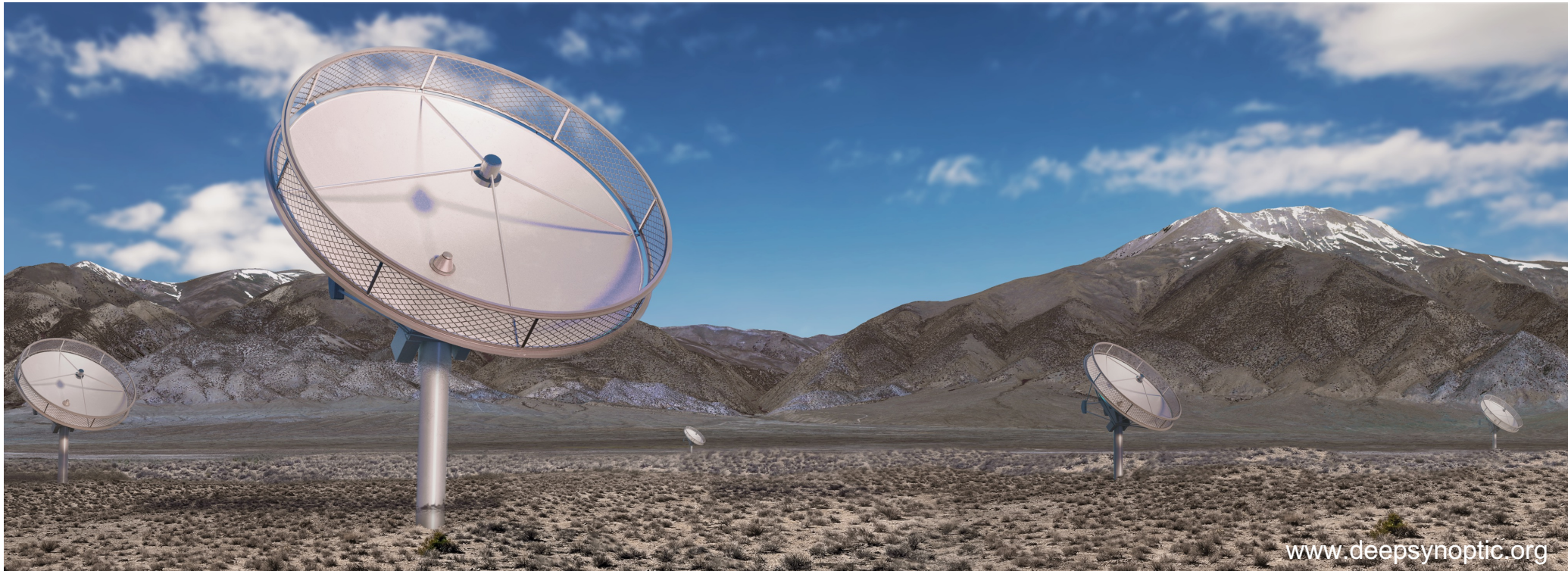


# The DSA-2000 Radio Telescope Project

*Ely City Council Meeting*



[www.deepsynoptic.org](http://www.deepsynoptic.org)

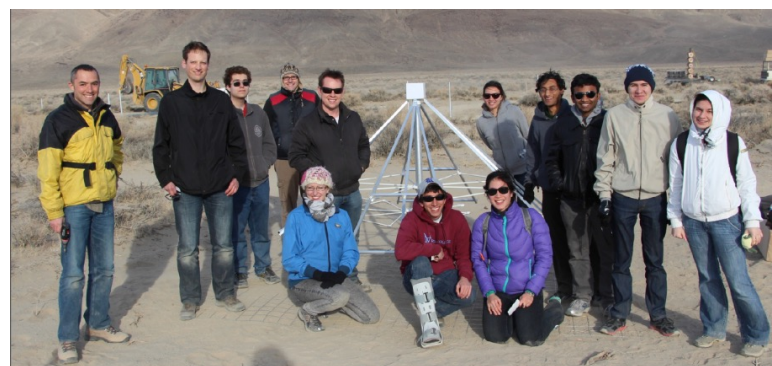
**Caltech**

Prof. Gregg Hallinan - Principal Investigator: [gh@astro.caltech.edu](mailto:gh@astro.caltech.edu)  
Dr. Katie Jameson - Lead Project Manager: [kjameson@caltech.edu](mailto:kjameson@caltech.edu)  
Kevin Hostert - Environmental Manager: [khostert@caltech.edu](mailto:khostert@caltech.edu)

  
Schmidt Sciences

# California Institute of Technology

- Caltech is a university in Pasadena, CA
  - non-profit corporation
- Caltech has operated the Owens Valley Radio Observatory (OVRO) since 1958
  - Located on 1100 acres near Big Pine, CA
  - A key part of the community (referred to as the Big Ears)
  - Mission to carry out radio astronomy research and to train students/researchers
  - Research includes studying the early universe and searching for radio waves from exoplanets



# DSA-2000

## The world's most sensitive radio telescope

- **1650 x 20-ft dishes** (12 x 10.5-mile area)
- Will revolutionize radio astronomy
- Most data-intensive science experiment in the world
- A passive science instrument for astronomy (no emissions)
- Needs very dark skies (in the radio)

Design: Funded by Schmidt Sciences

Construction costs: ~\$230M

Targeted construction period: 2026-2028

**Caltech**



# DSA-2000

## Proposed Project Elements

### 1) 1650 20-ft antennas

Antenna posts installed with vibratory hammer (no cement/concrete)

### 2) Fiber network

Primarily installed via plowing to a depth of < 30 inches

Includes backhaul along NDOT

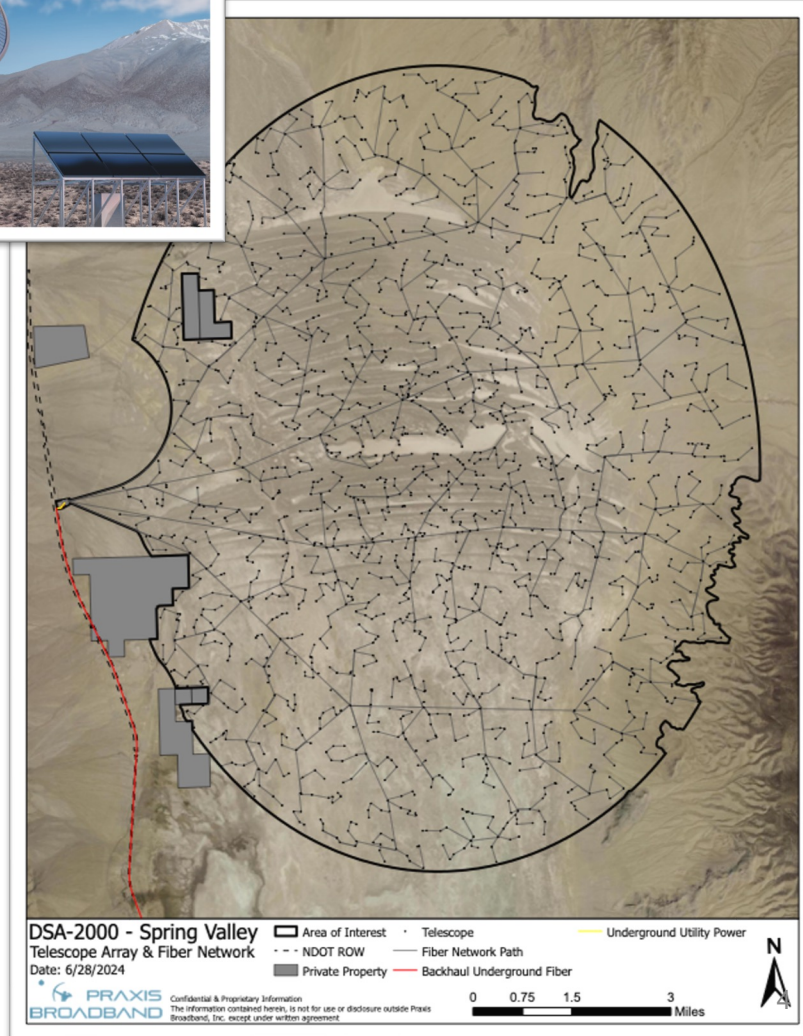
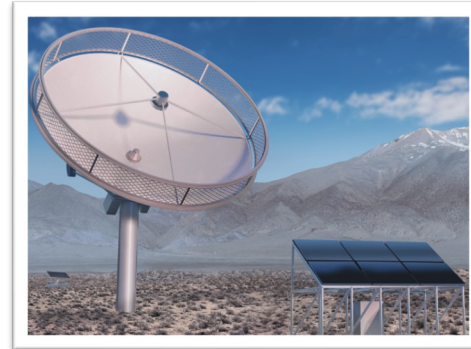
### 3) Buildings

