OHV Discussion

Sedona City Council Meeting
10/26/21

What is an OHV?

OHV stands for off-highway vehicle, and can include a variety of different types of vehicles, typically with four-wheel drive and designed for use on dirt and unimproved roads.

"*Simply put, any motorized vehicle used to travel over unpaved roads and trails is an off-highway vehicle.*"
- Arizona Trails 2015, A Statewide Motorized and Non-motorized Trails Plan

The following is the State of Arizona's legal definition in Title 28 of the Arizona Revised Statutes (A.R.S. *§28-1171*) of an OHV for purposes of operational regulations, title, and registration.

Off-highway Vehicle:
(a)Means a motorized vehicle that is operated primarily off of highways and that is designed, modified or purpose-built primarily for recreational nonhighway all-terrain travel.
(b)Includes a tracked or wheeled vehicle, utility vehicle, all-terrain vehicle, motorcycle, four-wheel drive vehicle, dune buggy, sand rail, amphibious vehicle, ground effects or air cushion vehicle, and any other means of land transportation deriving motive power from a source other than muscle or wind.
A.R.S. §28-1171

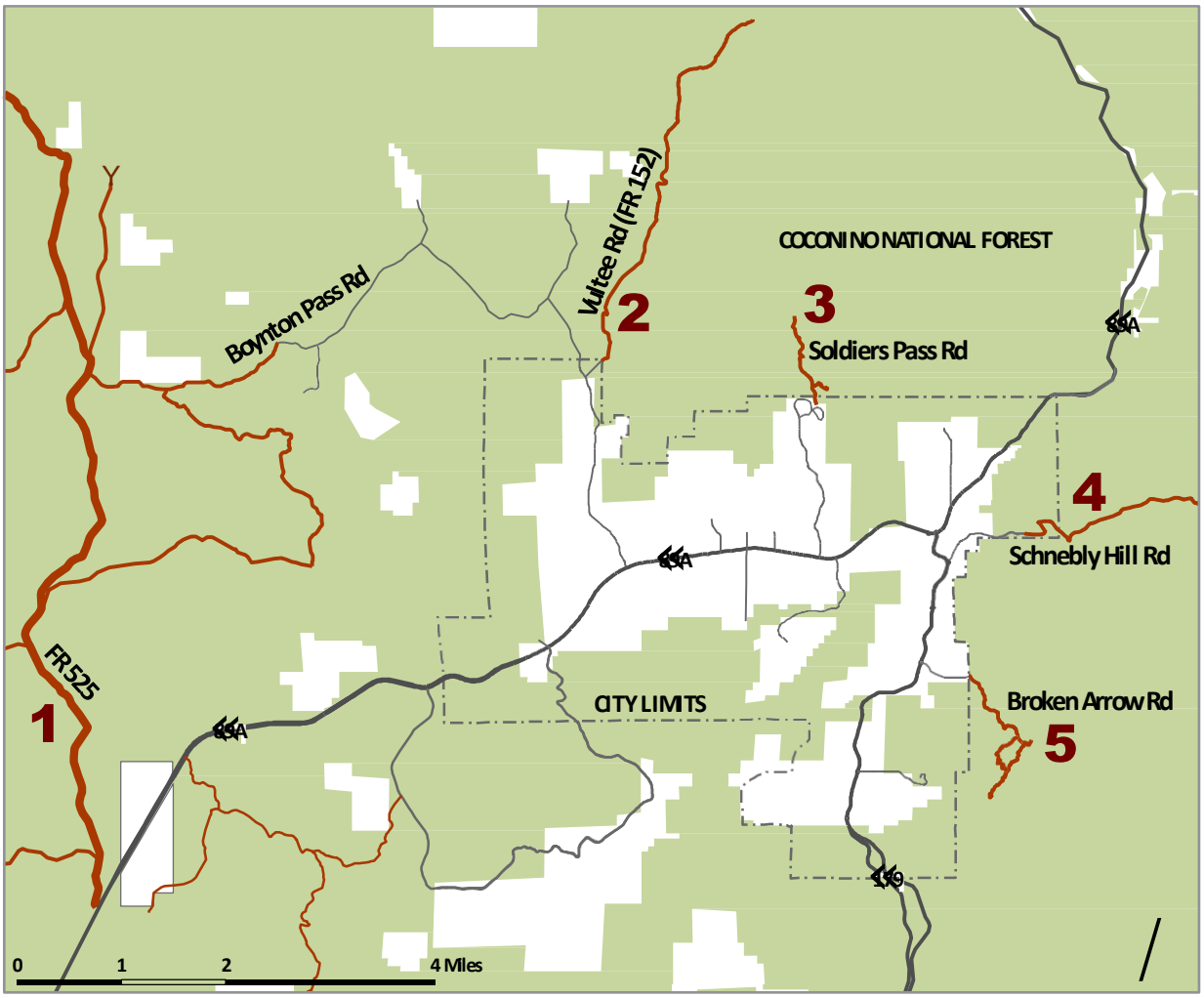
Vehicle Types

ATV (All Terrain Vehicle) or Quad. Features handlebars and straddle-style seat.

UTV (Utility Task Vehicle), ROV (Recreational Off-highway vehicle), or "side-by-side", such as Polaris RZR®. Features steering wheel and roll-bar.

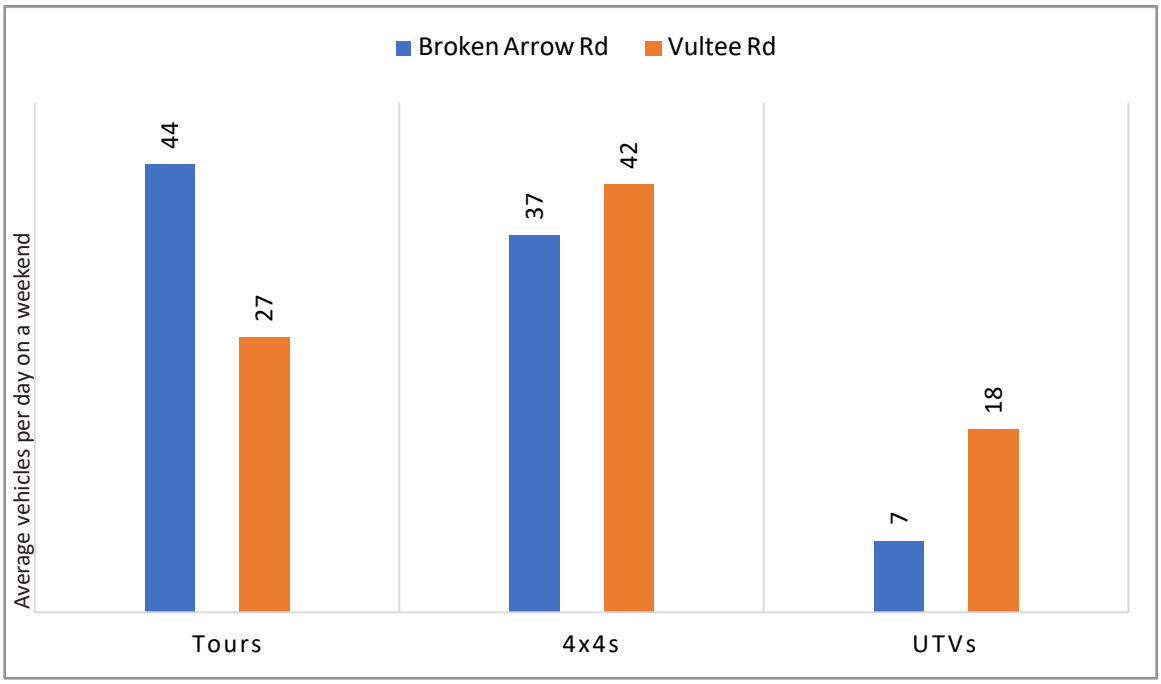
4x4/4WD, SUVs (Sport Utility Vehicles), trucks, and Jeep®.

OHV Access

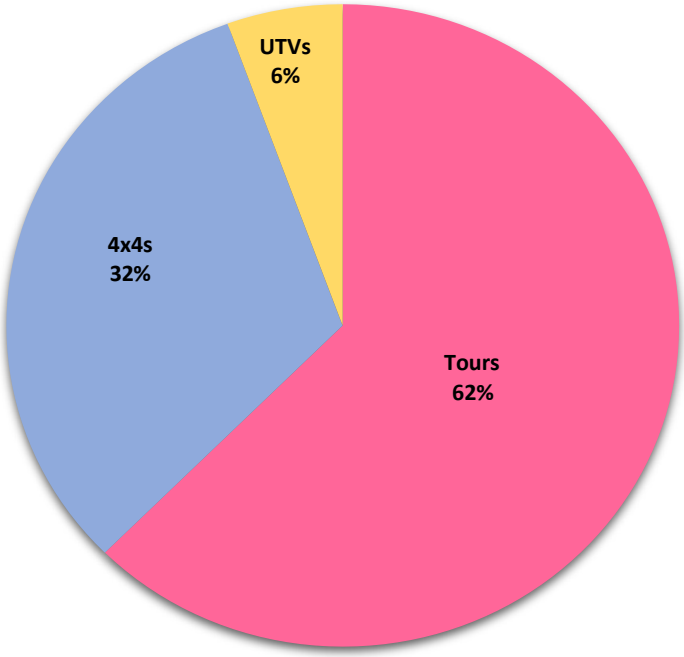


Region map of the City of Sedona and the National Forest showing National Forest roads/OHV routes accessible from the city.

2017 Data Collection

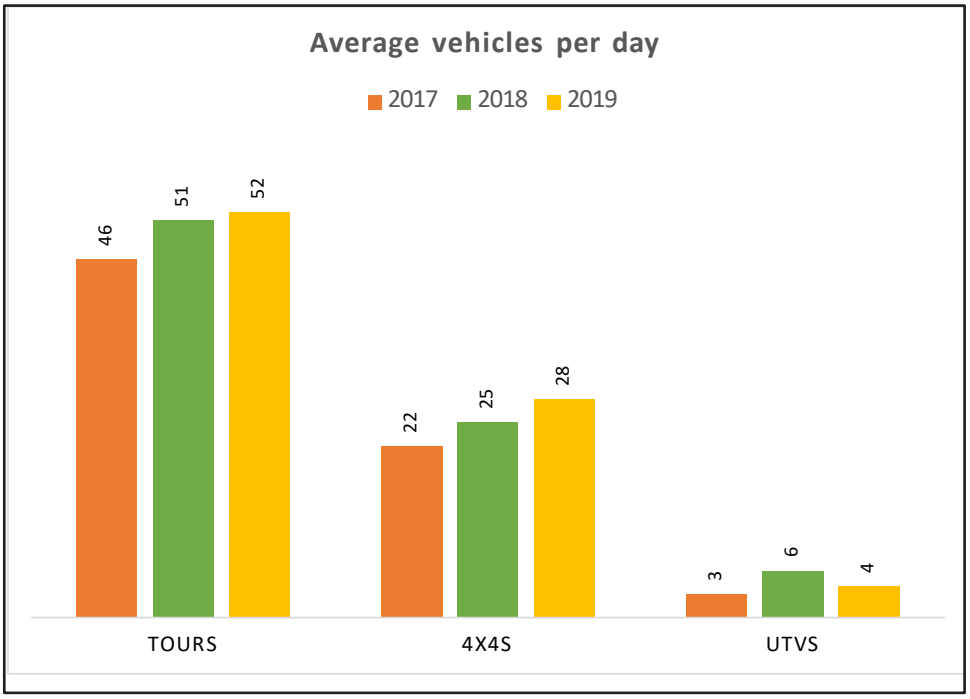


Comparison of OHV Use on Broken Arrow Road and Vultee Road: Average vehicles per day, between July and November 2017.



Broken Arrow Use by Type of Vehicle
Based on 463 days between March 2017 and September 2018

Broken Arrow Data 2017-2019



Comparison of Average Vehicles Per Day at Broken Arrow. Based on 131 days between March and September of 2017, 2018, and 2019.

Infographic summarizing results of Police Department monitoring of UTVs on Dry Creek Rd. in April 2018

NOISE:

March 2017 OHV noise readings (Morgan Road, Canyon Shadows, Dry Creek):

- No OHVs exceeded 96 decibels, range was 75-85 decibels

January 2018 OHV noise readings from inside the vehicle (2017

- While stationary and idling, from 10-feet away the sound reading was 73 dBa.
- While driving at various speeds the vehicle sound (measured two feet from the engine) varied from 84-92 dBa. The sound did reach 96-97 dBa once, at maximum speed, full throttle going 40 mph uphill.

November 2020 Moab, UT 20-inch test:
https://www.moabsunnews.com/news/article_d5dc1c1e-2aa6-11eb-b209-336f9a1eeca4.html

96 decibels at 20 inches or less corresponds to 82 decibels at a distance of 50 feet.

Sedona

Key Points of the Report

The following are the key points of this report:

- Off-highway vehicles (ATV/UTVs) are street legal in Arizona
- There are three OHV user groups in Sedona:
  1. Rentals
  2. Guided tours
  3. Private owners
- Four of the five roads that give OHV users access to the National Forest are city streets through residential neighborhoods:
  1. Dry Creek Road
  2. Soldiers Pass Road
  3. Schnebly Hill Road
  4. Morgan Road/Broken Arrow
- City of Sedona sound regulations (§8.25.090F) exempt "sound from the locomotion of properly muffled motor vehicles on a public right-of-way or residential driveway."
- State statute (§ 28-1179) sets the maximum sound limit for OHVs at 96 decibels (dBa).
- State statute (§41-194.01)/Senate Bill 1487 prohibits cities from enacting laws that are more restrictive than state laws. If found in violation, the city could lose approximately $4 million in state revenues.

Report Recommendations

Recommended Strategies

Education & Information:
- Signs
- Website
- Youth Education Programs
- Public Relations Campaign

- OHV License Information

Law enforcement:
- Checkpoints

- Speed Deterrents

Rental Vehicles:
- Newer, Quieter Vehicles
- Improved Equipment and Technology

- Electric Vehicles

Not Recommended

OHV Sound Regulations

Law Enforcement:
- Lower Speed Limits

Rental Vehicles:
- Modified Mufflers

Road Restrictions:
- Prohibit ATVs/UTVs on City Streets

- Restrict Use of Broken Arrow

Staging Area:
- Commercial Staging Area

CURRENT CONDITIONS

Forest Road 152C

BROKEN ARROW:

https://vimeo.com/476050302

OHV BUSINESS REGULATIONS:

1. Business Licenses
2. Screening
3. Parking

Questions Regarding City Action

2. Can the City enact an OHV-specific ordinance limiting OHV operation between certain hours?

- Yes. The State has not set OHV specific hours. The above provisions supporting local regulation (A.R.S. §§ 28-627 and 1174) support the City in regulating the operating hours as an OHV local rule, regulation, ordinance, or code. Thus, the City could adopt a nighttime closure prohibiting OHVs on City streets between certain hours, perhaps 7 p.m. to 7 a.m. There are a number of practical considerations to adopting any of these regulations that the PD, Public Works and Legal Departments would want to consider prior to adoption, including signage needs, enforcement capabilities and adequate empirical support for any new regulations.
- The City cannot impose any OHV regulations on state highways, SR89A or SR179.

Questions Regarding City Action

4. Can the City commission an Environmental Impact Study or consult with an environmental law firm?

- Yes, the City may consult with environmental law firm and commission Environmental Impact Study to further research areas for regulation. Evidence of public health and safety issues is necessary in order to take actions limiting numbers of OHVs or OHV businesses. An EIS may provide that needed information.
- EIS Study was not budgeted or programmed for this fiscal year, but can be for FY23

Questions Regarding City Action

5. Does the City work with Forest Service and other stakeholder groups?

- Yes, the City works with the United States Forest Service, the Sedona Chamber of Commerce & Tourism Bureau, and its newly created Red Rock OHV Conservation Crew (RROCC) and interested citizens in resolving OHV issues.

Two Partners Present Tonight:

- **Amy Tinderholt**, District Ranger, Red Rock Ranger District, Coconino National Forest.
- **Candace Carr Strauss**, President and CEO, Sedona Chamber of Commerce and Tourism Bureau.

Request to Coconino National Forest:

City of Sedona Request Regarding Motorized Use Trails

The Sedona Mayor and City Council, on behalf of concerned residents both within City limits and in the nearby rural communities, are requesting that the USFS implement a limited entry permit system for motorized use trails in the greater Sedona area, similar to the permit system implemented at Soldier's Pass. The City acknowledges that no two areas are exactly alike, and each should be assessed and appropriate capacity determined based on its own unique circumstances. Soldier's Pass, for example, currently allows for 12 visitors per day, but that may not be the right threshold for other areas.

Sedona is one of the most beautiful places on earth, and we must protect every acre of this sacred land we have been entrusted with. This unregulated traffic has created substantial environmental damage, health and public safety issues, high fire danger from dead trees, potential harm to the precious heritage sites, and general nuisance issues within residential neighborhoods, such as noise, trash, and odor emissions. The current situation is unsustainable and must be corrected.

The Sedona area has seen an increase in off-road travel in the past few years. As a result, there are negative impacts on natural resources, heritage sites, wildlife, and local residents' quality of life.

Time is of the essence. Restrictions are absolutely necessary to save our beautiful Sedona.

The following are reasons for a limited entry system:

Dust levels and air pollution from traffic on all forest service roads and OHV trails in the affected areas are causing the following environmental damage:

- Dust levels contribute to thousands of dead and dying trees
- Dust levels are damaging to grasslands
- Dust creates air pollution (Clean Air Act must apply)
- Dust levels create zero visibility dust clouds
- Breathing fugitive dust is harmful to humans (local residents and tour operators are at risk)
- Even when vehicles are traveling at speeds as low as 20 mph, dust levels are killing trees, damaging grasslands, and causing dangerous air pollution

Current Noise levels:

- Constant noise levels have the potential to cause hearing loss
- Noise levels disturb wildlife
- Noise levels diminish the outdoor experience for all other forest visitors
- Noise levels diminish the quality of life for local residents

Off-trail travel is causing the following environmental damage:

- Damage to native plants
- Compaction of soil
- Erosion

Speeding and Reckless driving is causing the following issue:

- Environmental damage
- Local residents afraid to drive on our own roads
- Forest roads are in poor condition
- Doughnuts cause significant environmental damage
- Ruins the outdoor experience for other forest visitors

OHV accidents are becoming more common:

- Inexperienced drivers may be contributing to a rise in accidents
- OHV accidents are becoming more frequent and more severe
- Some non-injury accidents are not reported, so true accident numbers may be higher than documented

Thank you for the attention the USFS has already given to these issues. The City recognizes that this is a complex issue with no easy solutions. The City also appreciates the tangible progress your team is making with respect to allocating resources to these efforts; hiring a new grant coordinator; your partnership with the Sedona Chamber of Commerce and Tourism Bureau to engage the industry to identify mitigations; engaging Tread Lightly for land preservation and education; and for seeking state grant funding for supplemental education.

Thank you in advance for your consideration of our request.

PRESS RELEASE

Red Rock OHV Conservation Crew Announces Dedicated Funds for Trail Improvements and OHV Rider Education in Greater Sedona

Sedona, Ariz. (October 6, 2021) The Sedona Chamber of Commerce & Tourism Bureau is announcing the formation of the Red Rock OHV Conservation Crew (RROCC), a coalition of more than a dozen private industry partners from Cottonwood to Sedona to Flagstaff in partnership with *Tread Lightly!*, a national nonprofit group dedicated to ethical and responsible motorized recreation, to tackle the effect of increased Off-Highway Vehicle (OHV) use in the region.

Beginning in September, private OHV rental and guided tour companies began dedicating 1% of sales to land preservation and rider education, a commitment that could achieve $400,000 in annual contributions to the US Forest Service Coconino National Forest Red Rock Ranger District.

Participating companies include Arizona Safari Jeep Tours, Barlow Adventures, Outback ATV, Pink Jeep Tours, Rainbow Adventures comprised of A Day in the West, Earth Wisdom, Red Rock Western Jeep Tours and Sedona Off-Road Adventures, additionally Red Rock ATV, Sedona ATV and Vortex ATV.

The collaboration originates from the City of Sedona's OHV Work Group, which brought together the US Forest Service, Arizona State Parks, Arizona Game & Fish, the motorized industry, citizens, and nonprofits to discuss the issue back in 2013.

"For years, increased Off-Highway Vehicles (OHVs) use in the Greater Sedona area has affected public lands, cultural assets and residential neighborhoods," said Sedona Chamber of Commerce & Tourism Bureau President and CEO Candace Carr Strauss.

During the pandemic, the number of OHV's registered in Arizona skyrocketed to more than 452,000. This coupled with urbanites flocking to Sedona to socially distance outdoors while enjoying motorized recreation provided by regional businesses raised community concerns.

"Sustaining recreation access on National Forest lands requires a collaborative approach," said Ranger Amy Tinderholt of the Red Rock Ranger District. "Fortunately, our OHV businesses along with *Tread Lightly!* are ready to do their part to reduce resource impacts, address stakeholder concerns and improve recreation opportunities."

"Red Rock Country is a sought-after destination for motorized recreationists who contribute substantially to our tourism-based economy," said Strauss. "We must strike a balance between the right to recreate on our public lands with environmental stewardship, preservation of cultural heritage and our resident quality of life," she added.

In addition, RROCC is working with *Tread Lightly!* to produce educational content on public safety, limiting speed, noise and dust, respecting others who use the roads, observing sensitive areas such as the grasslands west of Sedona and leaving historical or archeological sites undisturbed.

"Tread Lightly! is the leading nonprofit spearheading initiatives that protect outdoor recreation assets and opportunities," said Executive Director Matt Caldwell. "We are proud to be part of the Red Rock OHV Conservation Crew, heightening the good stewardship that is part of Sedona's commitment to sustainability."

"In anticipation of a busy weekend with Indigenous Peoples Day on October 11, an official USFS OHV Ambassador Program of participating company staff members will be out on the 525 west of Sedona, engaging one-on-one with riders to promote responsible recreation," said Strauss.

This effort is not an entirely new endeavor, however. All businesses permitted to operate on National Forest lands are required to contribute 3% of gross revenue, 95% of which stays on the local Forest for maintenance of existing infrastructure, ground operations, monitoring, and administration. Revenue collected from permitted OHV companies, including jeep tours and ATV tours, has helped to support road and trail maintenance, resource protection, projects and administration and monitoring efforts to ensure sustainability of uses into the future.

Follow the continued work of RROCC at rrohvconservationcrew.com.

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Candace Carr Strauss President | CEO
Sedona Chamber of Commerce & Tourism Bureau
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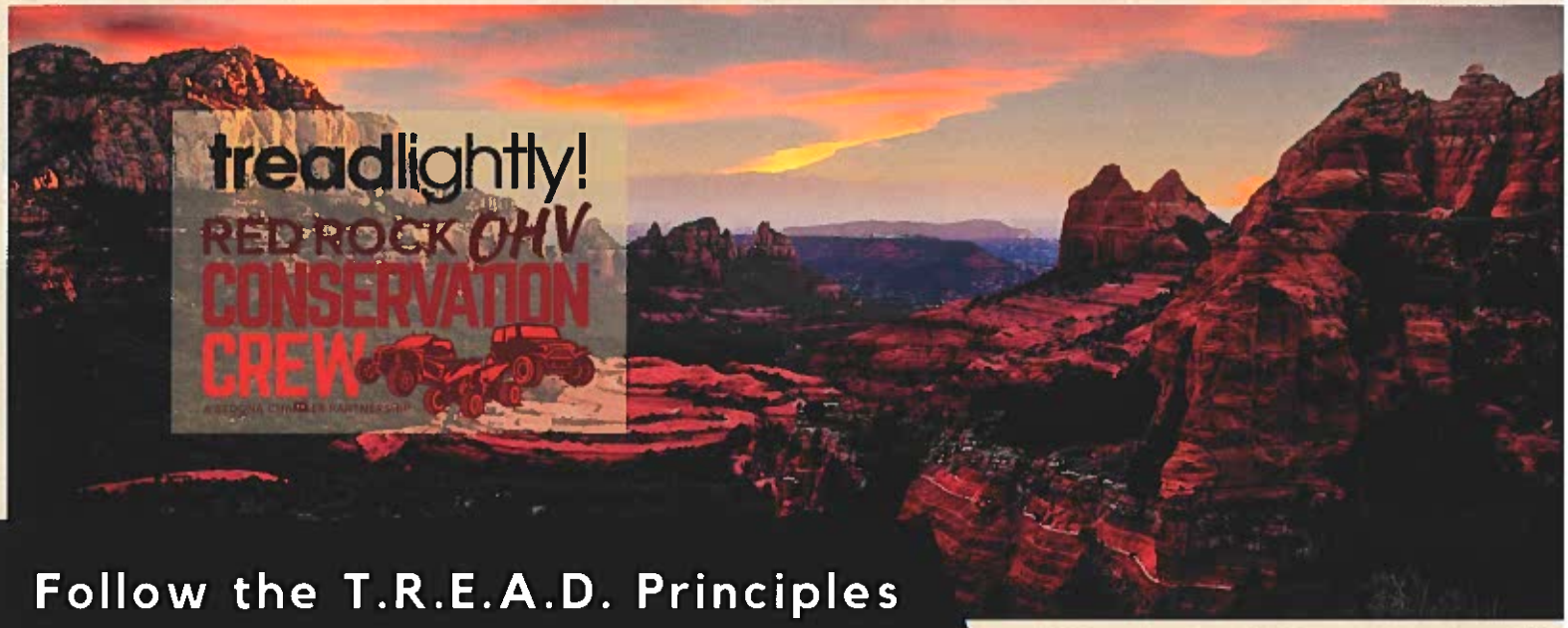
M: 928.295.5209
SedonaChamber.com | VisitSedona.com
Take the Sedona Cares Pledge!

DO YOU KNOW HOW TO TREAD LIGHTLY!?



Follow the T.R.E.A.D. Principles

Tread Lightly! gives you access to the nation's only full source of motorized and non-motorized outdoor ethics training and education materials. Elevate your skillset and enhance your experience by educating and supporting off-roading out on the trails.

Travel Responsibly

- TRAVEL ONLY IN AREAS OPEN TO 4WD USE.
- DRIVE OVER, NOT AROUND, OBSTACLES TO AVOID WIDENING THE TRAIL.
- CROSS STREAMS ONLY AT DESIGNATED FORDING POINTS.
- GO SLOW IN SOFT TERRAIN OR UNSTABLE GROUND.
- WHEN POSSIBLE, AVOID MUD.
- CARRY TOOLS TO MAKE REPAIRS AND A KIT TO CLEAN UP ANY SPILLS.

Respect the Rights of Others

- LEAVE GATES AS YOU FIND THEM AND ALWAYS GET PERMISSION TO ENTER PRIVATE PROPERTY.
- YIELD TO THOSE TRAVELING UPHILL, MOUNTAIN BIKERS, HIKERS AND HORSES.
- KEEP SPEEDS AND NOISE LOW IN CROWDED AREAS.

Educate Yourself

- CHECK THE WEATHER BEFORE YOU GO.
- CONTACT LAND MANAGERS FOR AREA RESTRICTIONS OR CLOSURES.
- TAKE A SKILLS COURSE - KNOW HOW TO SAFELY OPERATE YOUR MACHINE AND EQUIPMENT.

Avoid Sensitive Areas

- STAY ON DESIGNATED ROUTES.
- AVOID MEADOWS, LAKE SHORES, WETLANDS AND STREAMS.
- REMEMBER, MOTORIZED VEHICLES AREN'T ALLOWED IN FEDERALLY DESIGNATED WILDERNESS AREAS.

Do Your Part

- PACK OUT ALL TRASH AND LEAVE IT BETTER THAN YOU FOUND IT.
- BEFORE AND AFTER YOUR RIDE, WASH YOUR VEHICLE TO AVOID THE SPREAD OF INVASIVE SPECIES.

T.R.E.A.D. PRINCIPLES

tread lightly!.org

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TREE HEALTH ASSESSMENT

For

DEANNA BINDLEY

At

FOREST SERVICE ROAD 152C

SEDONA, ARIZONA 86336

June 22, 2020

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WHY DID SAVATREE PROVIDE AN ASSESSMENT OF TREE HEALTH ON FOREST SERVICE ROAD 152C IN SEDONA, ARIZONA?

DeAnna Bindley requested my help to determine if excessive dust from vehicular traffic is causing damage to trees growing along a section of Forest Service Rd 152C, west of Sedona. She also asked that if the dust is causing damage, what can be done to reduce the dust and mitigate the damage to the trees. Finally, DeAnna asked me about the long-term consequences for tree health if no action is taken to reduce the dust.

HOW DID SAVATREE CONDUCT THE ASSESSMENT?

I conducted a site visit and visual tree assessment, took photos and video, and collected and examined twig and leaf samples.

During the site visit, I noted the high levels of traffic and dust along FS152C, and examined several dozen, mainly juniper trees, on an approximately two mile stretch of road west of the cattle guard where the pavement ends at Boynton Pass Rd. I collected twig samples from trees at various locations and at various distances from the road. I also looked for evidence of insect and disease activity using a hand lens and handheld digital microscope.

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WHAT DID SAVATREE FIND?

During the site visit, I noted several things:

1. Heavy OHV traffic on Forest Service Road 152C
2. Thick dust caused by the vehicles
3. Dead and declining trees near the road

Heavy OHV Traffic on FSR 152C

On arrival on Saturday morning, May 9, 2020, I noted heavy, nearly *constant* Off Highway Vehicle (OHV) traffic along FSR152C. The high speeds and frequency of the passing vehicles created thick clouds of red dust that dispersed in the wind, blowing mainly west of the road. Many of the trees on both sides of the road are covered with dust, their previously green leaves and brown or gray bark turned Sedona red. See Figure 1 below.

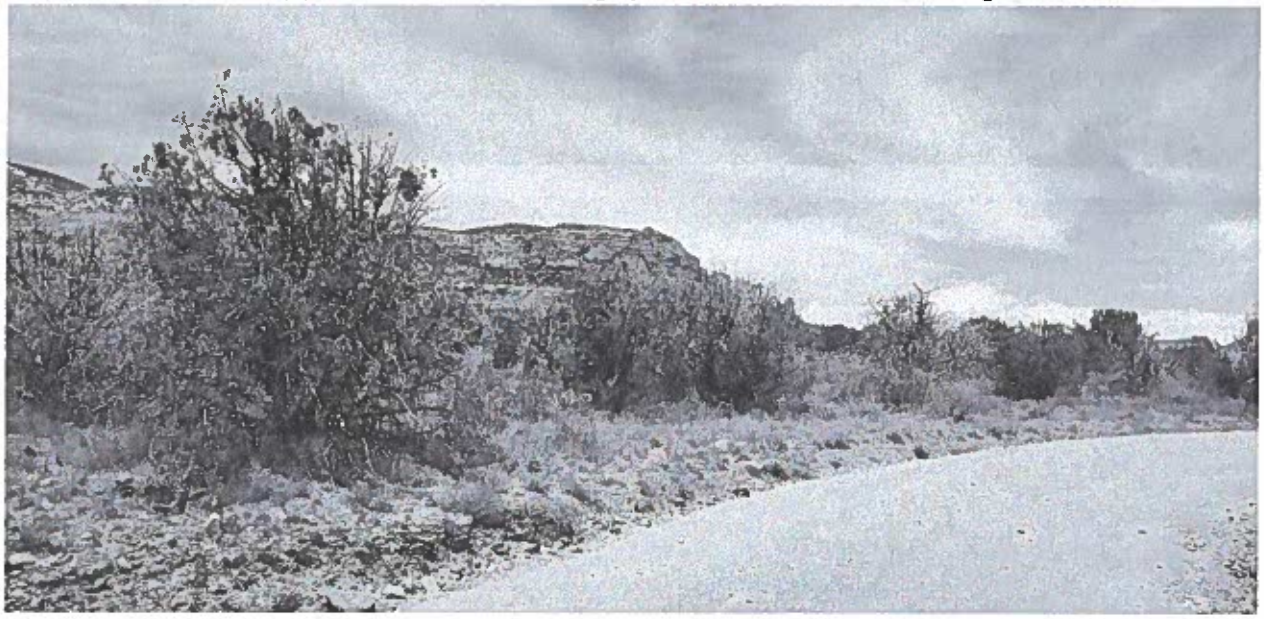

Figure 1 Dust covered trees along Forest Service Road 152C

Many studies show that dust settling on leaves blocks sunlight to the surface of the leaves, reducing their ability to photosynthesize to produce and store essential energy reserves for new growth, reproduction, and defense. One study suggests that reduced chlorophyll levels, a sign of declining health, may also be due to the clogging of stomata on leaf surfaces, restricting necessary gas exchange in the leaf cells.
http://oaji.net/articles/2017/736-1513406902.pdf

Another study shows that rolling vehicles also eject dust particles from the road surface with shearing force, adding physical damage to the roadside plants in addition to the other negative impacts listed above.
https://www.mdpi.com/2073-4441/7/1/116/htm

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Thick dust caused by the vehicles

Heavy traffic on dirt roads pulverizes soil particles into a fine powder, increasing the distance the dust can travel in the wind. And higher levels of vehicular traffic as well as higher vehicle speeds create dust at greater heights and distances from the road. See Figure 2 below.

Figure 2 Heavy, high-speed OHV traffic creates heavy dust long distances from road

Dead and declining trees near the road

The higher levels of dust seem to correspond directly to negative effects on tree health. And from my observations, there appears to be a strong correlation between poor tree health and proximity to the road. The

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trees closest to the road that receive the most dust also show greater levels of stress and decline. Many are completely dead, others partially defoliated. See Figure 3 below.

