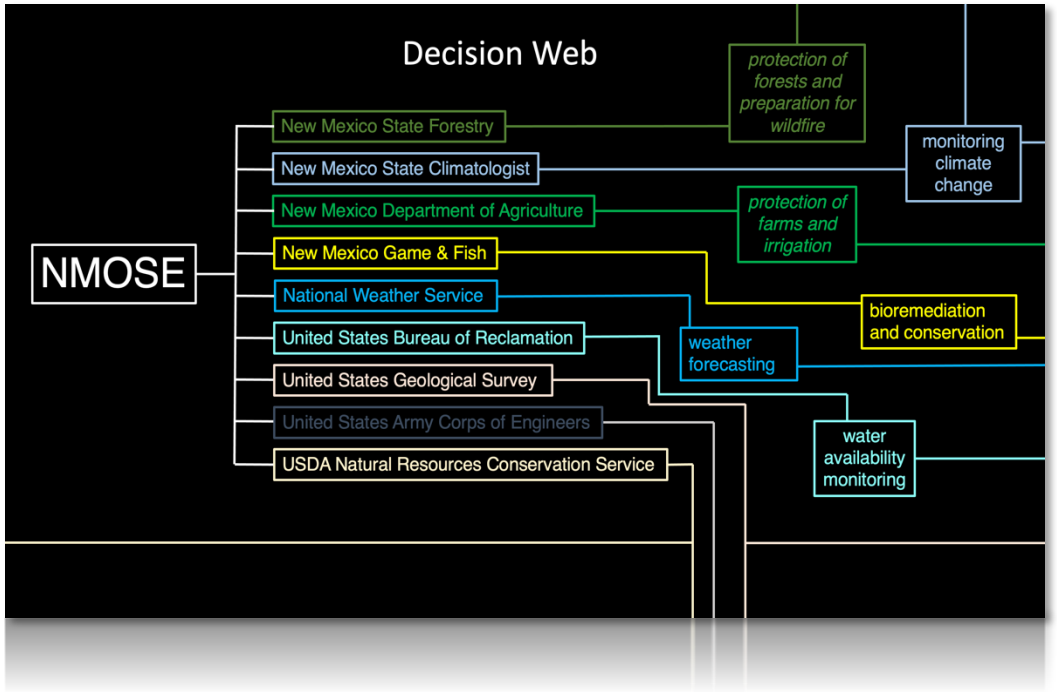
Water Management for the State of New Mexico

Joshua B. Fisher[1], Gregory Halverson[2], Julie Valdez[3], Matt Nelson[3], Scott Davidoff[2], Ryan Stonebraker[2], Madeleine Pascolini-Campbell[2], Michael Fedell[2], Michael Visser[3], Ian Alexander[3], Savannah Cooley[2], Holland Hatch[1], Ryan Joshi[1], Annalise Jensen[1], Jerri Pohl[3], Zoë von Allmen[1], Natalie Tarbox[2], Edward Schenk[4]

[1] Schmid College of Science and Technology, Chapman University
[2] Jet Propulsion Laboratory, California Institute of Technology
[3] New Mexico Office of the State Engineer
[4] Arizona-Flagstaff Water Services

Category 3 Project

- **Category 3**: **Proven Application and Full Transition to Operational Partner**
- Moving an established set of prototype hydrological remote sensing tools in use (ARL 7) and demand by the state operational water agency for New Mexico, the Office of the State Engineer (NMOSE), into **full operations and transition** to the partner (ARL 9).
- NMOSE has the authority over the appropriation and distribution of all surface & groundwater in New Mexico.
- WSWC (‘14) → DEVELOP (‘15) → WWAO (‘18) → WATER (‘22)



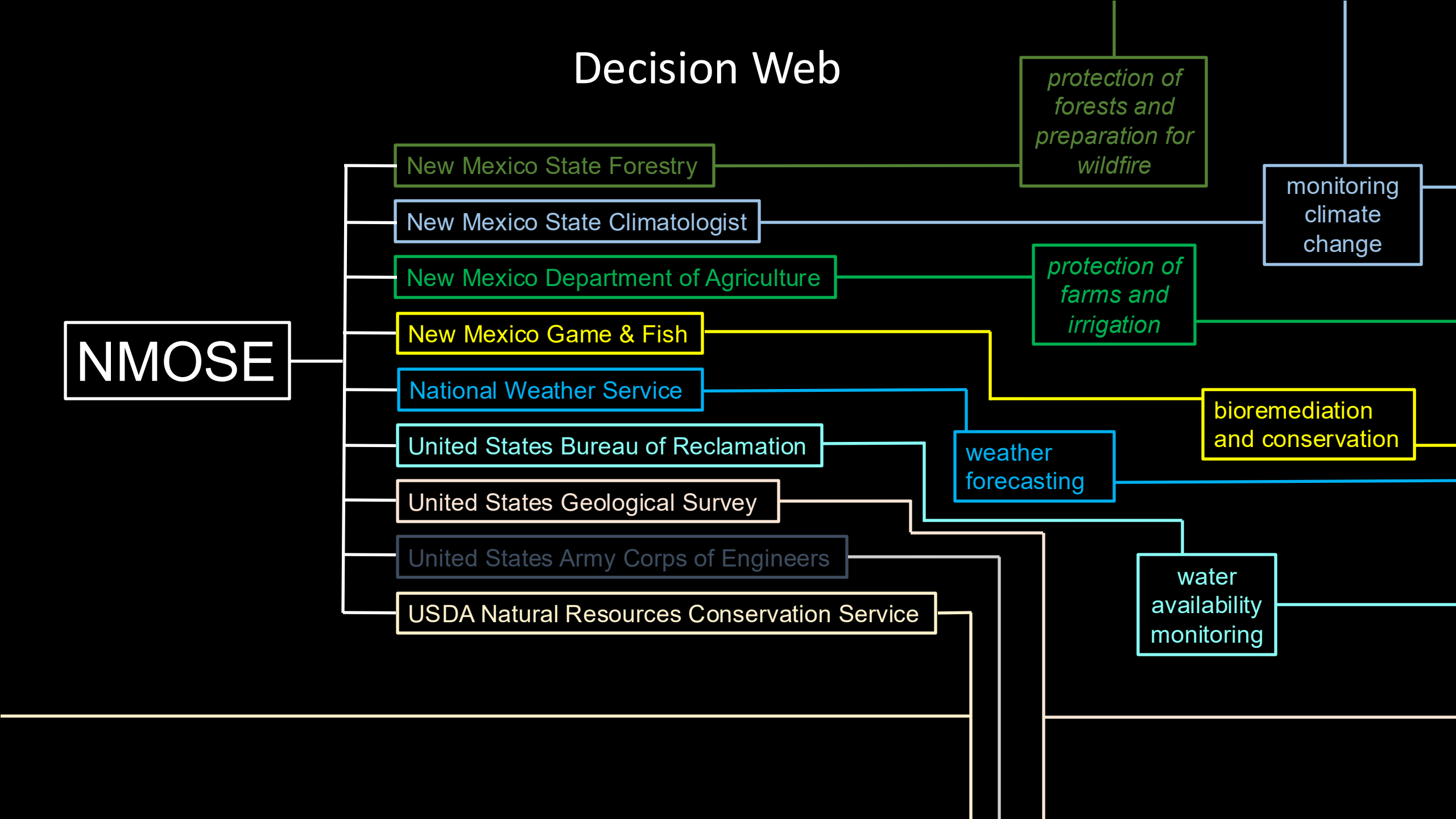
NMOSE Decision-Making Contexts

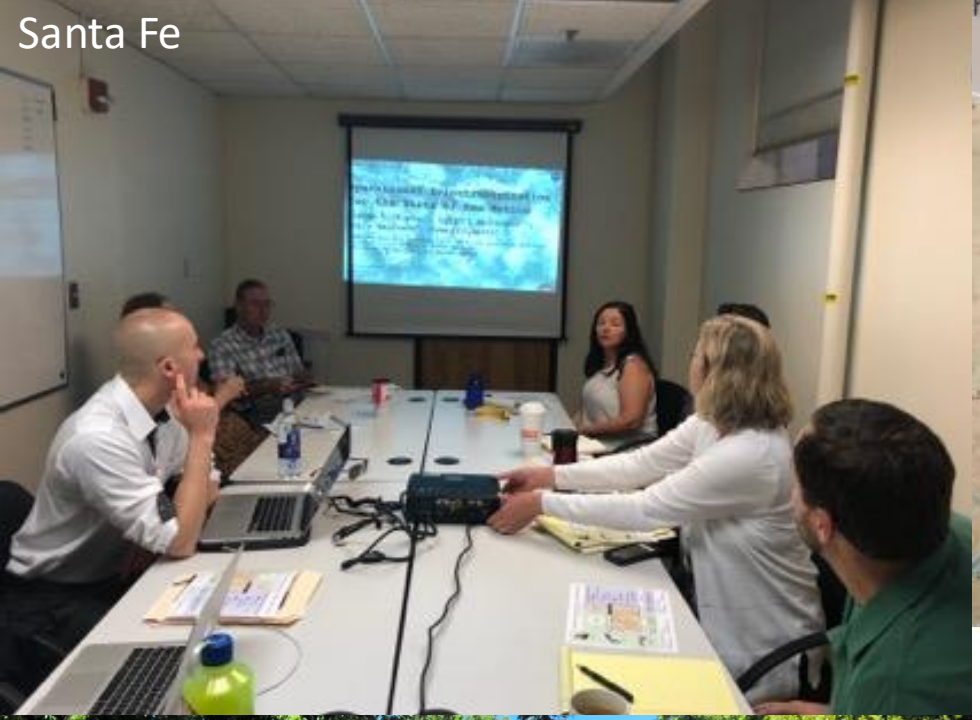
Drought Response & Mobilization

Forest & Wildfire Monitoring

Agriculture & Water Management

Decision Web




Santa Fe


Santa Fe
Status Update of New Mexico
Underground Storage & Recovery (USR) Projects