~2 storage containers in the valley,

Control and maintenance buildings in Ely

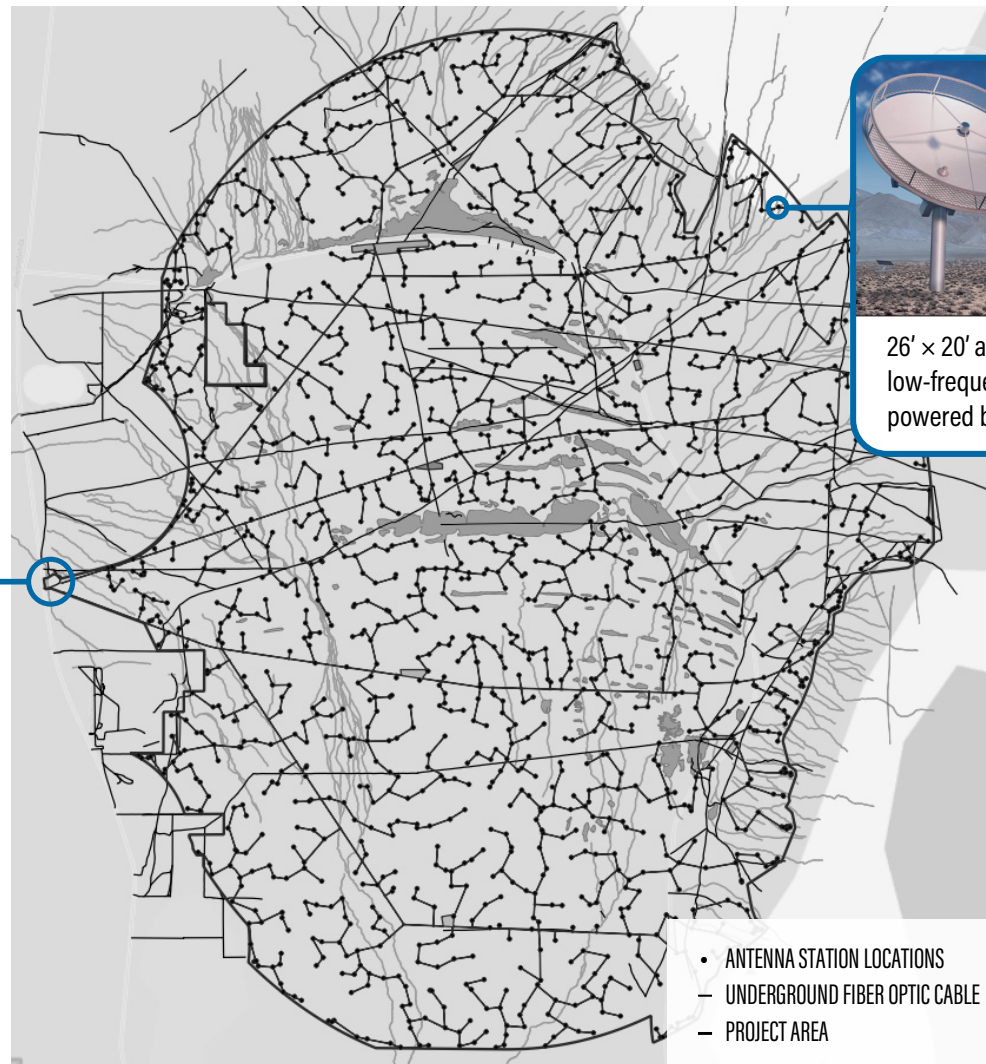
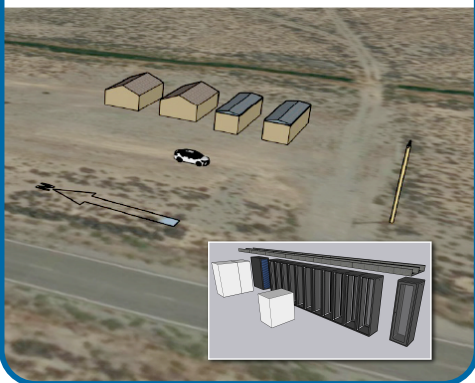
- Many aspects of the design are **flexible**

E.g., antenna location and fiber network will avoid sensitive resources identified during the technical surveys



# DSA-2000 Infrastructure in Spring Valley

- Equipment and housing for digitization of the signals from each antenna
  - < 200kW power
  - No water usage
- UHVs and equipment shed
- Maintenance team shelter

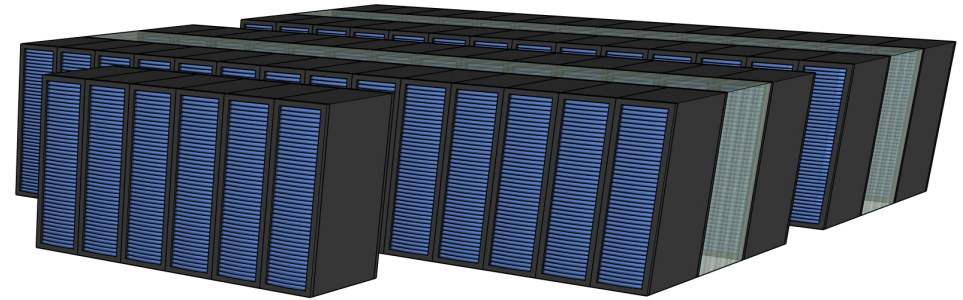


26' x 20' antennas and low-frequency dipoles powered by solar panels

- ANTENNA STATION LOCATIONS
- UNDERGROUND FIBER OPTIC CABLE
- PROJECT AREA

# DSA-2000

## Data Processing And Storage System



### Current Design

- Located near or in Ely Industrial Park
- Low Power Usage
- Design options for low to moderate water usage
  - Low: 100k gallons/yr for no evaporative cooling (eq. to small family house usage)
  - High: up to 3.6M gallons/yr (~11 acre-ft/yr) for full use of evaporative cooling

### Comparison to other Nevada data centers:

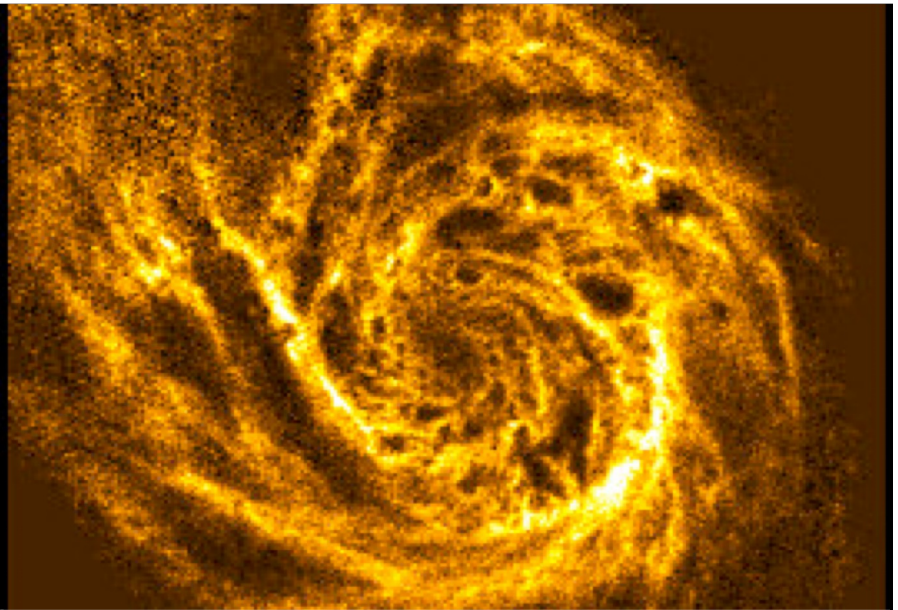
	DSA-2000 Data Processing	Switch SUPERNAP Las Vegas	Flexential Las Vegas (North)
Power	< 1 MW (solar possible)	495 MW	9 MW
Size	~3,000 sq. ft. building	470,000 sq. ft.	110,000 sq. ft.