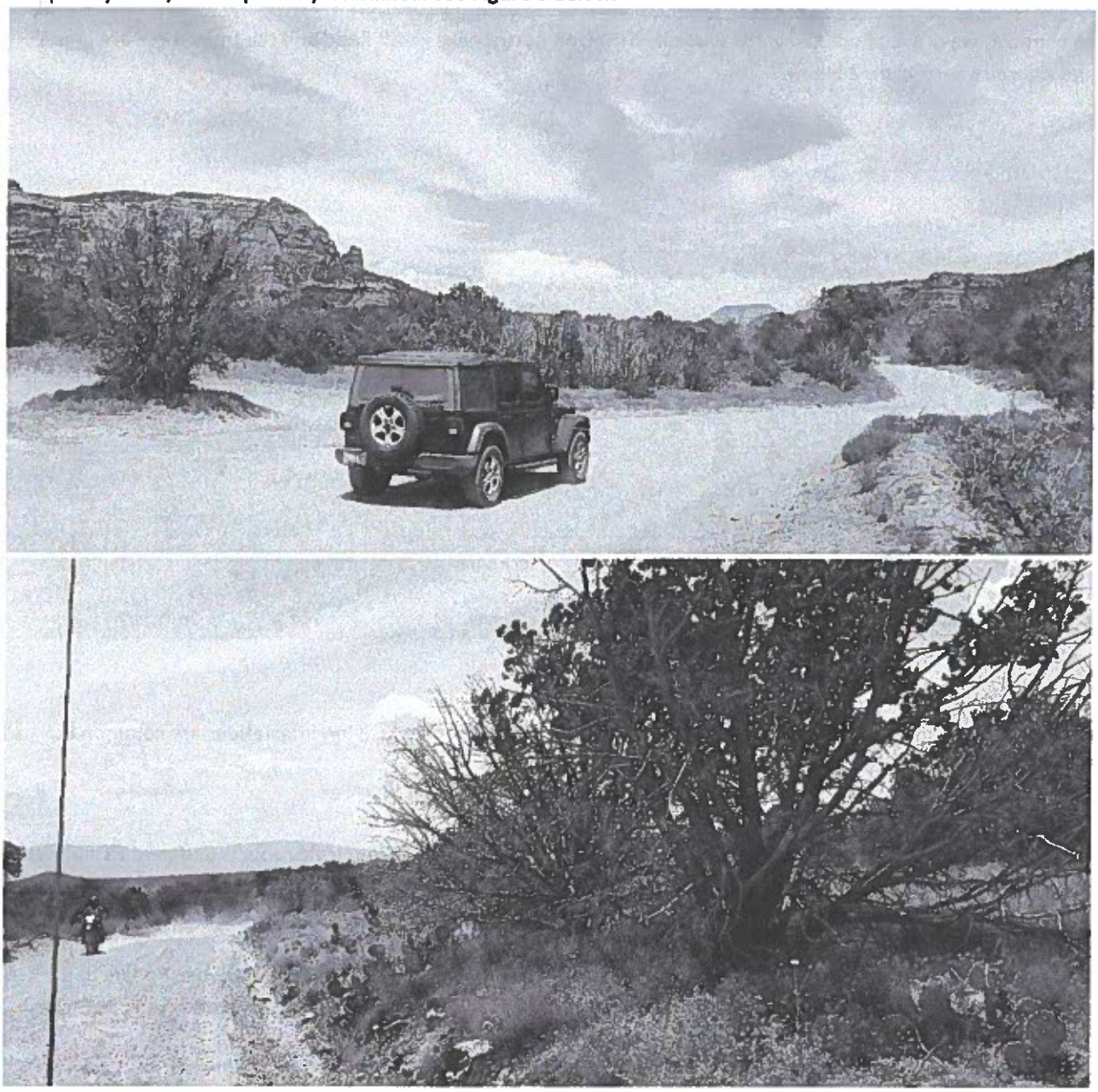

Figure 3 Both photos show roadside trees in declining health

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- 10 lots - 20 / 3 / 60

The road-facing branches of multi-stemmed trees even show more defoliation than branches growing away from the road. I noted trees up to 20 yards from the road that appear to be impacted by the dust. 60 feet not 400

In contrast, we drove about 150 yards east off FS152C on Rattlesnake Gulch Road and the trees there are green and vigorous. See Figure 2 below.

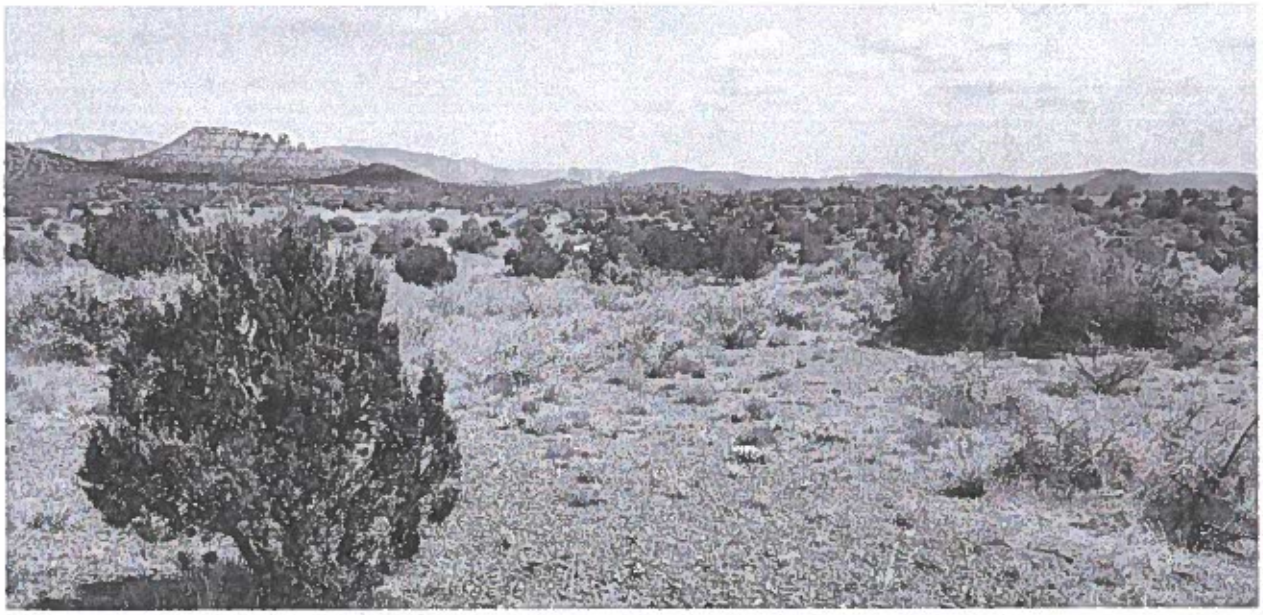

Figure 4 Healthy trees 200 yards east of Forest Service Road 152C

Dusty, dry conditions also create a favorable environment for spider mite activity. Infestations are common in juniper, cedars, and other conifers and can threaten tree health.
https://cals.arizona.edu/yavapai/anr/hort/byg/archive/spidermites.html

Dust on road surfaces can be controlled or mitigated by applying selected chemical products designed to stabilize the soil, but these products are not without their challenges including environmental impacts.
https://www.fs.fed.us/t-d/pubs/pdf/08771805.pdf

Water can also be applied to road surfaces to reduce dust. The level of natural rainfall in Sedona appears to do very little to wash off the heavy daily accumulation of dust on the roadside trees. Sedona receives only 23 inches of annual rainfall.

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WHAT DOES SAVATREE RECOMMEND BASED ON OUR FINDINGS?

Based on my assessment, I think dust is causing significant, irreparable damage to trees along Forest Service Road 152C. I recommend taking immediate action to reduce the dust to mitigate the negative impacts on tree health. Here are some options:

1) Pave the road

2) Limit access to the road

3) Limit the number of vehicles on the road

3) Control vehicle speed

4) Apply water to the road

5) Apply stabilizing chemicals to the road

In my professional opinion, unless dust control is achieved, the health of the trees along this stretch of Forest Service Road 152C will continue to decline. Hundreds of trees up to 20 yards from the road are now dead or declining and hundreds of other trees are at risk due to the heavy dust accumulation on leaves, branches, and bark. If measures are not taken, I think that tree morbidity and mortality will increase over the next several years.

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RESEARCH ARTICLE

Study of dust deposition on leaves of some plant species in GVISH. Campus of Amravati (MS) India

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ABSTRACT

A survey of fifteen dust polluted plants of different families were carried out in institute campus. The dust holding capacity of leaves, pH of dust wash of leaf surface and amount of total chlorophyll content with respect to dust deposition on leaves are determined. From the surveyed plants the quantity of dust deposition was recorded from the randomly sampled leaves. The maximum dust deposition on leaf surface was recorded in *Ficus benghalensis* and *Pongamia pinnata*. Minimum dust deposition was found on *Spathodea campanulata*. The pH of leaf wash of dust was found maximum on dust polluted leaves as compared to the control. The minimum total chlorophyll content was recorded in dust affected leaves.

Key words: Dust, Leaves, Chlorophyll, pH.

INTRODUCTION

The Government Vidarbha Institute of Science and Humanities is a major institute in Vidarbha region of Maharashtra State in India. The campus of this institute is occupied by many herbs, shrubs and trees. The institute is situated along the state highway. The amount of dust particles presents in the atmosphere causes air pollution. The dust present in the atmosphere is ultimately settle on ground and on vegetation. The dust is fine particle and particulate matter in the atmosphere. Dusts consist of solid matter in a minute and fine state of subdivision so that the particles are small enough to be raised and carried by wind. They may originate from many sources. A large range of industrial processes can produce particulate emissions (Fenelly, 1975). Dust particles emitting from different sources affects plant life in different ways. The plant exposed to heavy dust pollution shows variation according to the density of falling dust particles, the cover formed by deposition of dust particle decrease the pigment of plant leaves. The physical and chemical properties of plant tissue can also be changed by such large dust pollution. The dust deposition causes various effects on life activities of plants.

Plants are indispensable part of ecosystems and their sensitivity to air pollution is more considerable than standards of air pollution (Thomas,

1991). Air pollution has become a serious environment-tal stress to crop plants due to increasing industriali-zation and urbanization during the last few decades (Rajput and Agrawal, 2004). Diverse changes induced by different air pollutants in plants with respect to morphological, anatomical and physiological charac-teristics have been investigated (Rao,1981; Pawar and Dubey,1983; Rao and Dubey, 1988). Considering the role and effect of dust on plants, present work is attempted.

MATERIAL AND METHODS

Study area

The geographical area of state of Maharashtra is around 3,07,713 km^2, among which 61,939 km^2 is surrounded by green and beautiful forests. Amravati district has geographical area to 121,235. km^2, classified by tropical stunted semi-evergreen forests, stunted semi-evergreen shrubs forests, moist deciduous and dry deciduous forests. The Amravati district is situated between 20°32' and 27°46' North latitudes and 76°37' and 78° 27' East longitudes. The survey and study of dust polluted plants were carried out in campus of Government Vidarbha Institute of Science and Humanities, Amravati (M.S.), India.

Collection of sample:

Dust deposited fresh leaves of fifteen plant species like *Pongamia pinnata, Spathodea campanulata, Cassia fistula, Nyctanthus arbortristis, Ficus religiosa, Polyalthia longifolia, Morinda citrifolia, Bougainvillea spectabillis, Annona squamosa, Bahunia variegate, Ficus benghalensis, Plumaria alba, Tabebuia argentea, Butea monosperma, Sapindus mukorossi,* were collected in the month of January to March 2017. Observations of selected plants were carried out for 7 to 8 weeks. The polluted leaves from top, middle and basal region of each plant was considered, collected and used for experimental analysis.

Measurement of dust fall on the leaves :

Ten mature leaves of each sampled plants were collected in a separate polythene bags. Leaves were collected at the height of three to four meters from all the sites. The measurement of dust fall was carried out by the method of Dry technique described by Das and Pattanayak (1997). In this technique at first the intact leaf was weighted (in mg) and then dust particulates from leaf surfaces were gently collected with the help of camel hair brush and the weight of leaf was measured again. The amount of dust deposition in mg/ cm^2 was calculated as per the following formula.

$$\text{Dust content } (mg/cm^2) = \frac{\text{Weight of intact leaf - initial weight of leaf}}{\text{Total surface area of leaf } (cm^2)}$$

Estimation of dust holding capacity :

The leaves of dust polluted plants were selected about three meters from the ground level. The sample of leaves were plucked off randomly from aerial part of the plant . Five samples of leaves were taken and average of it is considered. The leaves were brought in the laboratory and washed with distilled water. Suspension of dust were collected in petridish. The distilled water is then filtered using preweighed filter paper and dust is collected. the weight of dust is noted after evaporation of moisture. The same weight is used to calculate dust holding capacity with the help of formula

$$\text{Dust holding Capacity } (gm/m^2)/month = \frac{\text{Total weight of dust}}{\text{Total leaf area}} X \frac{30}{\text{No. of days of exposure}}$$

Determination of pH of dust :

A pinch of dust collected from both the surface of leaves were taken and added in that 5 ml distilled water. The mixture is homogenized in a glass beaker. A broad range pH paper indicator is taken and dipped in the dust - water suspension. The colour change of paper is matched with colour scale on a pH paper booklet. The pH values of each sample were compared and noted.

Measurement of total chlorophyll :

The chlorophyll pigment of dust polluted leaves were estimated following the method of Arnon (1949). The fully expanded and dust deposited leaves from different sites of the Institutes campus were collected in the polythene bags and brought to the laboratory. The leaves were washed out thoroughly with distilled water. Three replicates were used for each plant. 01 gram leaf tissues of sampled material was grinded, homogenized and extracted thrice in chilled 80% acetone (v/v). It was then centrifused at 5000 rpm for five minutes and supernatant is made to 100 ml by adding 80 % acetone and the optical density was measured at 645nm and 663nm on a spectrophotometer. The concentration of the chlorophyll pigments was calculated using the following formula and the

results are expressed in mg/g fresh weight.

Chlorophyll a = [(12.7 X OD at 663) - (2.69 X OD at 645)] X dilution factor

Chlorophyll b = [(22.9 X OD at 645) - (4.68 X OD at 663)] X dilution factor

Total chlorophyll = [(20.2 X OD at 645) - (8.02 X OD at 663)] X dilution.

RESULT AND DISCUSSION

Monitoring of air pollution by higher groups of plants is a recent development in the field of environmental sciences. Monitoring of dust pollution by forage crops, taking morphological characters into considerations has earlier been worked out by many workers (Mishra *et al.* 1995 , Quadir, *et al.* 1997). The dust deposition on both the surface of leaves of different plants of different families were studied . Total fifteen plants were sampled (Table 1) . The amount of deposition of dust found varied with respect to the size and texture of leaves.

The leaves of members of different families were surveyed and collected from institute campus and observations were recorded. The various parameters of dust polluted leaves were recorded (Table 2) e.g. Dust holding capacity mg / cm^2 of leaf surface, pH of leaf surface dust wash and total chlorophyll content mg/g of fresh leaves etc. A considerable variation regarding the results were found at different air polluted locations of the campus. From the observations recorded, it is clear that, the maximum dust holding capacity is found in *Ficus benghalensis* and *Pongamia pinnata* respectively. It may be due to the large surface area, texture of leaf surface for holding the maximum dust particles. Such type of observations was noted by another worker in *Muntingia calabora* in which he found maximum dust deposition on leaves having rough nature and presence of minute hairs on surface of leaves. The minimum dust deposition was found on leaf surface of *Spathodea campanulata* and *Butea monosperma.*

The minimum dust deposition was found in *Acacia arabica* due to its minute, pinnate and smooth surface of leaves (Naik and Somasheker et.al 2006). The average of dust holding capacity of different dust polluted leaves were found to be 0.12 with standard error 0.07. The standard deviation and sample variance were found to be 0.28 and 0.08 respectively in studied plants sample. Supe and Gowande, et al. (2013) carried out the work on effects of dust fall on vegetation, according to their study dust pollution is important issue of ambient air.

Table : 1 List of plants sampled for dust deposition on leaf surface

S.N.	Family of the Plant	Name of the Plant
1	Annonaceae	*Polyalthia longifolia (L.) (Sonne).Thas.*
2	Annonaceae	*Annona squamosal L.*
3	Apocynaceae	*Plumeria alba L.*
4	Bignoniaceae	*Spathodea campanulata L.*
5	Bignoniaceae	*Tabebuia argentea L.*
6	Fabaceae	*Pongamia pinnata (L.) Pierre*
7	Fabaceae	*Cassia fistula L.*
8	Moraceae	*Ficus religiosa L.*
9	Moraceae	*Ficus benghalensis L.*
10	Nyctaginaceae	*Bougainvillea spectabiolis L.*
11	Nyctaginaceae	*Nyctanthus arbor-tristis L.*
12	Papilionaceae	*Bauhinia verigeta L.*
13	Papilionaceae	*Butea monosperma (L.) taub*
14	Rubiaceae	*Morinda citrifolia L.*
15	Sapindaceae	*Sapindus mukorossi L*

Table 2 : Estimation of DHC , pH and total Chlorophyll of dust deposited leaves

S.N.	Name of the plant	DHC (mg/cm² leaf surface)		pH (leaf wash)		Total chlorophyll (mg/g fresh leaves)	
		Control	Polluted	Control	Polluted	Control	Polluted
1	*Annona squamosa L.*	00	0.0003	8.5	9.2	0.42	0.39
2	*Bahunia variegate L.*	00	0.016	4.4	4.5	0.36	0.31
3	*Bogainvillea spectabilis L.*	00	0.003	3.4	4.1	0.34	0.25
4	*Butea monosperma (L). taub*	00	0.001	6.6	7.2	0.54	0.42
5	*Cassia fistula L.*	00	0.05	5.6	5.9	0.29	0.26
6	*Ficus benghalensis L.*	00	0.836	6.1	6.5	0.29	0.67
7	*Ficus religiosa L.*	00	0.04	5.4	6.5	0.22	0.14
8	*Morinda citrifolia L.*	00	0.014	7.6	8.1	0.64	0.55
9	*Nyctanthus arbor tristis L.*	00	0.02	6.1	6.4	0.31	0.29
10	*Plumaria alba L.*	00	0.004	8	9	0.5	0.45
11	*Polyalthia longifolia (L).(sonne). thas*	00	0.024	6.4	7.1	0.34	0.29
12	*Pongamia pinnata (L).Pierre*	00	0.77	5.6	6.1	0.44	0.35
13	*Sapindus mukorossi L.*	00	0.029	6.9	7.1	0.6	0.55
14	*Spathodia companulata L.*	00	0.001	3.4	3.9	0.39	0.25
15	*Tabovia argontea L.*	00	0.0022	6.5	6.9	0.28	0.21
	S.E.	00	0.07	0.39	0.41	0.03	0.04
	S.D.	00	0.28	1.49	1.57	0.12	0.15

DHC = Dust Holding Capacity

The pH of surface dust deposited on the leaf surface were found maximum as compared to the control plants that were sparingly deposited by dust where amount of dust was very less in the campus area and that were very less deposited by dust particles. The standard error found to be 0.03 and deviation of the samples by 0.12 respectively. The change in the pH value may be due to moisture content held by deposited dust.

The Maximum concentration of chlorophyll pigment found in the polluted plant in *Ficus benghalensis* and minimum was recorded in *Ficus religiosa*. The reduction in chlorophyll concentration in the polluted leaves could be due to chloroplast damage inhibition of chlorophyll synthesis. The dust particle affects plant leaves and ultimately affecting the photosynthesis and respiration. Dust can cause the leaf injury stomata damage, premature senescence and can decrease photosynthetic activity, disturb membrane permeability and reduce growth and yield in sensitive plant species. (Agrawal et al. 2006, Tiwari et al. 2006). Of the fifteen plants studied *Cassia fistula* were found more resistant to dust pollution followed by *Nyctanthes arbortristis*. The decrease in chlorophyll content was observed in *Ficus religiosa*.

The capacity of leaves as dust receptors depends upon epidermal and cuticular features of leaves, surface geometry, phyllotaxy, type of canopy, leaf pubescence etc. The dust deposition not only depend upon the size and area of leaf surfaces but also the nature of leaf surfaces, thickness of leaf, orientation etc. which play an important role in the concentration of dust deposition and chlorophyll content. The photosynthetic pigment are the most likely to be damaged by air pollution. It may be because of the age of the leaf period of senescence, sensitivity of the plant species, biotic and abiotic condition and position of plant at the cross roads, suggest that high level of automobile pollution decreases chlorophyll content in higher plant near roadside (Gami and Patel, 2015).

The study indicates that the total chlorophyll in control plants was always higher than that of the plants grown in dust polluted atmosphere. The reduction in yield may be attributed to the reduction in the photosynthetic pigments and the deposition of dust which leads to the clogging of stomata that interferes with gaseous exchange. The decrease in total chlorophyll content in unit fresh weight of polluted leaves might be due to chloroplast damage by incorporation of dust particulates into leaf tissue.

Similar observations have also been made by Singh and Rao (1978).

Pandey and Kumar (1996) are of opinion that alkaline condition caused by solubilization of dust in to cell sap might be the cause of chlorophyll degradation. Increased dust deposition and subsequent reduction in chlorophyll may be positively correlated with reduced photosynthetic efficiency.

CONCLUSION

The protection of healthy environment is an important issue. The Rapid deforestation and loss of vegetation helps to damage healthy environment as well as natural resources. The vegetation and forests are very important to balance the ecosystem. It is revealed that the exposure to particulate deposition may alter plant growth and their production even though there may or may not be any marked physical damage to the plant.

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Open Access Article

Effect of Dust Deposition on Stomatal Conductance and Leaf Temperature of Cotton in Northwest China

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Abstract

The Xinjiang Region in Northwest China is known as the "dust center" of the Eurasian mainland. Dust on the leaf surface affects overall plant development. While emphasis was on studying the impacts of industrial dust particles on crop development, the effect of natural dust deposition on the physiological parameters of cotton had not been studied before. The objective of this study was to examine the effects of dust deposits on cotton leaves and to estimate their impact on crop development and yield. For this purpose, an experiment was set up having two treatments and a control. In Treatment 1, cotton leaves were cleaned with water at three-day intervals or after a natural dust fall. In Treatment 2, 100 $g \cdot m^{-2}$ of dust was applied at 10-day intervals. The control received neither additional dust nor cleaning. In all of the treatments, stomatal conductance, leaf temperature, biomass and yield were measured. The results show a 28% reduction in yield and 30% reduction in stomatal conductance of the dust treatment compared to the control treatment. This indicates blocking of the stomata on the top of the leaf surface. In addition, the canopy temperature of the dust-applied leaves was always higher than the control and treatment.

Keywords: **Xinjiang (/search?q=Xinjiang); dust storms (/search?q=dust%20storms); abiotic stress (/search?q=abiotic%20stress); yield (/search?q=yield); plant physiology (/search?q=plant%20physiology); *Gossypium hirsutum* L. (/search?q=Gossypium%20hirsutum%20L.)**

1. Introduction

The desert regions in north and Northwest China are the major sources of dust and sandstorms (DSS) in the country. Due to the presence of some of the largest deserts, such as Taklamakan desert in the south and

Gurbantunggut in the north, the Xinjiang Region is also known as "dust center" of the Eurasian mainland [1]. About 90% of the DSS occur in the period from March to September and mainly during the afternoon [2]. Due to the variations in topography, vegetation cover and weather conditions the annual average number of DSS days in the south of Xinjiang is double that in the north of Xinjiang [3]. The highest frequency of DSS occurs in the Tarim Basin with more than 30 DSS days per year [4]. During summer time, high temperature, little rainfall and sandy soil provide favorable conditions for wind erosion. According to the dynamic characteristics of dust, grains with diameters <10 µm can be transported by wind for several thousands of kilometers [5]. Trends of DSS in Northwest China have been studied intensively [6]. Conclusions, however, remain controversial; while some researchers report an increase of DSS in recent years [7], others claim to observe a reducing trend [8].

Without a doubt, DSS cause many detrimental effects to human health, like respiratory and cardio-vascular problems [9], and environmental impacts, such as soil fertility loss or direct damage to crops, thereby reducing agricultural production and, consequently, causing economic losses on a large scale [10]. Plants exposed to high wind exhibit anatomical and morphological changes. For example, carbon assimilation is shifted from the leaf development to the growth of stems and roots, leading to reduced leaf area. The effects are devastating in an arid environment, because even drought-tolerant crops, if wind stressed, show an increased rate of water loss due to increased stomatal conductance, abrasion of the vapor barrier and an increase of transpiration [11,12]. A positive effect of the vegetation to the environment is its air filtering ability: dust particles in the atmosphere get deposited on the leaves, which improves the air quality. The leaves' ability to act as dust receptors depends upon their surface geometry, orientation, epidermal and cuticle features, leaf pubescence and plant height [13]. However, at the same time, dust on the leaf surface affects plant growth and development. For example, dust deposits on the leaves can alter their optical properties, especially the surface reflectance in the visible and near-infrared range of the wavelength [14]. Leaves covered with dust receive less light for photosynthesis; this interferes with gas exchange between the leaf and air, and the reduction of leaf stomatal conductance influences plant biomass formation and yield. Cornisch *et al.* [15] concluded that an increase in yield is associated with the stomatal conductance in Pima cotton (*Gossypium barbadense* L.). Stomatal conductance depends on environmental factors, position at the canopy and age of the leaves [16]. This may occur only on the lower (abaxial) surface (hypostomatous leaves), only on the upper (adaxial) surface (hyperstomatous leaves) or on both the abaxial and adaxial surfaces (amphistomatous leaves).

In addition, dusted canopies have a high absorption of solar radiation, raising the leaf temperature [17]. Other impacts, such as sandblasting, result in the loss of plant leaves, which reduces photosynthetic activities and the development of grain or fruit. In the long term, dust can also affect plants via changes in soil chemistry or it may also worsen other stresses, such as drought stress or pathogen stress [18].

In the past, emphasis was on studying the impacts of industrial dust particles on crop development and crop physiological parameters [19,20]. The chemical composition of dust, its particulate size, age of plants and deposition rate were studied intensively [19,21]. For example, cement kiln dust reduced 73% of the photosynthesis in green beans [22], while ash reduced up to 90% of the rate of photosynthesis of apple trees [23]. Nanos and Ilias [24] described the effects of cement dust, such as a reduced stomatal conductance and transpiration rate of olive trees. Similarly, Shukla *et al.* [25] reported that the highly alkaline nature of the cement dust resulted in the reduced chlorophyll content of dusted plants. This leads to reduced photosynthesis, due to reduced leaf area, clogging of stomata and interception in the incident light due to cement encrustations on the leaf surface. Thomson *et al.* [26] studied the effects of roadside dust on photosynthesis and leaf diffusion resistance over a range of light intensities. They concluded that photosynthesis was reduced tremendously when leaves were dusted with 5 to 10 g of dust per m^2 of leaf surface.

Increased concentration of industrial dust particles from cement, coal or thermal power plants has drawn much attention due to their serious impacts on human and plant health. Similarly, much focus was given to study the trend

of DSS in the Xinjiang region. However, the effect of dust deposition on the physiological parameters of cotton, the main crop in Northwest China, has not been studied yet. Thus, the objective of this study was to examine the effects of dust deposits on cotton leaves and to estimate the impact on canopy temperature, stomatal conductance and yield.

2. Materials and Methods

2.1. Experimental Site

The experiment was conducted at the Kuerle experimental station of Xinjiang Agriculture University, located at Xinier Township, Kuerle City, Xinjiang (41°35' N, 86°09' E). Located in the warm temperate climatic zone, the area is arid, with an average annual rainfall of 60 mm and an average annual potential evaporation of 2450 mm (ø 120 cm evaporation pan). The soil at the experimental station is classified as sandy loam soil. The field capacity (FC) and permanent wilting point (PWP) are 0.25 $m^3 \cdot m^{-3}$ and 0.09 $m^3 \cdot m^{-3}$, respectively. The detailed soil analysis at different depths is shown in **Table 1**. A meteorological station positioned at the site provides hourly measurements of solar radiation, rainfall, air temperature, relative humidity and wind speed during the growing season. The monthly average values measured throughout the growing season are shown in **Table 2**.

Table 1. The soil chemical and physical properties at Kuerle experimental station: cation exchange capacity (CEC), bulk density (BD), electrical conductivity (ECe), organic carbon ($C_{organic}$), total nitrogen (N_{total}), calcium carbonate ($CaCO_3$), carbonate (CO_3^{2-}), bicarbonate (HCO^-_3), chloride (Cl^-), sodium (Na^+), calcium (Ca^{2+}) potassium (K^+), magnesium (Mg^{2+}) and sulfate (SO_4^{2-}).

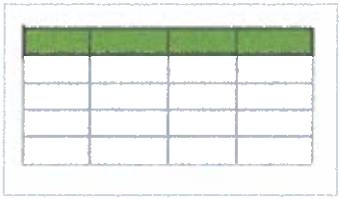
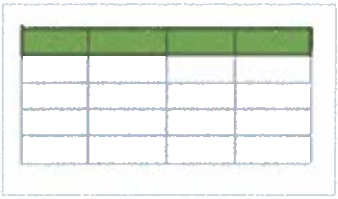


Table 2. Meteorological information at Kuerle experimental station during the whole sowing season: mean maximum (T_{max}) and minimum air temperature (T_{min}), average temperature (T_{avg}), relative humidity (RH), mean wind speed (u_2), daily average solar radiation (Rs) and rainfall (P).



2.2. Experiment Design

Cotton (*Gossypium hirsutum* L., Xinluzhong-21) was sown on 4 May 2012, which was covered with 0.08-mm transparent polythene film as a mulch. Plastic mulch covered four cotton rows (N-S direction) having a width of 140 cm. The inter-row spacing was 20-40-20 cm, leaving a bare soil width of 60 cm (**Figure 1**). Hence, the ground surface was approximately 80% covered by the plastic mulch. Two drip lines were placed underneath each of two cotton rows with a dripper distance of 29 cm and a discharge rate of 1.6 $L \cdot h^{-1}$. Plastic mulch and drip lines were placed with a specially equipped sowing machine. In total, 24 irrigation events took place starting from mid-June until the end of August.

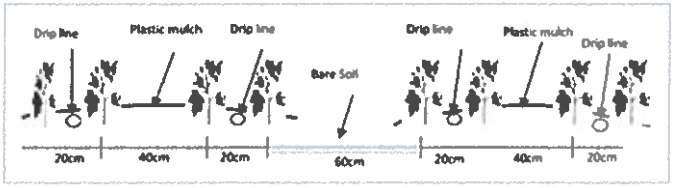


Figure 1. Planting pattern with drip irrigation and plastic mulch.

The experiment consisted of two treatments and a control. In Treatment 1, cotton leaves were cleaned with water at 3-day intervals or after a natural dust fall. In Treatment 2, 100 $g \cdot m^{-2}$ of dust was applied at 10-day intervals. For this, dust was collected by placing paper sheets in the cotton field, which was later sieved to get a uniform particle size. The control received neither additional dust nor cleaning, but was exposed to the natural conditions. Treatments and control were repeated 3 times with a random arrangement of plots each of an area of 5 m × 5 m (**Figure 2**). Only the plots in Treatment 2 were surrounded by a 1.5 m-high polythene fence, called a "dusting chamber". The dusting chamber kept the dust confined within the specified area, was placed at each dust application time and removed afterwards. All plant samples were taken from the center area of 3 m × 3 m. Leaf dusting began at the budding stage in the morning hours of every tenth day and was continued till the end of the experiment. The treated plants were visibly dusty compared to the control and cleaned plants and retained dust on the leaves between the application (**Figure 3**).

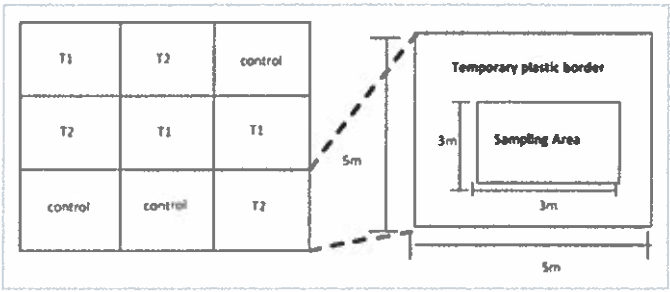


Figure 2. Experiment design showing the treatments and layout of the dusting chamber (zoom out).

Figure 3. Cotton leaves of the control and treatments.

2.3. Measurement of Canopy Temperature and Stomatal Conductance

A high resolution (384 × 288 pixel) thermal camera (VarioCAM, Infra Tech GmbH, Dresden, Germany) was used to measure canopy temperature (T_c). All images were acquired between 12:00 and 14:00. Thermal images were analyzed using the IRBIS-PROFESSIONAL-3 software (Infra Tech GmbH, Dresden, Germany), which allowed corrections for object emissivity, object distance and temperature. Infrared pictures were pre-processed manually to exclude any extraneous surfaces in the analysis of leaf temperature, such as the marking sticks, plastic mulch and soil. The temperature difference between the soil and the upper leaves was in the range of 15 to 25 °C. Since the soil (53 °C) and plastic mulch (52 °C) had a much higher temperature (red and blue color) than the leaves (30 °C)

(purple color), it was easy to differentiate during the image analysis, as shown in **Figure 4**. The selected area of interest was outlined by vertical dotted lines, and statistical parameters, like maximum, minimum, average temperatures and standard deviation, were calculated by the image processing software.

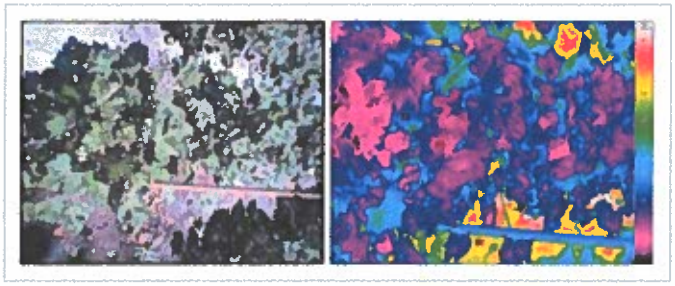


Figure 4. Digital image and the corresponding infrared image of a cotton row.

Stomatal conductance (g_s) was measured at the same time when infrared images were taken using a portable porometer (SC-1; Decagon devices, Washington, DC, USA). Measurements were taken on the abaxial side on three randomly-selected, fully-developed, sunlit leaves per plot. Before each measurement, the instrument was calibrated according to the manufacturer's instructions.

2.4. Soil Moisture Content, Plant Dry Matter and Yield

Volumetric soil water content was measured with TDR-TRIME tube access probes (IMKO GmbH, Ettlingen, Germany). One access tube per plot was installed, and the measurement was made down to a depth of 0.7 m in 0.1-m intervals. Measurements were taken at 3-day intervals, before and after irrigation and whenever there was a rainfall event. The irrigation amount supplied to the field was based on the soil water content: whenever the water content dropped below 65% FC, it was irrigated up to 100% FC. Total available water content (TAW) was estimated to be 110 mm, assuming the maximum rooting depth of cotton to be 1 m **[27]**. The readily-available water content (RAW) was calculated as 55 mm based on a depletion factor of 0.5. Fresh biomass above the ground was taken by cutting three randomly-selected plants per plot, which were than dried at 70 °C for 48 h to get the dry biomass.