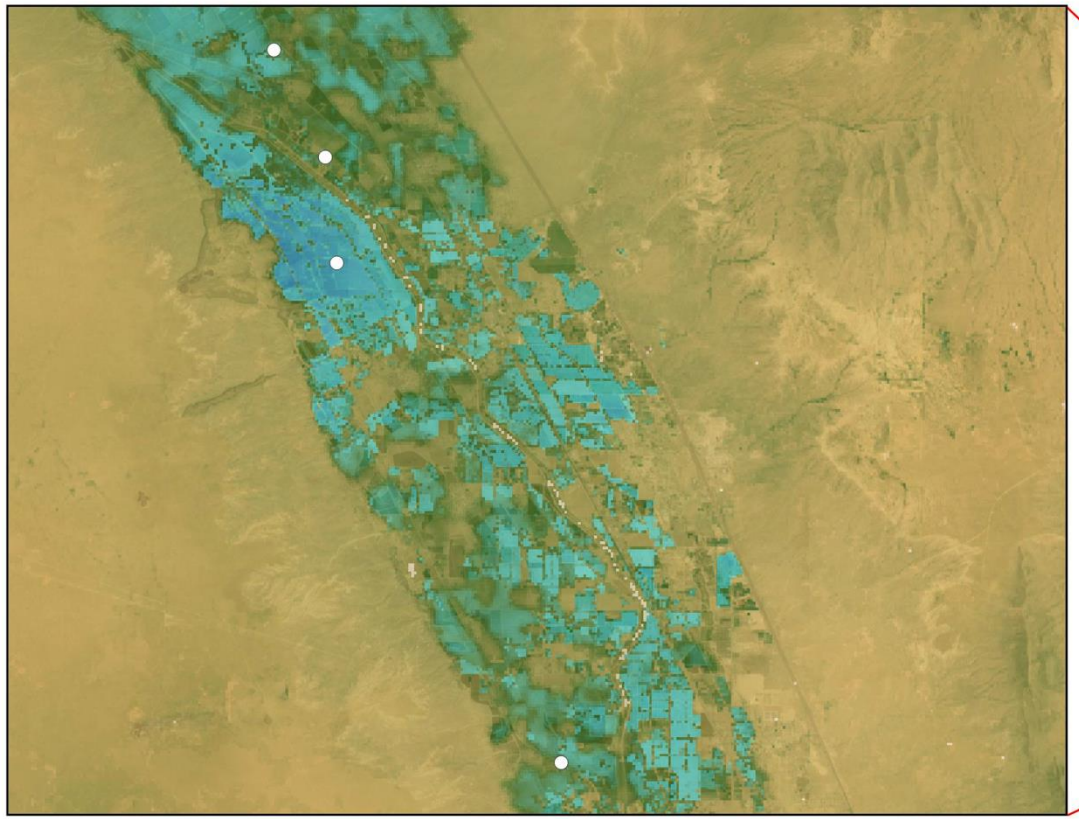

Santa Fe

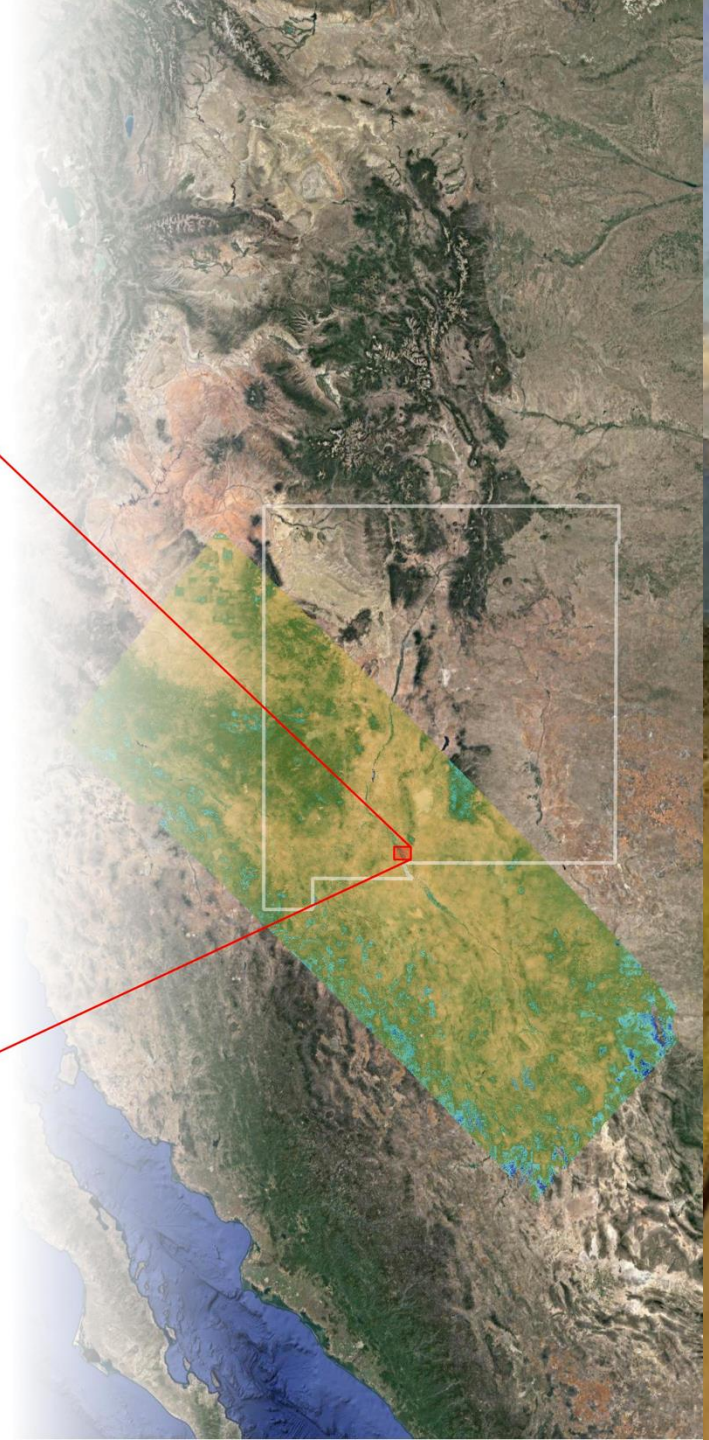

Las Cruces


Albuquerque

Initial ECOSTRESS Acquisitions over New Mexico State University

2018-09-04 09:10 UTC-7.1



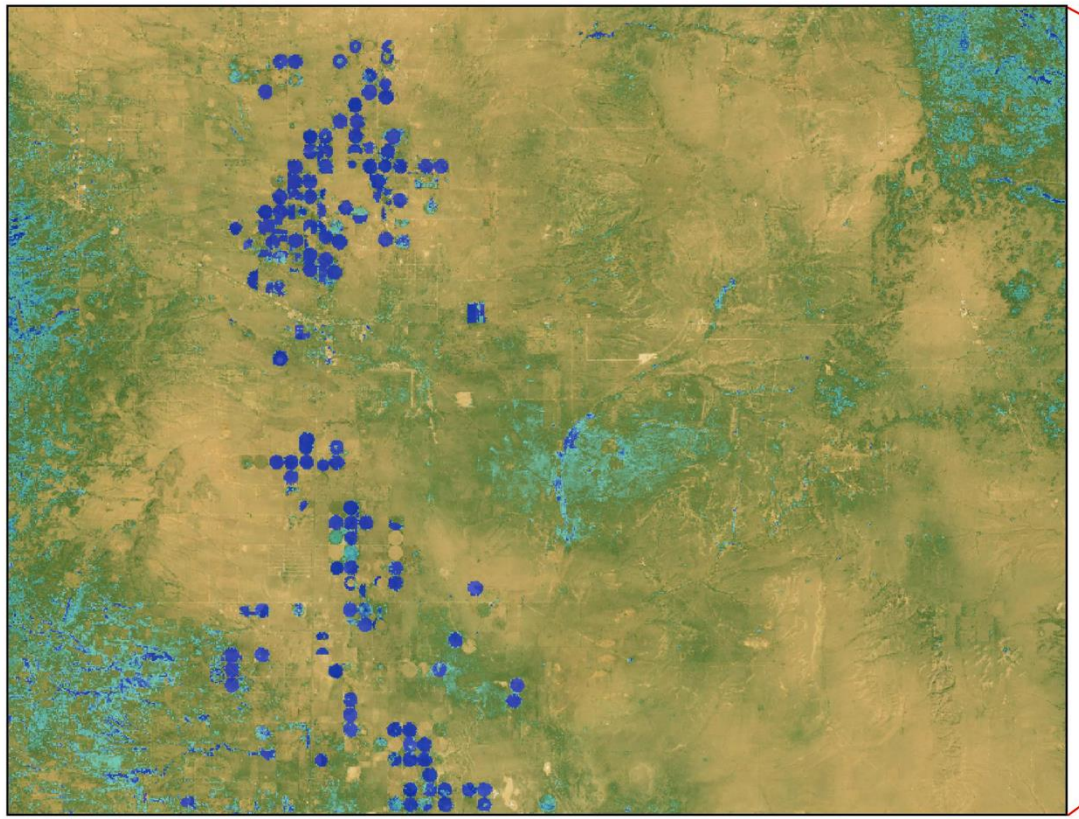


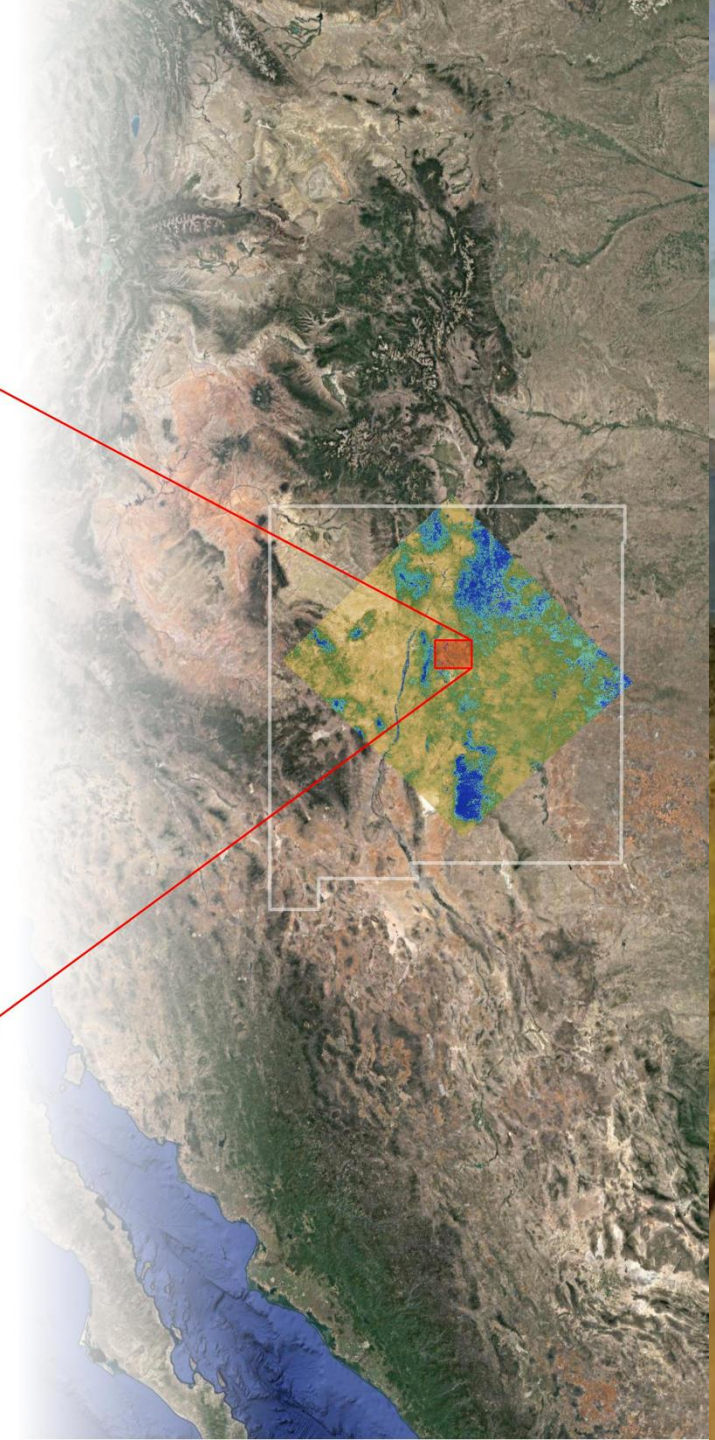
0.00 g H_2O s^{-1} m^{-2} 0.27

NMSU Ground Observation Tower

ECOSTRESS Preview over Estancia, New Mexico

2018-08-14 10:06 UTC-7.1





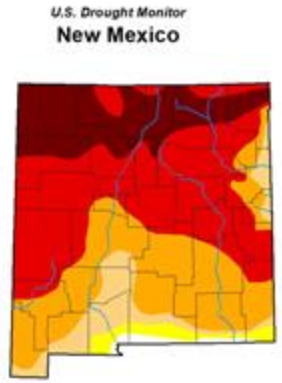
0.01 g H_2O s^{-1} m^{-2} 0.18

○ NMSU Ground Observation Tower

Drought Monitoring Working Group (DMWG)

Royce Fontenot, Senior Service Hydrologist, National Weather Service, royce.fontenot@noaa.gov
David DuBois, New Mexico State Climatologist, New Mexico State University, dwdubois@nmsu.edu

The Monitoring Working Group of the Drought Task Force includes water resource, agriculture, and climate professionals from all levels of government. The group is responsible for monitoring all available climatological data to analyze the current status of drought conditions in the State of New Mexico. The group also examines and reports on long-term forecasts to assist the DTF in their preparedness and response actions. As necessary, the MWG issues "notices" based on various stages of drought that trigger actions by the Drought Task Force. The inclusion of remotely sensed evapotranspiration as a drought indicator can greatly improve this drought monitoring process.



Decision

- Determine drought threat across New Mexico in regular meetings with the Monitoring Work Group
- Declare drought for the state
- Convene the Drought Task Force during state of drought

Impact

- Drought classification can impact federal assistance given to agriculture and ranching. ($$$)

Data Requirements

- Spatial: State-wide (1 km)
- Temporal: Daily
- Historical: Anomalies
- NRT: Yes

Data Delivery

- GeoTIFF
- Map images and summary statistics

NEW MEXICO ET CASE STUDIES

1

MANAGEMENT & ADMINISTRATION

2

State Water Plan

Lucia Sanchez, Water Planning Program Manager, Interstate Stream Commission, Lucia.Sanchez@state.nm.us
Molly Magnuson, Water Use and Conservation Bureau Chief, Office of the State Engineer, molly.magnuson@state.nm.us
NM reviews the State Water Plan every 5 years. This plan describes the top-level water use and needs throughout the state. The plan quantifies consumptive use (ET) for planning and infrastructure investments. The NM Water Resources Research Institute (WRRI) is currently developing the Statewide Water Assessment, which may be used as part of the State Water Plan. NM has not had state-wide ET maps to use for the Plan.

Decision
- Statewide planning for water through infrastructure investments
- Determination of what is needed to support and manage consumptive use (ET)

Impact
- Improve formulation of State Water Plan ($)
- Infrastructure investments ($$$)

Data Requirements
- Spatial: State-wide (1 km)