# Why build DSA-2000?

**Radio telescopes** are needed to understand the past and present of the universe by seeing beyond visible light.



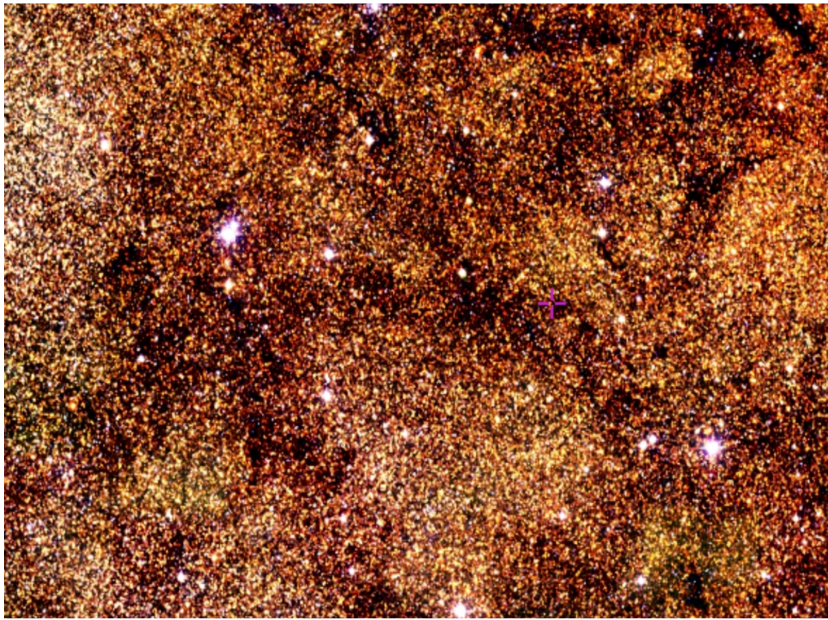
Hubble Space Telescope image of stars and gas  
(optical/visible light)



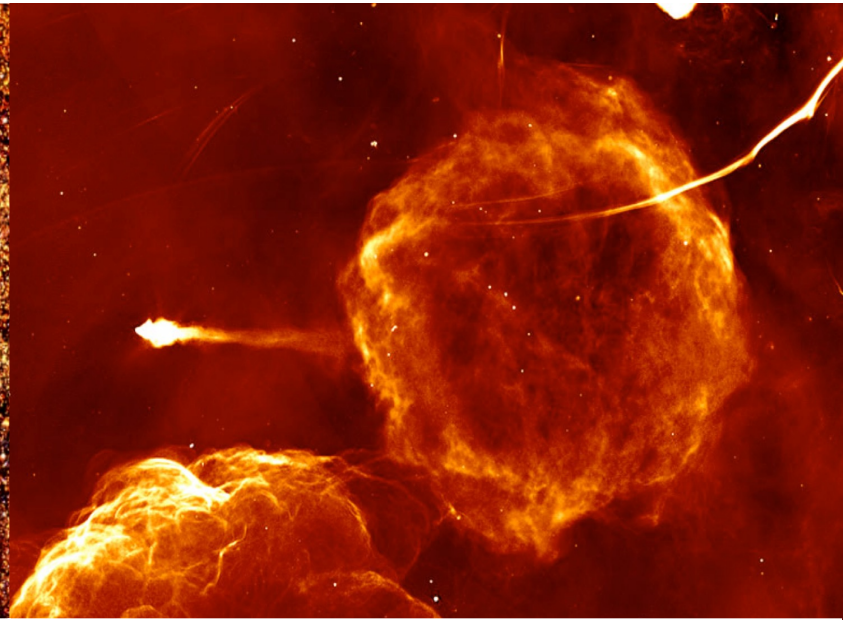
Very Large Array (VLA) image of neutral hydrogen gas  
(radio light)

# Why build DSA-2000?

**Radio telescopes** allow us to understand a whole other part of the universe.



**2MASS image of stars**  
(near infrared light)



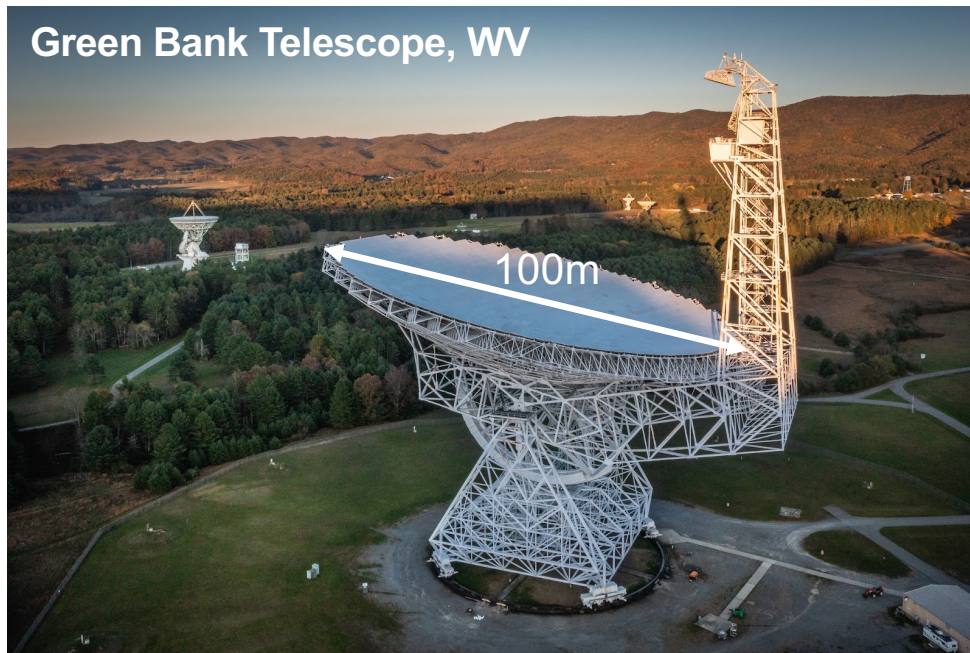
**MeerKAT image of supernova remnants**  
(radio light)

# Radio Astronomy Telescopes

Green Bank Telescope, WV

Spatial resolution  $\sim$  wavelength/Diameter

# Radio Astronomy Telescopes



**How do we build a bigger telescope?**

**Solution: create a “synthetic aperture” or pieces of a mirror to image the sky**

## DSA-2000

Many small antennas are better than a handful of large antennas

- Small, low-cost, low-impact
- Flexible positioning

DSA-110 dish in front of the 27-m dish at OVRO

# The path to DSA-2000

DSA PROTOTYPE



September 2013

DSA-10



September 2017

DSA-110



September 2019

DSA-2000



# DSA-2000 Antennas

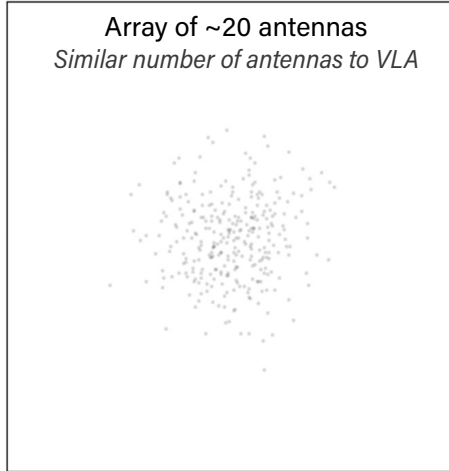


- 20-ft diameter dishes
- ~28-ft at its tallest height
- Antennas have very low level of noise
- Antenna posts installed with vibratory hammer (no cement/concrete)
- Antenna is constantly moving (a perch deterrent); other perch deterrents can be added
- 1 antenna per ~30 acres; occupying <math><0.02\%</math> of site (you could fit all 2000 antennas in 10 acres!)

# Why do we need so many antennas?

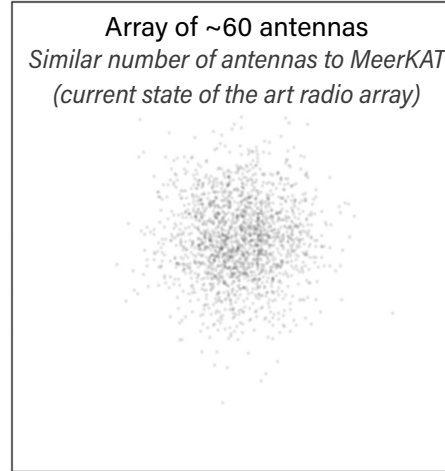
Instantaneous Sky Coverage

Array of ~20 antennas  
*Similar number of antennas to VLA*



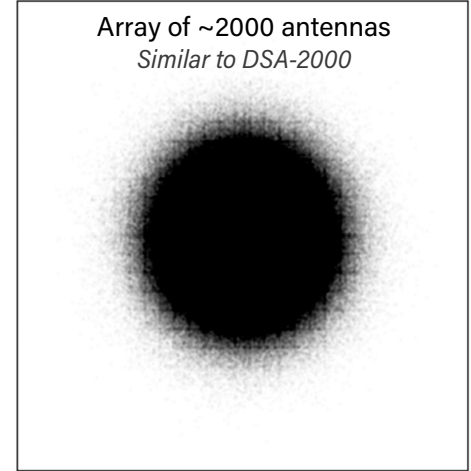
Instantaneous Sky Coverage

Array of ~60 antennas  
*Similar number of antennas to MeerKAT  
(current state of the art radio array)*