At physiological maturity, all bolls were harvested manually, and the plant density (D_p), capsule with cotton (C_c), without cotton (C_{wc}) and capsules smaller than 2 cm (N_{sc}) were determined for each treatment. The weight per capsule (m_c) was determined before and after oven drying at 70 °C for 24 h. The average capsule number per cotton plant (N_c) and cotton seed yield (Y_{cs}) in $t \cdot ha^{-1}$ was calculated for each plot using the method described by the Ministry of Agriculture of China **[28]**.

$$Y_{cs} = D_p \times N_c \times m_c \times 85\% \quad (1)$$

$$N_c = Cc + Cw_c + 1/3N_{sc} \quad (2)$$

2.5. Data Analyses and Statistics

An analysis of variance (ANOVA) was performed in order to evaluate the influence of the different treatments on canopy temperature, stomatal conductance and yield. Linear correlations were calculated for the relationship between canopy temperature and yield. The significance of the correlation was determined using a Pearson coefficient analysis.

3. Results

3.1. Irrigation and Soil Moisture Content

Potential evapotranspiration (ET_0) from the date of sowing till the harvesting time amounted to 693 mm and the total irrigation amount was 631 mm. This does not included pre-plant leaching for salinity management. The crop received a total of 40 mm of rainfall throughout the growing season (**Figure 5**).

3.2. Canopy Temperature and Stomatal Conductance

The maximum temperature difference between the plants treated with dust and cleaned with water was 4.1 °C, whereas the temperature difference between plants applied with dust and control plants was 2.9 °C. The canopy temperature (**Figure 6**) difference between the treatments showed that dust treatment generally or on average had a higher canopy temperature when compared with the clean and control treatment. **Figure 7** shows the difference in temperature between canopy (T_c) and ambient air (T_a), with the dust treatment showing higher values than the non-dusted treatments. Differences in canopy temperature between control, cleaned and dust applied were found to be significant ($p < 0.001$) for all of the measured days. In order to find out the influence of the quantity of dust on the canopy temperature, the accumulated amount of dust was divided into the total number of days when dust was applied. The increasing trend of the canopy temperature with the dust quantity in the beginning and later had no change in the canopy temperature with the amount of dust observed, as shown in **Figure 8**.

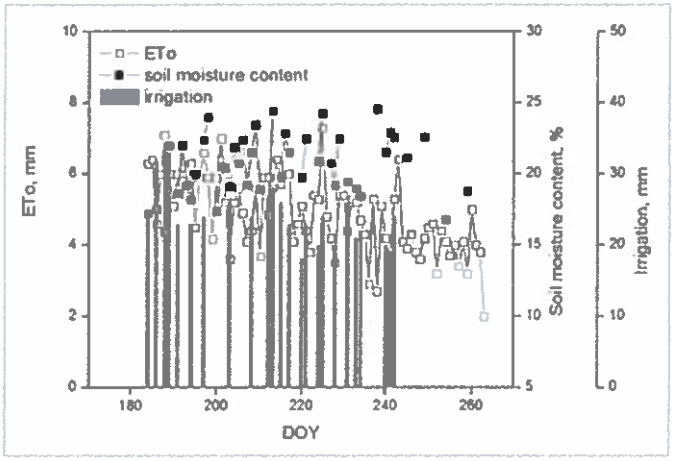


Figure 5. Potential evapotranspiration (ET_0), irrigation and volumetric soil moisture content throughout the growing season (DOY = day of year).

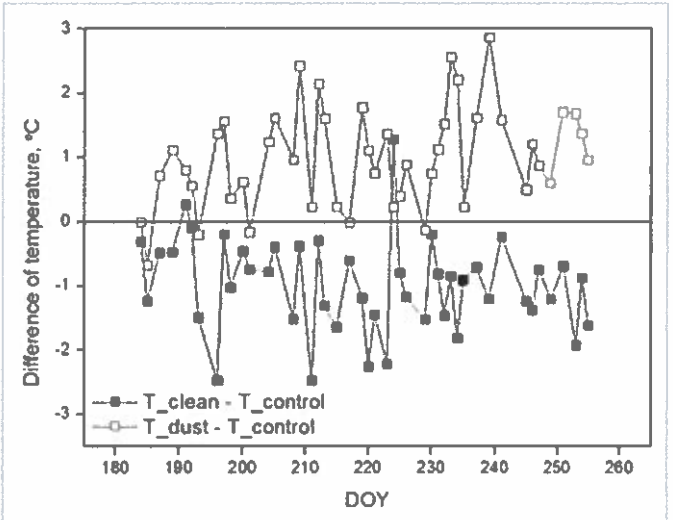


Figure 6. Canopy temperature difference between the treatment and control throughout the growing season.

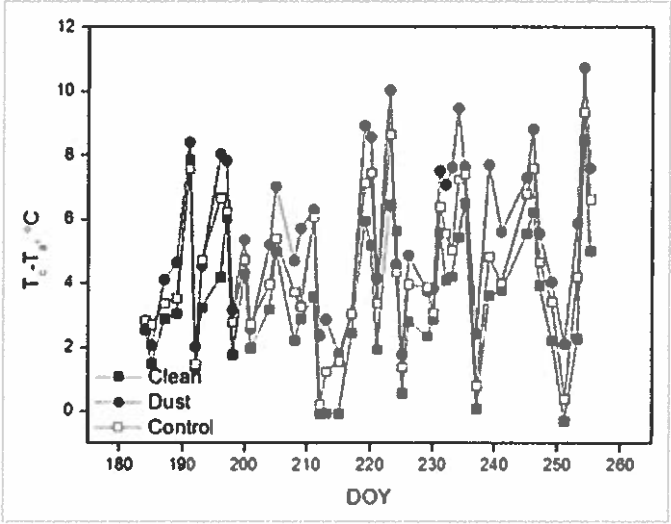


Figure 7. Difference of canopy temperature (T_c) and air temperature (T_a) for treatments and control.

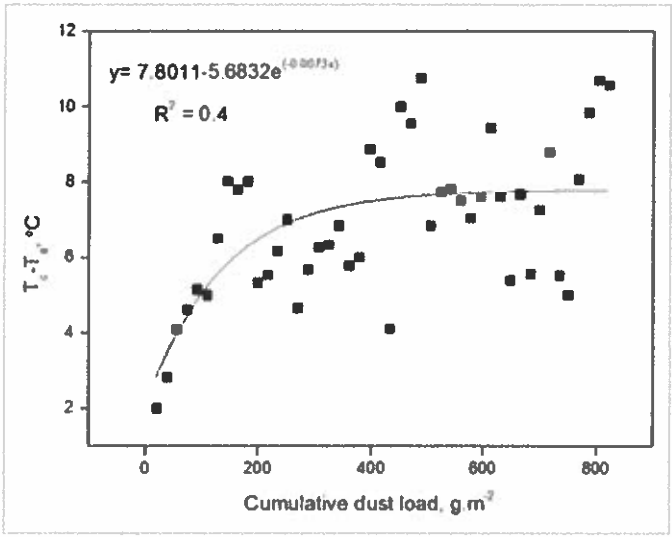


Figure 8. Influence of cumulative dust load on the difference of canopy temperature (T_c) and ambient temperature (T_a).

The stomatal conductance (g_s) of dusted plants was lower than that of control plants at all growing stages. The differences of g_s among the treatments are shown in **Figure 9**. The g_s of the clean leaves was compared to the dust-applied and control canopies, and the differences were higher between the dust-applied and control treatment. ANOVA analysis showed highly significant differences ($p < 0.001$) in stomatal conductance between the treatments. The stomatal conductance in all of the treatments decreased at the end of the experiment. The correlation between g_s and the canopy temperature of all of the treatments showed a good correlation (**Figure 10**). It was observed that the canopy temperature of the dust treatment increased as g_s decreased.

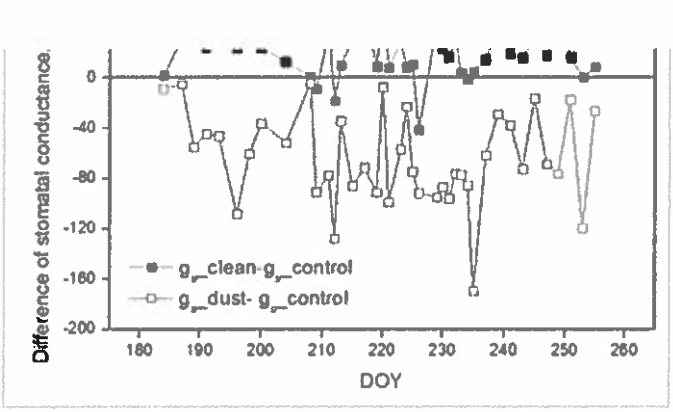


Figure 9. Difference of stomatal conductance between treatment and control.

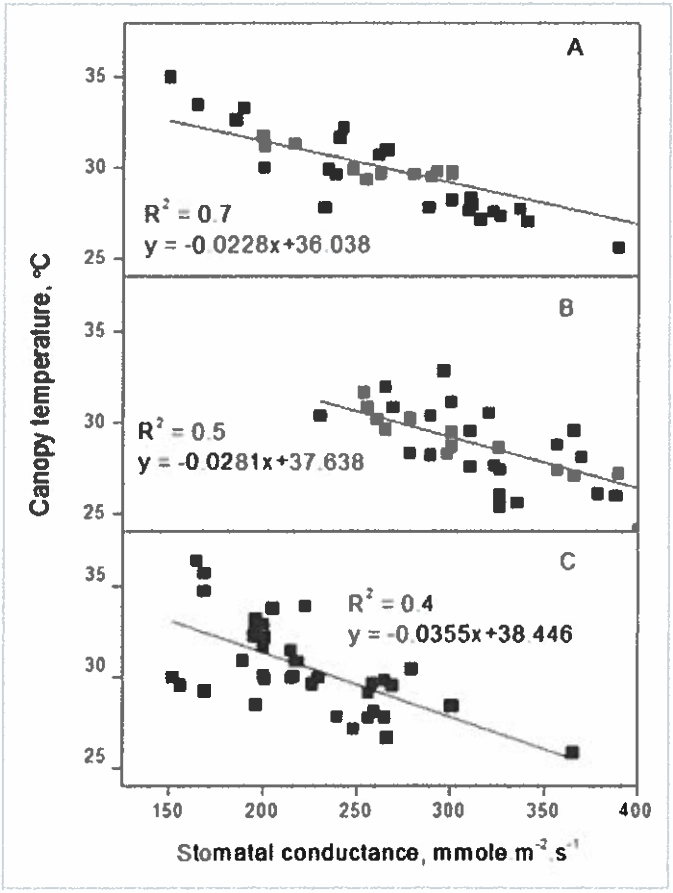


Figure 10. Canopy temperature *vs.* stomatal conductance: (**A**) control; (**B**) cleaned; (**C**) dusted.

3.3. Biomass and Yield

Dry matter development throughout the measurement period is shown in **Figure 11**A. The dust treatment showed the lowest dry matter development when compared with the control and clean treatments. Significant differences ($p < 0.05$) of biomass between the control and clean treatments were visible after DOY 225. Box plots in **Figure 11**B show the yield data of all of the treatments. About a 28% yield reduction was observed when plants were exposed to additional dust compared with the control. By cleaning the leaves with water at a regular interval, there was a yield increase of 10%.

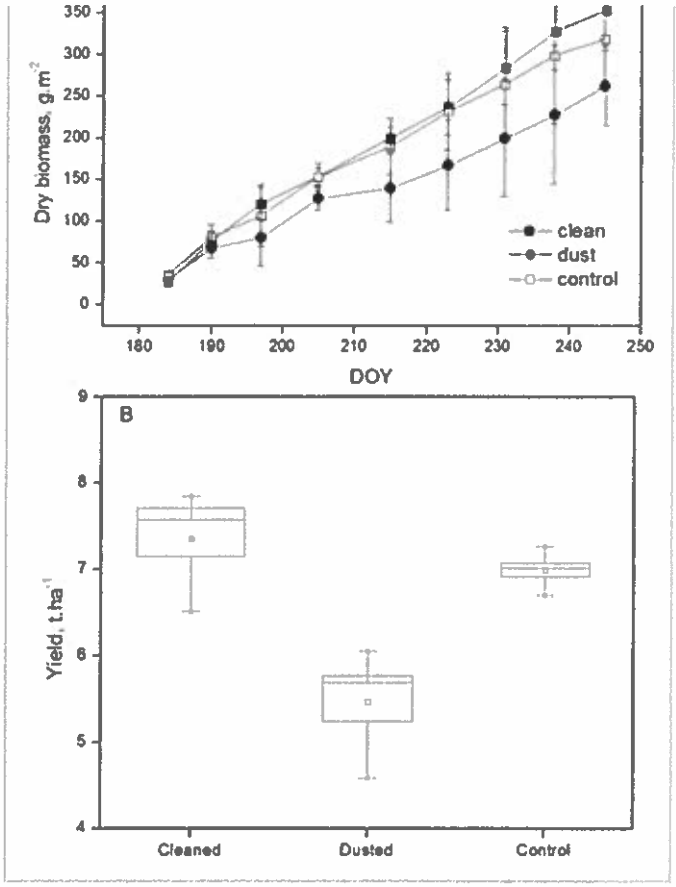


Figure 11. Dry biomass (**A**) throughout the growing season (DOY = day of year) and yield (**B**) of all of the treatments.

4. Discussion

The highest cotton yield of 8 $t \cdot ha^{-1}$ was achieved in the plots where leaves were cleaned with water, which indicates the most favorable growing conditions. The mean reduction in yield of the dusted treatment was about 28%, indicating that the stress conditions in this experiment were relatively severe. Therefore, the reduction in yield can be taken as an integrated plant response to dust deposition on the cotton leaves. Previous studies reported similar results for black gram when leaves were dusted with cement dust, and a 50% reduction in the number of flowers was observed [**29**]. From the physiological measurements of control and dusted plants, it is quite apparent that a dusted environment had an unfavorable effect on the flowering and fruiting potential of plants, thus indicating a considerable reduction in the productivity of cotton [**29**]. It is important to state that by cleaning of the leaves, yield was increased by a substantial extent. While this is, of course, not a practical measure to be taken in field production, it shows the considerable damage that dust deposition causes to agricultural production. However, this data can contribute to analyzing the impact of dust deposition on agricultural production. In addition, environmental services in terms of DSS reduction can be evaluated.

Dust particles deposited on cotton leaves resulted in the reduction of the total dry matter weight (**Figure 11**). This is due to the reduction in the stomatal conductance, which might be due to the reduction in the photosynthesis rate, as it was not measured. This resulted in the decreased plant biomass, even just five to six days after dust was applied. In contrast to our results, [**30**] reported the decrease in dry plant weight after one to three days of the dust application, but this is due to the increased frequency of the dust application. Chaurasi *et al.* [**31**] reported a decrease in the aboveground biomass of a groundnut crop planted in the vicinity of the cement factory, and it increased as the distance between the two increased.

Since the stomatal conductance in cotton leaf is higher on the abaxial (lower) than on the adaxial (upper) surface [**32**,**33**], only the abaxial surface was used to determine the whole leaf stomatal conductance. Furthermore, due to the large number of measurement points and a small measurement window, *i.e.*, 12:00–14:00 h, only one side of the leaf was used to measure conductance. This is unlike beans and cucumber, where the difference between the adaxial and abaxial stomatal conductance is large, and therefore, the sum of the values on both the surfaces is used to determine the whole leaf conductance [**32**]. Further, since the dust load on the adaxial surface is larger than that on the abaxial surface, it can be inferred that the adaxial surface influences the stomatal conductance more significantly than the latter. The transpiration rate of the dusted treatment was lower than that of the control treatment at all stages of growth. A 30% reduction in the stomatal conductance (**Figure 9**) of the dust-treated plants compared to the control treatment shows the blocking of the stomata on the top leaf surface due to the shading effect caused by the dust layer, which decreased the overall net photosynthesis rate soon after the dust was applied. Similar results were reported by Singh and Rao [**20**], where the transpiration rate was decreased by 22% as a result of cement dust on wheat plants. They concluded that cement crust reduces the light reaching the leaf surface and, thereby, decreases the thermal balance of the leaf. Hirano *et al.* [**34**] showed that this effect became greater as the dust particle size decreased.

The canopy temperature of the dust-applied leaves was always higher than the control and the water-cleaned treatments. An increase of 2 to 4 °C was observed between all treatments; however, thedust-applied treatment had the highest value of 4.1 °C when compared with the water-cleaned treatment. A lowered g_s of the dusted treatment resulted in the higher leaf temperature [**35**]. A similar result was reported by Hirano *et al.* [**34**], where the temperature of the dusted leaves was higher than that of the control leaves, and the differences were 3.7, 3.1 and 1.7 °C at an air temperature of 15 °C, 25°C and 40 °C respectively. It was reported that road dust could raise the leaf temperatures by 2 to 4 °C [**36**]. **Figure 8** depicts the effect of dust on leaf temperature, which clearly shows an increasing trend of the difference in T_c and T_a as the amount of dust applied increases, but later, no change in T_c-T_a was observed. This is in contrast to the results of Wijayratne *et al.* [**17**], who showed an increase in canopy temperature with the quantity of dust. The effect of the chemically inert dust on plant physiology is apparently similar to drought stress, which leads to stomatal closure and higher leaf temperature [**37**]. It is thus important to point out that a possible increase in the plant leaf temperature due to water stress can be excluded in this study, due to the fact that the soil moisture content was always about 70% of the field capacity. Sharifi *et al.* [**38**] reported that dust of 10 $g \cdot m^{-2}$ reduced Photosynthetically active radiation (PAR) absorption by 20% in desert shrubs. They found an inverse relationship between the weights of dust per unit leaf surface to absorptance of PAR. Therefore, apart from the closure of the stomatal conductance, another reason for the increase of canopy temperature of the dusted treatment is due to the increased absorbance of the near-infrared solar irradiance. For example, Eller [**36**] reported an experimental study in Switzerland and showed a doubling of absorptance in the near-infrared (700–1350 nm) for dusty leaves compared with control leaves, which resulted in a 2–4 °C increase in leaf temperature.

5. Conclusions

It was found that the dust accumulation on leaf surfaces induces water stress-like conditions, such as a reduction of stomata conductance, photosynthesis and transpiration and increased leaf temperature. More importantly, the results of this study show that both the growth of cotton plants and the yield are adversely affected by dust deposits by DSS over a short interval of time during the flowering period. There is no regular natural removal of dust particles on the plant leaves by strong winds and rain in arid climates, like in the study area, as rainfall is scarce and wind brings more dust rather than alleviating the situation. Future research should focus on measures to reduce the dust deposition on the plants, such as wind breaks and the avoidance of wind erosion, and their potential to increase the cotton yield in Northwest China.

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Author Contributions

Shamaila Zia-Khan, Wolfram Spreer and Joachim Müller designed the experiment. Shamaila Zia-Khan analyzed the data and wrote the first draft of the manuscript. Wolfram Spreer, Xiongkui He and Joachim Müller remotely supervised data collection, elaborated the statistical analysis and gave input on the draft of the manuscript.

Yang Pengnian provided his support and guidance throughout the field experiment. His timely suggestions during the experiment and writing have greatly improved the experiment design and the manuscript.

Zhao Xioning and Hussein Othmanli took the soil samples at different depths and did the soil chemical and physical properties analysis.

All authors reviewed the final manuscript.

Abbreviation

DSS	Dust and sand storms
T_c	Canopy temperature (°C)
T_a	Air temperature (°C)
g_s	Stomatal conductance (mmole.m^{-2}·s^{-1})
FC	Field capacity (m^3·m^{-3})
PWP	Permanent wilting point (m^3·m^{-3})
TAW	Total available water content (mm)
RAW	Readily available water content (mm)
D_p	Plant density
C_c	Capsule with cotton
C_{wc}	Capsule without cotton
N_{sc}	Capsules smaller than 2 cm
m_c	Weight per capsule (g)
N_c	Average capsule number per cotton plant
Y_{cs}	Cotton seed yield (t·ha^{-1})
ET_0	Potential evapotranspiration (mm)
DOY	Days of the year (days)

Conflicts of Interest

The authors declare no conflict of interest.

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An assessment of dust accumulation and leaf morphology at roadside plants in Kathmandu Valley, Nepal

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Abstract

Air pollution is one of the serious environmental issues. The vehicular emissions have a very harmful effect on the environment, human health and ecology. This research was planned to assess dust deposition on leaves of two selected plants are Callistemon citrinus and Lagerstroemia indica growing along the roadside of a city having high traffic density and construction. The work determines the variation in dust deposition on leaves and different structure of leaf with respect to species, seasons and study sites. The study was conducted in these seasons, i.e. spring, summer, autumn and winter, during 2017 / 2018. In C. citrinus, the deposition of dust on leaf was highest in heavily polluted sites in all seasons. The dust deposition and the morphology of leaf show the interrelationship in the growth and development. If dust accumulation was increased then the

growth was decreased instead if dust deposition was decreased then leaf growth was increased. In L. indica, the deposition of dust on leaf was highest in heavily polluted sites. In different seasons, the dust deposition and the value of morphology of leaf showing the interrelationship in the growth and development differently. It was because of different environmental factors. In heavily polluted site, some dust deposition result and with this the growth of morphology of leaf was decreased. The result about the deposition of dust and in the morphology (length, breadth, area and specific length area) indicated that it was affected from the environment and deposition of dust on leaf.

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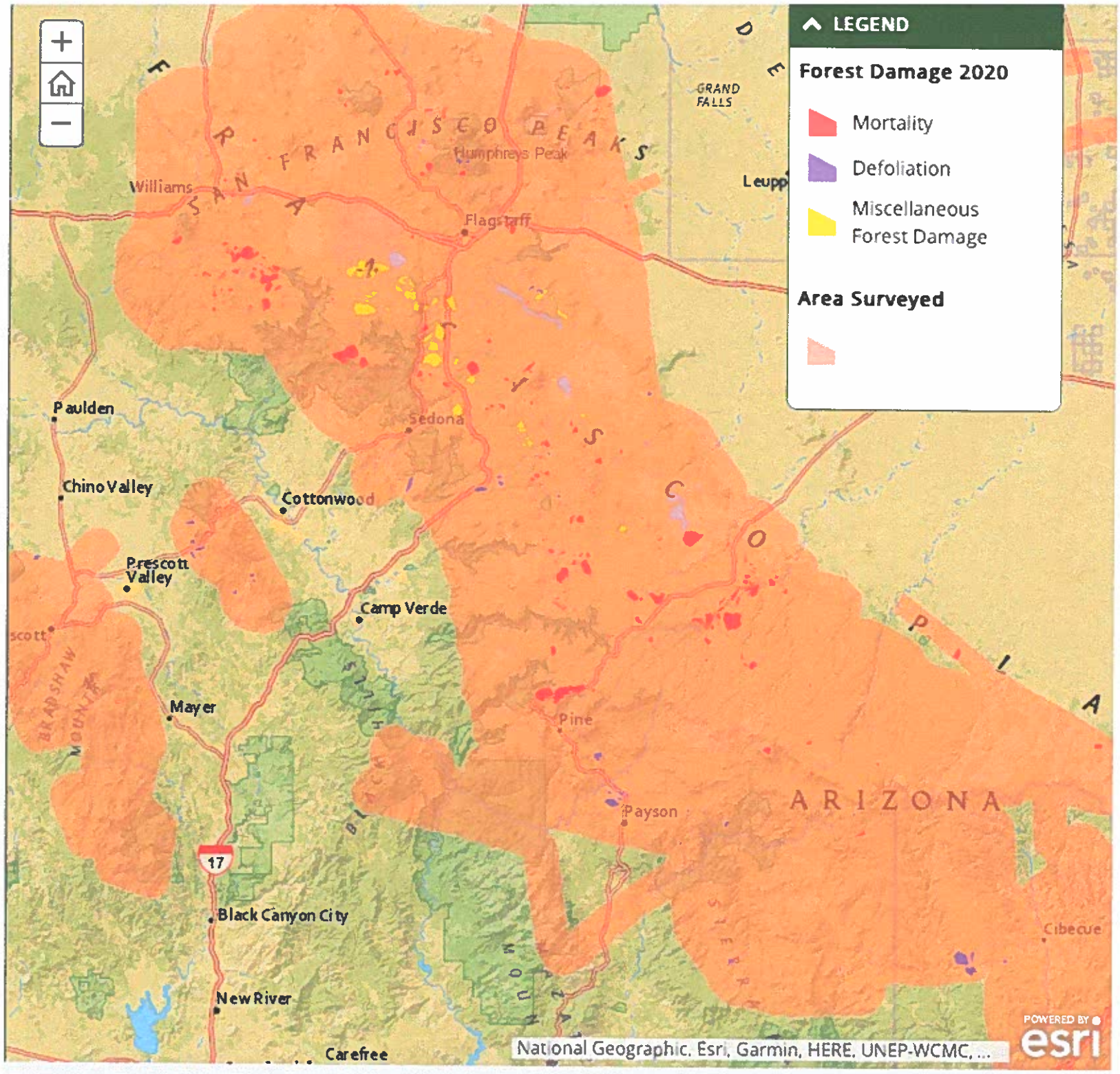
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Mortality
Defoliation
Miscellaneous Forest Damage
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Humphreys Peak
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Flagstaff
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Leupp
Paulden
Sedona
Chino Valley
Cottonwood
Prescott Valley
Camp Verde
Mayer
Pine
Payson
ARIZONA
Black Canyon City
New River
Carefree
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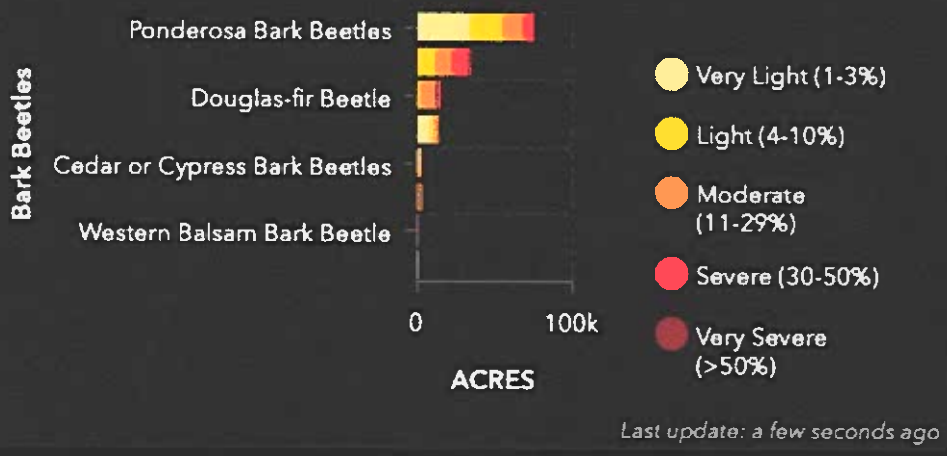
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, ...
POWERED BY esri

Forest Health Data 2020 USFS Southwestern Region



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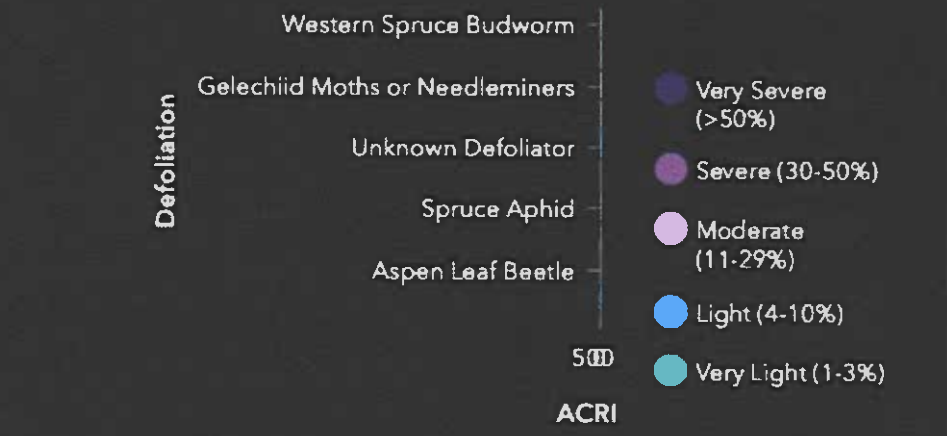

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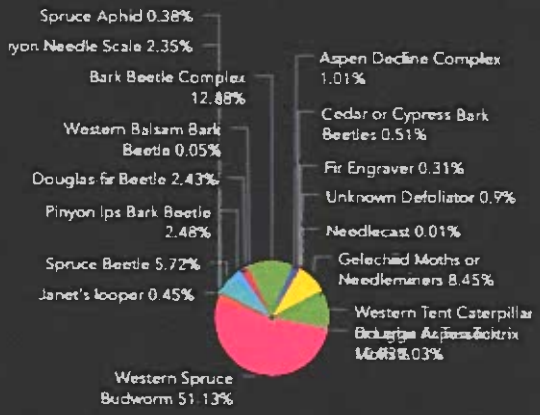
2020 Forest Damage by Percent Impacted



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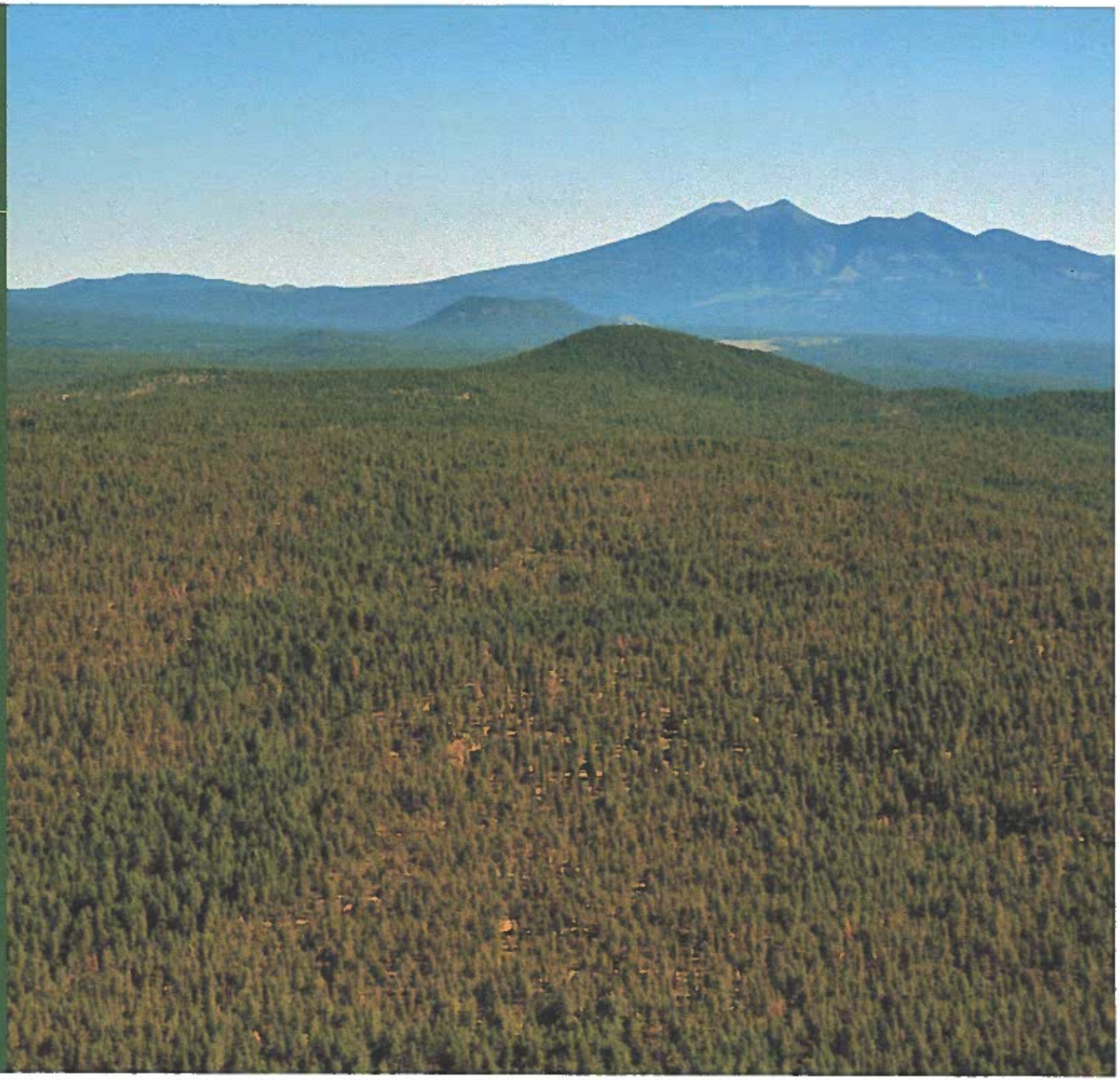
Pie Chart | Map

Forest Health Summary for the Southwestern Region

all tree species across the Southwest, especially in ponderosa pine. At the landscape level, drought stress occurred most heavily across the Mogollon Rim in northern Arizona and throughout central and northern New Mexico. Drought-stressed ponderosa pine located on ridges and upper slopes displayed a slight yellow color, while ponderosa located in drainages, which receive more moisture, remained green as seen in the image on the right. Abiotic stressors, such as drought, can increase the susceptibility of trees to insects and diseases that do not normally affect healthy, vigorous trees.

Climate projections predict increases in drought frequency and intensity in the Southwest as a consequence of climate



Arizona Drought Monitor Report

July 2009

Watershed Drought Level
- Normal
- Abnormally Dry
- Drought - Moderate
- Drought - Severe
- Drought - Extreme

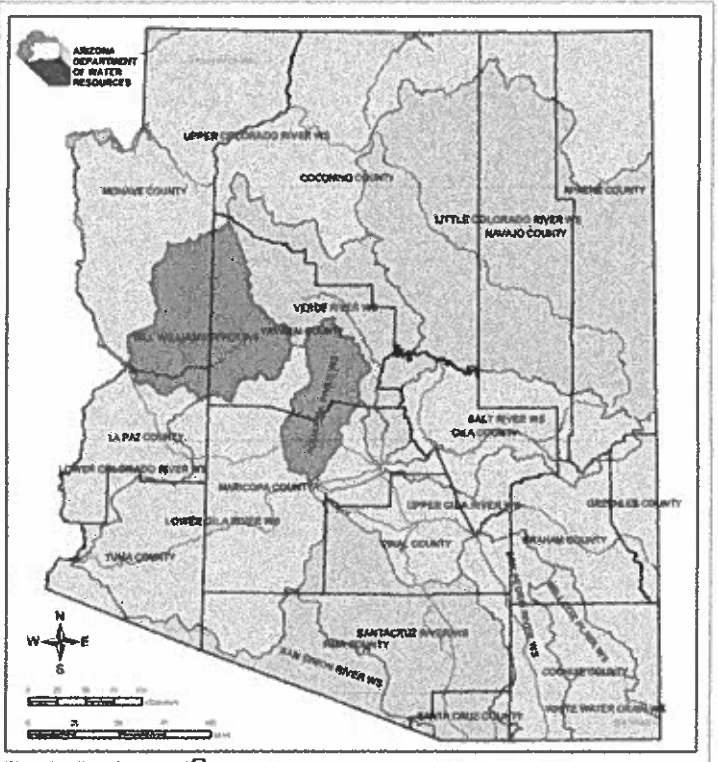
Counties
Lakes
Rivers
CAP Aqueduct
Merged Watershed*

July 2009 Short Term Drought Status

Data Through June 30th, 2009

Arizona Drought Preparedness Plan Monitoring Technical Committee

* Watershed merged due to limited data



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Short-term drought

Monsoonal precipitation during June was well above average in the eastern half of the state, and near average or slightly wetter than average in most other parts of the state. This led to a one category improvement from moderate to abnormally dry drought conditions in the Bill Williams and San Pedro watersheds. Temperatures in June were also cooler than average, reducing water demand. As we move into the heart of the monsoon, further improvement in short-term drought is anticipated.

