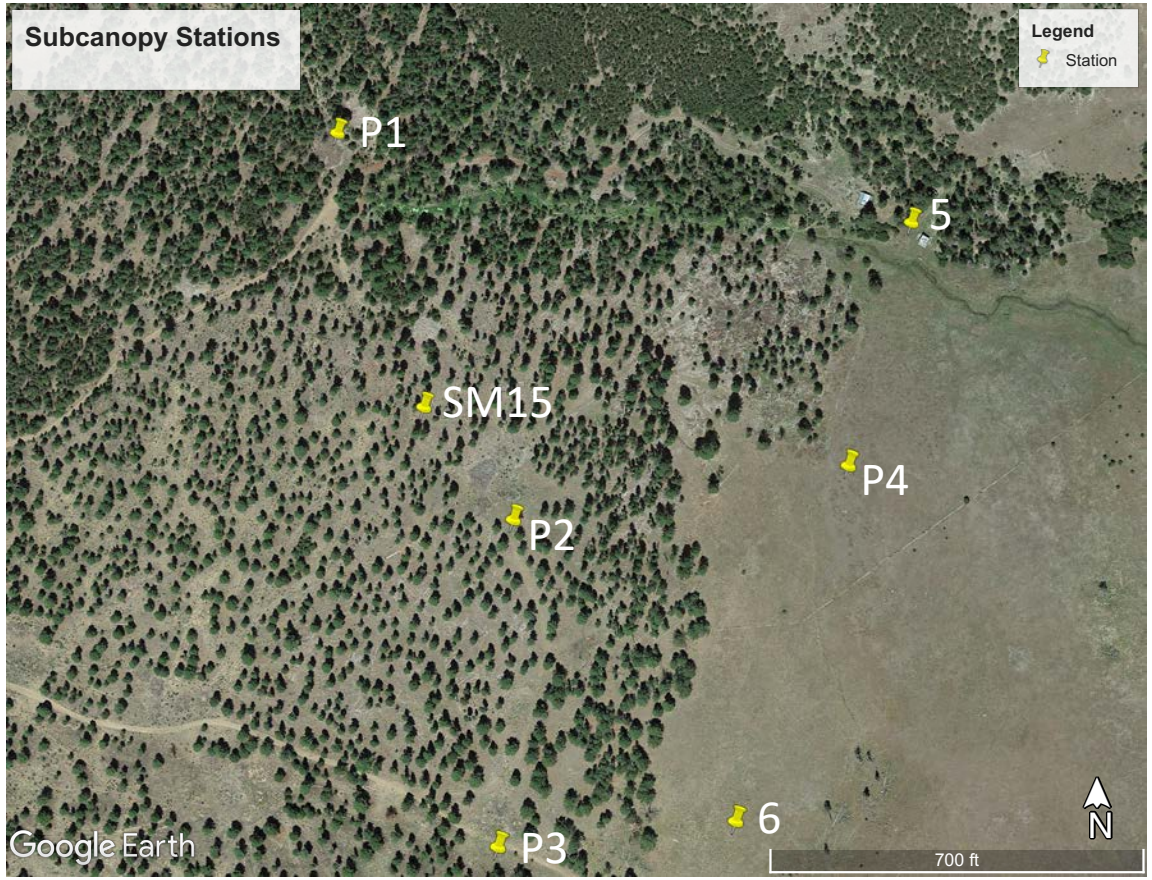

Wind Speed (m s-1)
Time (PST)
08:00
12:00
16:00
20:00
24:00
0
1
2
3
4
5
6
P1
SM15
P2
P3
Stn5
P4
Stn6