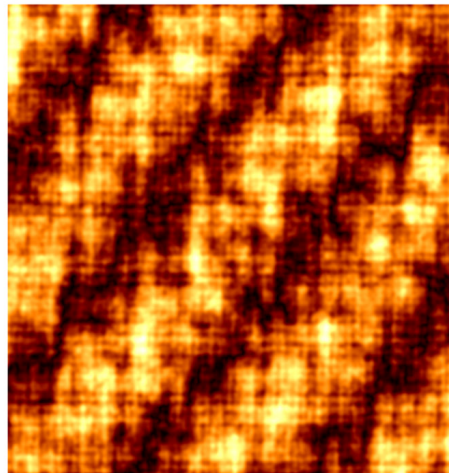


Instantaneous Sky Coverage

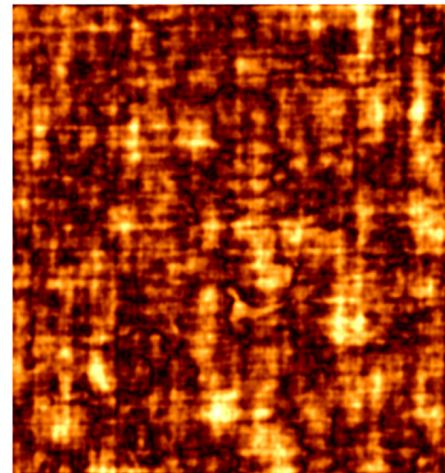
Array of ~2000 antennas  
*Similar to DSA-2000*



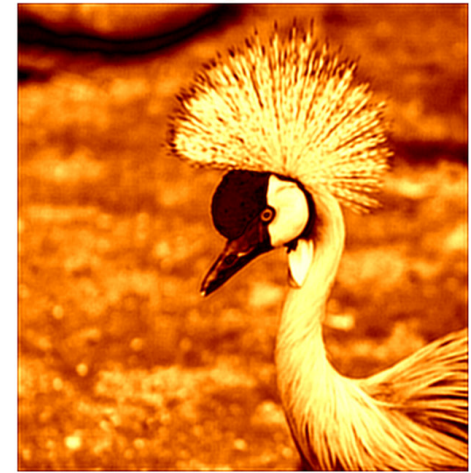
Simulated "Raw" Output Image



Simulated "Raw" Output Image



Simulated "Raw" Output Image



# DSA-2000

A world-leading radio telescope

Can map the sky...  
2,000x faster than Arecibo  
1,000x faster than the VLA

Will detect 1 billion radio sources  
(100x larger than we know today)

Passively observes the Universe  
(no transmissions)



Very Large Array (VLA)  
New Mexico



Arecibo  
Puerto Rico

# DSA-2000 TIME ALLOCATION

5%

## GRAVITATIONAL WAVE FOLLOW-UP

Search for, and characterize, the electromagnetic counterparts to the compact binary coalescences detected by LIGO-Virgo-KAGRA.

## DEEP FIELDS

5%

Conduct daily observations of select fields, particularly the Rubin Observatory deep fields.

## NANOGrAV

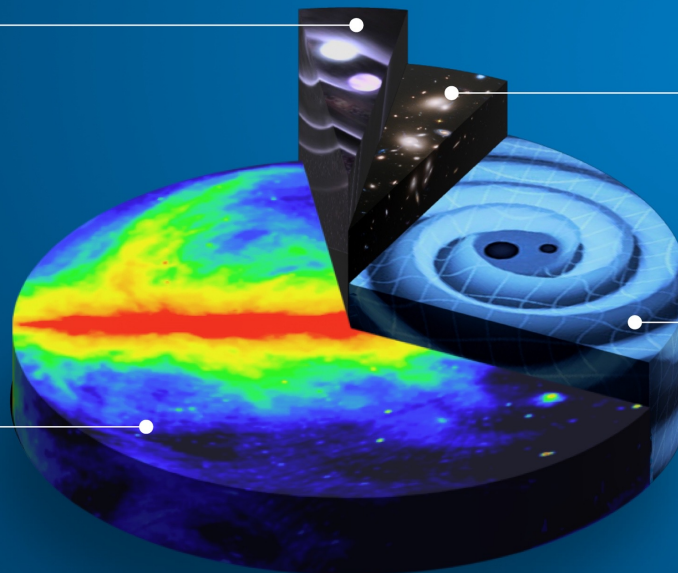
25%

Survey the nanoHertz gravitational-wave (GW) sky through pulsar timing observations conducted by the NANOGrav collaboration.

65%

## CADENCED ALL-SKY SURVEY

Image the entire sky 16 times over 5 years, producing fully polarized, spectral image cubes spanning 0.7 – 2 GHz, increasing the population of known radio sources to >1 billion.



***Making the radio sky accessible  
all will be publicly available***

# DSA-2000

## Key Science

### ***Multi-messenger astronomy***

Pulsar timing for gravitational wave detection, electromagnetic counterparts to compact-object mergers.

### ***Our cosmic history***

A high resolution view of fuel, fire, and feedback in tens of thousands of galaxies, and a billion-source radio catalog reaching to the first galaxies and black holes.

### ***The dynamic radio sky***

Tens of thousands of fast radio bursts (FRBs) to measure the distribution of cosmic baryons; a million slow transients uncovering hidden endpoints of stellar evolution.

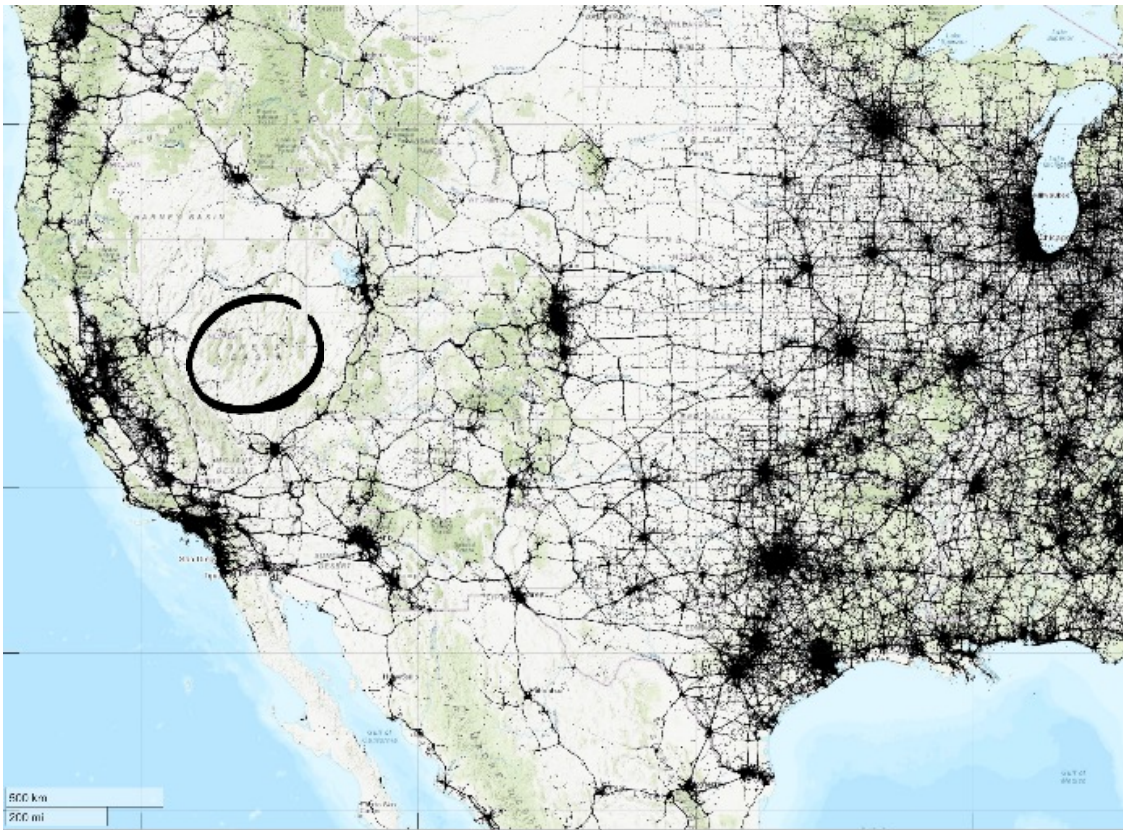
### ***The dark sector and strong gravity***

Dynamical measurements of dark-matter halo profiles for tens of thousands of galaxies, and a 22,000 new pulsars to test gravitational physics.