- Temporal: Annual, Monthly?
- Historical: 5 year?
- NRT: No

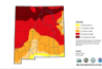
Data Delivery
- Map images and summary statistics (need to collaborate with WRRI)

3

Drought Monitoring Working Group (DMWG)

Molly Magnuson, Water Use and Conservation Bureau Chief, Office of the State Engineer, molly.magnuson@state.nm.us
Royce Fontenot, Senior Service Hydrologist, National Weather Service, royce.fontenot@noaa.gov
The NMOSE participates in the DMWG with other state and federal agencies, and regularly assesses drought conditions for the State. Drought classification can impact federal assistance given to agricultural lands. Improved ET data provided to the National Weather Service (NWS) would feed into the US Drought Monitor (USDM) and improve drought assessments for the State.

Decision
- Statewide declaration of Drought



Impact
- Federal financial assistance ($$$)

Data Requirements
- Spatial: State-wide (1 km)
- Temporal: Daily
- Historical: Anomalies
- NRT: Yes

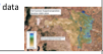
Data Delivery
- Map images and summary statistics
- Data format input to NWS?

4

Pecos River Basin Study Report

Dagmar Llewellyn, Hydrologist, US Bureau of Reclamation, dllewellyn@usbr.gov
Hannah Riseley-White, Pecos River Bureau Chief, Interstate Stream Commission, hannah.riseley-white@state.nm.us
Report describing USBR capabilities for water assessment. High demand for ET data. Report to point to WWAO project. The Pecos River Basin Study seeks to develop strategies for anticipated future reductions in water supplies by improving water budget estimates in the Fort Sumner Basin and achieving consensus on climate change scenarios, including water supply, demand, and reliability issues.
https://www.usbr.gov/watersmart/bsp/docs/fy2012/FactSheet-PecosRiverBasinStudy.pdf

Decision
- Develop strategies to adapt to reduced water supply
- Investments and mobilization of resources to respond to analysis and decision needs based on available resources
- Investments to equip for use of ET data



Impact
- Improve climate resilience to uncertain water supply ($$)
- Resource investments to improve water management capabilities ($$$)

Data Requirements
- Spatial: Fort Sumner Basin (1 km)
- Temporal: Annual
- Historical: 2008-2016
- NRT: No

Data Delivery
- Map images
- GeoTIFFs

5

Active Water Resource Management

John Romero, Water Rights Division Director, Office of the State Engineer, john.romero2@state.nm.us
Active Water Resource Management (AWRM) manages water shortages without solely following priority administration and cutting people off. AWRM allows for compromises, such as shortage sharing agreements, rotational and deficit irrigation. The OSE needs to ensure compliance (ET) when these agreements are in place. This program currently relies on gauge data, which is sparse, and in some parts of the state completely unavailable. Remotely sensed ET can fill this need.