July 2008 short-term drought conditions.

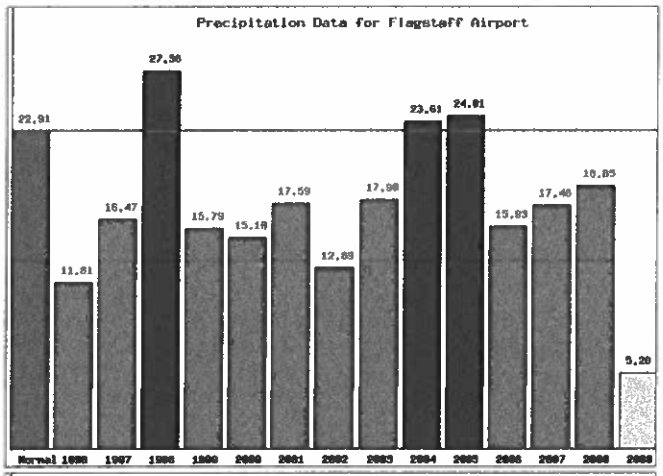
Long-term drought

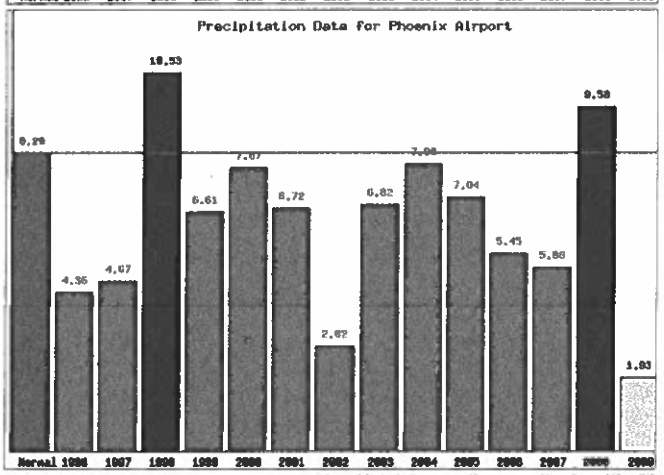
Drier than average conditions this past winter, and throughout the past year, have led to worsening long-term drought conditions in four watersheds. Bill Williams and Agua Fria had been in moderate drought through March, but they both dropped to severe drought as the previous 36 and 48-month precipitation has been extremely dry, below the 25th percentile. In the southeast, the San Pedro and Whitewater Draw saw improvement in the past year from moderate drought to abnormally dry, and the San Simon watershed along the southern border improved from severe to moderate drought, mostly due to the summer monsoon rainfall over the last 24-months. Since the April update, the Santa Cruz and Verde watersheds, which respond more to winter precipitation, have dropped from abnormally dry to moderate drought, due to the dry conditions in the late winter and early spring.

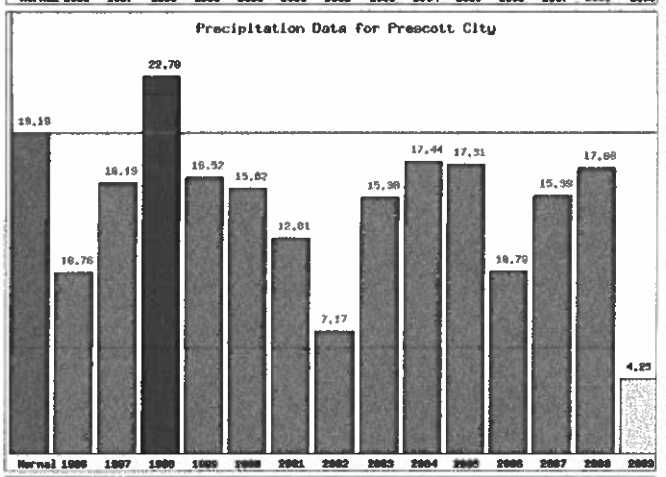
July 2008 long-term drought conditions.

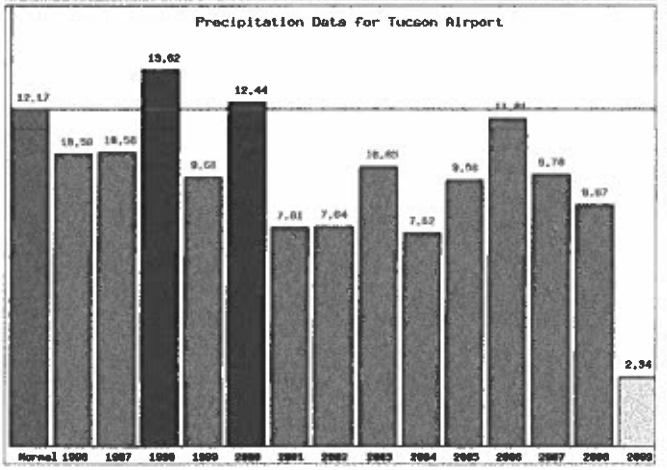
Watersheds in Arizona have experienced significantly drier than average conditions over the last six months to four years. The cumulative effect of the dry periods requires consecutive wetter than average years to recover from the drought. Groundwater aquifers are very slow to recharge, compared to surface reservoirs, so the full reservoirs within the state of Arizona are not good indicators that the drought is easing. Water conservation is important even when we are not experiencing drought conditions. Practicing a low water-use lifestyle is a way each citizen can help ensure a long-term, sufficient water supply.

These maps refer to an integrated assessment of moisture status that includes consideration of precipitation, streamflow, vegetation, ecosystem health, rangeland status, and other measures of drought. They are not intended to portray the status of the state's water supplies. For an explanation of how these maps are produced, visit:
www.azwater.gov/azdwr/statewideplanning/drought/droughtstatus.htm









Annual precipitation totals compared to normal (green bar and line) from weather stations in Bullhead City, Jerome, Phoenix and Tucson. 2009 data from January to June. Resource - http://www.wrh.noaa.gov/psr/DroughtPage.php?wfo=psr&data=ALLDATA

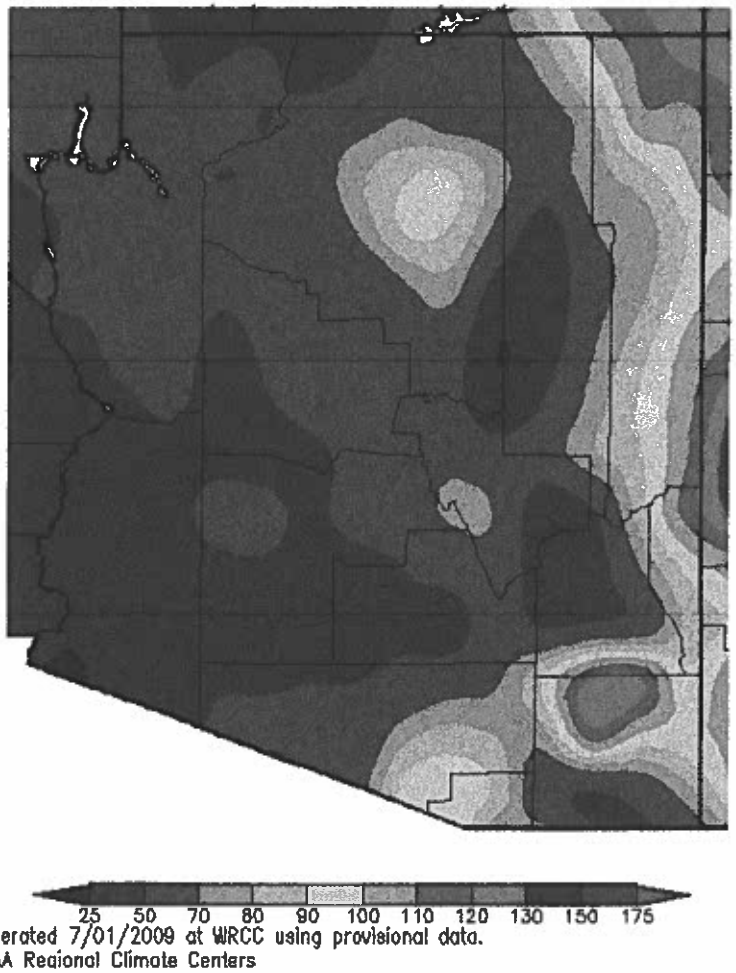
Precipitation

The graphs of annual precipitation to the left show the wet and dry years over the past 14 years. Tucson and Phoenix have only had two of the past 14 years above average for annual precipitation, and this year they have only received 25% of average. Prescott is also at 25% of the annual average, and has only had one wet year in the past 14. This year, Flagstaff has received 23% of average, and three wet years in the past 14. Unless the second half of the monsoon is exceptionally wet, we are unlikely to make up this deficit.

Precipitation across most of Arizona is still below 70% of average from January through June. The southwest deserts have received less than 50% of average. Some higher elevation areas along the New Mexico border and in the southeast have received 120% of average or more. Since monsoon precipitation stalled in mid-July, rangeland conditions are rapidly degrading as we await the next moisture surge.

For more climate information, visit the Arizona State Climate Office at http://azclimate.asu.edu/.

Percent of Average Precipitation
January - June 2009



Mountain Precipitation

Based on data from mountain monitoring sites, precipitation during June was widely variable across the basins, ranging from a low of 26% of average in the Verde River Basin to a high of 176% of average in the San Francisco-Upper Gila River Basin. Cumulative precipitation for the 2009 water year (October through June) remains average for the Salt River, Verde River, and Little Colorado River Basins, and below average for the San Francisco-Upper Gila River Basin (see graphic).

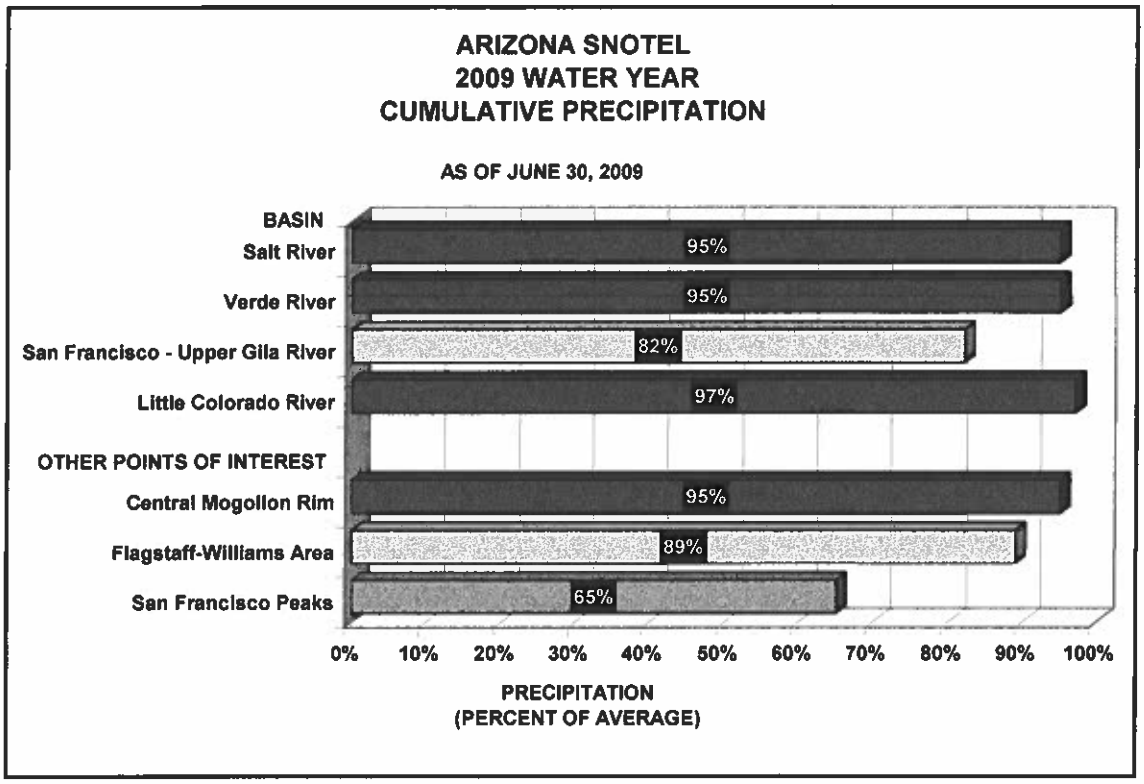
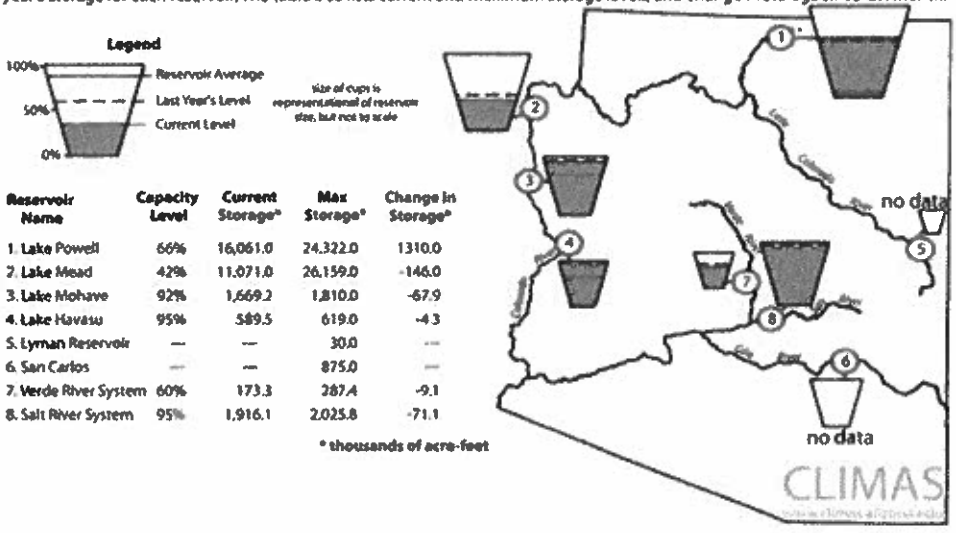


Figure 6. Arizona reservoir levels for June 2009 as a percent of capacity. The map depicts the average level and last year's storage for each reservoir. The table also lists current and maximum storage levels, and change in storage since last month.



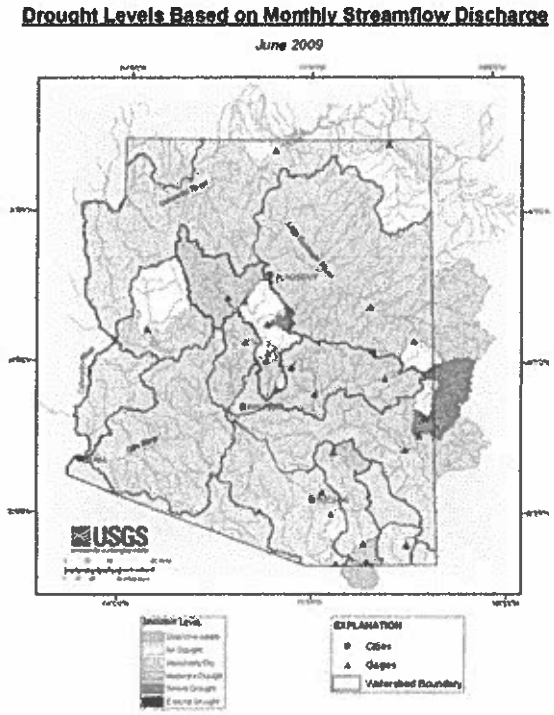
Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Lake Powell	66%	16,061.0	24,322.0	1310.0
2. Lake Mead	42%	11,071.0	26,159.0	-146.0
3. Lake Mohave	92%	1,669.2	1,810.0	-67.9
4. Lake Havasu	95%	589.5	619.0	-4.3
5. Lyman Reservoir	---	---	30.0	---
6. San Carlos	---	---	875.0	---
7. Verde River System	60%	173.3	287.4	-9.1
8. Salt River System	95%	1,916.1	2,025.8	-71.1

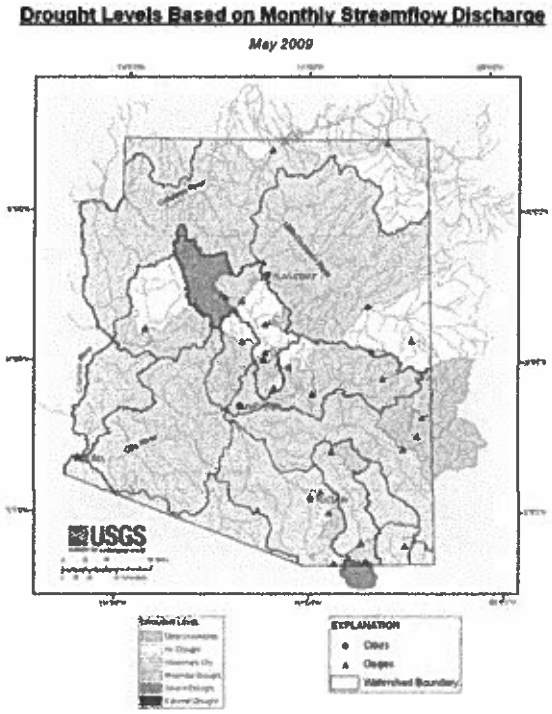
* thousands of acre-feet

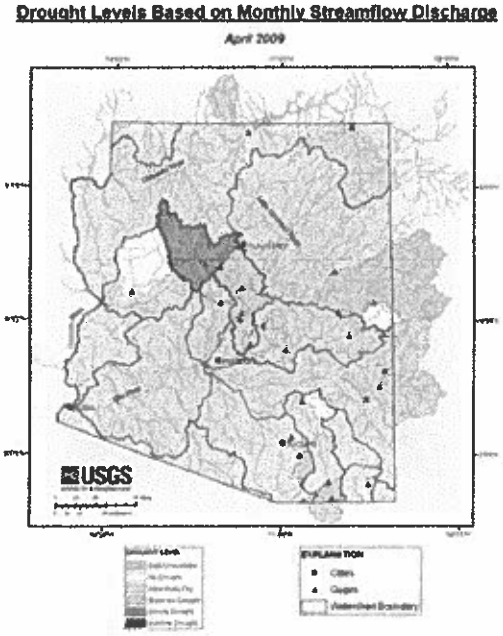
Reservoir Status

Water levels in Lake Powell increased by 1.3 million acre-feet during June. However, water storage in all the other large reservoirs dropped slightly this past month, and no water level data have been reported for the San Carlos and Lyman reservoirs (Figure 6). Even with the rise in water level, Lake Powell is at 66 percent of full capacity, well below the long-term average of 81 percent. Lake Mead is at 42 percent of capacity, which reflects the effects of long-term drought conditions across the Upper Colorado River Basin.

In water-related news, the Arizona Game and Fish Department received a $74,145 Water Quality Improvement grant to improve riparian habitat along the Little Colorado River in Apache County (wmicentral.com, July 17). The grant will help protect important wildlife habitat and two federally threatened and endangered species: the southwestern willow flycatcher, a small passerine bird, and the Little Colorado spinedace, a threatened native fish.







Water body	June Runoff in Acre Feet	% of Median
Salt River near Roosevelt	11,187	64%
Tonto Creek above Gun Creek near Roosevelt	265	31%
Verde River at Horseshoe Dam	6,843	85%
Combined Inflow to Salt River Project (SRP) reservoir system	18,295	66%
Little Colorado River above Lyman Lake	952	344%
Gila River to San Carlos Reservoir	411	22%

Streamflow Observed at USGS Streamflow-Gaging Stations

Streamflow

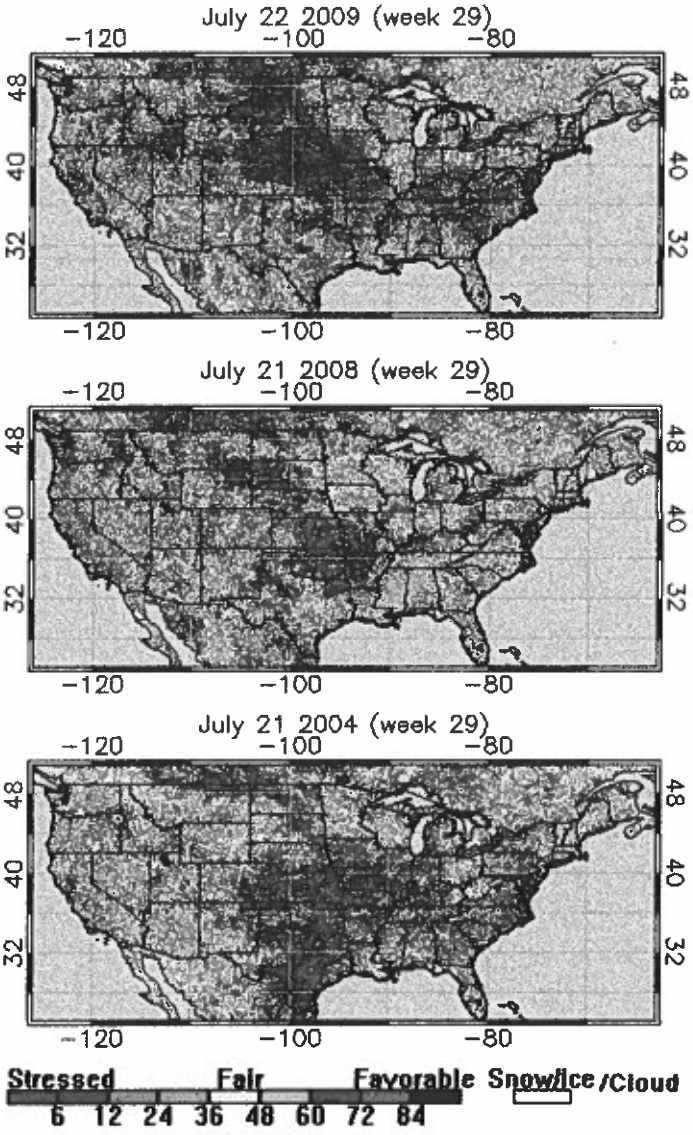
From April through June 2009 streamflow within Arizona indicated low to moderate drought conditions. From April to May six basins changed to No Drought status. From May to June conditions remained stable for the most part. At the end of May there was a fair amount of precipitation but it unfortunately did not result in significant increases to streamflow. Each month during this quarter there were only two instances of severe drought and no instances of extreme drought.

Basins contributing streamflow to the Salt River Project reservoir system show that things have been relatively stable during this quarter. Although they appear stable they are far below normal. During May the Little Colorado River above Lyman Lake increased to near normal conditions and then in June significantly exceeded normal monthly streamflow. This is due to discharge from upstream reservoirs. The Gila River that contributes streamflow to the San Carlos reservoir has remained far below normal and has averaged 18% of

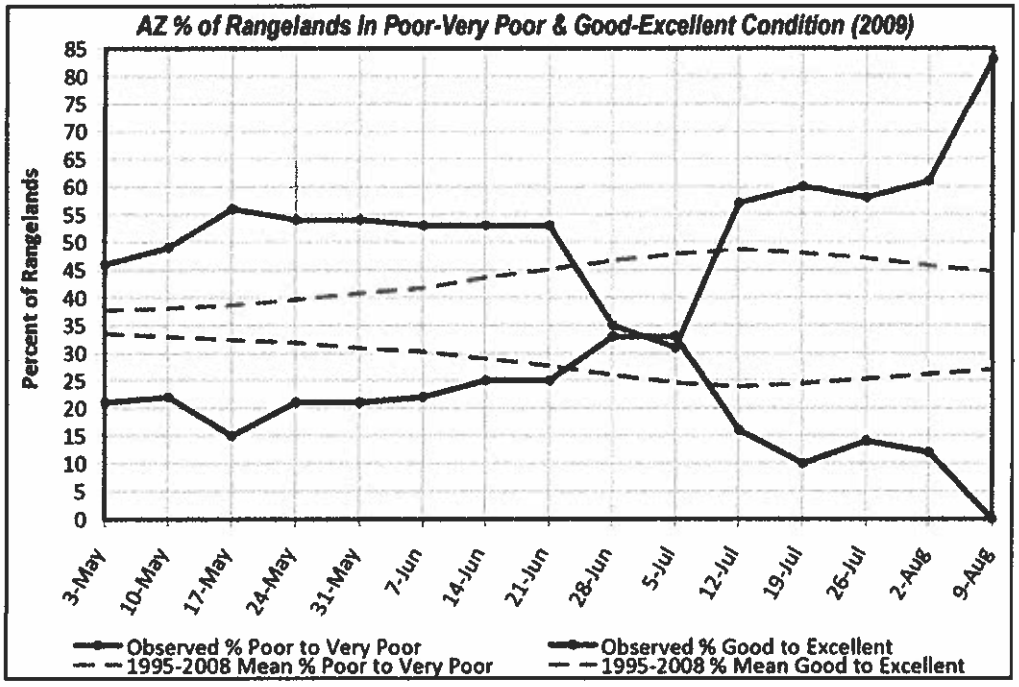
Vegetation Health

Across much of Arizona vegetation health index (VHI) values are in the stressed-to-fair range (top). Fair-to-favorable vegetation stress levels are mostly found along the Mogollon Rim, Colorado River, and the Four Corners region. The VHI values reflect below average water year precipitation across most of the state, and a spotty North American Monsoon, thus far. Note the favorable VHI values for the northwest Mexico highlands, and across the central plains of the U.S. Compared to one year ago, VHI values are considerably lower (middle), except in the rainshadow to the northeast of the Mogollon Rim. Though there are no exact analogues in the past, this month's VHI map for Arizona looks a little like 2004 (bottom). Thus far, acres burned in Arizona wildland fires are well below the historical average. For more information on fire, from the Southwest Coordination Center, see http://gacc.nifc.gov/swcc/index.htm.

NOAA Center for Satellite Applications and Research



Rangeland Health



The graph to the left shows a time series of rangeland conditions by week for this year in Arizona compared to the 1996-2008 mean.

There is rapid deterioration of rangelands underway in the state. Notice the striking change from August 2nd to the 9th. Even in the desert, flash drought conditions can occur.

Arizona Drought Monitor Report - Produced by the Arizona State Drought Monitoring Technical Committee

Chair:
Nancy Selover, State Climatologist
Arizona State University

Mike Crimmins, Extension Specialist, University of Arizona Cooperative Extension

Gregg Garfin, University of Arizona – Institute for the Study of Planet Earth

Dino DeSimone, Natural Resources Conservation Service

Charlie Ester, Salt River Project

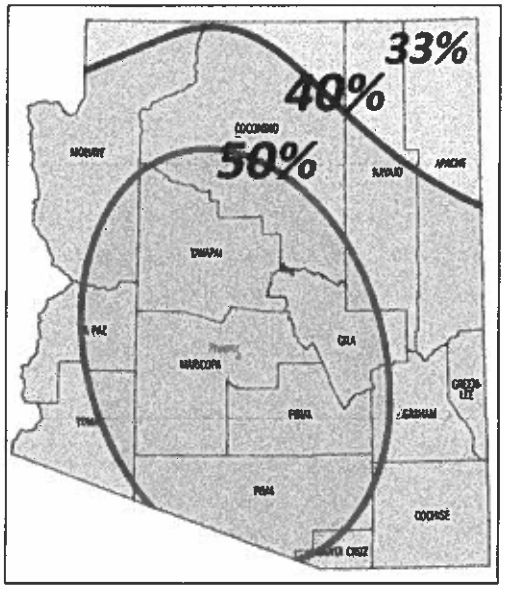
Ron Ridgway, Arizona Division of Emergency Management

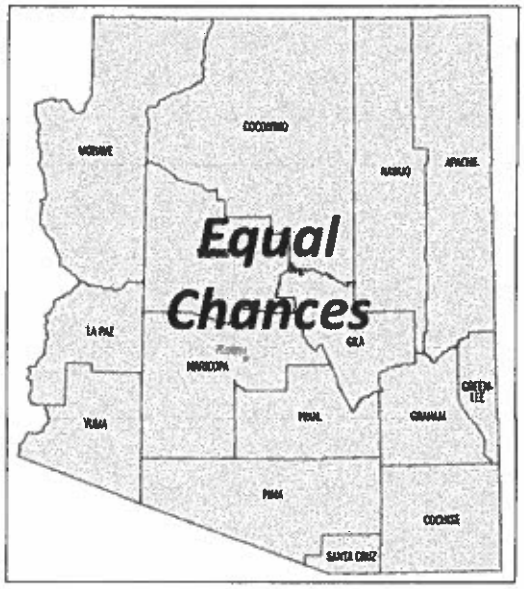
Chris Smith, U.S. Geological Survey

Coordinator: Susan Craig, Arizona Department of Water Resources
Computer Support: Andy Fisher, Arizona
Department of Water Resources

For more information visit http://www.azwater.gov/azdwr/statewideplanning/drought/droughtstatus.htm

Three-month Temperature and Precipitation Outlook



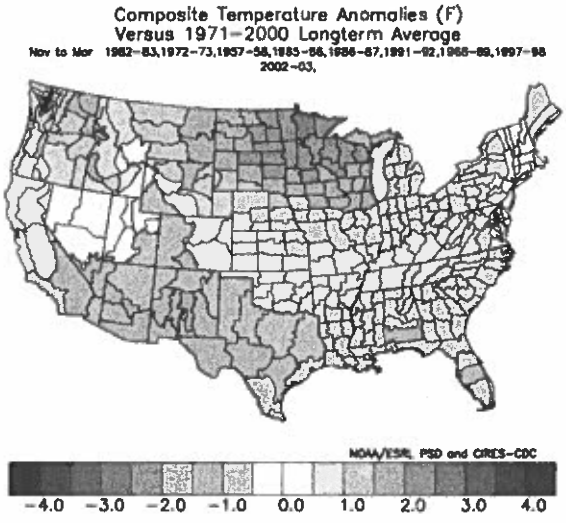


The CPC Temperature Outlook for August through October indicates an increased probability for the mean temperature during the 90-day period to be above normal (35-55%). The CPC Precipitation Outlook for the same time period indicates equal chances for above, near, or below normal precipitation across Arizona.

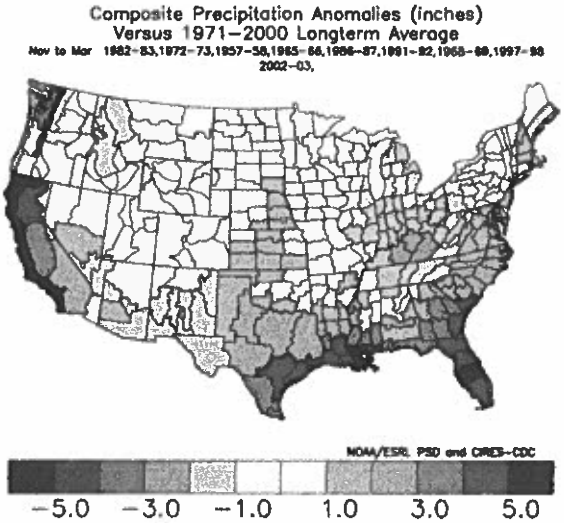
Drought Outlook - The NOAA CPC Drought Outlook, released August 6, 2009, forecasts that **drought development** is likely in the eastern half of the state.

El Niño Advisory in Effect...

El Niño conditions will continue to develop and are expected to last through the Northern Hemisphere Winter 2009-2010. During June 2009, conditions across the equatorial Pacific Ocean transitioned from ENSO-neutral to El Niño conditions. Current conditions and recent trends favor the continued development of a moderate-to-strong strength El Niño into Fall 2009, with further strengthening possible thereafter.



During previous El Niño events, temperatures across the southern U.S., including Arizona, have tended to be cooler than normal during the winter.

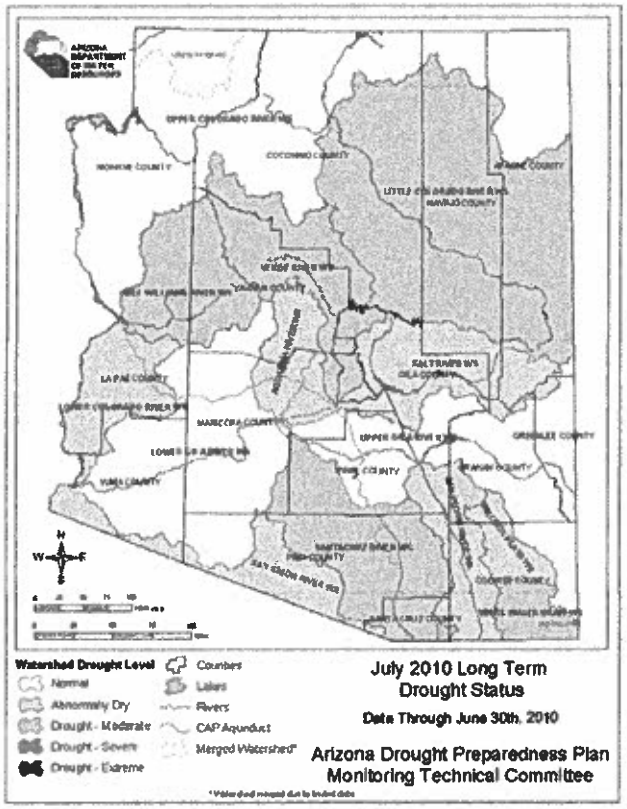


During previous El Niño events, precipitation amounts across the southern U.S., including most of Arizona, have tended to be higher than normal during the winter.