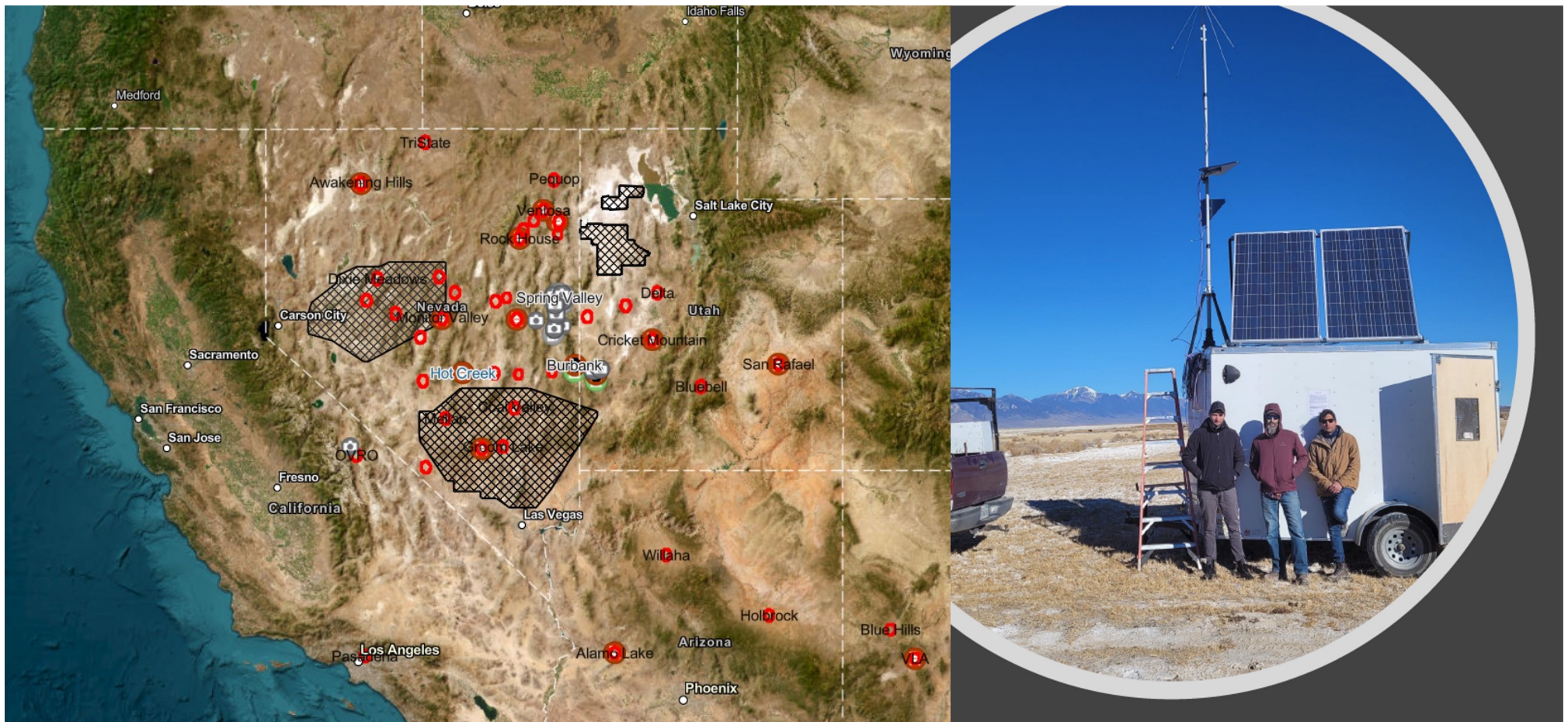
# Why Spring Valley?

**Northern Spring Valley is the most suitable site for DSA-2000 in the U.S.**

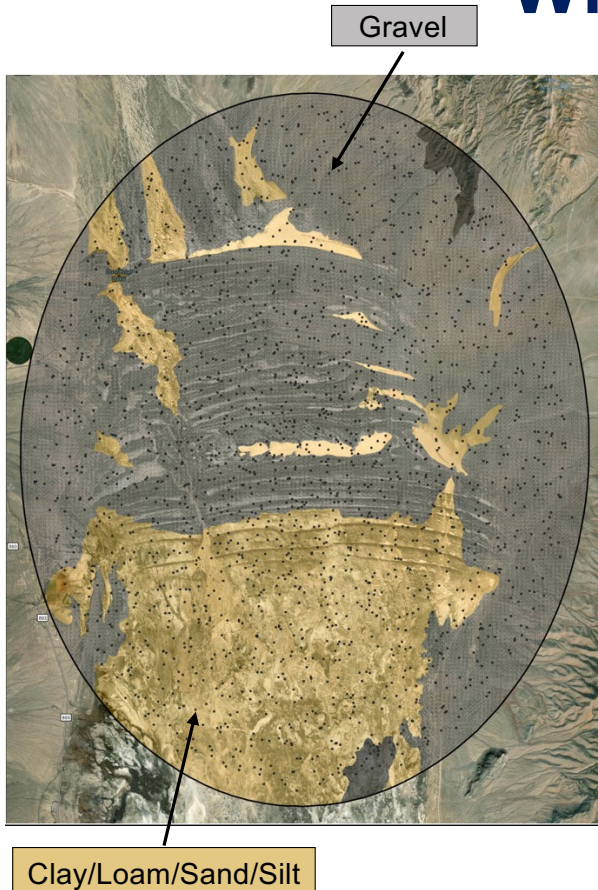


- Approximately 9- x 12-mile area (OVRO is too small)
- Low population area, away from cell towers
- Ideally surrounded by mountains to block cell signals
- Suitable soil for low-impact installation of antennas

# Why Northern Spring Valley?



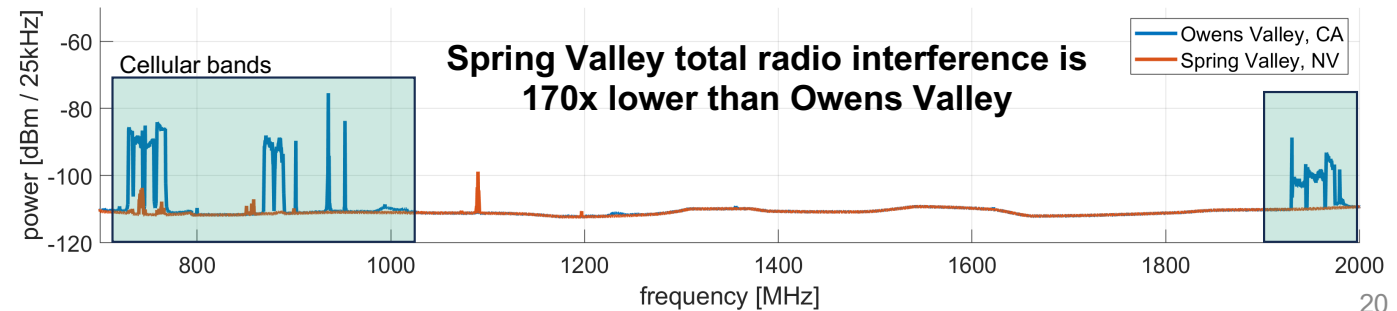
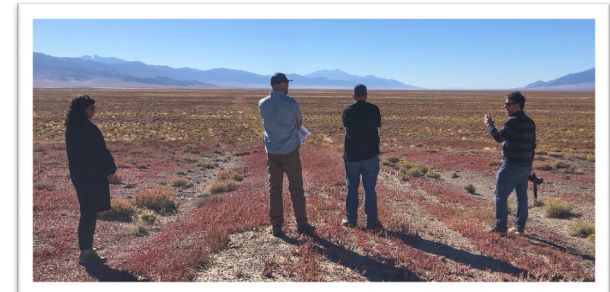
# Why Northern Spring Valley?



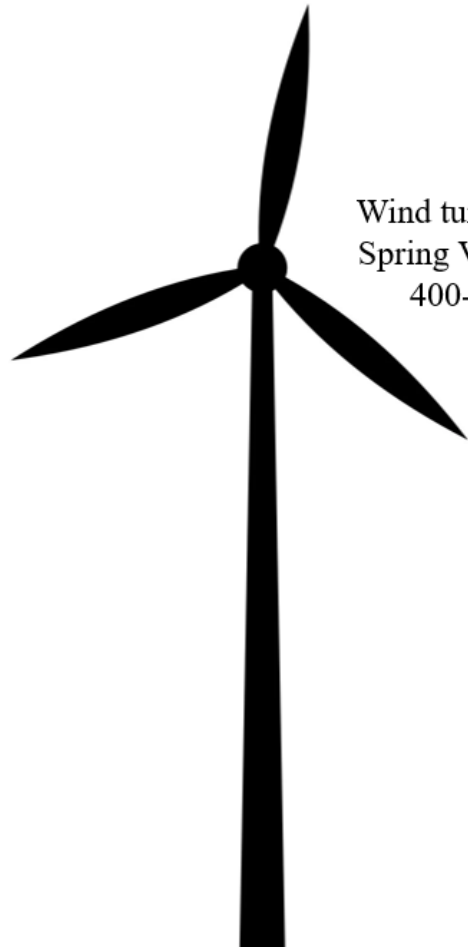
## Top ranked site

*The best location for DSA-2000 in the entire continental U.S.*

- The most “radio quiet” of all possible areas surveyed
- Preferred soil conditions for construction
- Existing infrastructure
- No known major issues