Decision
- Arbitrate water needs (ET) claims from users and managers
- Shortage sharing agreements during scarcity
- Ensure compliance (ET)
- Select farms for deficit irrigation (ET)

Impact
- Maximize production and sustainability under water shortage ($$)
- Ensure compliance (💧)
- Improve relations between water masters and farmers (👪)
- Reduce litigation ($$$)

Data Requirements
- Spatial: Field scale (30 m)
- Temporal: Weekly?
- Historical: 1 year?
- NRT: Yes

Data Delivery
- Potential phone app for quick access
- Map images showing irrigation "light up"
- Review ET on a timeline

6

Interstate Compact Compliance

Paul Harms, Staff Engineer, Interstate Stream Commission, paul.harms@state.nm.us
Rolf Schmidt-Peterson, Colorado River Bureau Chief, Interstate Stream Commission
Prioritization and subsidization of fallowing (ET stop) and deficit irrigation (ET decrease) to increase downstream water deliveries. Current methods include field surveys, examining NAIP imagery, and point-estimates of ET using Blaney-Criddle.

Decision
- Select farms for fallowing (ET stop)
- Select farms for deficit irrigation (ET decrease)
- Determination of water savings (ET decrease with river increase)

Impact
- Maintain compact water compliance between states, avoid litigation ($$$)

Data Requirements
- Spatial: Field scale (30 m)
- Temporal: Monthly?
- Historical: Near-term history to see if farms actually stopped irrigating or not
- NRT: Yes

Data Delivery
- Map viewer?
- GeoTIFF, UTM 13 N?
- Map images for a parcel showing ET light up over time

7

Priority Administration

POC Name, Position, Institution, email
Application description

Decision
- ...

Impact
- ...

Data Requirements
- Spatial:
- Temporal:
- Historical:
- NRT:

Data Delivery
- ...

8

Water Rights Transfer

John Romero, Water Rights Division Director, Office of the State Engineer, john.romero2@state.nm.us
The OSE reviews applications (currently backlogged, especially in southeastern NM) to transfer the place and purpose of use for water rights. The OSE must assess the historic continuous beneficial use of water (ET) for each water right application in question. Long-term historical records of field scale ET will be highly beneficial.

Decision
- Accept, deny, or reappraise water rights transfer applications based on historical beneficial use (ET)

Impact
- Re-appraisal of over-valued water rights, reducing waste ($)
- Hundred of thousands of dollars in applications ($$$)
- Expedite application processing ($)
- Improve economic activity ($$)

Data Requirements
- Spatial: Field scale (30 m)
- Temporal: Monthly?
- Historical: As long as possible (decades)
- NRT: None

Data Delivery
- Time-series browser quantifying beneficial use over a long historical record
- Map images for a parcel showing ET light up over time, or NOT light up

9

Reservoir Depletion

Dagmar Llewellyn, Hydrologist, US Bureau of Reclamation, dllewellyn@usbr.gov
Kenneth Richard, Project Manager/Hydrologist, US Bureau of Reclamation, kenneth.richard@state.nm.us
Molly Magnuson, Water Use and Conservation Bureau Chief, Office of the State Engineer, molly.magnuson@state.nm.us
Page Pegram, Acting Basin Manager of the Rio Grande, Interstate Stream Commission, page.pegram@state.nm.us
Reservoirs lose water through evaporation (ET) (and infiltration), but at different rates depending on reservoir and within reservoirs. Water can be transferred between reservoirs to avoid loss. The State is required to pay for water losses. The USBR lacks consistent, large-scale, and high quality data on reservoir evaporative loss.

Decision
- Determine evaporative loss among reservoirs
- Determine management strategies for r
- Calculate how much the State owes for

Impact
- Save water used to make up for evaporative loss (💧)
- Save money to State in paying for loss ($$$)
- More accurate compact delivery numbers ($$$)

Data Requirements
- Spatial: Bathymetry-scale (30 m)
- Temporal: Monthly
- Historical: 3 years
- NRT: No

Data Delivery
- Summary statistics

10

RIVER/BASIN MONITORING

11

River Health Support, Pecos Diversions, Fort Sumner Basin

Carolyn Donnelly, Civil Engineer, USBR, cdonnelly@uc.usbr.gov
Molly Magnuson, Water Use and Conservation Bureau Chief, Office of the State Engineer, molly.magnuson@state.nm.us
Hannah Riseley-White, Pecos River Bureau Chief, Interstate Stream Commission, hannah.riseley-white@state.nm.us
Reinterpreted water rights in Fort Sumner basin have been taking more water than they should. The river must have enough water to support fish. How much water is being used (ET) in Fort Sumner that can be saved for the river?

Decision
- Maintain water for biology
- Determine how much water is being used (ET) in Fort Sumner that can be saved for the river
- When and where to transfer populations of minnows along the river

Impact
- Protect endangered species (🐟)
- Avoid litigation from Endangered Species Act ($$$)

Data Requirements
- Spatial: Field scale (30 m)?
- Temporal: Monthly?
- Historical: Decadal
- NRT: Need timely information for bioremediation actions?

Data Delivery
- GeoTIFF, UTM 13 N?
- Summary statistics?

12

River Realignment Monitoring, San Acacia Reach of the Rio Grande

Page Pegram, Acting Basin Manager of the Rio Grande, Interstate Stream Commission, page.pegram@state.nm.us
Engineered river realignments (e.g., on the Rio Grande, San Acacia reach) affect riparian habitats. We need to know how this affects total streamflow. Is there more or less ET within a basin/sub-basin when a river is moved? When the ISC finds a depletion in the river, the USBR has to cover it and figure out who pays for the water.

Decision
- Determine where there is a depletion based on change in basin/sub-basin ET

Impact
- Save water (💧)
- Protect endangered species (🐟)
- Avoid litigation from Endangered Species Act ($$$)
- Save labor with less people needed to do fieldwork and review data

Data Requirements
- Spatial: Riparian scale (30 m); or basin scale (1 km)?
- Temporal: Monthly?
- Historical: No (except for research demonstration)
- NRT: Yes

Data Delivery
- GeoTIFF, UTM 13 N?

13

FORESTS

14

Fire Risk Mitigation

Susan Rich, Forest & Watershed Health Coordinator, NM Energy, Minerals & Natural Resources Dept., SusanE.Rich@state.nm.us
Identify forest areas drying (anomalously low ET) for fire prevention, management, mobilization. May be due to disease (bark beetle).

Decision
- Identify dry areas (anomalously low ET)
- Select areas of forest for treatment (thinning, prescribed burn)

Impact
- Prevent catastrophic fire, preserve ecosystem health, reduce fire-fighting costs, save lives, improve air quality ($$$, 👪, 🌬)

Data Requirements
- Spatial: 1 km
- Temporal: Daily
- Historical: Decade for anomalies
- NRT: Yes

Data Delivery
- GeoTIFF linked to monitoring system?

15

Forest ET Reduction

Susan Rich, Forest & Watershed Health Coordinator, NM Energy, Minerals & Natural Resources Dept., SusanE.Rich@state.nm.us
Page Pegram, Acting Basin Manager of the Rio Grande, Interstate Stream Commission, page.pegram@state.nm.us
Reduce water use (ET) by forests so more water is available to the river for other uses.

Decision
- Identify forest areas with high ET
- Selectively treat those areas, including thinning and prescribed burns

Impact
- Reduce water consumption of forest (💧)
- More water available for other uses ($)

Data Requirements
- Spatial: Forest heterogeneity (30 m)
- Temporal: Monthly
- Historical: 5 years before and after historical treatments
- NRT: Yes

Data Delivery
- GeoTIFF
- Maps or tables TBD

16

Snowpack Improvement, Rio Grande Water Fund

Susan Rich, Forest & Watershed Health Coordinator, NM Energy, Minerals & Natural Resources Dept., SusanE.Rich@state.nm.us
Snowpack is better preserved below forest canopies than on top of canopies (less direct radiation and sublimation). Thinning dense parts of the forest improves below-canopy snow storage. Is there less evaporative (ET) and sublimation loss given different management approaches?

Decision
- Different management approaches to preserve below-canopy snowpack
- Is there less evaporative (ET) and sublimation loss given different management approaches?
- Select areas of forest for treatment

Impact
- Maximize below-canopy snowpack, transfer to river, minimize evaporative and sublimation loss (💧 , $$$)

Data Requirements
- Spatial: Management scale (30 m)
- Temporal: Monthly
- Historical: Yes?
- NRT: No

Data Delivery
- GeoTIFF

17

MODELING

18

URGWOM (Upper Rio Grande Water Operations Model), Rio Grande New Mexico Basin Study, Middle Rio Grande Cochiti to Caballo, Upper Rio Grande Basin Focus Area Study, Pecos River Basin Study Report

Page Pegram, Acting Basin Manager of the Rio Grande, Interstate Stream Commission, page.pegram@state.nm.us
Kyle R. Douglas-Mankin, Supervisory Research Hydrologist, US Geological Survey, kdouglas-mankin@usgs.gov
Dagmar Llewellyn, Hydrologist, US Bureau of Reclamation, dllewellyn@usbr.gov
Characterize changes to water supply in a changing climate. Constrain existing ET in model and test different climate scenarios.
https://www.usgs.gov/centers/nm-water/science/upper-rio-grande-basin-focus-area-study?qt-science_center_objects=0#qt-science_center_objects

Decision
- Project future water supply
- Develop strategies to adapt to reduced water supply
- Predict consequences of cutting irrigated agriculture
- Pick which crops best fit with climate scenarios
- Decide size of grazing allotments
- Decide stocking rates

Impact
- Adapt to trend of increasing temperatures and changes in water supply and demand (💧 , $$$)
- Improve efficiency of irrigation (💧)
- Increase agricultural productivity ($$$)
- Better utilize land, reduce degradation (🚜)
- Income from efficient grazing ($$$)

Data Requirements
- Spatial: Basin-scale (1 km)?
- Temporal: Daily?
- Historical: TBD?
- NRT: No?
- Limitations: Requires capability to parameterize model and run scenarios

Data Delivery
- CSV averages?
- Table of values for hydrologic response units for each day (need shapefile for HRUs)

19

Evapotranspiration Toolbox, Irrigation Network

Carolyn Donnelly, Civil Engineer, US Bureau of Reclamation, cdonnelly@uc.usbr.gov
Molly Magnuson, Water Use and Conservation Bureau Chief, Office of the State Engineer, molly.magnuson@state.nm.us
An ET calculator has been available for diverse users for multiple uses. But, the calculator is outdated and unlikely to be supported into the future. A replacement will be needed.