Drought Status Update
July 2010

Short-term Drought Status Update

After a very wet winter that improved short-term drought conditions for all areas of the state except the Colorado Plateau, the dry spring and dry early monsoon caused deterioration in rangeland on the Colorado Plateau, Mohave County and along the lower Colorado River. The dryness has persisted, leading to an expansion of abnormally dry and moderate drought conditions in the western counties. The Mogollon Rim and eastern Arizona continued to have a very wet monsoon through July, with above average rainfall eventually moving through central Arizona. Some recent rainfall in Apache and Navajo counties has improved short-term conditions there as well. Short-term seasonal forecasts continue to indicate equal chances of above, below, or normal precipitation for the remainder of the monsoon and the early fall.



Summaries produced by the State Drought Monitoring Technical Committee - Aug. 10, 2010

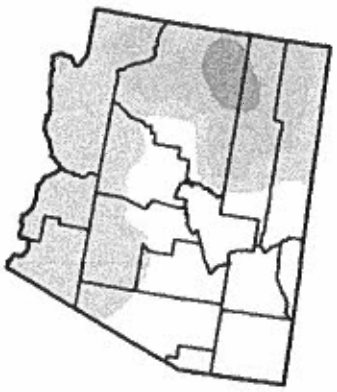
U.S. Drought Monitor
Arizona

August 3, 2010
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	40.0	60.0	21.9	3.6	0.0	0.0
Last Week (07/27/2010 map)	28.8	71.2	28.6	5.1	0.0	0.0
3 Months Ago (05/11/2010 map)	43.1	56.9	14.4	2.7	0.0	0.0
Start of Calendar Year (01/05/2010 map)	0.0	100.0	97.2	71.1	5.1	0.0
Start of Water Year (10/06/2009 map)	1.4	98.6	80.3	10.7	0.0	0.0
One Year Ago (08/04/2009 map)	10.5	89.5	0.0	0.0	0.0	0.0

Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, August 5, 2010
Author: D. Miskus, CPC/NOAA

Long-term Drought Status Update

The long-term (hydrologic) drought depends on accumulated precipitation over multiple years. The spring of 2006, which was very dry, has been replaced in the drought analyses by the spring of 2010, which, although dry, was comparatively wetter. Similarly, the spring of 2007 has dropped out of the 3 year interval. In terms of cumulative precipitation over the past 2, 3, and 4 years, long-term drought has improved significantly. Four watersheds show a two category improvement, and five others show a one category improvement. The streamflow in many parts of the state is still relatively high, indicating more recharge of groundwater basins, reducing the water deficit we have accumulated over the past decade or more. Reservoir systems within the state, particularly the Salt-Verde watershed, are near 100% of capacity well into the high demand summer season. Unfortunately, the lower Colorado Basin reservoir system (Lakes Powell and Mead), a major water supply for much of the state, remains near 50% of capacity. This means that areas of the state that depend on groundwater and Colorado River water through the Central Arizona Project system are still very much in a long-term drought condition. Seasonal forecasts call for a warmer and drier fall and winter, based on the development of La Niña. Although the monsoon activity began late in many areas of the state, heavy rainfall events have pushed both the calendar and water year precipitation to average or above average levels. Three years ago the La Niña winter was exceptionally wet, while two years ago the La Niña winter was very dry. Whether this winter turns out to be a dry or wet La Niña will determine whether we continue the improvement in long-term drought conditions or not.

Drought Status Update
July 2011

Short-term Drought Status Update

July has brought some minor relief to eastern Gila, Pinal and Pima counties, and most of Yavapai and northern Mohave counties. The dry conditions in early spring have recovered slightly with a few early monsoon storms.

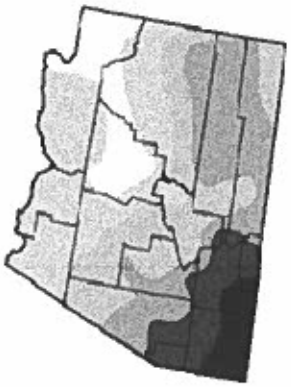
Cochise, Greenlee, Graham and Santa Cruz counties continue to be in extreme or exceptional drought in the short term. Range conditions are extremely poor and stock tanks are dry. Water is being hauled to fill stock ponds and tanks, and feed must be brought in to supplement poor forage conditions.

The outlook for winter forage depends on the amount and timing of the monsoon precipitation. Too little too late will not improve the rangeland.

U.S. Drought Monitor

August 2, 2011

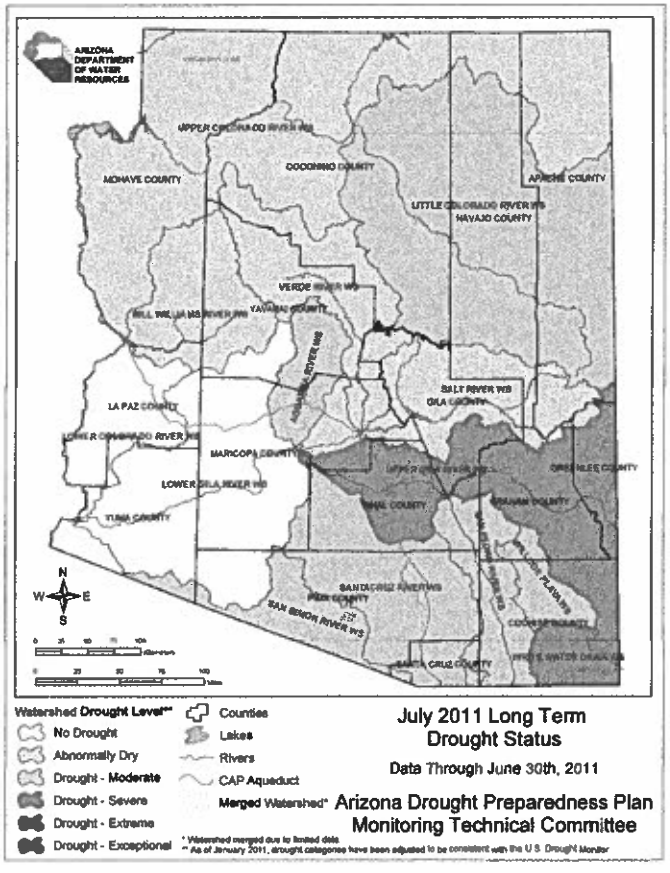
Arizona



The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, August 4, 2011
Brad Rippey, U.S. Department of Agriculture



Long-term Drought Status Update

In the past year, the southeastern watersheds have become even drier as a weak monsoon in 2010 and a very dry winter in 2011 worsened already dry conditions.

San Simon, San Pedro and Willcox Playa dropped one category from abnormally dry to moderate drought. White Water Draw dropped one category from moderate to severe drought, and the Upper Gila dropped two categories from abnormally dry to severe drought.

Monitoring wells in the southeast have shown a steady decline over the past year. Reductions in groundwater pumping have failed to reverse the declining groundwater levels due to drought. If the current monsoon does not improve, the long-term conditions in the southeast are likely to deteriorate even further.

The western watersheds have had a mixed signal with the southwest and west central watersheds improving slightly while the northwest and northern watersheds became drier. This is a reflection of the winter storm tracks that crossed into western Arizona and tracked to the north or northeast, essentially missing the eastern watersheds.

Summaries produced by the State Drought Monitoring Technical Committee

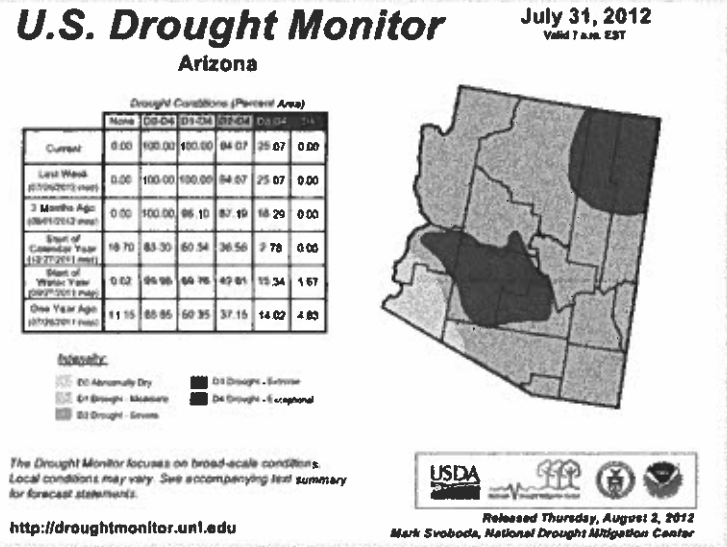
August 11, 2011

Drought Status Update

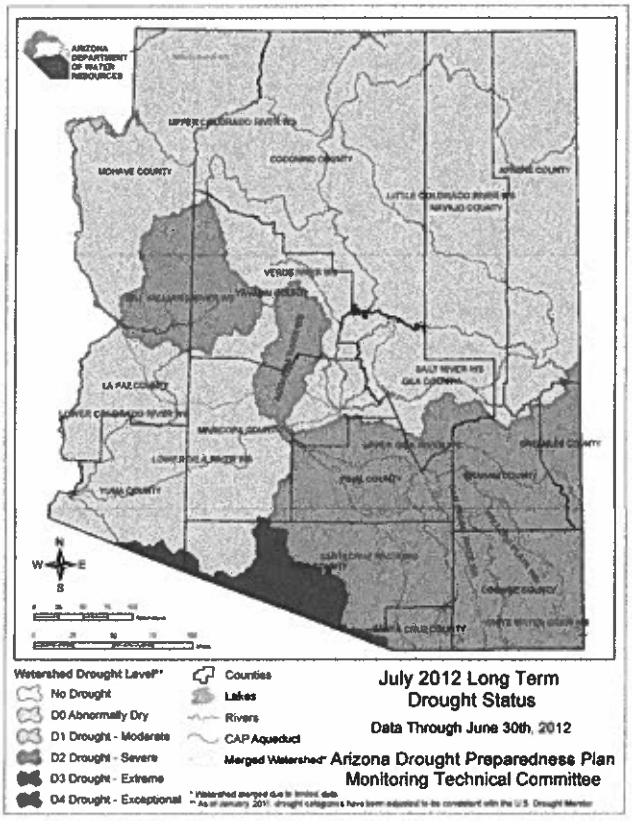
Short-term Drought Status Update

July finally brought some monsoon rainfall to the state, but so far the monsoon has been drier than normal. Storms have been quite localized, with some areas receiving significant rainfall and nearby locations receiving none.

We have not changed the short-term map because the overall conditions are still very dry in most areas. Recent rainfall has not yet been enough to make up the deficits on the rangeland or fill the stockponds.



Long-term Drought Status Update



Northern and eastern Arizona have been much drier than normal with the Upper Colorado, Little Colorado, Salt and Upper Gila River watersheds all downgraded one drought category since April.

Spring of 2012 was drier than spring of 2010 (a relatively wet year) and spring of 2009, so the cumulative dryness has increased. Following the very dry winter, wild fire conditions were very bad. Fortunately, Arizona had very few large fires, unlike last year or like New Mexico had this year.

The current shift toward El Niño is strengthening, so we are cautiously optimistic for a wetter than normal winter.

Summaries produced by the State Drought Monitoring Technical Committee - August 1, 2012

Eye On Drought — Drought Status Report

Short-term Drought Status: July 2013

Despite rainfall in July, drought impacts worsened in northern Arizona. Areas of severe (D2) and extreme (D3) drought have expanded, and exceptional drought (D4) was introduced into central Navajo and Apache counties. The extremely dry conditions on the Navajo Nation have resulted in loss of livestock as stock ponds and watering holes have dried up.

In central and southeastern Arizona, areas of drought have been reduced. Southeastern Arizona has seen numerous rainfall records broken, though rainfall totals have been quite localized.

Despite the increased drought in northern Arizona, flash flooding has been common around the state, with the most recent flooding through Supai village in Havasu Canyon.

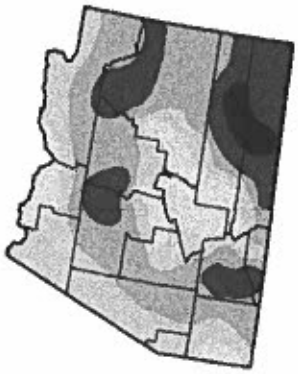
U.S. Drought Monitor

July 30, 2013
Valid 7 a.m. EST

Arizona

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	86.71	57.90	22.81	3.04
Last Week (07/23/2013 map)	0.00	100.00	91.13	63.58	22.81	3.04
3 Months Ago (04/30/2013 map)	0.00	100.00	86.66	68.26	16.22	0.00
Start of Calendar Year (01/01/2013 map)	0.00	100.00	97.91	37.78	8.68	0.00
Start of Water Year (09/25/2012 map)	0.00	100.00	100.00	31.83	5.57	0.00
One Year Ago (07/24/2012 map)	0.00	100.00	100.00	94.07	25.07	0.00



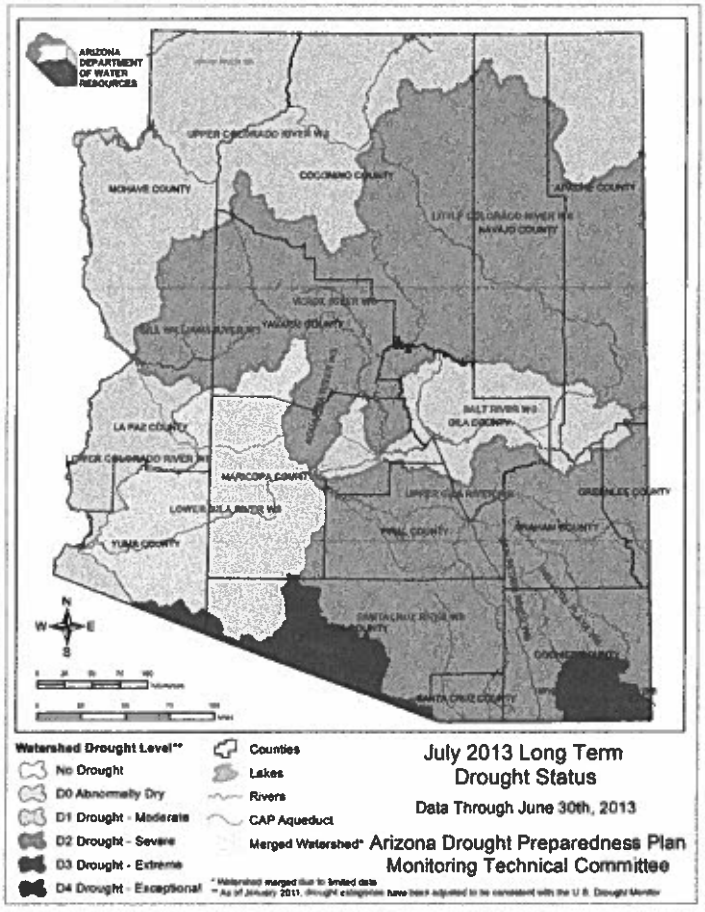
Intensity:
D0 Abnormally Dry
D1 Drought - Moderate
D2 Drought - Severe
D3 Drought - Extreme
D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu

USDA

Released Thursday, August 1, 2013
Brian Fuchs, National Drought Mitigation Center



Long-term Drought Status: April — June 2013

A very dry spring that followed a dry winter resulted in worsening of the long-term drought status, particularly in northern and western Arizona. The winter storms that typically pass through the northern half of the state were pushed further north into Utah and Colorado, leaving much of Arizona with warmer than normal temperatures and dry conditions. The dry winter and spring exacerbated the wildfire situation.

A wet monsoon (June 15—September 30) will help reduce the moisture deficit in many watersheds. Summer rainfall provides the majority of precipitation for southern Arizona and almost half the annual precipitation for central and northern Arizona. The first month of the monsoon has been wet in many locations, particularly along our eastern border.

Summaries produced by the State Drought Monitoring Technical Committee - August 9, 2013

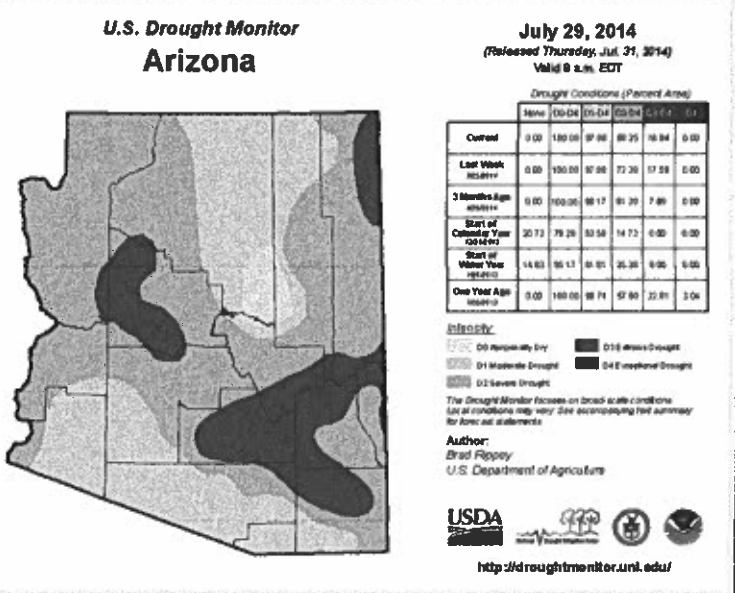
Drought Status Report

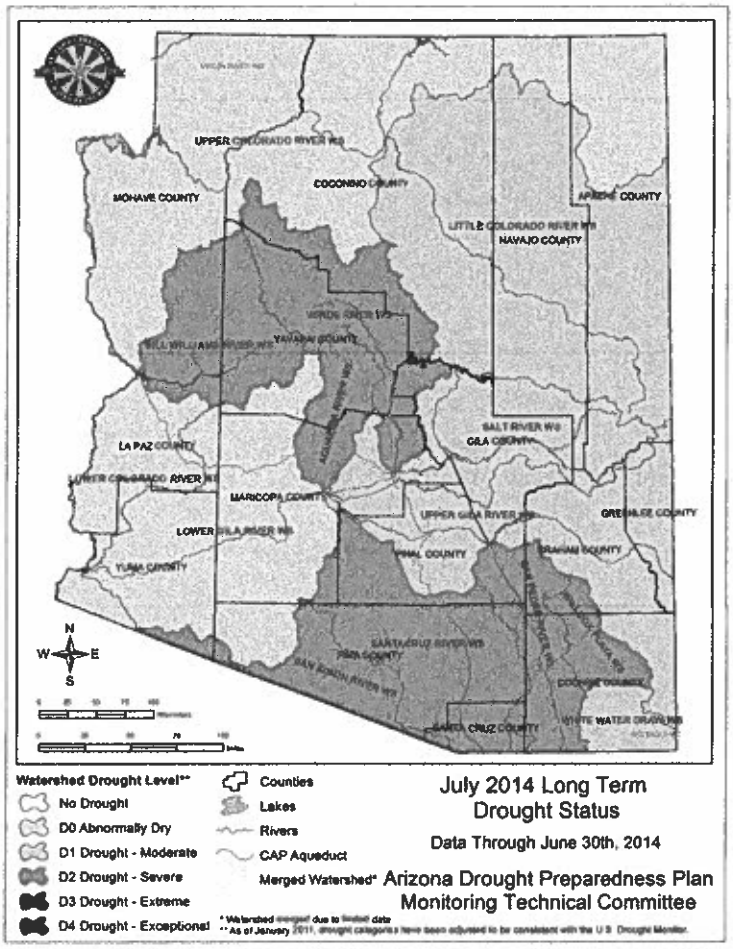
Short-term Drought Status — July 2014

Although many areas have received above average rainfall this monsoon, precipitation has been highly localized so far.

July precipitation brought some improvement to the southern and eastern parts of the state, where parts of Pima and Cochise counties, southern Apache County and northern Greenlee County improved from severe to moderate drought.

Further improvement is anticipated, as August is typically our wettest month in central and southern Arizona.





Long-term Drought Status April — June 2014

Spring was typically dry across the state, and all watersheds except the lower Colorado River saw no change in their long-term drought status. The lower Colorado River watershed dropped from no drought to abnormally dry (D-0).

Even though dry conditions are normal for spring, the deficits are mounting. BLM observations include dirt tanks going dry earlier than usual, a decrease in perennial grasses not related to grazing, and die back of creosote bush and ironweed trees in the southeastern part of the state. State parks report low lake levels at Lyman Lake, Fool Hollow, Patagonia Lake and Alamo Lake.

Further degradation is likely unless the monsoon precipitation meets or exceeds the long term average.

The next update in early November will reflect the monsoon conditions of July, August and September.

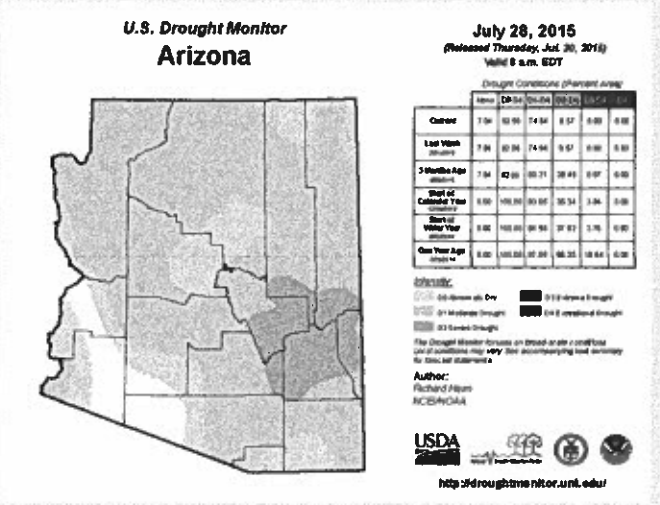
Summaries produced by the State Drought Monitoring Technical Committee - August 8, 2014

Eye On Drought — Drought Status Report

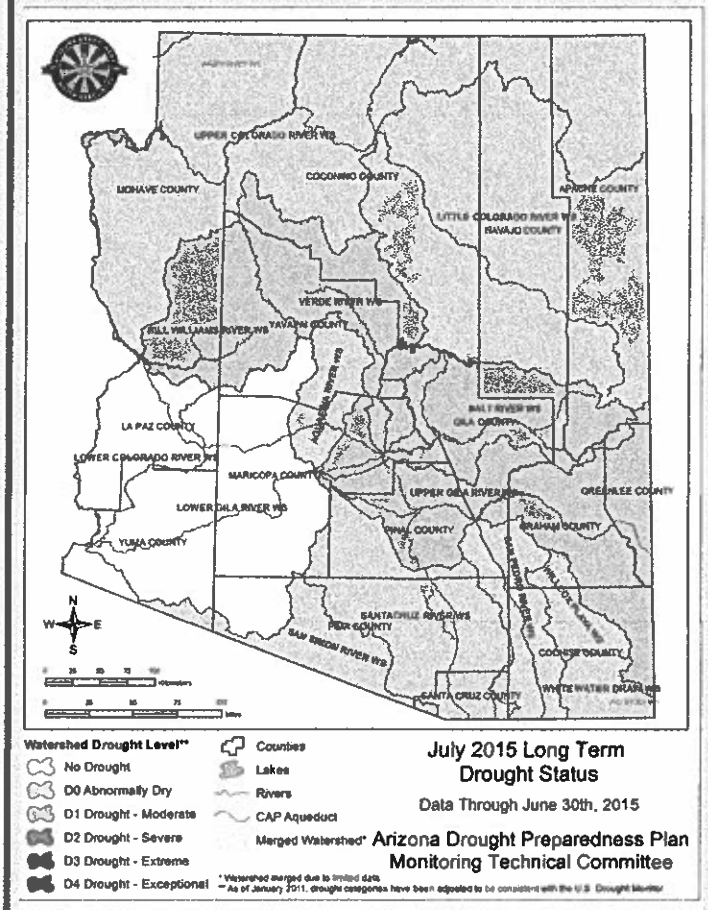
July 2015 Short-term Drought Status

July was near average for monsoon activity and precipitation, so there has not been much change in the short-term drought situation, and most of the state remains in moderate drought.

The heavy rainfall has been highly localized, but northeastern Arizona has received relatively consistent moderate rainfall from the convective activity this summer. As a result, severe drought has been downgraded to moderate drought in northern Coconino and Mohave counties and in central Apache County.



April—June 2015 Long-term Drought Status



There has been slow improvement across the eastern half of the state over the past 4 months, finally resulting in changes to the long term drought map. Seven watersheds in the eastern half of the state have improved from moderate drought to abnormally dry, while the Upper and Lower Colorado and Lower Gila have remained in either abnormally dry or no drought. The Salt and Upper Gila remain at moderate drought even though stream flow has been above average recently. The longer term water resource condition for these watersheds is still a significant long-term deficit.

Much of the improvement is due to spring precipitation, and even the Upper Colorado system in Colorado has several very late snowstorms, which will help alleviate the poor run-off into Lakes Powell and Mead from the dry winter.

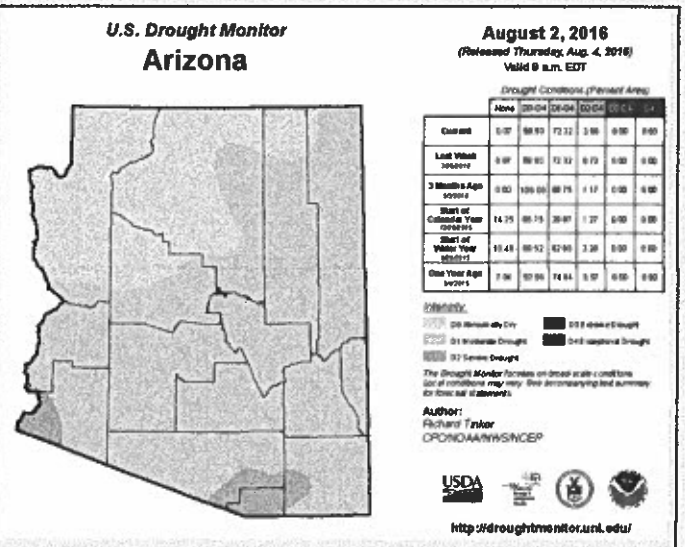
So far the monsoon has been a little wetter than normal in some parts of the state, but very localized. There are two more months of monsoon left, and the eastern Pacific Ocean is still quite warm, so there are good prospects for more moisture to be drawn into the monsoon circulation.

Summaries produced by the State Drought Monitoring Technical Committee , August 7, 2015.
The next update in early November will reflect the conditions of July, August and September.

Eye On Drought — Drought Status Report

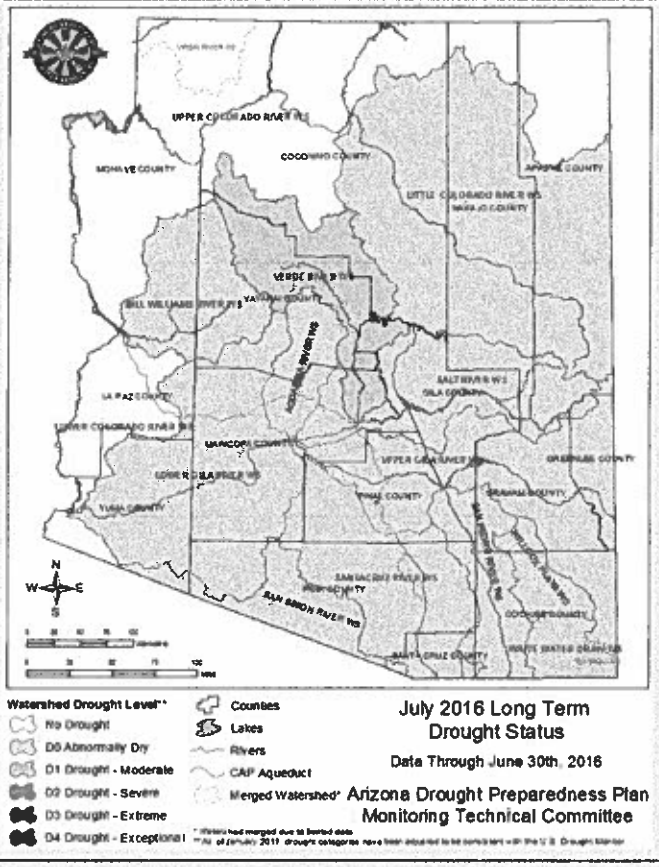
July 2016
Short-term Drought Status

Monsoon activity over northeastern Arizona has been quite spotty and has not made up the precipitation deficit from the disappointing El Niño winter. Therefore, moderate drought (D1) has expanded into northern Apache, northern and central Navajo and eastern Coconino counties.



In southeastern Arizona the monsoon has been quite active and locally heavy rainfall has been reported across parts of Cochise and Pima counties. This has led to an improvement from severe drought (D2) to moderate drought (D1) in Cochise County and northeastern Pima County, including Tucson.

While some areas of Santa Cruz County have received significant rainfall, the precipitation has been quite localized and many areas are still feeling the impacts from the dry winter, so there is no change to Santa Cruz County's drought status at this time.



April—June 2016
Long-term Drought Status

There are no changes to the long-term drought status in Arizona. Winter was drier than normal in much of the state, particularly in southern Arizona, causing several watersheds to move into the abnormally dry category.

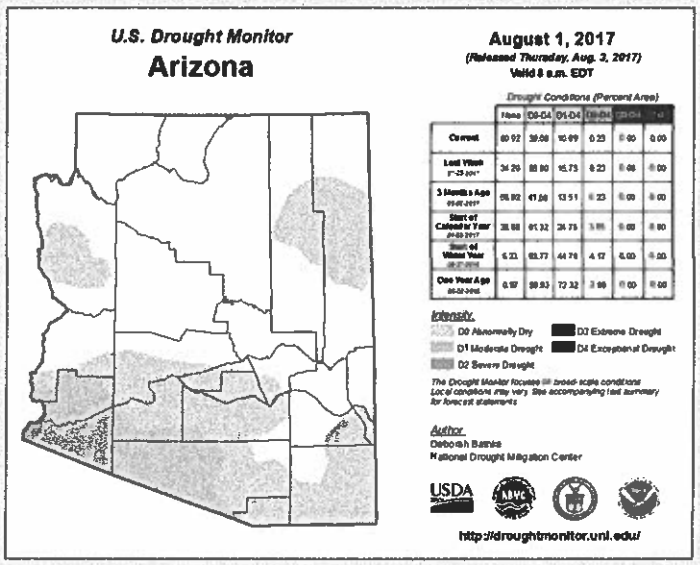
Spring produced local pockets of wetter than normal conditions, however snow pack over higher terrain ended the season on a poor note. Long term drought status focuses on state water resources and precipitation during the first half of the calendar year proved insufficient to allow for long term drought improvement.

The monsoon has been quite localized so far, having little impact on reservoirs or aquifers, and its effects on the long-term drought will be evaluated after September.

Summaries produced by the State Drought Monitoring Technical Committee, August 4, 2016

Eye On Drought — Drought Status Report

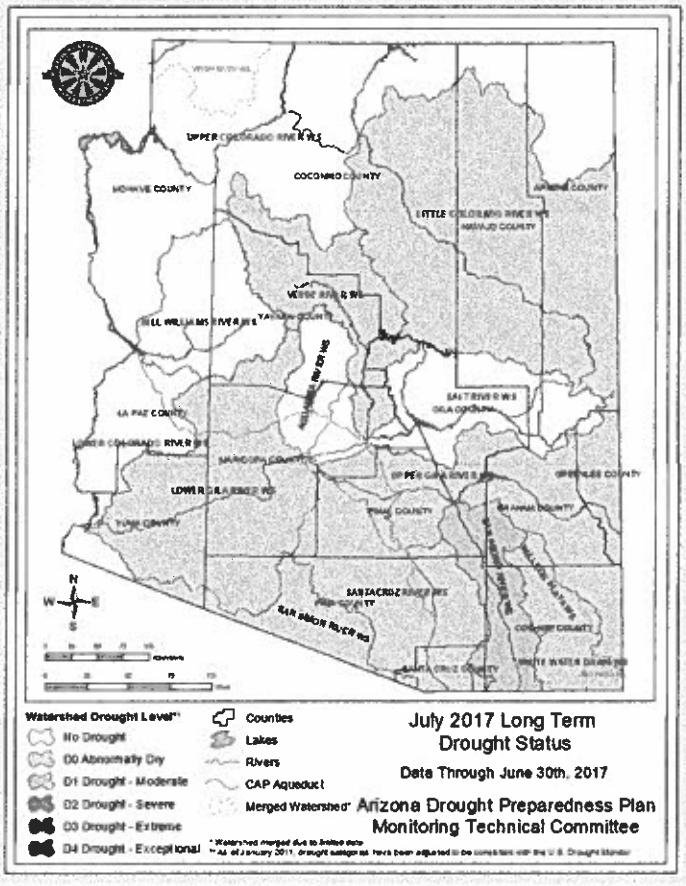
July 2017
Short-term Drought Status



The monsoon began slowly but has gathered momentum and brought wide-spread rain showers to eastern and northern Arizona. While the rainfall was localized, since July 7th there has been precipitation somewhere in the state everyday.

Rainfall in the eastern and southeastern counties has brought above normal calendar-year precipitation to many parts of these areas.

This summer's storms have swept in from the southeast, but have been far less numerous in the southwest corner of the state, leaving Yuma and western Pima counties in Moderate Drought (D1).



April—June 2017
Long-term Drought Status

The long-term map shows that drought conditions deteriorated on the little Colorado River watershed from no drought to abnormally dry (D0) and on the San Pedro watershed from abnormally dry to moderate drought (D1). This is largely due to the continuous dry conditions in these areas since last year's monsoon.

It's likely that the San Pedro and some of the other neighboring watersheds may improve after this monsoon season as this is usually the wet time of year for the southern watersheds.

Summaries produced by the State Drought Monitoring Technical Committee, Aug 4, 2017

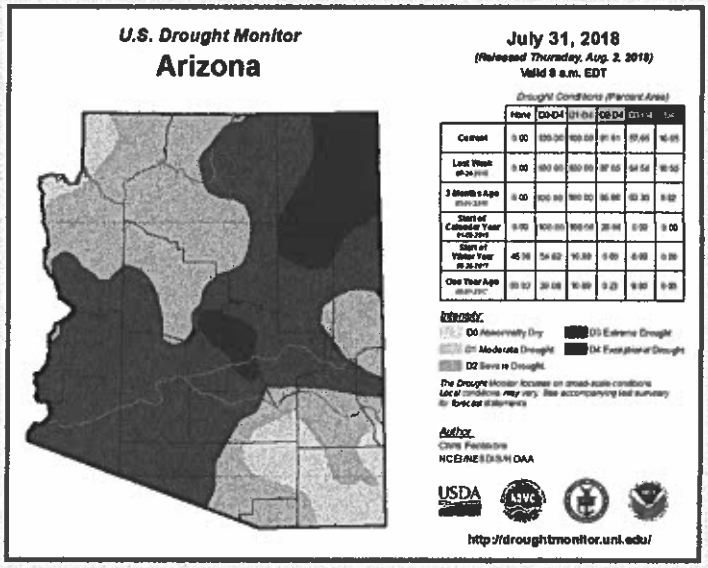
Eye On Drought — Drought Status Report

July 2018 Short-Term Drought Status

The monsoon activity began later than usual this summer and rainfall has been localized across much of the state with some locations receiving twice their normal amount and others remaining dry.