# DSA-2000 is a Unique Project



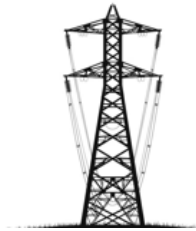
Wind turbine:  
Spring Valley  
400-ft

**DSA-2000 is a unique project with no precedent – it is both large and small at the same time.**

Cell tower, Baker, NV  
166-ft



Proposed Cross-Tie  
Transmission Tower  
~95-ft



Distribution pole,  
Spring Valley  
35-ft



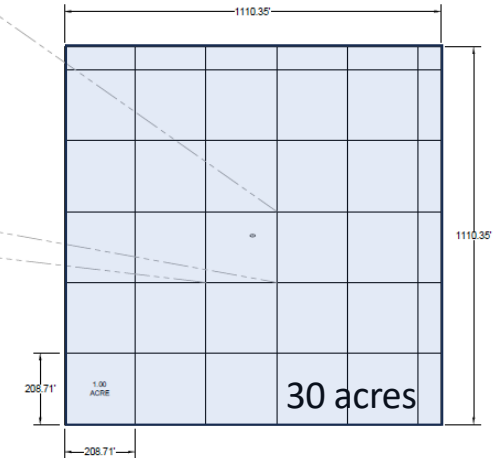
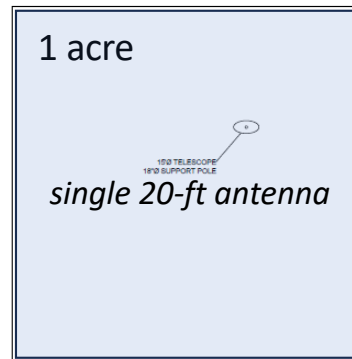
**DSA-2000 dish**  
**Typical: ~26-ft**  
**Max: 28-ft**



# Antenna Distribution Design

**One antenna per ~30 acres**

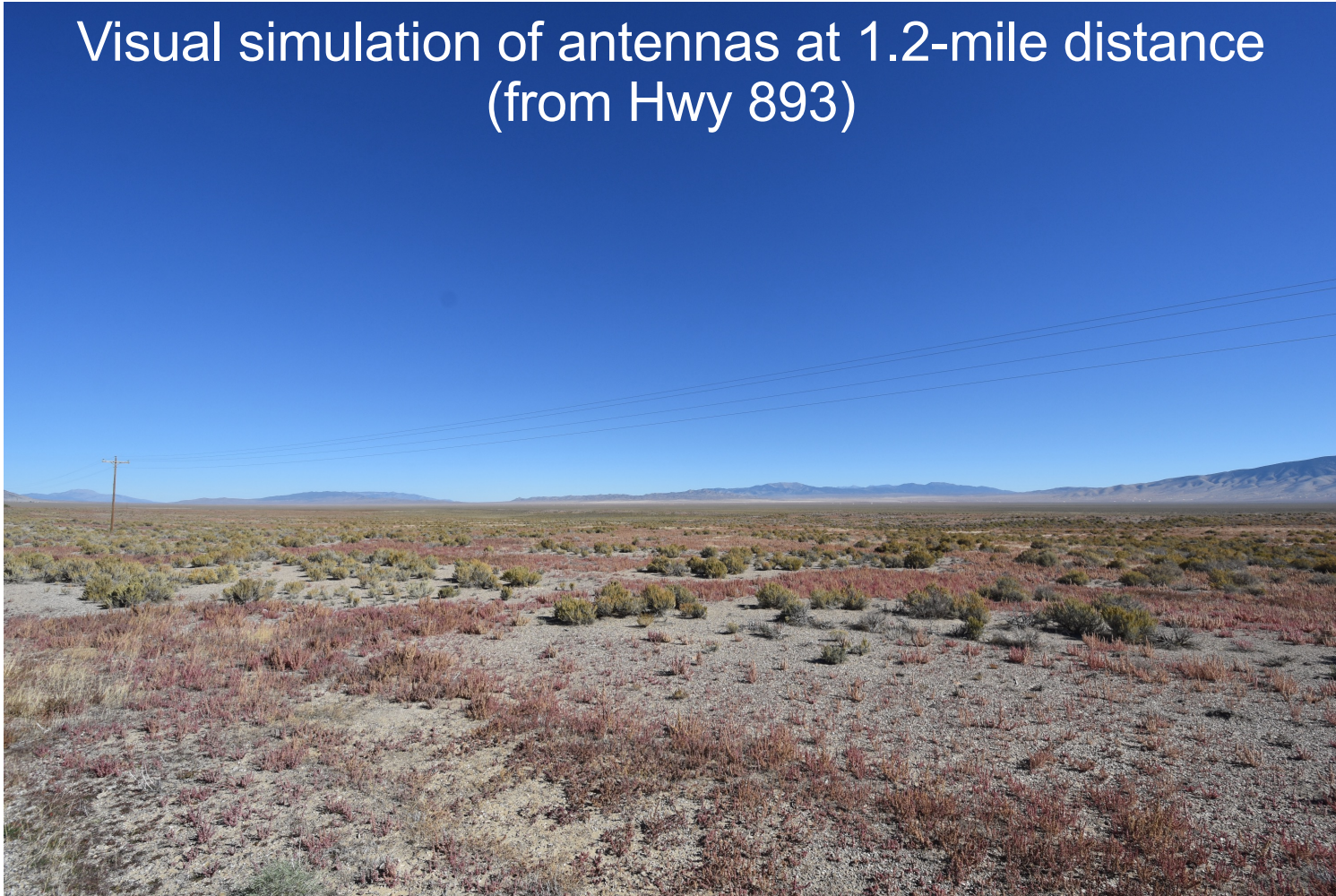
*Suitable for shared usage  
(e.g. grazing)*



	Area (acres)	Percent of Full Site (%)
<b>Full Site</b>	~60,000	100
<b>Construction Disturbance</b>	~1,500	~2.5
<b>Operation Disturbance</b>	~700	~1

## Putting DSA-2000 in Perspective

Visual simulation of antennas at 1.2-mile distance  
(from Hwy 893)



## Putting DSA-2000 in Perspective

Visual simulation of antennas at 1.2-mile distance  
~12x enlargement



# Minimizing Environmental Impact



DSA-2000 antenna to scale next to wind turbine that is 1 km from the road.

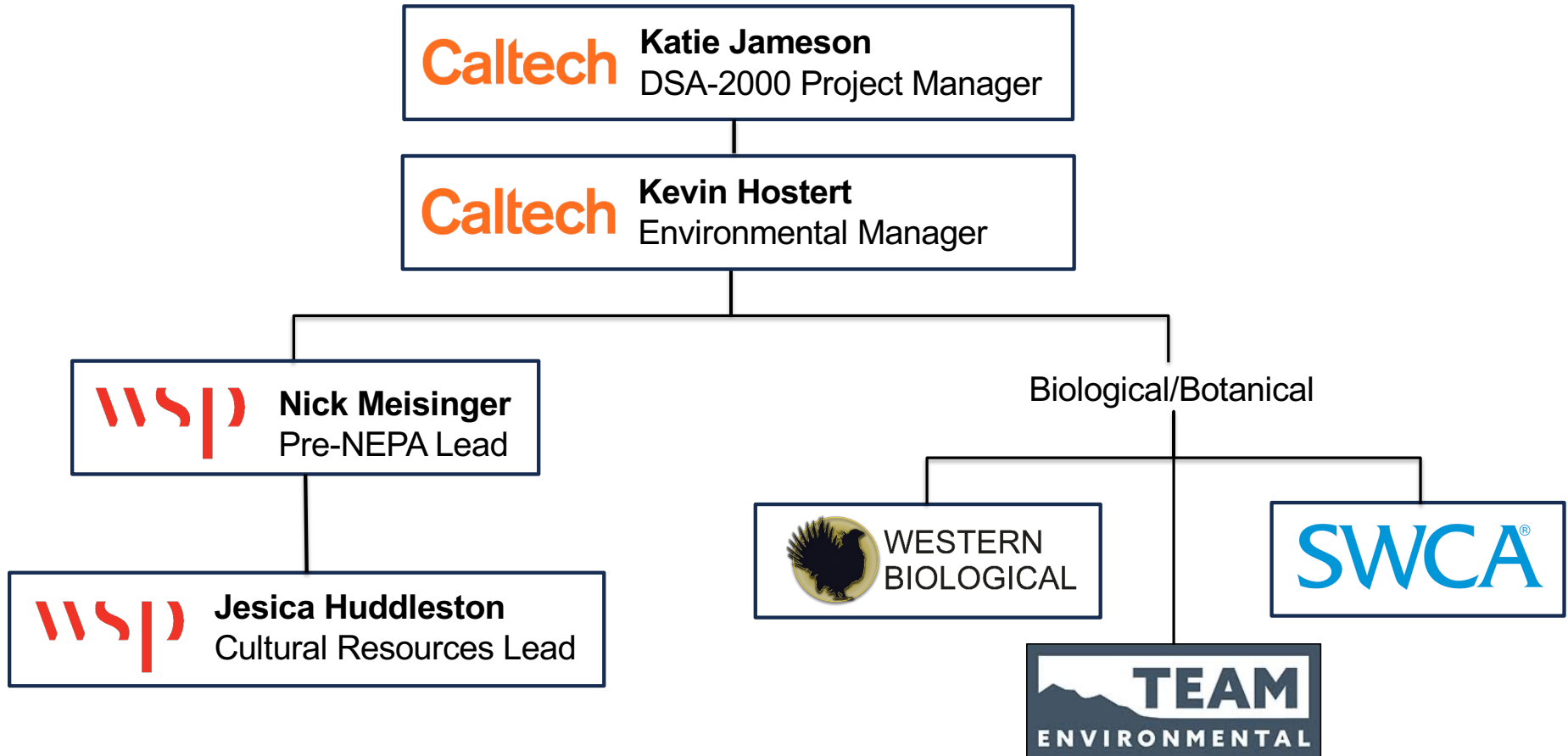
- No concrete planned for antennas or solar panels
- Project does not require water
- Minimal visual impact
- ~2% of land area disturbed, ~1% continued use
- Commitment to avoid sensitive water, biological and cultural resources with flexible fiber and antenna placement
- Recognize importance of involvement and participation of area Tribes