Decision
- Multiple uses (undefined, but see report)
- Irrigation and reservoir management

Impact
- Multiple? (💧 , $$$)
- Improve irrigation (💧)

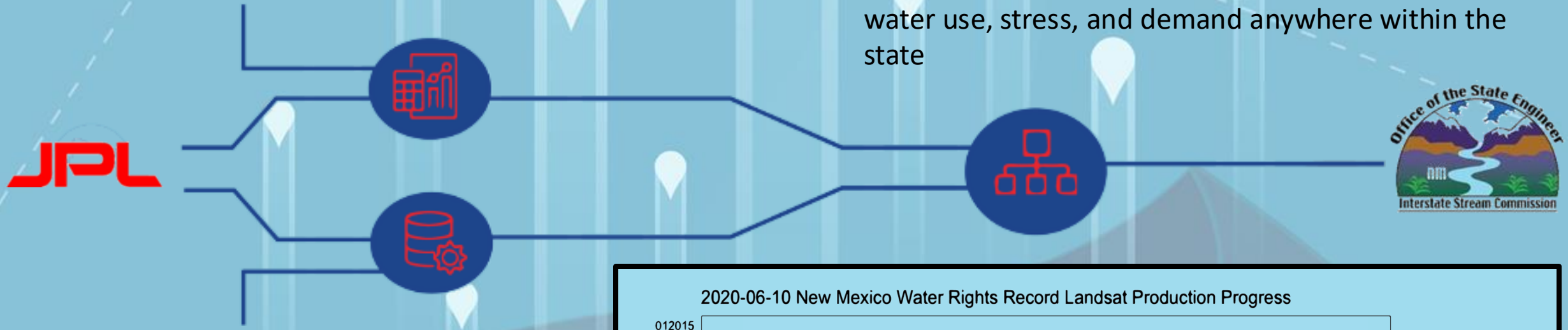
Data Requirements
- Spatial: ?
- Temporal: 7-day forecast
- Historical: NA
- NRT: Yes

Data Delivery
- TBD

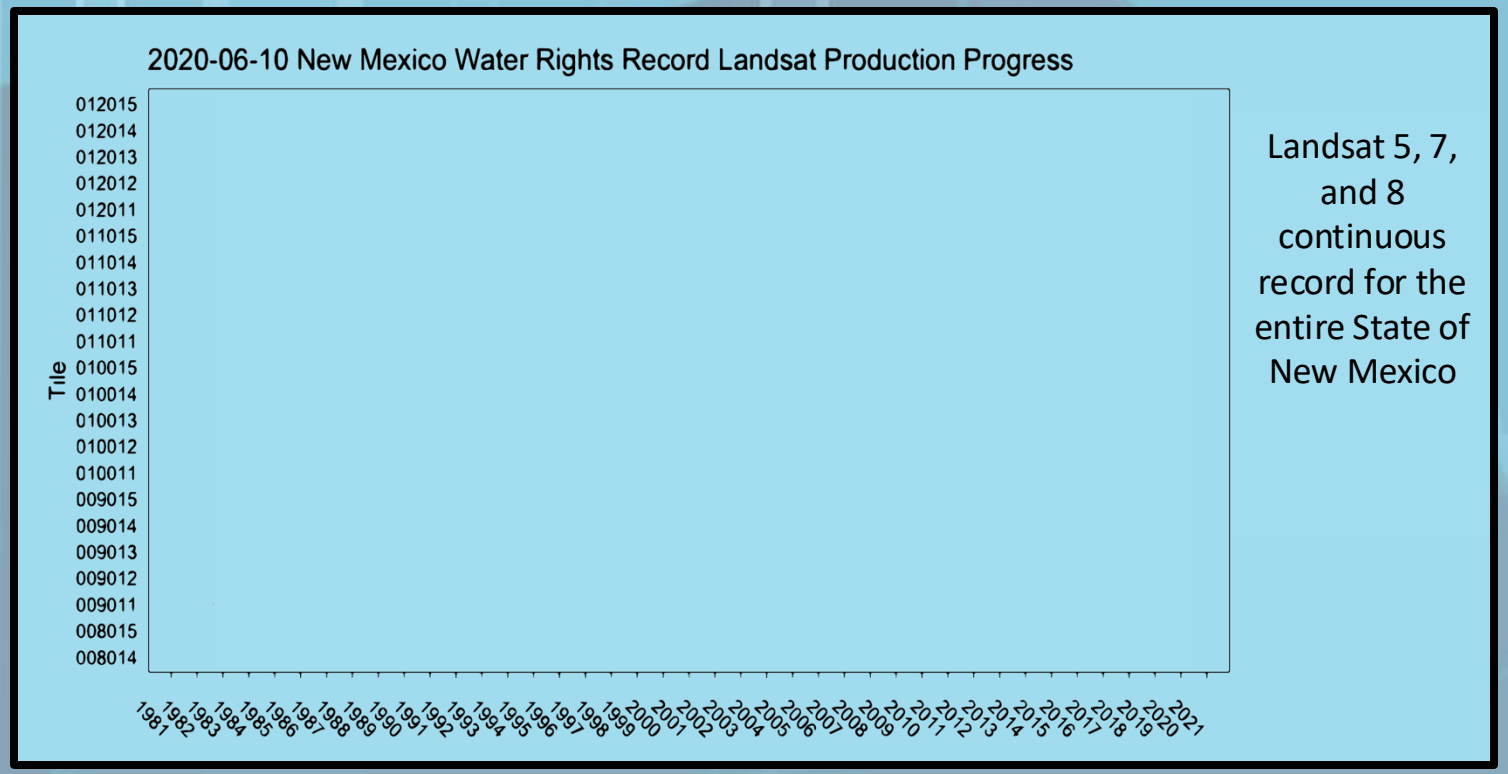
20

NMOSE ET Visualizer allows users to gather, analyze, and visualize ET and other information over a given area of interest

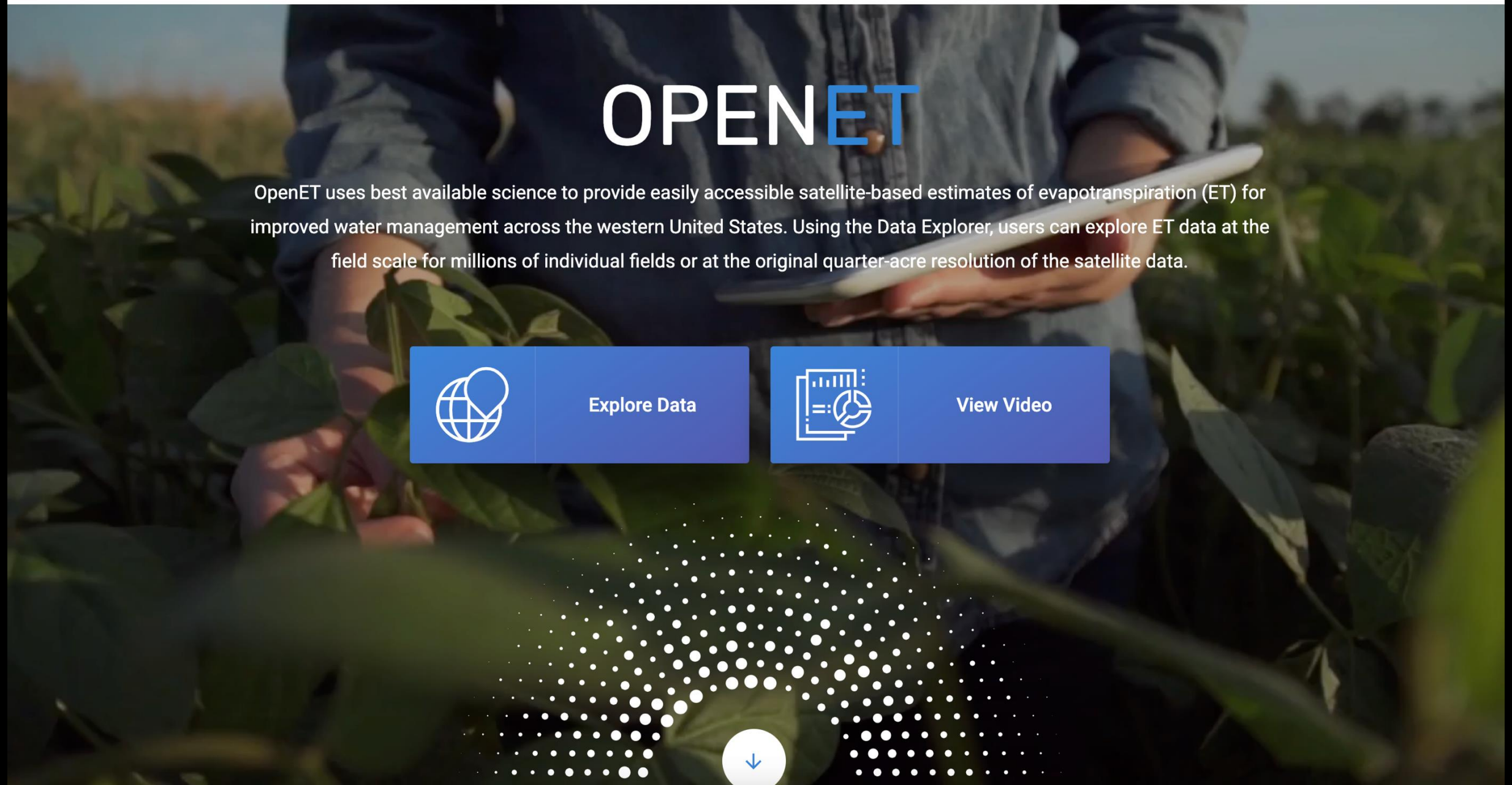
Once transitioned, our New Mexico partners will be able to **independently** generate and visualize historic water use, stress, and demand anywhere within the state