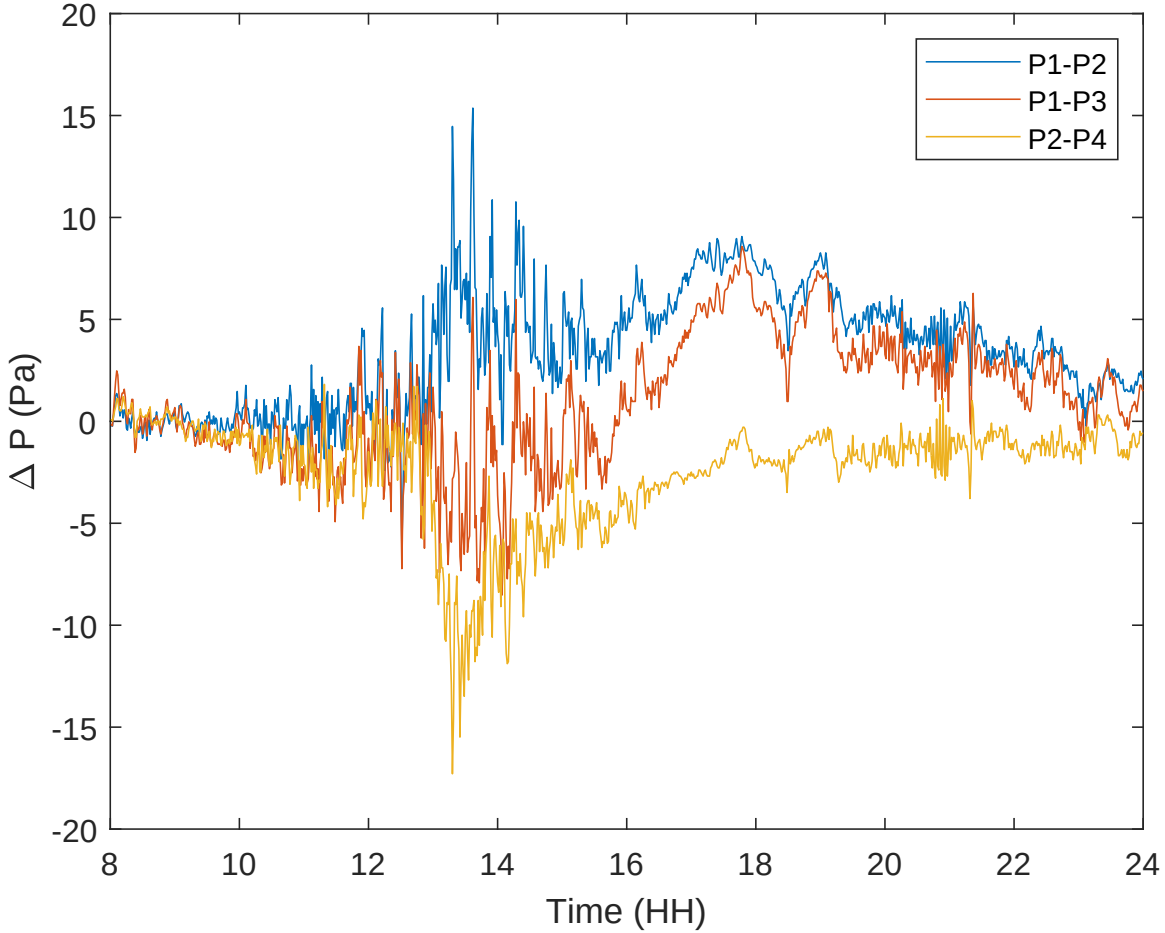
Wind Direction

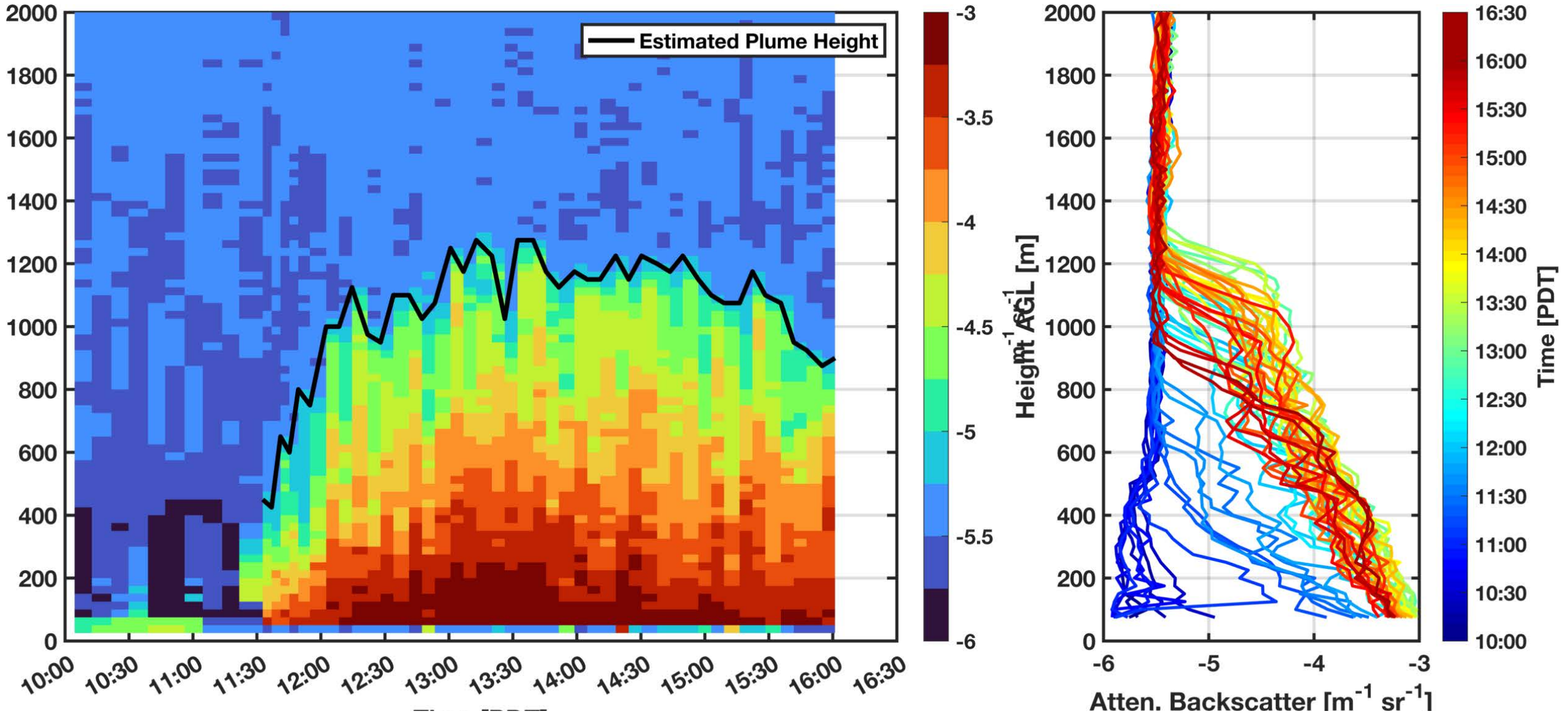




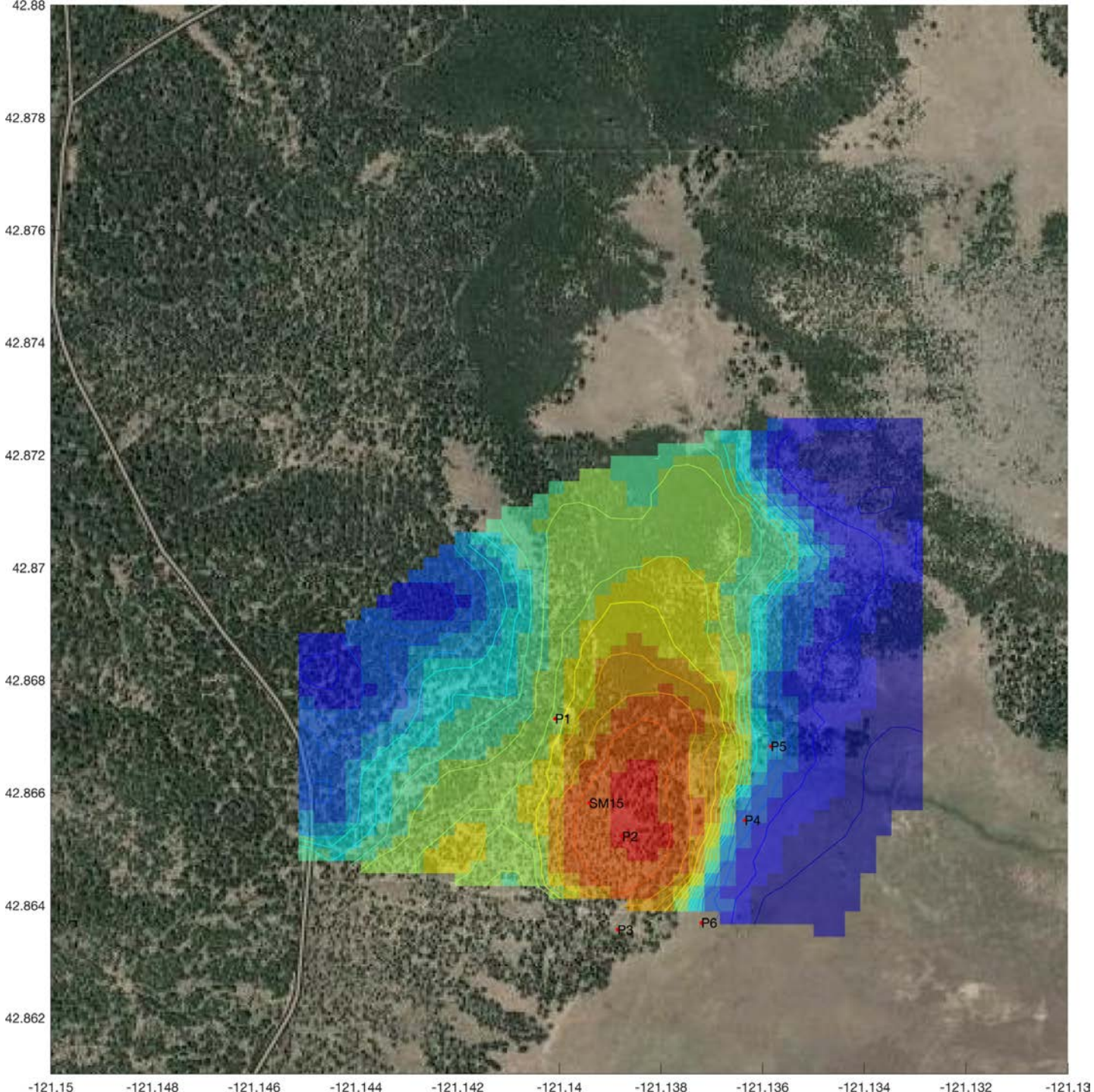
Pressure Difference



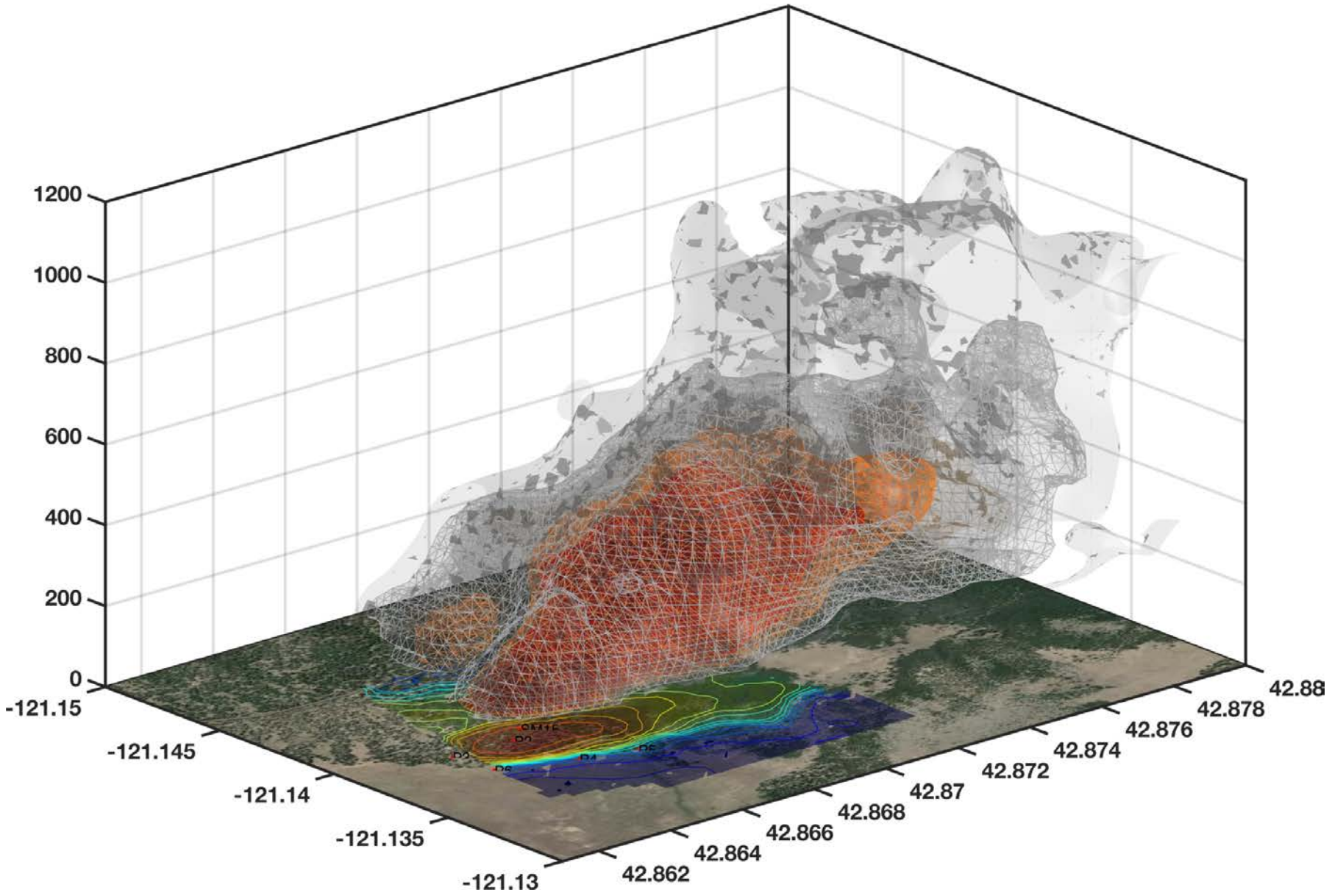



Estimated Plume Height
2000
1800
1600
1400
1200
1000
800
600
400
200
0
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
16:00
16:30
-3
-3.5
-4
-4.5
-5
-5.5
-6
Height AGL [m]
Atten. Backscatter [m-1 sr-1]
Time [PDT]

- Can georeference lidar data
- Georeferenced perspective affords the ability to co-locate other remotely sensed data such as IR measurements from drone platforms



- When the plume is not vertically aligned it may be more accurate to use the distance along the plume centerline rather than height
- This is a topic of active research



Comparing Sagehen and Sycan 2A Plumes

- Similarities
  - Convective initial conditions
  - Upright plume with minimal near-field fumigation
  - Quasi-linear distribution of particulates in $\log_{10}$ space -> exponential decay
- Differences
  - Sagehen was an underburn whereas 2A was more aggressive
  - Burn 2A consumed more biomass, quicker
  - Burn 2A produces a much taller plume
  - Burn 2A produces more large ash that visibly deposited not far from the burn area
  - In burn 2A Heavy fuels were purposefully ignited

Next Steps

- Further quantify plume dynamics as a function of meteorological conditions
- Assimilate other's findings (Sycan burns)
- Search for similarity relationships and thus pertain to a larger set of prescribed fires