# Permitting Status

- SF-299 submitted in late 2023, still in pre-NEPA phase
- 2025 Spring Surveys concluding (second year of surveys)
  - Biological, Cultural, Botanical
  - No major findings for biological and botanical to date
- Anticipate starting NEPA by end of 2025
- NEPA will be complimented by Mitigation and Monitoring plans for specific resources during construction



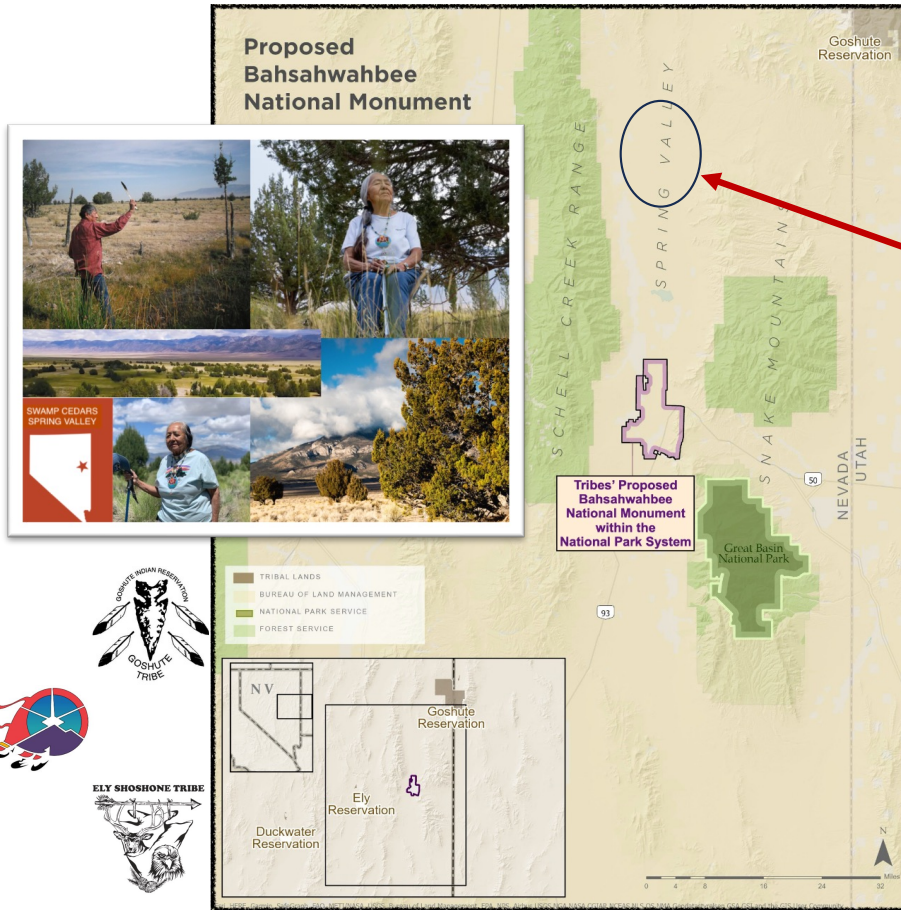
# Environmental Team



# Known Concerns in Spring Valley

- Tribes and cultural resources
- Sage-grouse and sage brush ecosystem
- Impacts to Spring Valley lands
  - Non-natives and invasives
  - Grazing

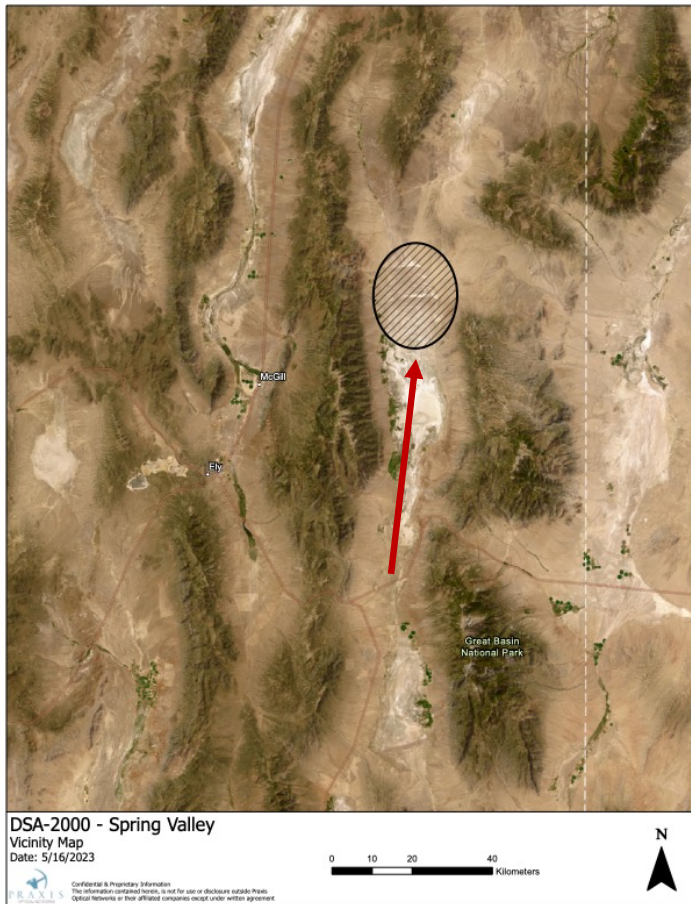
# Tribes and Cultural Resources



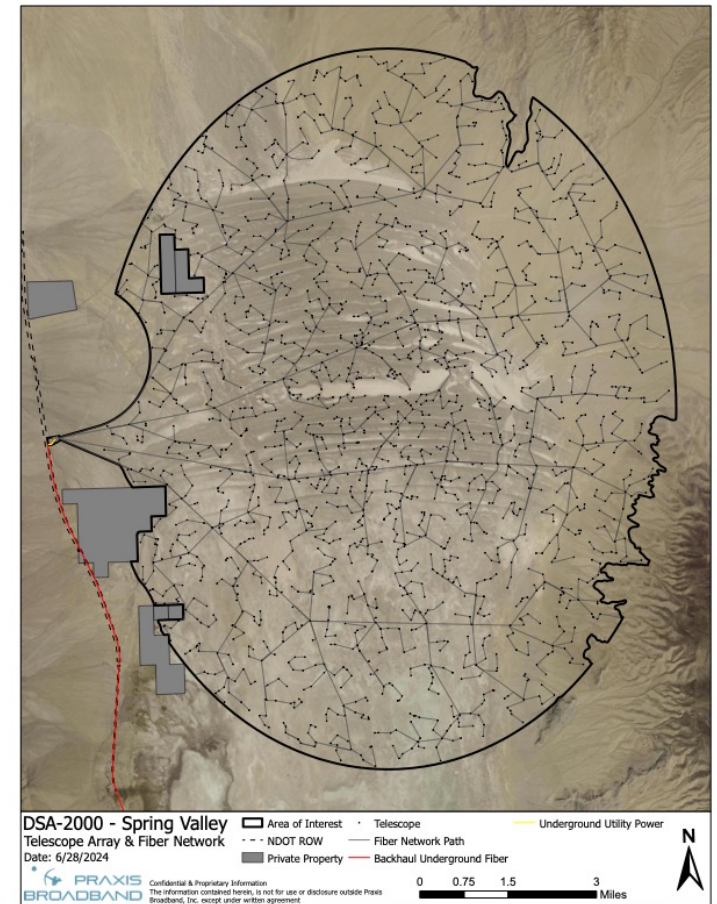
~20 miles to the North of proposed Bahsahwahbee National Monument