7.3 Terabytes of data, in the form of Landsat images covering the entirety of the State of New Mexico from 1982 to present were processed and delivered to NMOSE



Landsat 5, 7, and 8 continuous record for the entire State of New Mexico



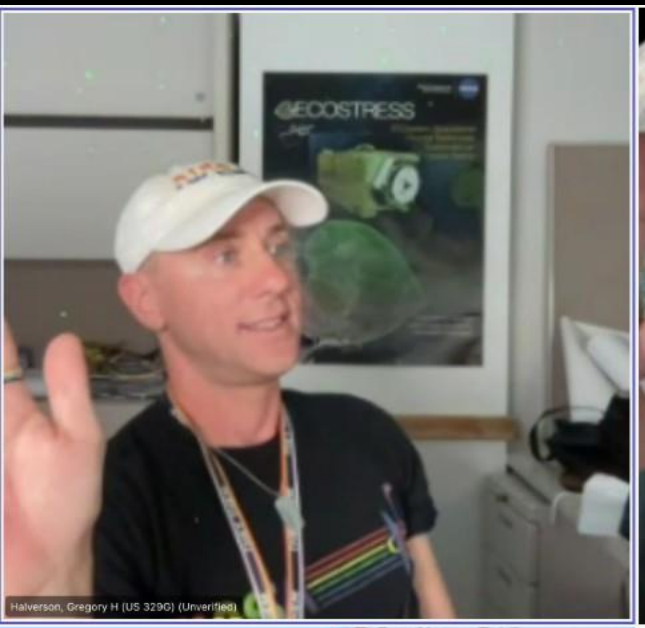
OPENET

OpenET uses best available science to provide easily accessible satellite-based estimates of evapotranspiration (ET) for improved water management across the western United States. Using the Data Explorer, users can explore ET data at the field scale for millions of individual fields or at the original quarter-acre resolution of the satellite data.

Explore Data

View Video

1. Technical Transition


ECOSTRESS
Halverson, Gregory H (US 329G) (Unverified)


Davidoff, Scott (US 397F) (Unverified)

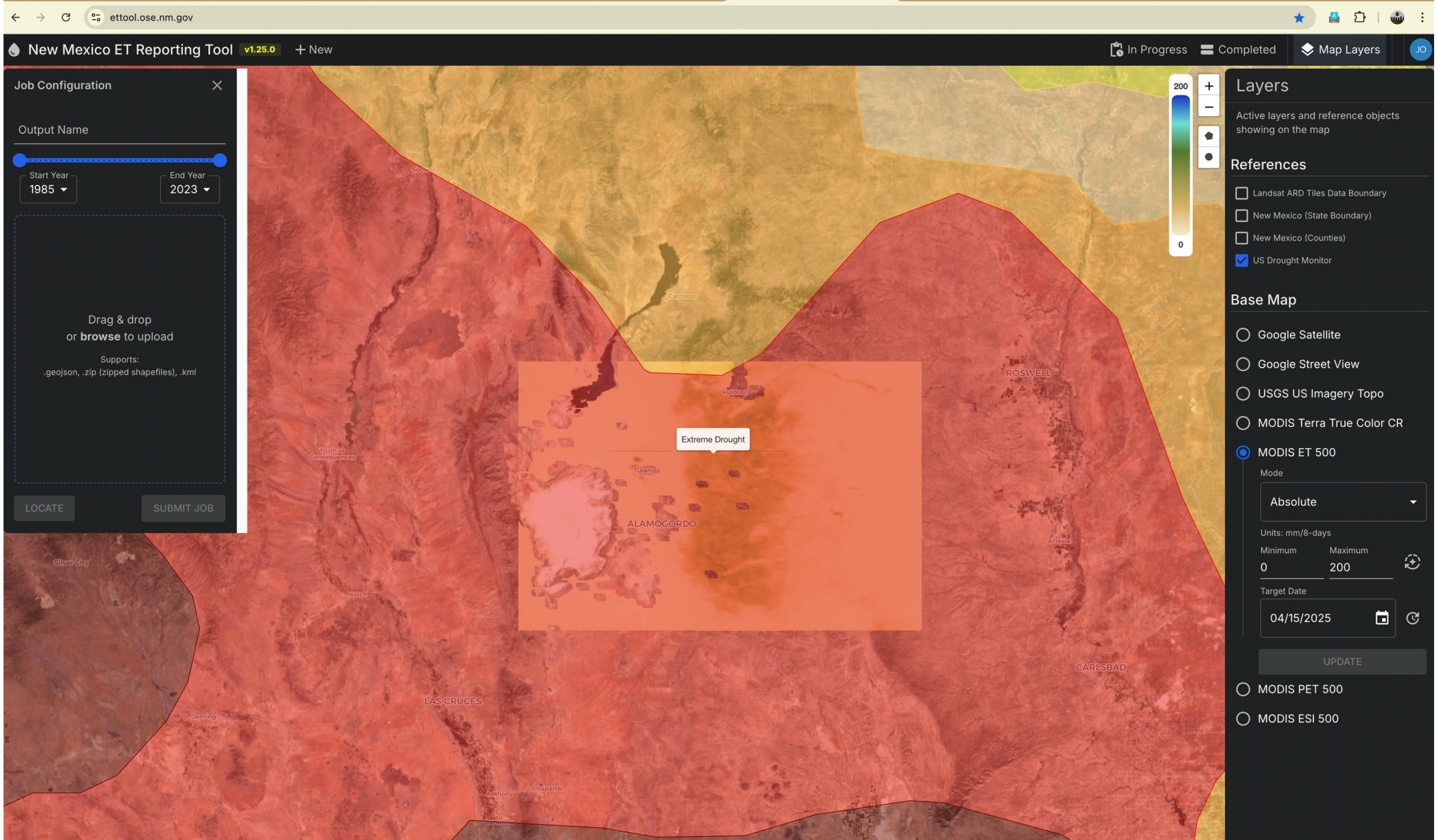

Zimdars, Paul A (US 173B-Affiliate) (Unverified)


Stonebraker, Ryan (US 174A) (Unverified)


Valdez, Julie, OSE (Unverified)


Hy, Franklin H (US 397G) (Unverified)

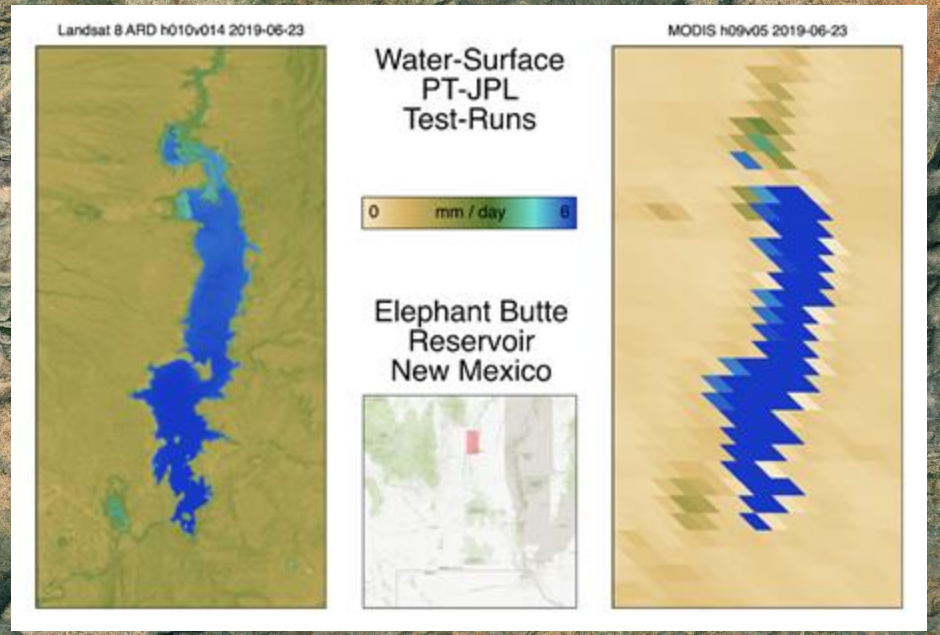

Visser, Michael, OSE (Unverified)


ettool.ose.nm.gov
New Mexico ET Reporting Tool
v1.25.0
+ New
In Progress
Completed
Map Layers
JO
Job Configuration
Output Name
Start Year
1985
End Year
2023
Drag & drop
or browse to upload
Supports:
.geojson, .zip (zipped shapefiles), .kml
LOCATE
SUBMIT JOB
200
0
Layers
Active layers and reference objects showing on the map
References
Landsat ARD Tiles Data Boundary
New Mexico (State Boundary)
New Mexico (Counties)
US Drought Monitor
Base Map
Google Satellite
Google Street View
USGS US Imagery Topo
MODIS Terra True Color CR
MODIS ET 500
Mode
Absolute
Units: mm/8-days
Minimum
0
Maximum
200
Target Date
04/15/2025
UPDATE
MODIS PET 500
MODIS ESI 500
Extreme Drought
Socorro
Carrizozo
Ruidoso
Truth or Consequences
Tularosa
ALAMOGORDO
ROSWELL
Artesia
CARLSBAD
Silver City
Hatch
LAS CRUCES
Deming
Anthony
Chaparral
Canutillo

Historical Use

Historic Water Use Seen by Landsat 5, 7, and 8 ARD PT-JPL Evapotranspiration

Water-Surface PT-JPL
Evaporation
First Output
Landsat 8
Elephant Butte
Reservoir
New Mexico
2019-07-09



6.7 mm day^{-1} 7

• **Fisher, J.B.**, Dohlen, M.B., Halverson, G.H., Collison, J.W., Pearson, C., Huntington, J.L., 2023. Remotely sensed terrestrial open water evaporation. *Scientific Reports* 13(8174): 1-13.