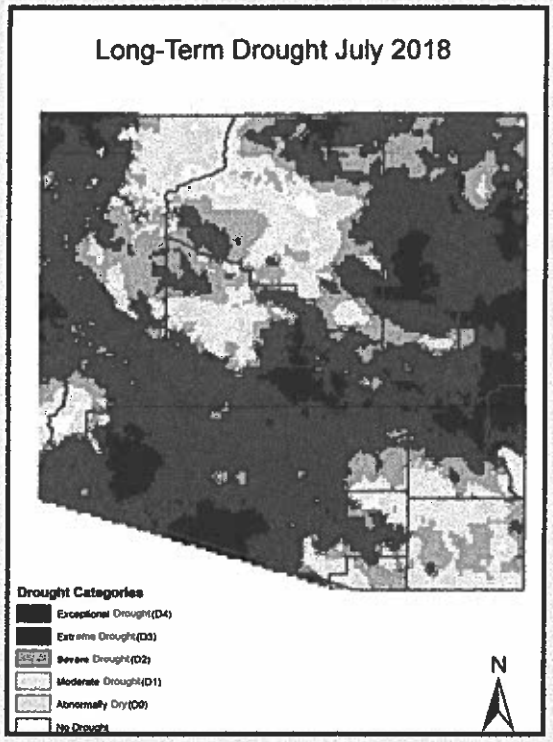
Rainfall has been plentiful along the Mogollon Rim, through western Coconino and northern Yavapai counties across to southern Navajo and northern Gila counties. This moisture has led to a removal of Exceptional Drought (D4) across the Rim, and reduction of Extreme Drought (D3) in western Coconino, northern Yavapai, eastern Pima and Pinal, and southern Apache counties.

The rain improved rangeland conditions in some areas and the humidity has slowed the spread of wildfires, though potential for significant flash flooding over the burn scars exists.



Substantial moisture deficits remain after the exceptionally dry winter and further improvements in drought conditions will require a robust monsoon season.

July 2018 Long-Term Drought Status



In the area of the Grand Canyon in northern Mohave, northwestern Coconino and southwestern La Paz counties, the depiction of No Drought and Abnormally Dry is incorrect due to the lack of stations, moving of stations, and the terrain. Most of the area has been quite dry during the long-term.

The lack of moisture this winter season has had significant long-term drought impacts on the state water resources with wells and springs drying up and almost non-existent reservoir inflows.

Groundwater pumping has increased statewide to accommodate water needs for agriculture as well as consumption by people, livestock and wildlife. in addition, water hauling has been common across the state. Dry conditions continued from April through June leading to expansion of Moderate Drought (D2), Severe Drought (D3) and Extreme Drought (D4) across northern and southeastern Arizona.

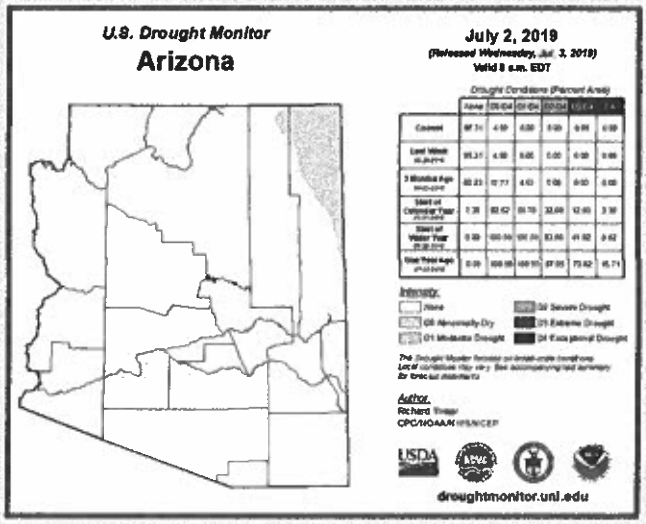
As of August 1st, the Salt-Verde reservoir system is 49% full, Lake Powell is 52% full, and Lake Mead is 37% full. There is a 52% chance for a declaration of a Colorado River shortage in 2020.

There are indications the remainder of the monsoon season will continue to provide good rainfall for the state. However much like the first half of the season, beneficial rainfall during the monsoon is more localized. A weak to moderate El Nino is likely during the upcoming autumn and winter, though its effects on precipitation on the state only justify a very slight tilt in odds towards wetter weather.

Summaries produced by the State Drought Monitoring Technical Committee, August 3, 2018

Drought Status Report

June 2019 Short-Term Drought Status

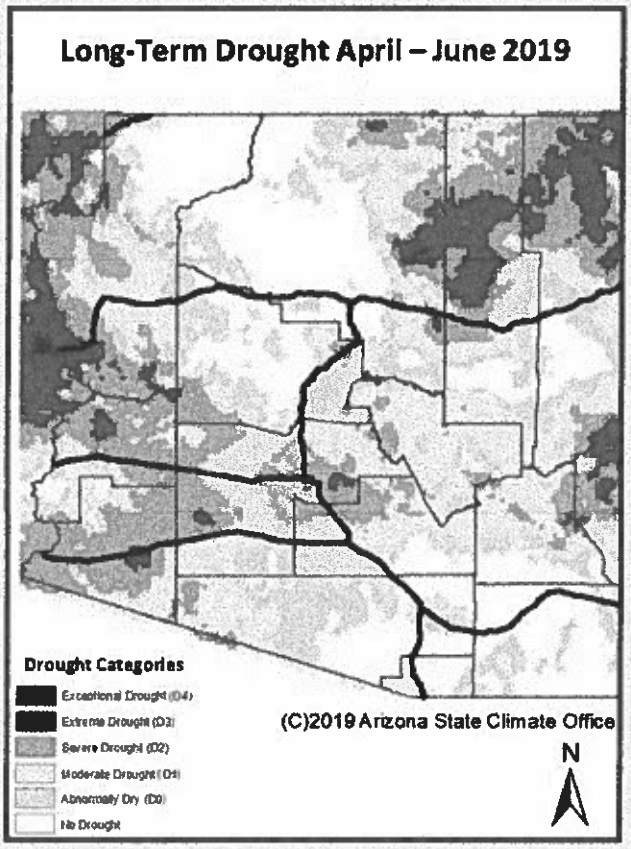


May and June are typically the driest months in Arizona, but this year precipitation was reported for both months at many places around the State, continuing the wet winter pattern that Arizona has enjoyed during the past nine months.

Rain (and snow at the highest elevations) at the end of May and scattered rain showers in northern and eastern Arizona in June led to the removal of Moderate Drought (D1) from northeastern Arizona and pulling back Abnormally Dry (D0) conditions from Coconino, Navajo, and Yuma counties.

Currently only 4.69% of the State is Abnormally Dry, while the rest of the State is free of drought in the short-term. This means that rainfall was sufficient to fill stock ponds and grow grass and forage on the rangelands, and many streams are flowing with greater volume than normal for late spring.

However, Arizona's water resources are still impacted by long-term drought after many years of below average precipitation resulting in the depletion of Arizona's reservoirs and aquifers.



April — June 2019 Long-Term Drought Status

Precipitation in May and June led to further reduction of long-term drought conditions across the State.

Groundwater levels have risen in some fast response basins, particularly in central and southern Cochise County, while other basins are slower to recharge and continue to be low.

The Salt and Verde reservoir levels have increased significantly this year as runoff kept flowing downstream longer than in previous years. In addition, reservoirs on the Colorado River Basin are seeing significant inflows. Once the monsoon activity begins, there may be additional runoff into Arizona's reservoirs, depending on the nature of the storms.

While this winter was significantly wetter than the last, it will take several consecutive years of above-average precipitation to overcome the deficits of the long-term drought.

A dry weather pattern will persist through the early summer with fewer than usual thunderstorms throughout the State in July. Typical summer monsoon conditions, characterized by highly variable precipitation patterns and scattered thunderstorm activity, will likely return for the second half of the summer.

Summaries produced by the State Drought Monitoring Technical Committee, July 5, 2019

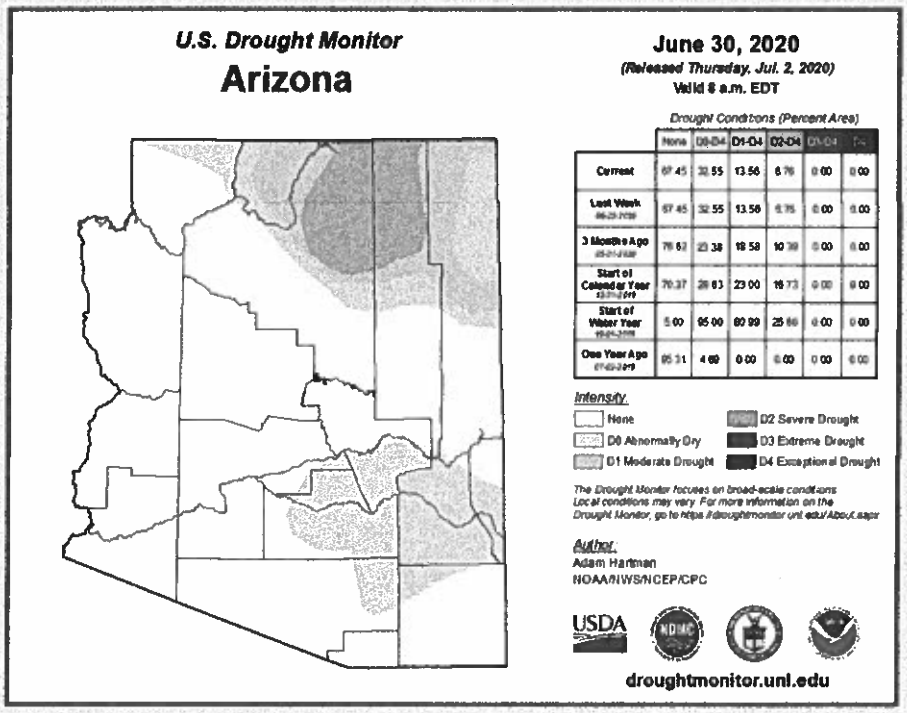
Drought Status Report

June 2020 Short-Term Drought Status

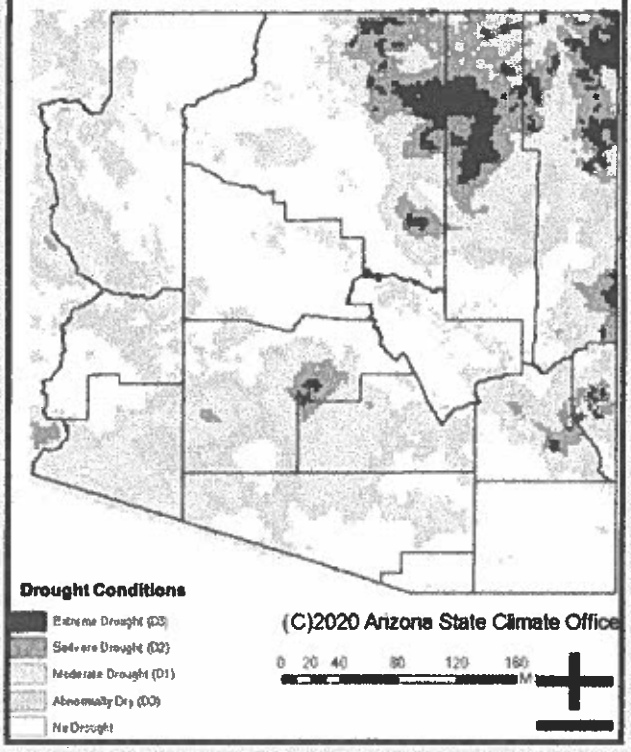
A combination of minimal precipitation in June and warmer than normal temperatures since May led to significant evaporation from soils and vegetation.

The resulting dry conditions led to extremely dry rangelands throughout east central Arizona; as a result, Abnormally Dry (D0) conditions were introduced in Pinal, Graham, southern Gila, southern Greenlee and northeast Pima counties.

Several large wildfires burned through Arizona in June. Wildfire risk is currently high and will continue until the monsoon rains begin.



April—June 2020 Long-Term Drought



April—June 2020 Long-Term Drought Status

The long-term drought map shows some drought degradation across the state with the expansion of Severe Drought (D2) and Extreme Drought (D3) conditions in northeastern and central Arizona, and in Graham, Greenlee and southern Apache counties.

While this winter's precipitation was beneficial, it ended early and was followed by extremely high temperatures that reduced runoff and streamflow.

The last two monsoon seasons were relatively dry across most of the state, though southeastern Arizona had favorable monsoon precipitation the past two years. There are currently no model trends indicating how wet or dry the monsoon may be this summer.

Summaries produced by the State Drought Monitoring Technical Committee, July 8, 2020

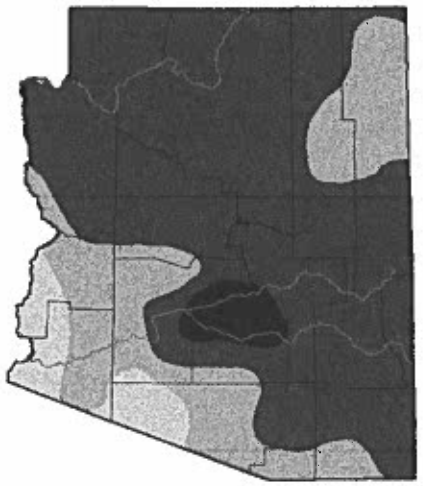
DROUGHT STATUS REPORT

September 2020 Short-Term Drought Status

A combination of less than 50% of average precipitation and record setting high temperatures across Arizona resulted in a significant expansion of short-term drought conditions.

Some rainfall was received along the southern border, particularly in Cochise and Santa Cruz counties. However, total rainfall was generally less than an inch across the state with Phoenix, Flagstaff, and Tucson all reported zero inches.

The entire state is in Moderate (D1) or worse drought. Currently, 67% of the state is in Extreme Drought (D3), compared to 42% at the beginning of September, and 3% is in Exceptional Drought (D4) compared to 0% last month.



September 29, 2020
(Released Thursday, Oct. 1, 2020)
Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	89.97	69.95	3.37
Last Week 09-22-2020	0.00	100.00	100.00	89.97	67.34	0.00
3 Months Ago 06-30-2020	67.45	32.55	13.58	6.78	0.00	0.00
Start of Calendar Year 12-31-2019	70.37	29.63	23.00	16.73	0.00	0.00
Start of Water Year 09-01-2020	5.00	95.00	89.99	25.66	0.00	0.00
One Year Ago 09-29-2019	5.00	95.00	89.99	25.66	0.00	0.00

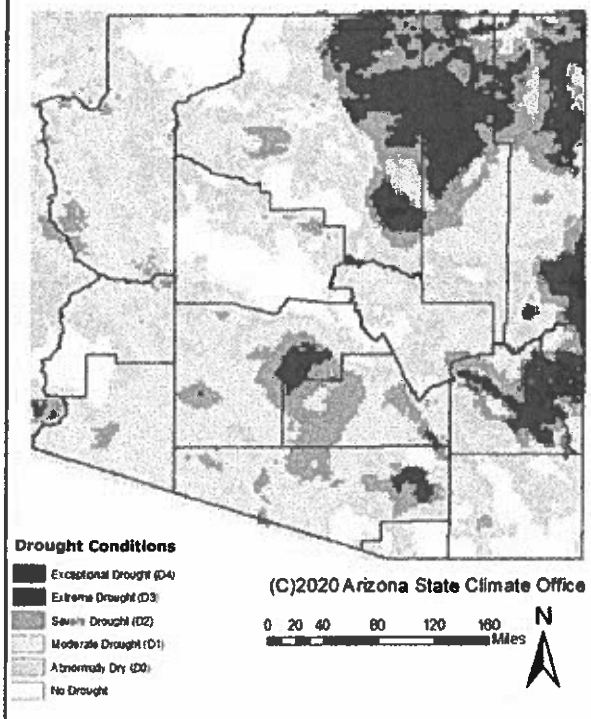
Intensity:
None
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drough

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
Brad Rippey
U.S. Department of Agriculture

droughtmonitor.uni.edu

July-September 2020 Long-Term Drought



July-September 2020 Long-Term Drought Status

The driest and hottest summer on record has resulted in degradation of long-term drought conditions across the state and the introduction of Exceptional Drought (D4) to Coconino, Apache, and Greenlee counties.

The summer is not typically a major contributor to statewide water resources, however, the extreme heat and dry conditions this season led to increased evaporation from water bodies and the soil. This led to a reduction in water supply and significant increase in the need for irrigation within the agricultural community.

The water year started quite wet but ended with less than 70% of average precipitation across northern and eastern Arizona.

As La Niña continues to develop over the central and eastern Pacific Ocean, climate model trends point towards a drier than average fall and winter.

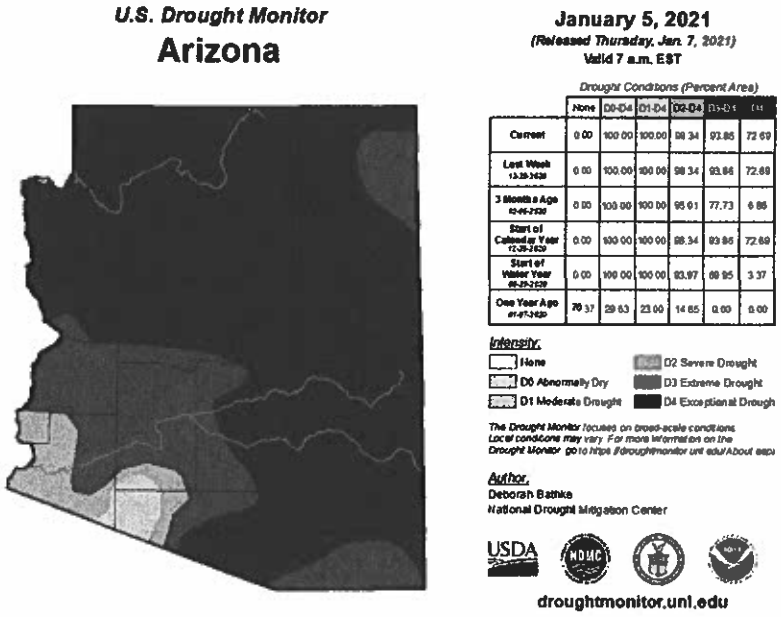
Summaries produced by the State Drought Monitoring Technical Committee, October 8, 2020

DROUGHT STATUS REPORT

December 2020
Short-Term Drought Status

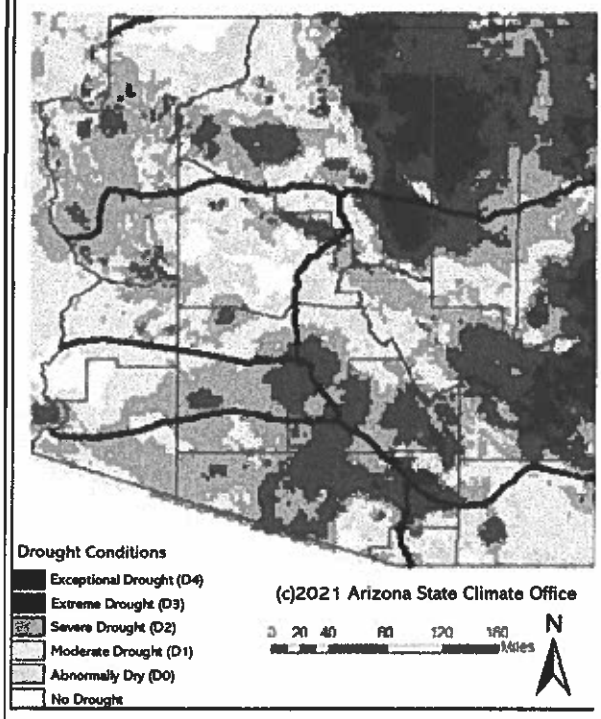
While December precipitation was minimal, drought conditions in the northeast corner of the state, primarily around the Chuska Mountains in northern Apache County, were improved by the few storms that passed through Arizona.

This led to a slight reduction in the extent of Exceptional Drought (D4), from 77% of the state at the beginning of December to 73% at the end, with a corresponding increase in Extreme Drought (D3) from 16% of the state to 21%.



Persistent dry conditions this winter have led to a lack of substantial forage and low stock ponds and water catchments, potentially impacting livestock and wildlife.

October-December 2020
Long-Term Drought



October-December 2020
Long-Term Drought Status

The minimal summer monsoon and persisting dry conditions throughout the fall and early winter have led to a significant increase in long-term drought conditions.

Severe (D2), Extreme (D3) and Exceptional Drought (D4) have expanded across the state impacting streamflow and recharge. The resulting dry soils will reduce future recharge by absorbing potential run-off in the spring.

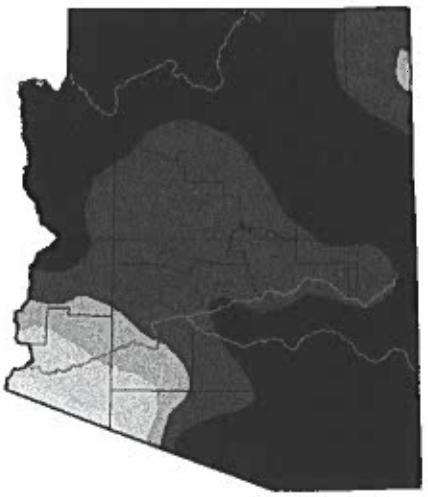
Dry weather will likely continue through the remainder of the winter and spring given a mature La Niña in the tropical Pacific Ocean.

Summaries produced by the State Drought Monitoring Technical Committee, January 13, 2021

DROUGHT STATUS REPORT

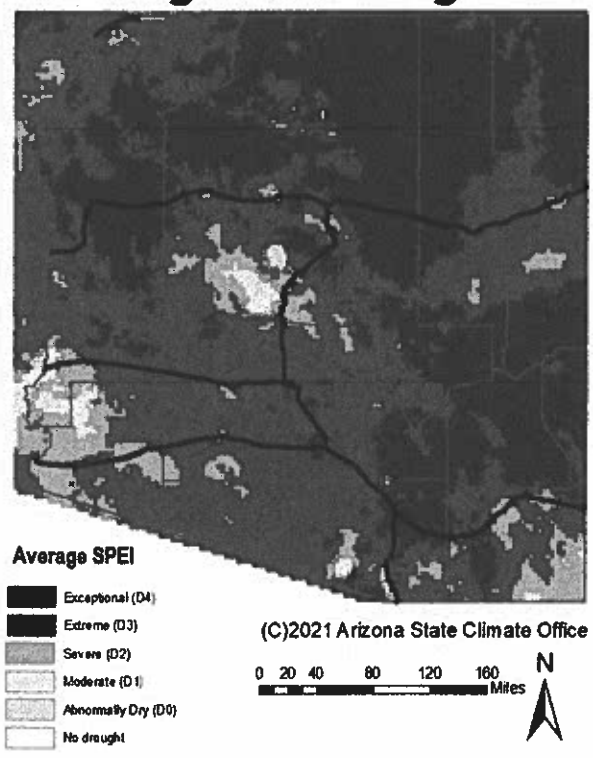
June 2021
Short-Term Drought Status

Despite moderate amounts of precipitation across the state in June, short-term drought severity increased, with approximately 90% of the state reaching Extreme (D3 at 32%) or Exceptional (D4 at 58%) drought conditions. The only portion of the state that remained Abnormally Dry (D0 at 1%) was the lowest area of the southern Yuma County border and a slight portion of southwestern Pima County. Yavapai County fully reached Extreme drought, as did the southern Coconino County border.



The 3-month (July, August, September) precipitation outlook for the monsoon season shows equal chances for above, below, or near-normal precipitation amounts possible. While summer precipitation does not typically alleviate long-term drought conditions, it is possible to see some short-term improvement.

April-June 2021
Long-Term Drought



April-June 2021
Long-Term Drought Status

The long-term drought has intensified and expanded across the state. Severe (D2) drought spread across southern La Paz County and southeastern Cochise County, with little Moderate (D1) drought remaining anywhere across the state.

Extreme (D3) drought spread through southeastern Yuma County, southwestern Maricopa County, southern Navajo and Apache Counties, north-central Cochise County, and much of Santa Cruz County.

Exceptional (D4) drought expanded into much of Mohave County, western Coconino County, north-central Navajo and Apache Counties, with some deepening in Pinal, Graham, and Greenlee Counties.

A La Niña Watch has been issued for the upcoming fall and winter, potentially resulting in another cool season of below average precipitation.

Summaries produced by the State Drought Monitoring Technical Committee, July 13, 2021

2021 Forest Health Update

Reporting on the 2020 activity

Aly McAlexander, Forest Health Specialist
Arizona Department of Forestry and Fire Management

Background

- The DFFM conducts an annual aerial survey of dead and dying trees.
- DFFM certified arborists, entomologists, and service foresters ground truth data and provide land managers and the public with information.
- In times of significant drought, trees become increasingly stressed and thus more susceptible to insect and disease infestation.
    - Specifically, bark beetle caused tree mortality increases following times of drought.

Forest Health Conditions in 2020 - RECAP

- There was a decrease in total acres of bark beetle caused tree mortality
    - The majority of bark beetle damage occurred in ponderosa pine forests
- There was an increase in damage caused by forest insect defoliators and sap feeding insects
- Due to the lack of monsoonal moisture and the La Niña winter there was an increase in abiotic stress caused by drought.

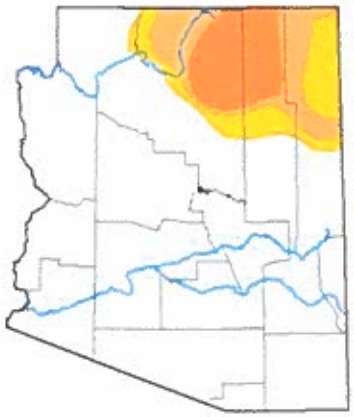
Forest Health Conditions in the FALL of 2020 - RECAP

- There was a lack in monsoonal moisture, along with La Niña winter conditions, which increased abiotic stress caused by drought
- Due to this lack in moisture and increased drought stress, forest health professionals around the state began noticing an increase in mortality from bark beetles in the fall and winter of 2020.

U.S. Drought Monitor

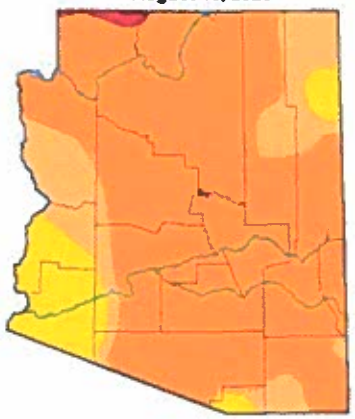
Arizona

April 14, 2020



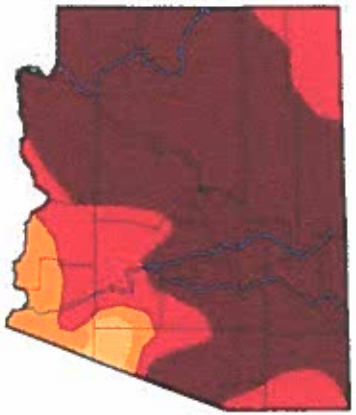
Author
Brian Fuchs
National Drought Mitigation Center

August 18, 2020



Author
David Simeral
Western Regional Climate Center

November 24, 2020



Author
Richard Heim
NCEI/NOAA

Intensity

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

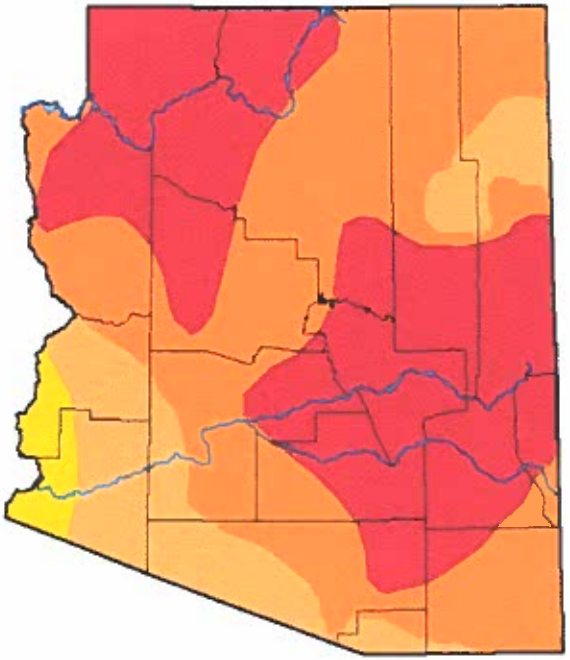
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

droughtmonitor.unl.edu

Forest Health Conditions in 2020 - RECAP

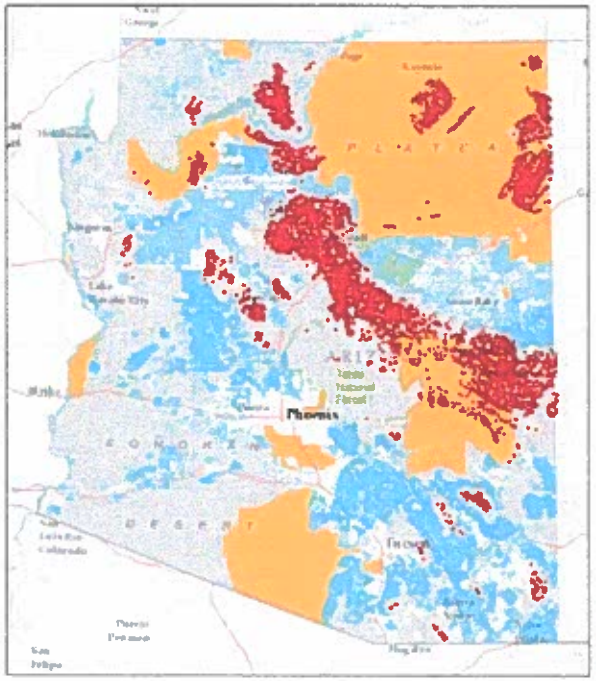
- **81,031 acres with** bark beetle caused tree mortality (survey season July-September)
- This was an **82% decrease** in bark beetle cause tree mortality from 459,239 acres in 2019
- However, bark beetle caused tree mortality increased after the survey season, and we will inevitably see an increase in damage for the 2021 season

Summer - 2020



https://droughtmonitor.unl.edu/

ADS Insect and Disease Locations - 2020

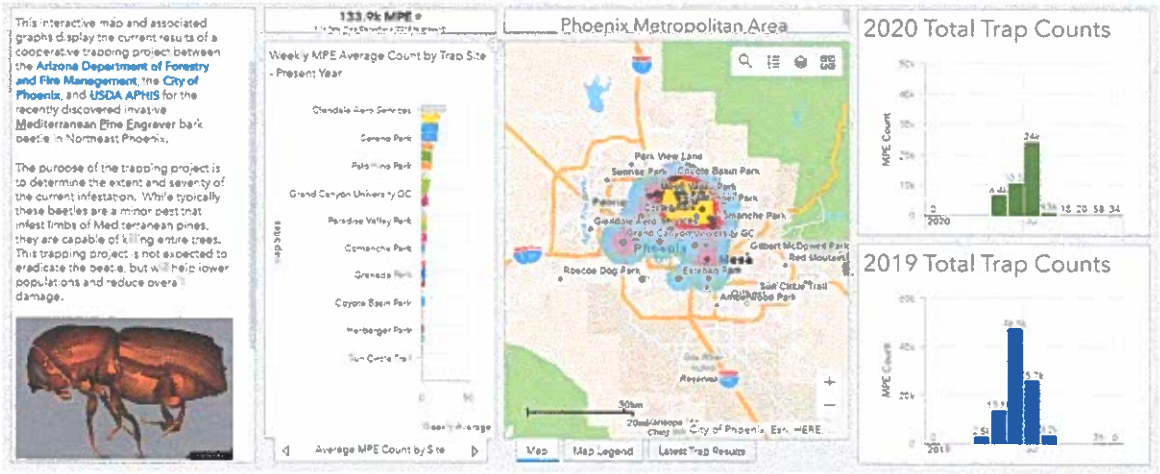


Forest Health Conditions in 2020

- Forest and woodland vegetation are showing signs of improvement.
    - But due to latent drought stress after the survey season, we are anticipating a significant increase in insect and disease mortality in the 2021 survey season.
- Moisture improves tree health, and therefore lets hope for a better monsoon season.

Urban Forest Health Conditions – Summer 2020

- There was an increase in Mediterranean pine mortality caused by the Mediterranean Pine Engraver bark beetle throughout the Phoenix Metropolitan area



Urban Forest Health Conditions – Summer 2020

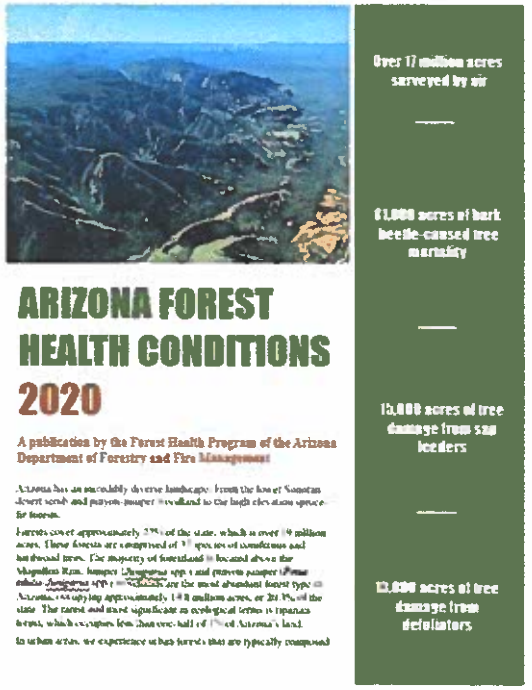
- Also an increase in Aleppo Pine Blight activity was seen throughout the Phoenix Metropolitan area.