- Not visible from Bahsahwahbee
- No lights on antennas
- Very low noise
- No water needed

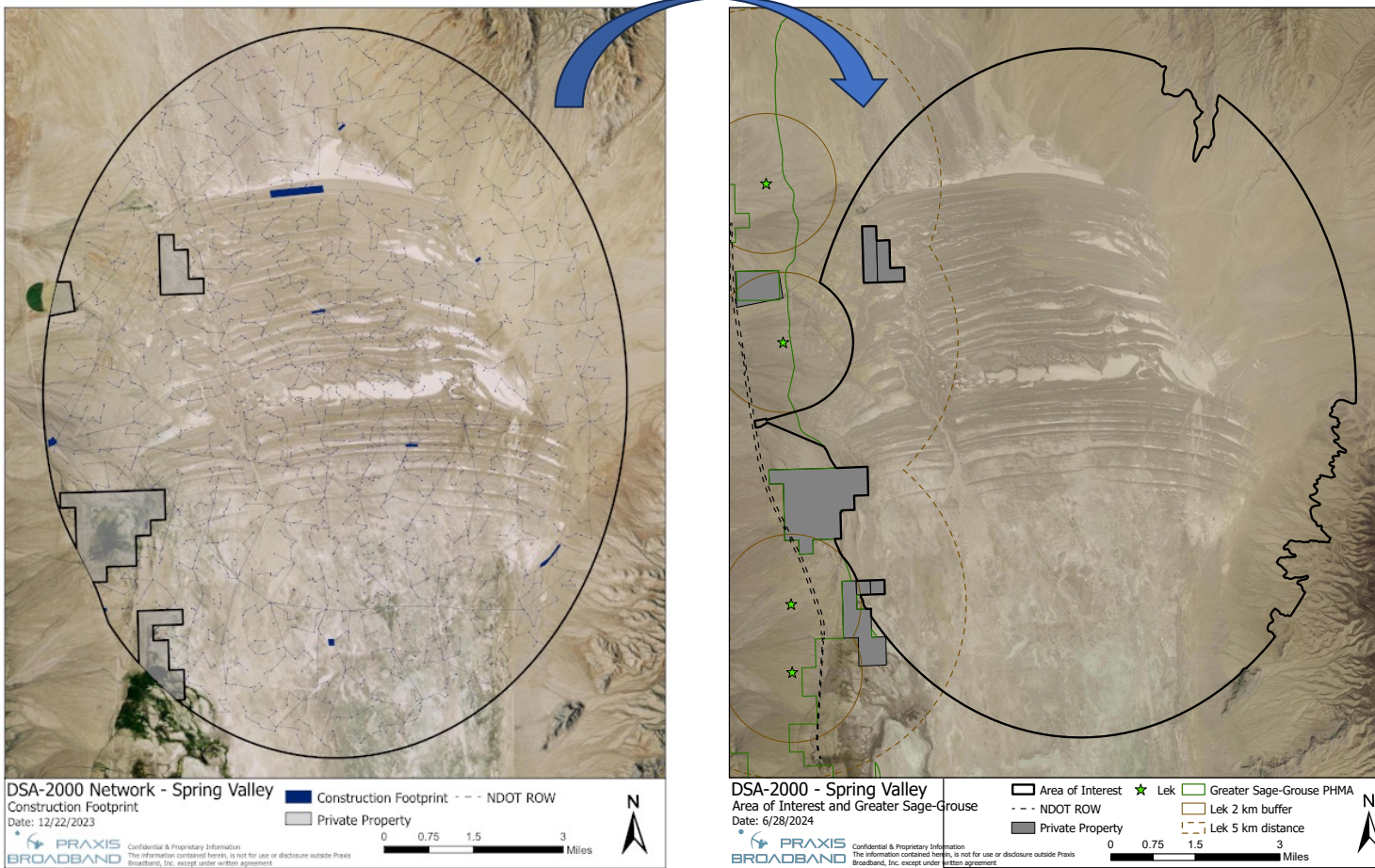
# Tribes and Cultural Resources



- Antenna and fiber paths are flexible to avoid any culturally significant areas
- MOA with Warren Graham (Duckwater THPO) for Tribal monitors for cultural resources survey, also sent to Ely Shoshone and Goshutes



# Shift for sage-grouse avoidance



Shifted project out of prime sage brush habitat and as far from the active leks as possible

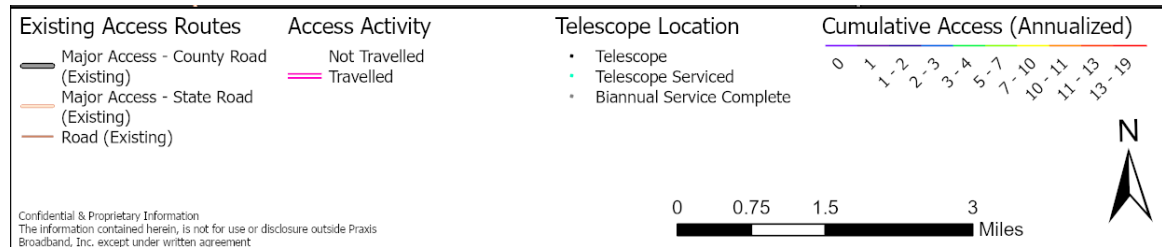
# Minimizing Impacts to Spring Valley Lands



- No use or impact to water in Spring Valley
- Working with Eastern Nevada Landscape Coalition and Prof. Tamzen Stringham and Dr. Lucas Phipps (UNR Rangeland Ecology Lab) on how to prevent invasives (e.g., Halogeton)
- Open to shared land usage that does not produce radio frequency emission that would disrupt observations
  - Includes grazing
  - OVRO has grazing, antennas are protected by empty conduit



# Minimizing Impact: Operation Access Plan



**Access plan maximizes use of existing roads, most access routes will be used on average 1x per year by 4 maintenance teams in UTVs.**



Maintenance designed to be completed with UTVs that will drive overland using GPS pre-determined routes.

# Caltech's Restoration Track Record



*(Note: the red is buckwheat, not cheatgrass)*

# Caltech's Restoration Track Record

## CARMA Site Restoration in Inyo Mountains

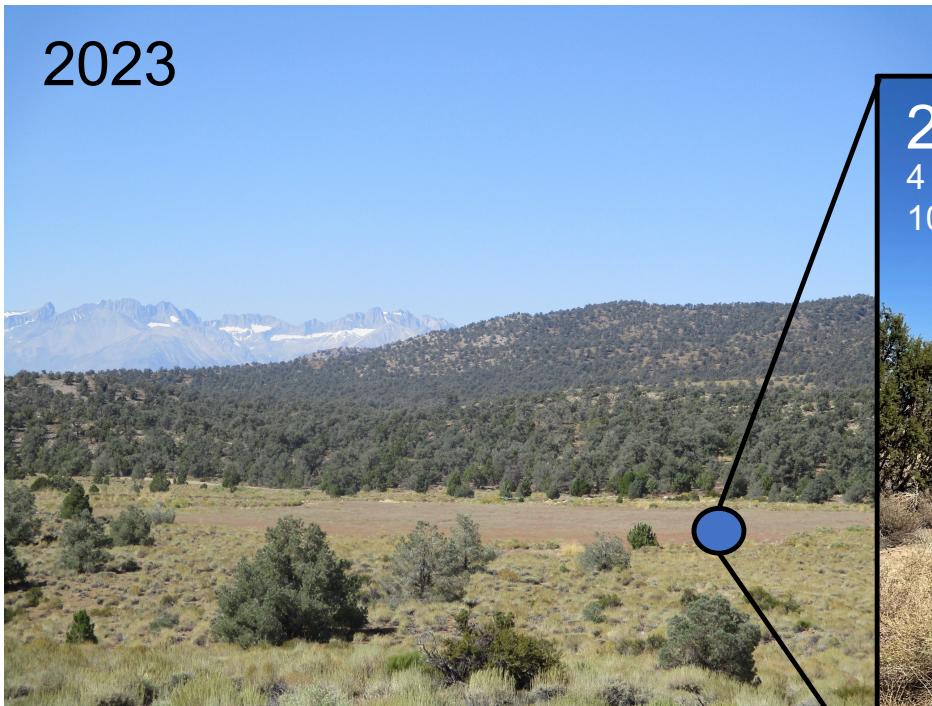


*(Note: the red is buckwheat, not cheatgrass)*

# Caltech's Restoration Track Record

## CARMA Site Restoration in Inyo Mountains

2023



2025

4 years since restoration deemed complete by US Forest Service  
10 years since close of the facility