2. Training & Education

- Training program based on the principles of **learning science**, **active learning**, and the social science of **organizational transformation**.
- Discussion board to structure project-specific tasks, and system documentation
  using the principles of
  Human-Centered Design.

2. Training & Education

- Training protocol: step-by-step walkthrough includes example-based learning
- Google Slides with in-line images, step-by-step videos
- Accessible from GitHub
- Companion documentation: Wiki allows for offline/async training & reference

Table of Contents

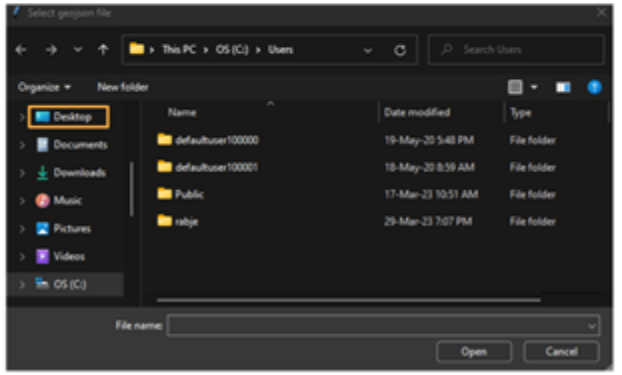
Running a Single Process

Let's walk through an example for the `Example.geojson` we created and for the dates 2000-2001