Tree Number	RPP35	Picture taken in 2019
Combined Crown Rating	5	
Mite Condition	Light	
DBH	12	

Tree Number	RPP35	Picture taken in 2020
Combined Crown Rating	2	
Mite Condition	Light	
DBH	12	

Thank You

Aly McAlexander
Forest Health Specialist
amcalexander@dffm.az.gov
602-290-9644



Susan Irvine

From: wow houses <wowhouses@hotmail.com>
Sent: Monday, October 25, 2021 2:42 PM
To: Susan Irvine
Subject: Regarding AB2714

To The City Clerk

It's my suggestion that the Forest Service and the City use GPS technology to
create a simple and effective deterrent for the improper use of ATVs on Forest Service land.
Have the Forest Service require that all ATVs have a GPS transponder. This GPS transmitter would be included on all ATV rentals. Private owners would need to rent one from a local ATV Rental outlet also.

GPS technology would allow all ATF activity within a certain geographic area to be monitored. The entire process can be automated by creating digital maps of where ATVs can go and where they can't. When an ATV enters an area on the digital map that is off limits, an alarm can be triggered and messages can be immediately sent to the ATV driver and to enforcement officials. The GPS software would handle all that without any human intervention.

To monitor one ATV costs $10 per month. If an ATV rental outlet rented that ATV 20 times per month and charged a $10 GPS fee per trip, there would be quite a revenue stream. Charge private ATV owners $10 per day.
That seems reasonable considering the effects of ATVs on the landscape. The revenue generated could be used to maintain the Forest as well as give an incentive to the ATV rental outlets. THE SOFTWARE TO MONITOR
ALL THE ATV TRAFFIC IS FREE.

As previously stated, the ATV Rental outlets could easily do point of sale distribution of the GPS devices and could also be the point of notification when one of their vehicles went off trail. The contract for the GPS rental could include a monetary penalty based on the extent of the violation.

Even if the Forest Service cannot mandate GPS transmitters, all the local ATV outlets could voluntarily implement
this plan for themselves just to increase profits and track assets. It would also be a monumental PR statement, showing
the public that they care about the Forest and are doing their best to mitigate potential ATV damage.

This solution may seem high tech and perhaps involved, but it isn't. In researching this idea, I spoke to a GPS tracking company by the name of SAMSARA. I myself contracted to the US Army Logistics Command (lots of GPS tracking) and worked for a Florida company called Asset Trax. All in a previous life.

Thanks for reading this!

Peter Sorando
1660 Johnny Guitar St.

703 999-8490

Susan Irvine

From: Blue Boelter <blueaz50@gmail.com>
Sent: Tuesday, October 26, 2021 12:36 PM
To: Susan Irvine
Subject: BAN OHV's

RE: AB 2714 Discussion/possible action regarding regulation of Off-Highway Vehicles within the Sedona City limits and the surrounding area.

Please ban the rental and use of off-highway, off-road or all-terrain vehicles in and around Sedona. Reasons:

1. Recent studies suggest that airborne dust from OHV's is harming and killing native trees around Sedona.

2. Research is showing that dust from OHV's is damaging ancient petroglyphs at Palatki, Honanki and other sites.

3. The proliferation of OHV rental facilities in West Sedona is unsightly and out of balance with other needed services.

4. OHV's on City of Sedona streets, roads and highways is a hazard and a nuisance. Hazardous because first-time users of these vehicles don't know or observe proper safety guidelines for OHV's and are a distraction to normal drivers. This adds to the noxious overload of traffic here. Nuisance because they are loud.

5. Since many of Sedona's dirt roads are now paved, OHV users are going farther out and farther off roads. This exacerbates the destruction of our delicate desert crust, the only thing preventing Sedona from turning into a red dust bowl.

6. Countless residents and visitors who seek the quiet enjoyment of nature cannot, due to the noise and dust of these vehicles.

7. Why allow carpetbagging profiteers to make money destroying Sedona's natural beauty by providing this dubious "service"? Like the AirBnB's, a few were all right; hordes are unacceptable!

Sincerely, Barbara Boelter, 80 Sunset Lane, Sedona AZ 86336

A CITIZEN'S PROPOSAL FOR REDUCING OHV TRAFFIC IN BROKEN ARROW

As a member of the Sedona OHV Work Group in 2019 and a resident of the Broken Arrow neighborhood, I have been upset by the City's and Forest Service's refusal to address the ever-increasing conflict that unrestricted OHV use in the forest has created. I hold the Red Rock District of the Coconino National Forest to their words:

> *"We recognize the national and international importance of the Sedona/Oak Creek ecosystem. We respect the links between ourselves, all human activities and the natural world, and realize that the environment is a sensitive and limited living system in need of actions to sustain and enhance it. We will not regard the area as a potential theme park for commercial exploitation at the expense of nature. We will not sell the day to profit the hour."*

This quote is the mission statement of Guiding Principles from the Forest Service in the introduction to the 1998 Amendment 12 updating the previous 1987 Forest Plan for the Sedona/Oak Creek area. These words represented the high ideals and commitment from the Forest Service to protect our environment here in Sedona.

Unfortunately, things in our National Forest have changed since 1998 and not for the better. In 2018 the Forest Service approved a new plan for our forest which stated:

> *"Recreational use of the Coconino National Forest has changed significantly since the 1987 Coconino National Forest Plan. Some of the trends and conditions related to recreation include: increased use of developed recreation areas; changing demographics; increased conflicts in social values, culture and expectations tied to public lands and new types of recreation."*

In other words, this current Forest Plan accurately diagnoses the problem, but abandons its original mission statement both in word and deed.

One of the most impactful changes that has occurred in our public lands and in our neighborhood communities is the proliferation of OHVs (Off Highway Vehicles). I experience this invasion firsthand every day in my Broken Arrow community. Since 2009, OHV use in the forest has increased exponentially with a negative impact on our forest lands and on our neighborhood streets as they access the trails. These OHVs have increased in size and power, producing more noise and destructive impacts to the natural environment and the adjacent neighborhoods than ever before. With the increase in tourism traffic in Sedona, more rental companies are offering an off-road experience to tourists, many of whom drive

through our neighborhood on Morgan Road on their way to the Broken Arrow trail, with absolutely no experience operating these powerful machines. To many of them, the object of being in nature is not to enjoy the sights, sounds and solitude, but to conquer an obstacle course that happens to be our forest. All other users of the forest now suffer a diminished experience because of these noisy machines that physically damage the flora, fauna and the quietude of the forest. On acceleration, these machines with up to 180 horse power fuel injected engines can reach more than 100 decibels in sound emission. That's comparable to a jack-hammer in decibels. These machines can achieve 60 mph in less than six seconds. Newer models come with large exterior speakers mounted high on the rollbars for all within miles to hear. The sound impact of these machines on other users of the forest can travel for miles and interferes with a wide variety of recreational activities that are enhanced by peace and quiet. When they drive through our neighborhoods to access the forest, the impacts of the noise, speeding and careless behavior of the OHV operators has an extremely disruptive effect on the ability of property owners to enjoy the peace and privacy of their own homes. The neighborhood streets become a form of invasion, with machines roaring through the neighborhood with sound systems blaring. OHVs often convoy on Morgan Road in large groups. They stop and congregate with their loud engines running and often loud music blaring at the head of Broken Arrow trail in front of our homes. There have been ugly confrontations between OHV drivers and neighbors who simply asked them to slow down and drive quietly. The end of Morgan Road at the head of the trail has become a gathering rendezvous location, often more than ten and sometimes as much as twenty machines gather here causing traffic jams with the OHVs coming off the narrow trail.

Once on the trails, after disrupting the neighborhood, OHV use demands a disproportionate amount of forest land compared to other recreational uses. A few OHV riders can overwhelm an area that can otherwise be comfortably shared by countless, hikers, bikers, birders, wildflower enthusiasts and nature photographers. So, we have a small minority causing significant harm to the majority of users of public lands, exactly the opposite of the Forest Service's stated ideals of stewardship, laid down by the founder of the Forest Service, Gifford Pinchot, more than one hundred years ago, that public lands are to be managed for

"the greatest good for the greatest number for the longest time."

There are more than 3000 miles of Coconino National Forest four-wheel drive roads available in the Sedona area. The areas of Broken Arrow, Soldiers Pass, Schnebly Road and the Dry Creek area bear the burden of the OHV traffic that access the Forest directly

through their neighborhoods. This is in clear conflict with specific language in Amendment 12 and the 2018 Coconino Forest Plan. Community concerns about OHVs including excessive speed and noise issues have been discussed at the City Council level since 2013. As the result of ongoing public concern and pressure, the Forest Service began study of the impact of OHVs on the Soldiers Pass area and in 2017 dramatically limited OHV use there by requiring non-fee permits. While this was a step forward in achieving the mission and goals of the Forest Service, it was the result of significant public and political pressure, not a proactive action on the part of the Forest Service.

The result of the Soldiers Pass decision by the Forest Service was to immediately over burden other communities as the traffic went to the remaining non-permitted trails, especially Broken Arrow. In fact, even the Forest Service admitted this in its Soldiers Pass Environmental Assessment of 2016 stating that:

> *"Overcrowding will eventually cause some (motorized vehicle) users to seek other areas. A likely alternative location would be Broken Arrow Road, as it is the only similar type of recreation experience within Sedona's iconic red rock scenery. Like Soldiers Pass, Broken Arrow is accessed through a residential area, has a single permitted outfitter/guide and has a network of non-motorized hiking trails. Displacement of motorized use to this area would create similar issues there. User conflicts, noise disturbance to residents, increased safety risks, and noncompliance with forest plan direction would occur in the Broken Arrow area."*

It's obvious this short-sided Soldiers Pass decision did not address the holistic issue of OHV over-use of our Sedona area forest trails. The Forest Service, like the old saying goes, "kicked the can down the road," or should I say trail. Because of this short-sightedness the Forest Service has caused a "wack-a-mole" situation of ever-increasing OHV traffic through our remaining communities with trail access, resulting in non-compliance with the Forest Plan's stated goals in Broken Arrow.

So where do we go from here? If we do nothing, it will only get worse with more traffic on our off-road trails, with bigger machines and more noise and damage. Fewer recreationists, hikers, bikers, birdwatchers and meditators will be able to enjoy a peaceful day in the forest as the traffic and noise become unbearable on the trails. Our neighborhoods will become intolerable and lose residents who move away in disgust that nothing could be done by the City and the Forest Service to manage this out of control situation blasting by their homes on the way to the amusement park obstacle course that we call Sedona. Is this our future? I

say no. We can act together as a community of residents and users of the forest and fight to stop this madness.

We propose a solution based on the Soldiers Pass decision for Broken Arrow. For some unknown reason, the Broken Arrow neighborhood has not received the same attention and action that the Soldiers Pass neighborhood has received. The similarities between the two neighborhoods are strikingly similar in terms of public access to the forest, the terrain, the surrounding primitive/semi-primitive areas, the flora and fauna and the proximity to the neighborhood. In spite of multiple requests from the neighborhood for action to mitigate the impacts from the OHV's, little has been accomplished.

I am proposing and requesting that the Forest Service begin the NEPA process and move toward a gate and limited permit access to the Broken Arrow Basin. The establishment of a permit system will finally allow the Forest Service to perform according to its original ideals of stewardship of the lands and return to its sanctified role, honoring its own principles. With their own words, I will hold the Forest Service to account:

> *"realizing that the environment is a sensitive and limited living system in need of actions to sustain and enhance it. And will not regard the area as a potential theme park for commercial exploitation at the expense of nature…where we are free to imagine, to explore and to reconnect with the land. Through this landscape we can experience a rebirth of awe and a renewal of Spirit."*

Jerry Hartleben
520 Morgan Rd.
Sedona, AZ

Susan Irvine

From: Karen Osburn
Sent: Thursday, October 28, 2021 9:24 AM
To: Susan Irvine
Subject: Fw: City Council meeting on Tuesday
Attachments: CITY COUNCIL PRESENTATION.docx

Hi Susan, can you pass this along to City Council? thanks, Karen

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From: Robert Adams <light3@esedona.net>
Sent: Thursday, October 28, 2021 9:07 AM
To: Karen Osburn <KOsburn@sedonaaz.gov>
Subject: City Council meeting on Tuesday

Hi Karen,
I was unable to attend the meeting on Tuesday because I had a reaction to the Moderna booster.
I am attaching the presentation that I was going to give to the Council. Please forward it to them.
I believe that my research and narrative make a strong case for beginning a NEPA process for a gated/permitted access into the Broken Arrow Basin. There are many references in the forest service documents that I studied that support mitigating impacts of motorized vehicles on the forest, neighborhoods and neighboring lands. There are also specific references to consideration of limited access and night closures.
It has become clear to me that our forest ranger is not following the guidelines of the USNF plans. During a Zoom meeting last week, she stated “trail closures are not my style of management.” This is disturbing. Does that mean that one person in the Forest Service can ignore the guidelines of the Forest Plan according to her own “management style?”
I was delighted to hear that the Council approved a letter that supports our cause.
Regards,
Rob

CITY COUNCIL PRESENTATION
Oct. 26 2021

I believe that the single most important action that you can take when confronted with a problem that needs a solution is to get yourself thoroughly educated on the history, background and written materials that are relevant to the problem.

I have been involved in discussing the explosive growth of OHV's and their impacts to our neighborhoods and surrounding forest since 2010. I have been in endless meetings to discuss these impacts and to search for solutions. The conclusion that I have come to is there is no one solution. Different areas that are impacted by the noise and destructive nature of OHV's will need different approaches to mitigating the impacts. Are the OHV's traveling on city roads, state roads or forest roads? Are they driving through neighborhoods to access the forest? How much disruption and forest destruction is taking place?

I am not going to try to tackle the entire spectrum of solutions. I am here representing approximately 50 lot owners that have signed petitions in the Broken Arrow subdivision and will focus on a mitigation plan for that neighborhood. My **conclusions are based on many hours of reviewing the current and past Forest Plans, Amendment 12, the Coconino Forest Outfitter Management Plan, and the history of the Study of Motorized Use in Soldiers Pass**. These are the playbooks for forest management in this area. You have a copy of my research with all the quotes that were taken directly from these documents.

In the ***Coconino National Forest Outfitter and Guide Management Plan****, written* ***in 2006,*** it states " . **Optimize the availability of Broken Arrow for popular outfitter-guide activities and help mitigate impacts to adjacent residents and to the National forest by"**

a) Installation of a night gate with motorized traffic hours of daylight to dark
b) Requiring private motorized vehicle users to have a "non fee" permit
c) Setting a cap on the Pink Jeep Tours permit

In the Coconino Forest Plan, Amendment 12, written in 1998, it states, "Address local neighborhood concerns about the impacts of visitor use on residential quality of life. Use such methods as nighttime closures, improving signs and limiting motorized access and number of visitors."

In the Land and Resource Management Plan for the Coconino National Forest, written in 2018, it states, "Motorized trails and trail systems should be designed to move users away from residential areas and to reduce conflicts between motorized users and neighboring lands."

The same plan also states "Collaborate with local governments, agencies and residents to protect resources and address local concerns. To address local

concerns, consider a variety of management actions such as nighttime closures, improved signs and limit on motorized access or number of visitors."

In the Study of Motorized Use in Soldiers Pass written in 2017, it states "*Overcrowding will eventually cause some motorized vehicle users to seek other areas. A likely alternative location would be Broken Arrow Road, as it is the only similar type of recreation experience within Sedona's iconic red rock scenery. Like Soldiers Pass, Broken Arrow is accessed through a residential area, has a single permitted outfitter and has a network of non-motorized hiking trails. Displacement of motorized use to this area would create similar issues there. User conflicts, noise disturbance to residents, increased safety risks, and noncompliance with forest plan direction would occur in the Broken Arrow area."*

Guess what, folks. That is why we are here today. There is clear non-compliance with Forest Service Plan direction by the Forest Service. Our forests and neighborhoods are being overwhelmed by hoards of people, automobiles, jeeps, bicycles and most intrusively, a new type of noisy destructive machine that I will identify as OHV.

In 2009, the Arizona Department of Game and Fish stated "OHV use in Arizona has exploded with a 347% increase in use since 1998." The use is outpacing the existing funding to manage that growth, protect wildlife habitat and help maintain recreational access." The use of OHV's continues to increase exponentially.

The problems with OHV use in the forest are twofold. ***First,*** they have a disproportionate effect on other forest users. The noise and dust levels created by these machines can carry for great distances, affecting the forest experience for hikers, birders, fishermen and others that are trying to experience some peace and solitude. This noise and dust also affects neighborhoods and neighboring lands. ***Secondarily***, many of the OHV users do not view the wild world as an opportunity to enjoy nature, but merely an organic obstacle course, offering challenges to his and his machine's technical abilities. This mindset creates a dangerous and confrontational environment for other forest users and for neighborhoods that they travel through.

I am here specifically to address the OHV impacts to the Broken Arrow Neighborhood and make an appeal for a strategy to mitigate these impacts. Our neighborhood is one of two neighborhoods in the Sedona city limits where forest users must drive directly through the neighborhood to access the trailhead. It has been documented that our neighborhood has close to three thousand recreational vehicles a month traveling on our streets. Many of these vehicles are speeding, driving carelessly, creating loud volumes of noise and parking, staging, loading and unloading in front of our homes.
This is creating an intolerable situation where homeowners are unable to enjoy the peace and privacy of living in their own homes. Our streets have become a form of a NASCAR racetrack.

The City's mission is to protect the health, safety and welfare of the residents. The Forest Service' mission is to protect the health of the forest for future generations. Additionally, there are multiple references in Forest Service Plans and Amendments that reference the Forest Service commitment to "engage in strong community partnerships for stewardship of the Sedona neighborhoods, and to "collaborate with local governments, agencies and residents to protect resources and address local concerns."

The Broken Arrow residents request that the city and the forest service work collaboratively to address the impacts that our neighborhood is experiencing from OHV traffic. Specifically, we request a gated, permitted access to be installed in the Broken Arrow Basin.

Why hasn't a NEPA process already been initiated? Precedence has been established in the Soldiers Pass neighborhood. The similarities between Soldiers Pass and Broken Arrow are strikingly similar in terms of public access to the forest, the terrain, the surrounding primitive/wilderness areas, the flora and fauna and the proximity to the neighborhood. The Sedona City Council approved partial funding for a NEPA study in Soldiers pass to determine if there was a need to restrict motorized traffic in that area.

At a City Council meeting in September 2016, the Forest Service gave a final presentation regarding proposed restrictions to motorized use in Soldiers Pass. ***Laura Jo West, the Coconino National Forest Supervisor, summarized the decision to limit motorized traffic with a gate and permit system. She stated "As the popularity of motorized recreation increases, so do concerns over impacts to other recreational uses and to the quality of life in adjacent residential areas***." At that same meeting, Mayor Sandy Moriarity urged the Forest Service to allow only permitted jeep tours and no public recreational use. This was even more restrictive than the original Forest Service recommendation and the Forest Service complied with this request from the city.

The Broken Arrow neighborhood formally requests the following actions to mitigate the impacts of motorized traffic in our neighborhood and the adjacent forest.

a) Begin a NEPA process for the Broken Arrow Basin and neighborhood with the goal of the "creation and maintenance of conditions under which man and nature can exist in productive harmony."
b) Increase enforcement in neighborhoods to mitigate noise, speeding, parking, loading/unloading and staging impacts by OHV users
c) Increase forest oversight through partnerships with tour operators, forest volunteers and neighborhood residents that give updated reports on the conditions in and around the forest

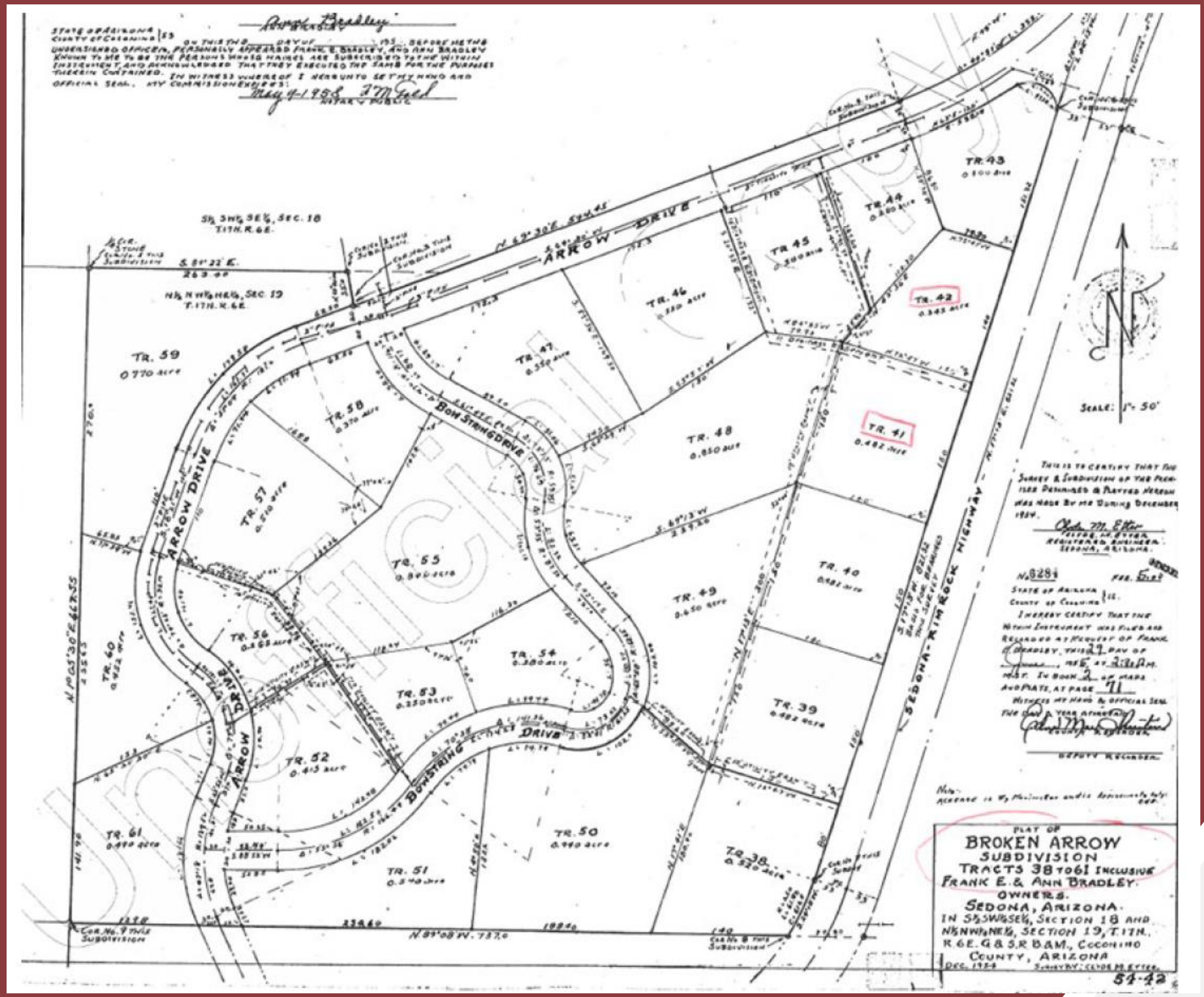
d) Increase funding for enforcement of protective guidelines for motorized forest use and access
e) Require more accountability from commercial OHV rental companies to oversee the impacts of their rentals on neighborhoods, the city and the forest
f) Initiate nighttime closures of residential trailheads
g) Improve signage and forest use education
h) Work with Federal government to legislate maximum permissible sound levels in the forest from engines and sound systems
i) Provide appropriate parking, turnaround and staging space, toilet and trash facilities at trailheads to accommodate an acceptable level of use.
j) Different recreational activities carried out in close proximity can interfere with one another. Consider segregating OHV's to areas where they will not be creating a disproportional impact to other forest users.

CITY OF SEDONA
& Son Silver West Gallery, Inc

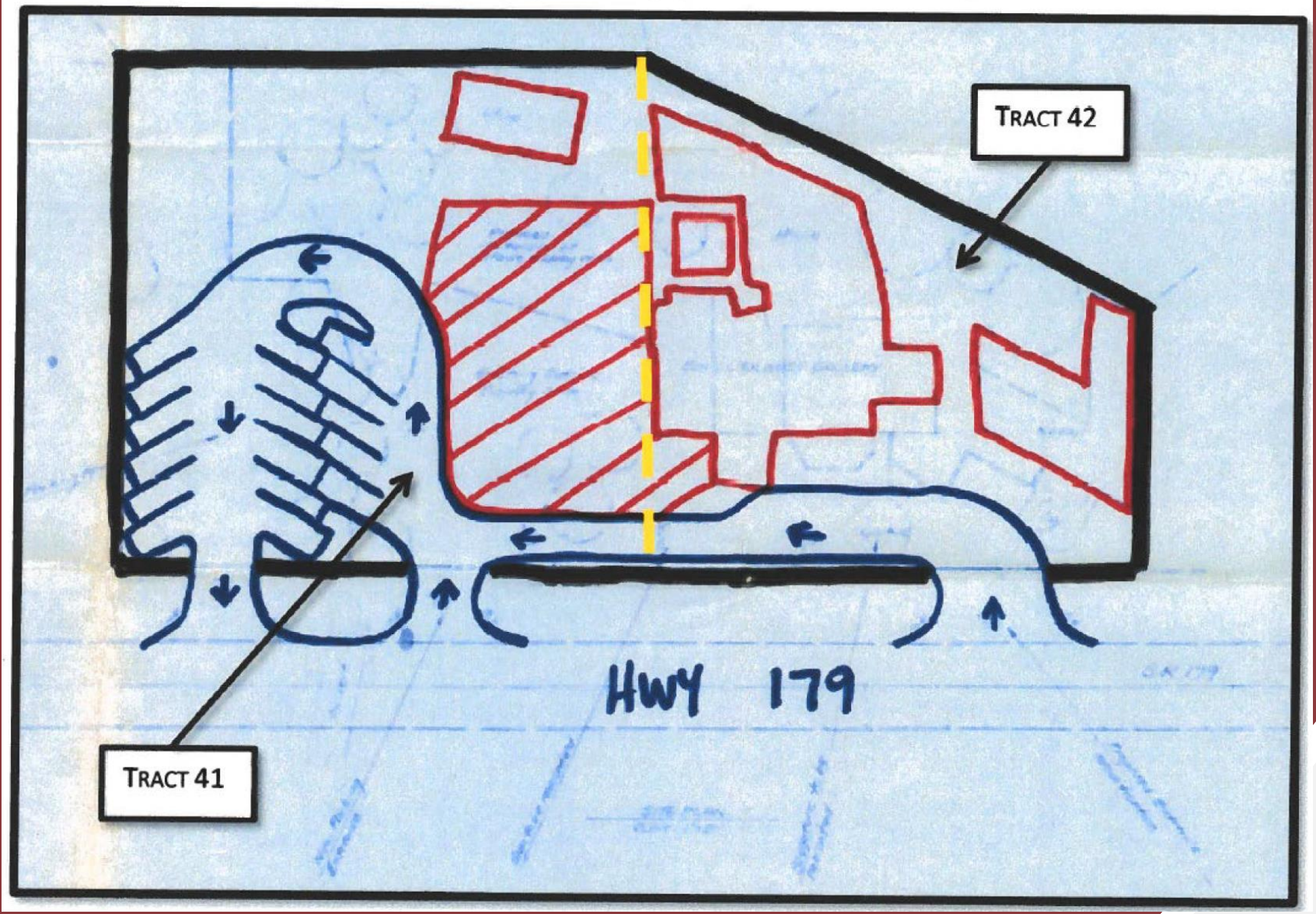
Development Agreement

History

- 1960 Small art gallery operated out of the residence
- 1964 Coconino County zoned residential, but a legal nonconforming use (grandfathered)
- 1989 NOV led to CUP 92-3 allowing 5,000 sq ft of outdoor retail space
- 2014 NOVs


PLAT OF
BROKEN ARROW
SUBDIVISION
TRACTS 38 TO 61 INCLUSIVE
FRANK E. & ANN BRADLEY
OWNERS.
SEDONA, ARIZONA.
IN S½SW¼SE¼, SECTION 18 AND
N½NW¼NE¼, SECTION 19, T.17N.,
R.6E. G & S.R.B.&M., COCONINO
COUNTY, ARIZONA
DEC. 1954
SURVEY BY: CLYDE M. ETTER
54-42
ARROW DRIVE
BOW STRING DRIVE
SEDONA-KIM ROCK HIGHWAY
SCALE: 1" = 50'

ALTERNATIVE SITE PLAN #2 APPROVED WITH CUP 92-3 ON SEPTEMBER 15, 1992



History

- 2015 - Appealed to Board of Adjustment which upheld the majority of the corrective actions.
- 2016-Special Action to Superior Court based on theories of vested rights and equitable estoppel.
- 2017/2018 - Superior Court and Court of Appeals upheld the Community Development Director's enforcement of violations of the Land Development Code and CUP 92-3 against SSW.
- 2019- Not all violations fully abated. City filed complaint in superior court requesting a permanent injunction and court ordered abatement. This case is still pending.

Art Gallery Retail Space

- 1987 Small Art Gallery

- 1992 CUP 92-3
  - 5,000 sq ft outdoor retail space
  - 2,250 sq ft of indoor retail space (*did not include* 1,300 sq ft of pottery shop)

- 2021 Development Agreement
  - 5,563.81 sq ft of outdoor retail space
  - 4,900 sq ft of indoor retail space (*includes* 1,300 sq ft for the pottery shop with kiln).

Development Agreement

(e) To refrain from using more than the maximum allowable space on Tract 49 located at 365 Bowstring Dr. (APN 401-31-020) as a home occupation, as that use is defined in the Sedona Land Development Code, or for commercial purposes including, but not limited to, fabrication, employee parking and warehousing of merchandise in support of the Son Silver West business activities and to allow the City staff upon notice to have access to the residence at 365 Bowstring Dr. for the purpose of inspection as provided herein.

(j) To allow the City staff entry onto Tract 40, Tract 41 and Tract 42 at any time during regular business operating hours of Son Silver West for the purpose of conducting inspections, including the taking of photographs, for compliance with CUP 92-3 and this Agreement in accordance with the City's standard practices for inspecting commercial properties within the City of Sedona.

Development Agreement

(f) To prohibit the parking of vehicles on Tract 40 located at 1535 SR 179 (APN 401-31-011), to maintain a physical barrier between Tract 40 and Tract 41 at the south edge of the improved driveway on Tract 40, and to refrain from the use of Tract 40 for commercial purposes, except for the existing commercial drive which shall be used only for ingress and egress of automobiles and for the loading and unloading of shipments of business merchandise, ~~and~~ equipment and supplies; provided, however, that unloading and loading of any such shipments shall occur before close of business by Son Silver West the same day as the arrival of the truck used for shipping and, provided further, that shipments ~~merchandise~~ received shall be removed from the commercial driveway area within 24 hours after being offloaded.[5] The northernmost 20 feet of the commercial drive shall be used only for ingress and egress. The remainder of the paved commercial drive shall be striped and marked with paint for unloading and loading of business merchandise, ~~and~~ equipment and supplies within thirty (30) days after the Effective Date, and thereafter maintained.

Development Agreement

(g) To install and maintain pre-approved screening and vegetation next to the existing wrought iron fencing, including the gates used for pedestrian access, on Tract 41 and Tract 42 along the frontage adjacent to State Route 179 so as to minimize visual impacts and maintain an attractive appearance of the Outdoor Retail Area.

Development Agreement

(i) To install permanent ground markers which will delineate the authorized Outdoor Retail Area as authorized in CUP 92-3 and accurately depicted on the site plan which is incorporated herein as Exhibit C. Further, that all areas and clear spaces on Tracts 42 and 41 lying outside the Outdoor Retail Area shown on Exhibit C without a use designation, shall be kept open and free of any merchandise or other tangible items at all times and maintained in their current state. Further, the Robsons and SSW agree to not store, place or locate anything, including but not limited to objects, items, merchandise, or artwork, whether for sale or not, at any exterior location on Tracts 40, 41 and 42 not within the Outdoor Retail Area as shown in Exhibits B and C and as described in Section 2(a)ii. of this Agreement without prior written permission from the City Community Development Director which shall not be unreasonably withheld. The City Community Development Director pre-approves only those non-retail items currently displayed outside the Outdoor Retail Area as recorded by video and photographs taken on July 12, 2021, by City staff and by photos provided by SSW to City staff on May 25, 2021.

Development Agreement

(l) (i) Subsequent to the full compliance acknowledged in this Agreement, Son Silver West will freely and voluntarily pay to the City a penalty in the amount of $500 per day during which any violation of CUP-92-3 or this Agreement continues without cure beyond forty-eight (48) hours after notice. The 48-hour cure period shall commence upon delivery of notice to Son Silver West as set forth in Section 5.1 provided, however, if Rio Cody Robson is absent from the State of Arizona for the purpose of purchasing merchandise and/or raw materials used in manufacturing by Son Silver West of merchandise for sale at the time of delivery of a notice, then notice shall be deemed effective seven (7) days after delivery of the notice provided, further, that (i) Rio Cody Robson shall furnish to the City reasonable evidence of such business purpose for his out-of-state travel; and (ii) the maximum number of 7-day grace periods shall not exceed four (4) during any 12-month period accruing from and after the execution of this Agreement. The 7-day grace period is specific to Rio Cody Robson and shall not transfer to any successor, heir or assign. In the event that any part of the 48-hour cure period were to include any day in which the City is not open for business, the City, nevertheless, will make available a Community Development Department employee to inspect the Property during such 48-hour period to confirm whether or not the noticed violation has been cured.

Development Agreement

(ii) In the event that any violation as described in this Section 2(m) continues for more than forty-eight (48) hours after notice, the Parties agree that the dispute resolution process identified in Section 5.14 herein shall immediately commence. The daily penalties shall not be tolled and will continue to accrue during the pendency of any such resolution process subject to resolution of daily penalties through the mediation or arbitration process. In the event that a re-inspection by the City does not occur until after the initial forty-eight (48) hour cure period and the Robsons have not cured the noticed violation, the penalties described in this Section 2(m) for failure to cure a violation will relate-back to the date which is forty-eight (48) hours following the notice in which the violation is identified.

Development Agreement

(iii) Any violation of CUP 92-3 or this Agreement that is the third (3rd) or more violation in any twelve (12) month period accruing from and after the execution of this Agreement, the daily penalty shall increase from $500 per day to $1,000 per day.