Click `Single` next to `Water Rights Boundary` to begin a single process

`Example.geojson` is located in the `ETVIS` folder

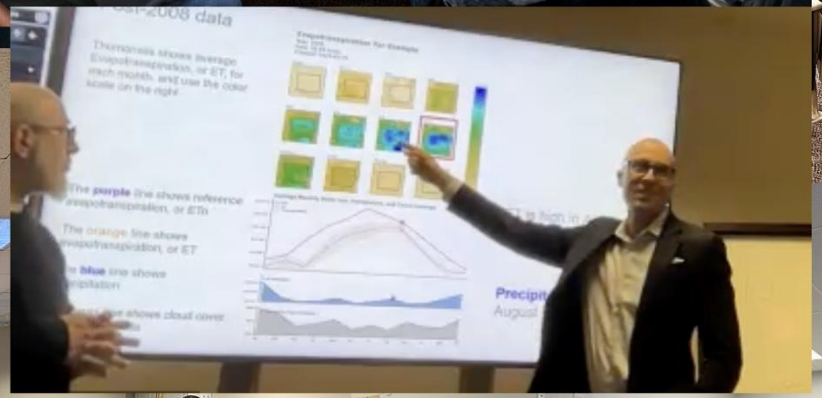
Start by clicking `Desktop`

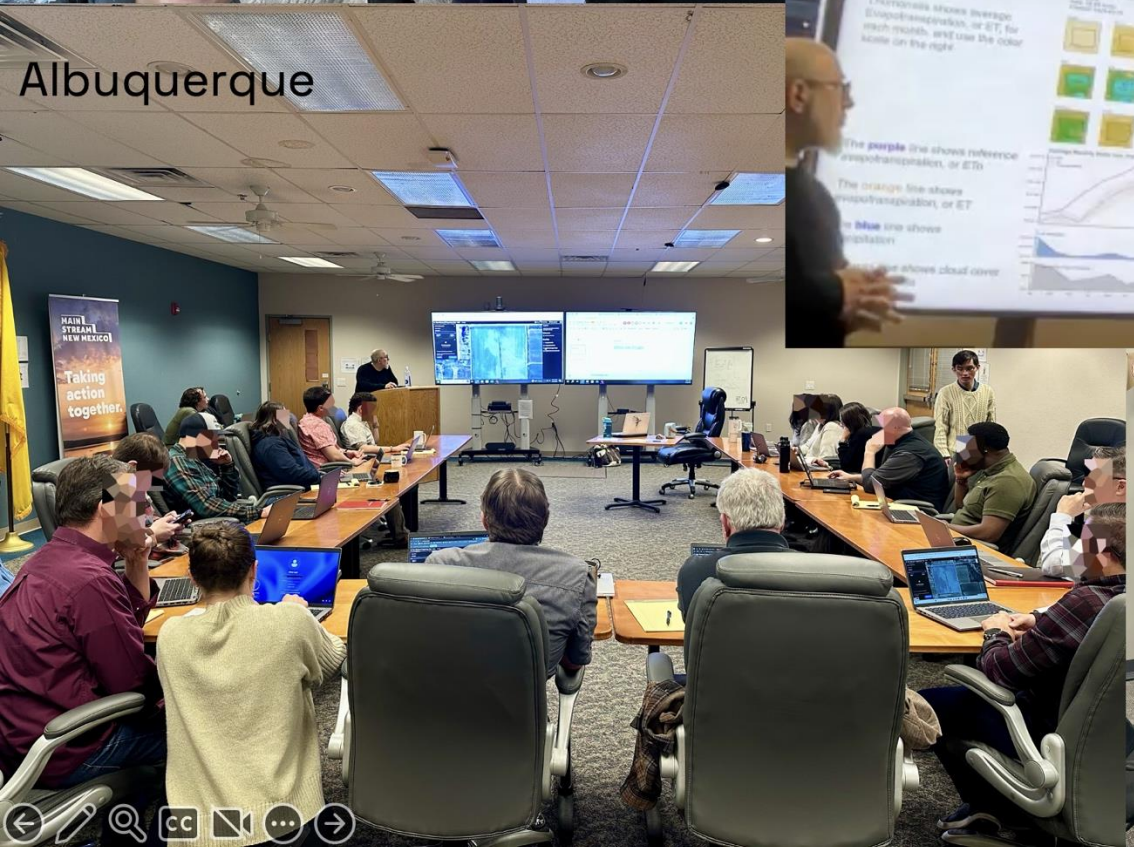


Training Week:
2025 Jan 27-30
> 100 people trained

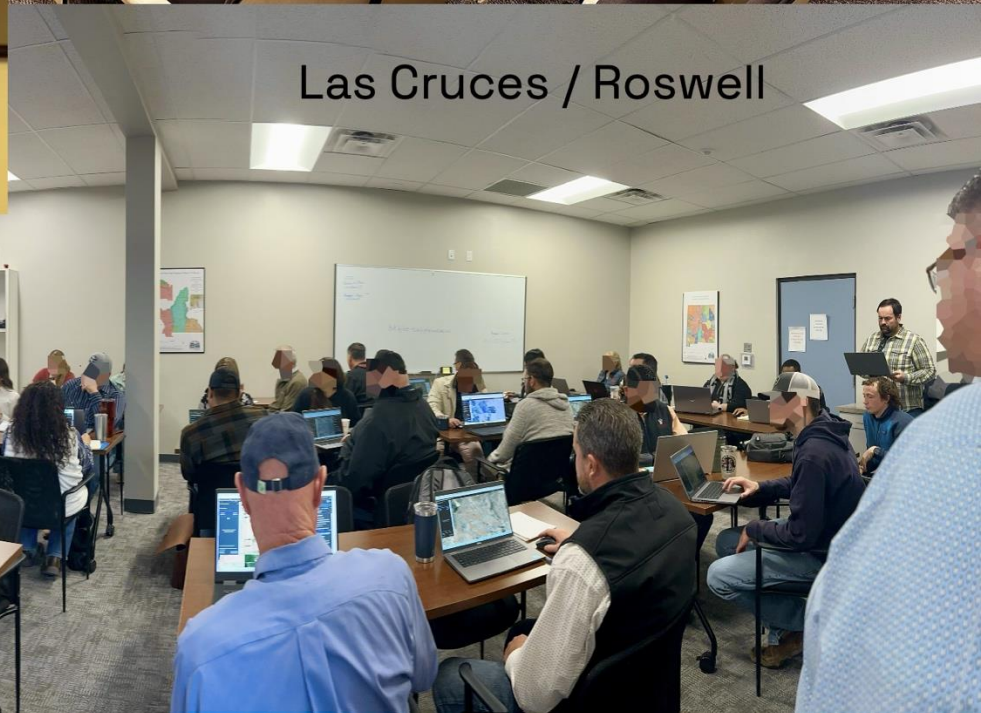
Santa Fe

Santa Fe



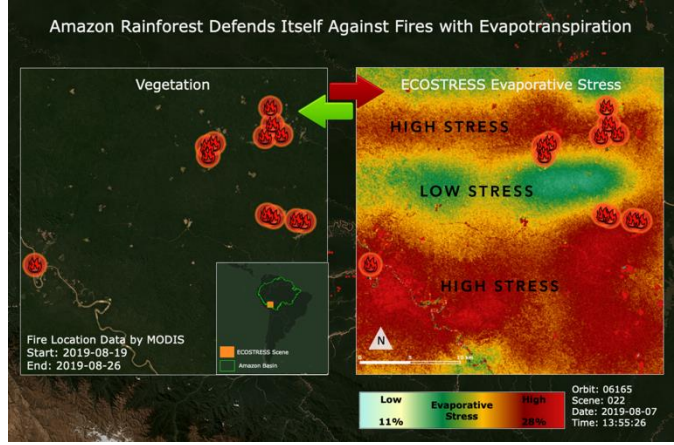


Albuquerque



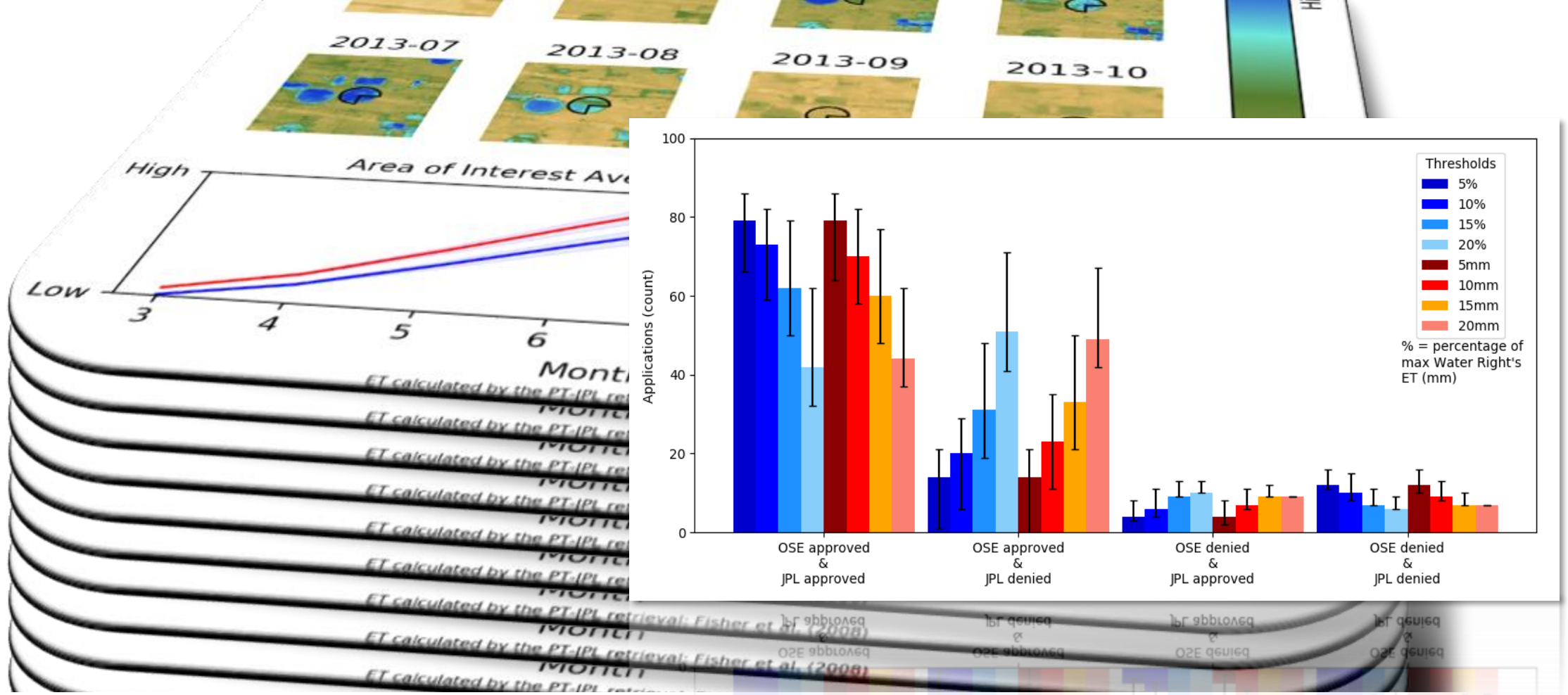
Las Cruces / Roswell

3. Impact assessment



- Performance measures using the impact assessment **methodology co-developed by NASA's WWAO and the VALUABLES Consortium** [*Cooley et al.*, 2019].
- Collaborating with RTI International + NASA HQ.
- **DROUGHT RESPONSE AND MOBILIZATION** | Retrospective analysis of historic drought in NM. Working with Drought Task Force's Drought Monitoring Working Group (DMWG). Collaborate with impact assessment teams from other drought-focused projects including the WWAO Western Land Data Assimilation System project.
- **FOREST AND WILDFIRE MONITORING** | Identification of past large fires in NM. Interviews with NM State Forestry to identify where previous decisions could have been altered, and fire prevention measures taken, given the availability of the satellite-based information. Track acreage burned, property value lost, and lives lost due to fires, and fish populations.
- **AGRICULTURE AND WATER MANAGEMENT** | Build on and refine preliminary IA, scaling up to all water districts in NM. Strengthen collaborations (e.g., WWAO projects, WSWC, OpenET) to align efforts, communication, and transparency with regards to water rights administration.

INTERVIEWS



IMPACT ASSESSMENT

USDM vs. ECOSTRESS ESI Drought Map for Curry County 2022

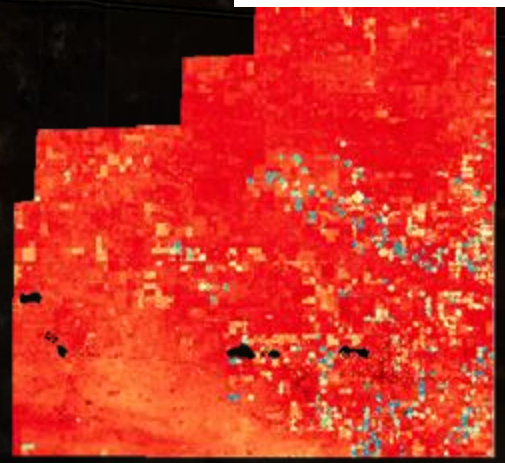
None
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

April 1

27, 2022

"Honestly, **it's really powerful, telling data**."
-Andrew Mangham, NOAA NWS

0.11
High Stress
ESI
0.76
Low Stress



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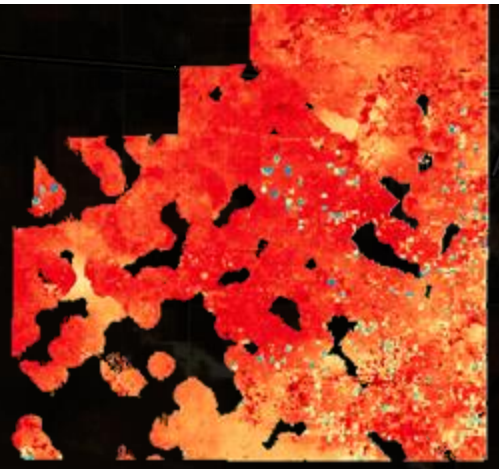

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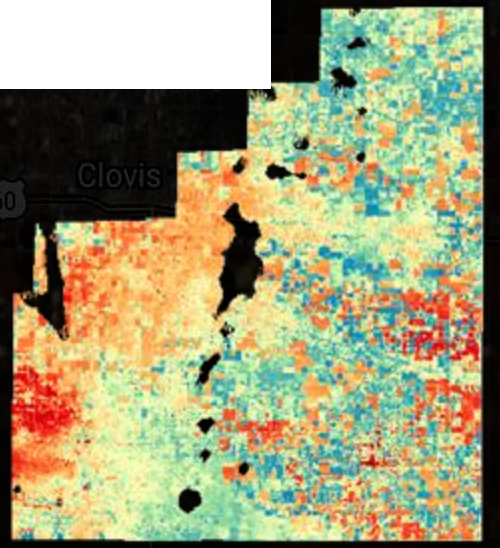

September 20, 2022

Testimonials

- According to WWAO, the data and tools may **save the State millions of dollars per year** and facilitate a **more accurate and precise management** of precious water resources.
- “Honestly, **it’s really powerful, telling data**.”
  - *Andrew Mangham, NOAA NWS*
- “**The ET data will be extremely useful** for me…I will use it for accurately determining non-use/abandonment and potential payback over years **where I had no information or data** of any kind.”
  - *Craig D. Cathey, OSE*
- ”The ET Visualizer Tool developed by NASA JPL/Chapman will **save time and resources** for the Office of the State Engineer and **help us do our work more efficiently and accurately**."
  - *John T. Romero, PE, WRAP/WR Director Office of the State Engineer*
- "**This tool can be described in one word: innovative**. I see this tool **optimizing the way our Agency operates** allowing us to provide better service to the public and enriching the knowledge of our employees.”
  - *Ramona Martinez, Santa Fe District VI Manager*
- "This is such a **game changer** from a time management perspective. Administration of water rights in the Middle Rio Grande is challenging at best, but nearly maddening when doing analysis in remote areas where aerial imagery is scarce and likely flown in a time where irrigation is not evident leaves a specialist to a subjective analysis; having access to this tool allows a type of objective analysis that **will revolutionize our work**. Not to mention the potential application in other areas of resource management. THANK YOU for giving New Mexico this opportunity!”
  - *Jerri Pohl, Water Resource Allocation Program-NMOSE Statewide Projects*


THANK YOU