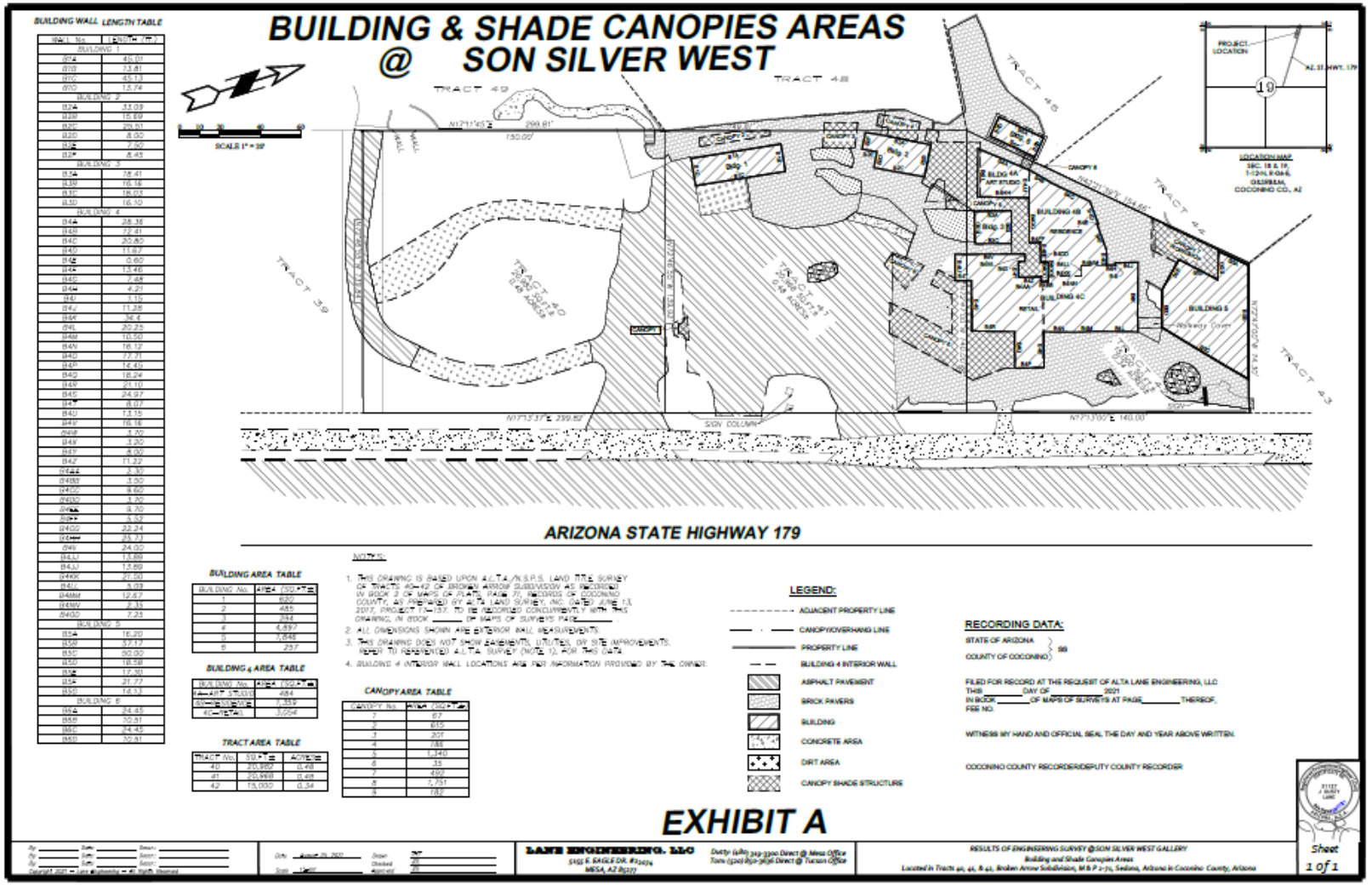
(iv) Any violation of CUP 92-3 or this Agreement that is the sixth (6th) or more violation in any thirty-six (36) month period accruing from and after the execution of this Agreement will result in the City having the unilateral discretion of whether to proceed with the dispute resolution process identified in Section 5.14 herein or to pursue litigation for breach of this Agreement in a court of competent jurisdiction.

Development Agreement

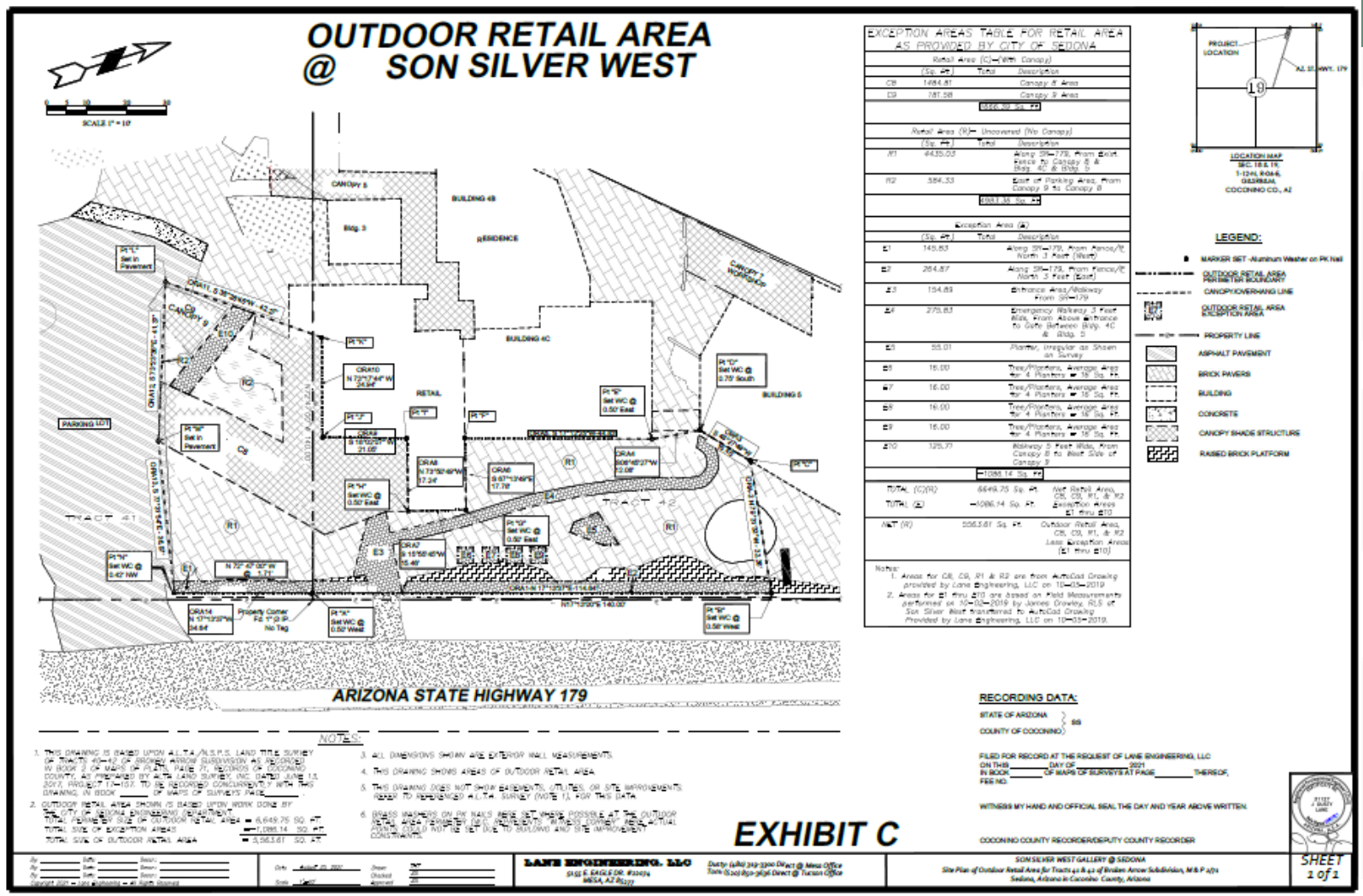
Section 3 - City agrees to:

1. Dismiss the City's abatement and injunction Case No. CV2019-00022.
2. Issue business license to SSW.
3. Follow procedures outlined in the Development Agreement for inspections and issuing notices of violations.

Development Agreement Exhibits



Development Agreement Exhibits



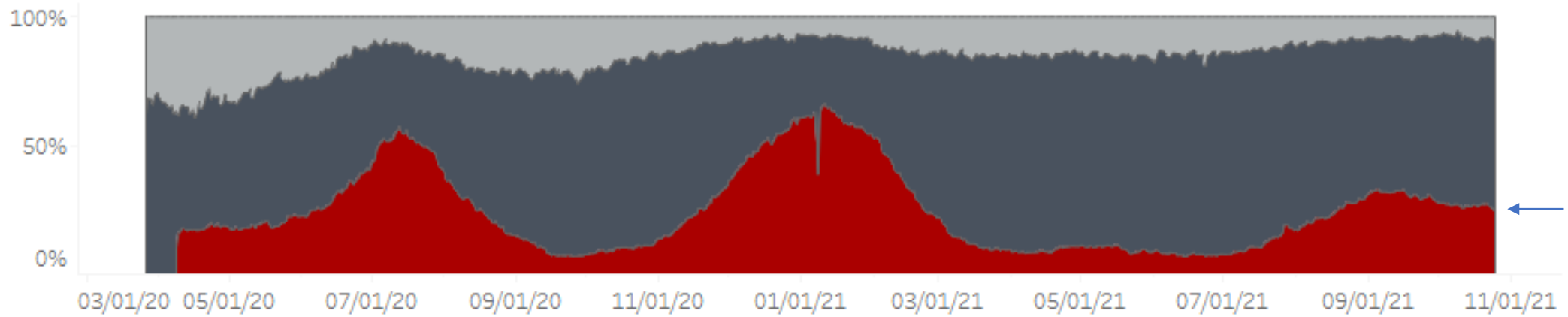
Questions?

COVID-19 Update

Sedona City Council Meeting

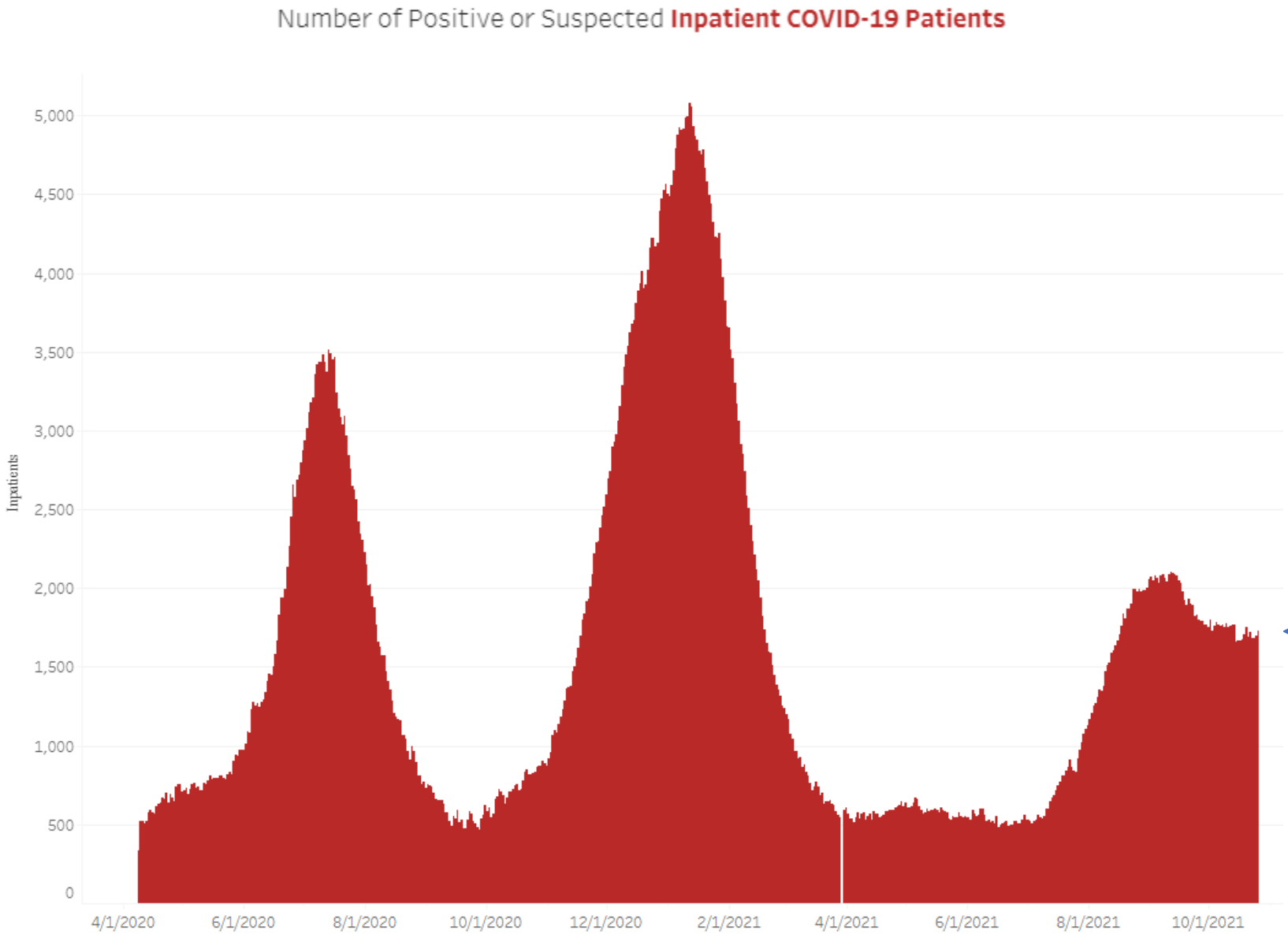
10/26/21

Number of **Intensive Care Unit (ICU)** Beds **Available,** **In Use by non-COVID Patients,** and **In Use by COVID Patients** (starting 4/10/20) at Arizona Hospitals



433 = down 5.9% from 10/11

https://www.azdhs.gov/covid19/data/index.php#hospital-bed-usage



1,728 = down 1.8% from 10/11

https://www.azdhs.gov/covid19/data/index.php#specific-metrics

AZ Changes in Total Deaths

Date	Total Deaths	Change	Deaths/day
8/11/20	4,199		
9/8/20	5,221	+1,022	36.5
10/13/20	5,767	+546	26
10/27/20	5,891	+124	8.9
11/10/20	6,192	+301	21.5
11/24/20	6,515	+323	23
12/8/20	6,973	+458	32.7
1/12/21	10,482	+3509	100.3
1/26/21	12,448	+1966	140.4
2/9/21	14,286	+1838	131
2/23/21	15,650	+1364	97.4
3/9/21	16,326	+676	32.2
3/23/21	16,798	+472	33.7
4/13/21	17,105	+307	14.6
4/27/21	17,208	+163	11.6
5/11/21	17,409	+201	14.4
5/25/21	17,555	+146	10.4
6/8/21	17,700	+145	10.4
7/27/21	18,171	+471	9.61
8/10/21	18,400	+229	16.4
9/14/21	19,304	+904	25.1
9/28/21	19,920	+616	44
10/12/21	20,453	+533	38.1
10/26/21	20,963	+510	36.4

Data pulled from City Council reports 8/11/2020 through 10/12/2021

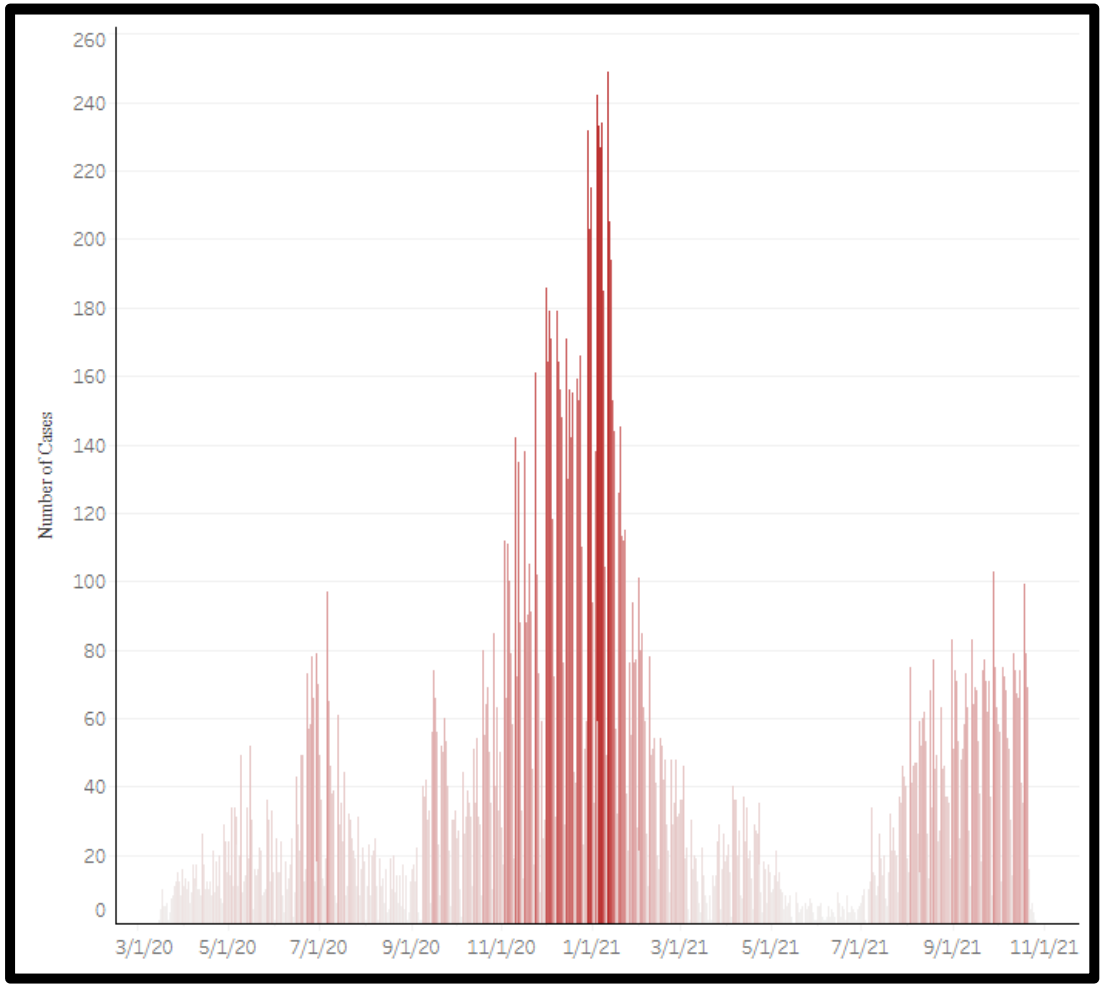
* 49 days between 6/8 and 7/27

** 36 days between 8/10 and 9/14

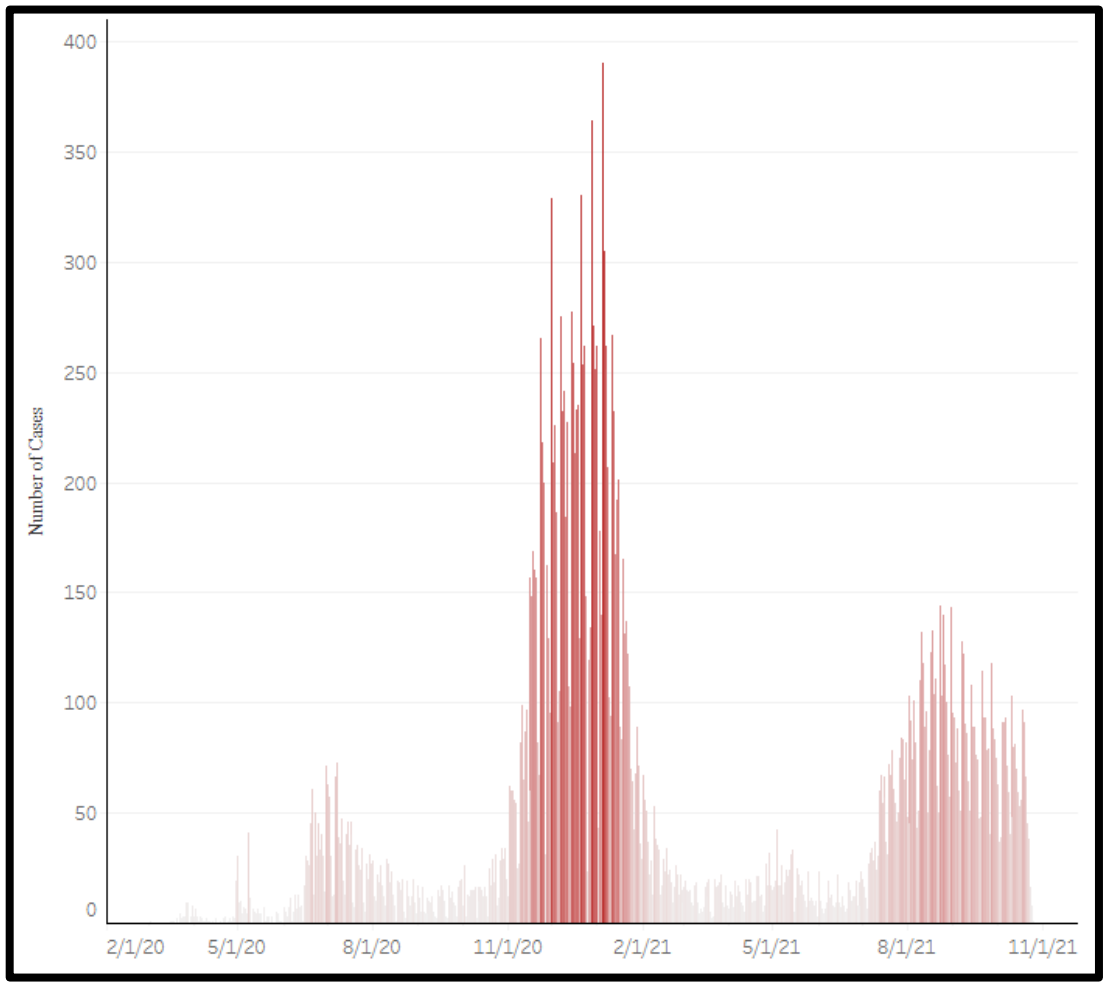
County Case Data

- **Coconino:** Cases as of 10/26: 22,782 - up from 22,027 on 10/12 (+3.4%)
- **Yavapai:** Cases as of 10/26: 27,958 - up from 26,967 on 10/12 (+3.7%)

Coconino County



Yavapai County

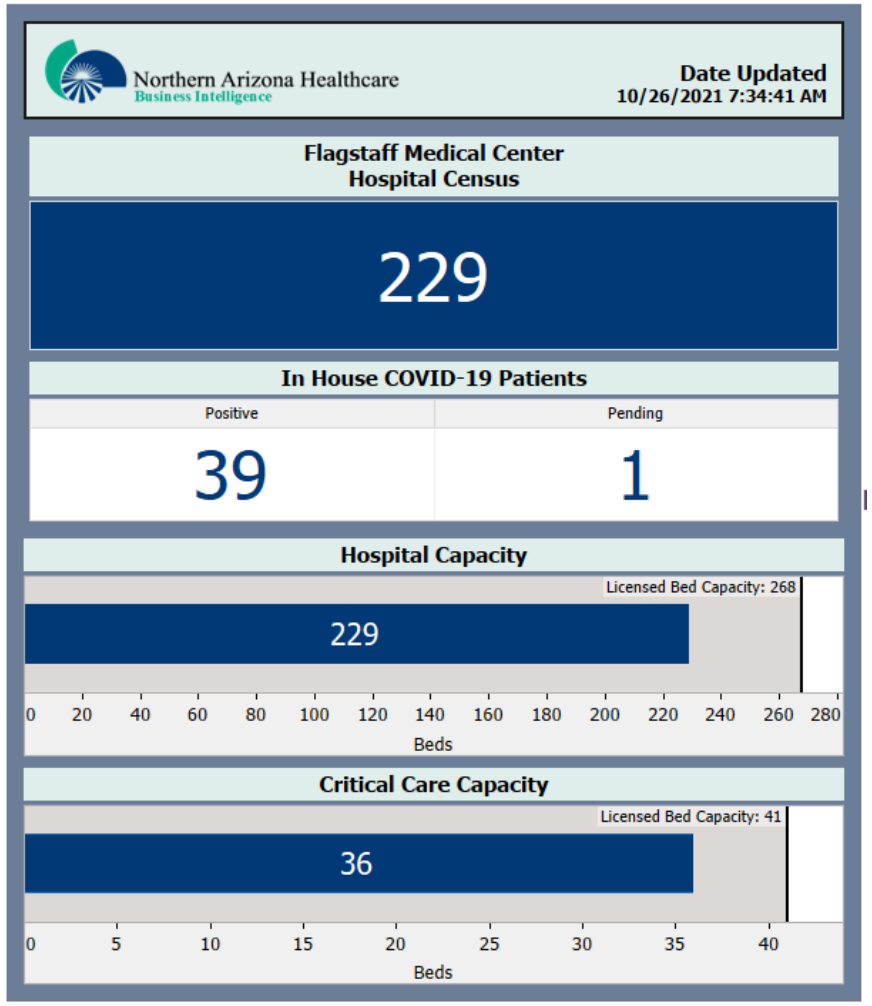


Date of specimen collection is used for day
https://www.azdhs.gov/covid19/data/index.php#confirmed-by-day

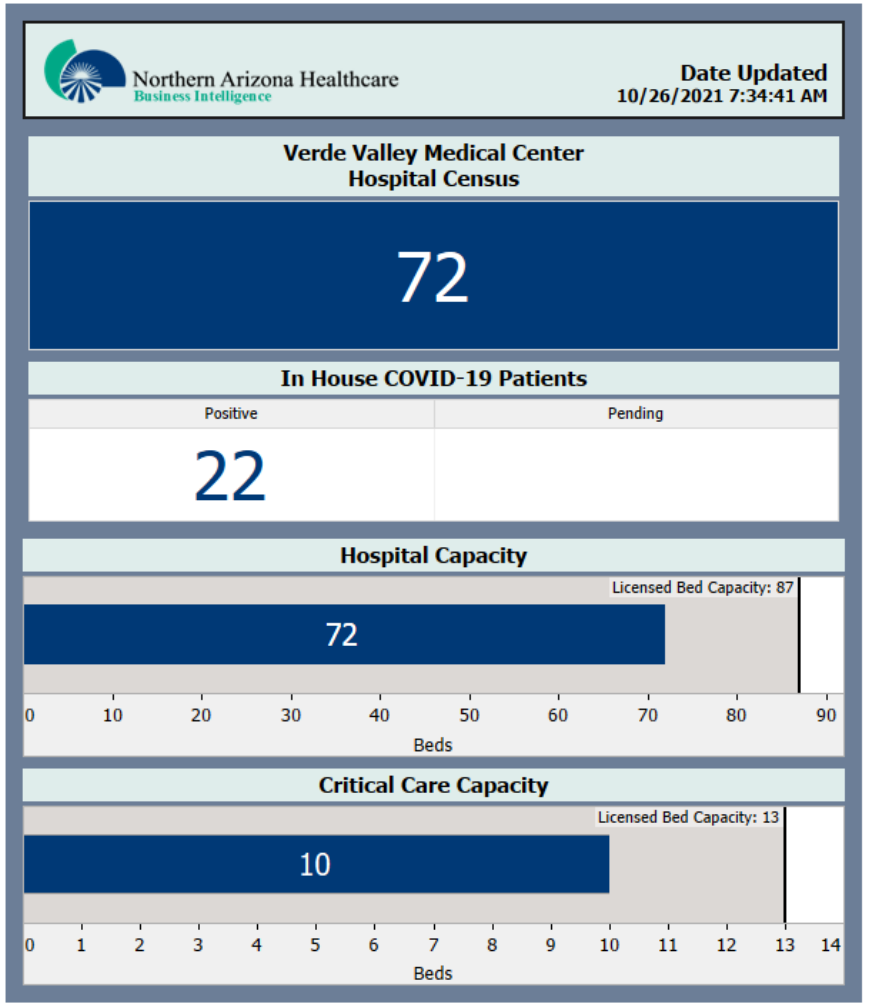
Hospital Data

- **Flagstaff:** In House COVID-19 as of 10/26: 39 - up from 36 on 10/12 (+8.3%)
- **VVMC:** In House COVID-19 as of 10/26: 22 - up from 21 on 10/12 (+4.8%)

Flagstaff Medical Center



Verde Valley Medical Center



https://www.azdhs.gov/covid19/data/index.php#confirmed-by-day
https://www.nahealth.com/covid-19-resources

Yavapai and Coconino County Vaccinations

Statewide:

- 58.8% of population has had at least 1 dose of vaccine *(down from 59.4% on 10/12)*
- 8.11 million doses administered *(up from 7.89 million on 10/12)*
- 69.2% of *eligible people* vaccinated (age 12 and older)

Yavapai:

- 46.9% of total population has had at least 1 dose of vaccine (108,975) *(down from 49.4% on 10/12)*
- 39.7%* of total population has been fully-vaccinated (92,198) *(down from 41.8% on 10/12)*
- 52.4% of *eligible people* vaccinated (age 12 and older)

Coconino:

- 58.7% of total population has had at least 1 dose of vaccine (86,414) *(down from 59.6% on 10/12)*
- 52.6%* of total population has been fully-vaccinated (77,426) *(down from 53.3% on 10/12)*
- 68.0% of *eligible people* vaccinated (age 12 and older)

https://www.azdhs.gov/covid19/data/index.php#vaccine-admin

* Population numbers used are those published on AZDHS website for consistency – Yavapai 232,386 Coconino 147,275

Yavapai County Stats on Vaccinated vs. Unvaccinated COVID-19 Cases since May 1, 2021, as of October 22, 2021

Vaccination Status	Number	Percent
Vaccinated	1008	12.2%
Unvaccinated	7226	87.8%
Total	8234	100.0%

Outcome	Vaccinated	Unvaccinated	% Vacc.
Hospitalized	84	688	10.9%
Died	9	141	6.0%

Age	Vaccinated	Unvaccinated	% Vacc.
13 to 17	14	687	2.0%
18 to 24	51	815	5.9%
25 to 34	71	1170	5.7%
35 to 44	103	1127	8.4%
45 to 54	138	970	12.5%
55 to 64	205	1078	16.0%
65 to 74	248	888	21.8%
75 to 84	138	393	26.0%
85 and older	40	98	29.0%

Source: YCCHS Epidemiologist

New Booster Guidance

- The Centers for Disease Control and Prevention (CDC) has authorized Moderna and Johnson & Johnson/Janssen COVID-19 booster doses for eligible individuals.
- All providers administering COVID-19 vaccines can administer the booster vaccine as well, including pharmacies and primary providers.

Moderna & Pfizer-BioNTech COVID-19 vaccines:

- A single booster dose is recommended at least six months after completion of the initial two-dose primary series:
  - 65 years and older
  - 18 years and older living in long-term care setting
  - 18 years and older who have underlying medical conditions
  - 18 years and older who live in high-risk settings.

Johnson & Johnson/Janssen:

- A single booster does is recommended for:
  - 18 years and older at least two months after the original dose.

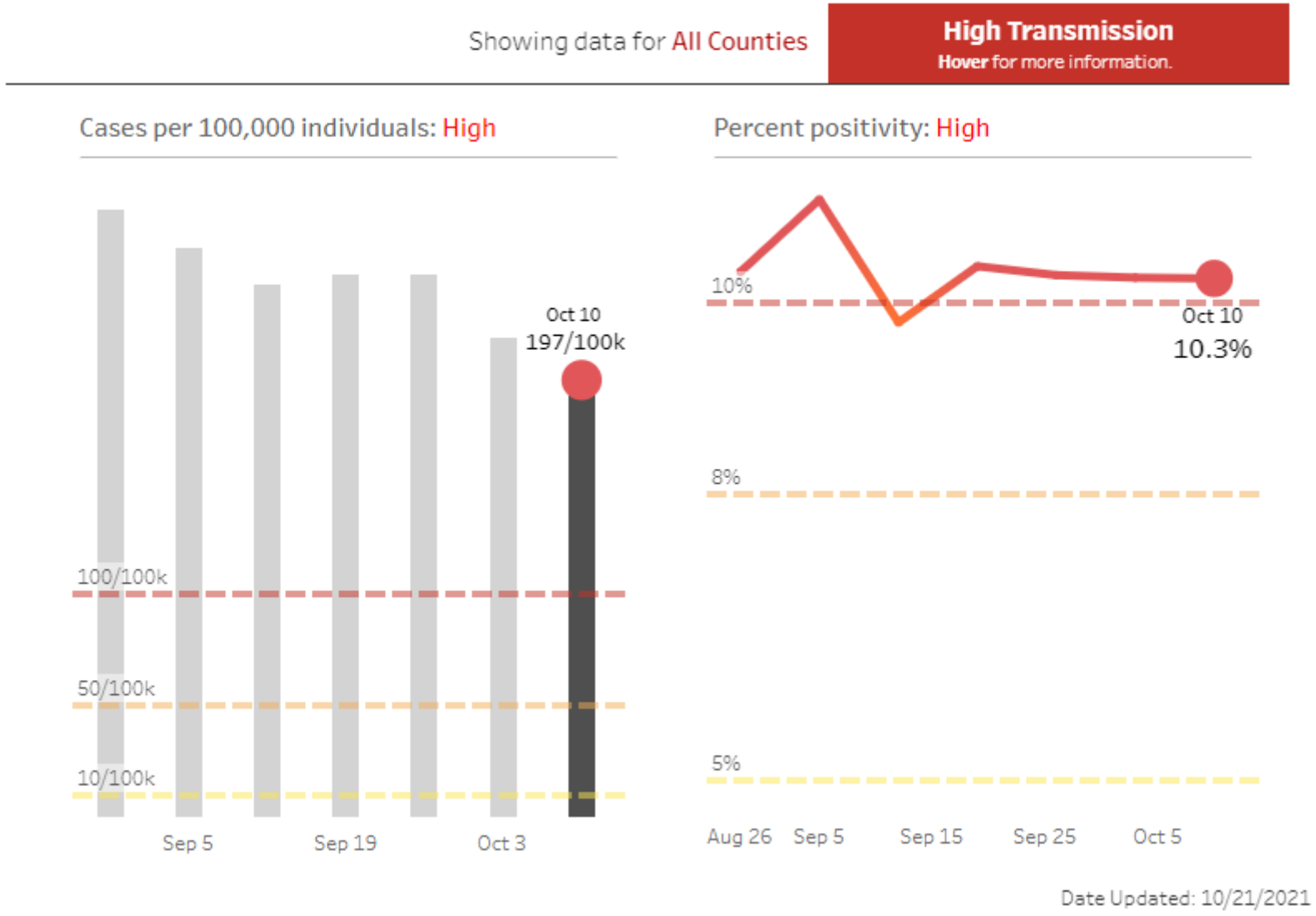
Heterologous or "Mix & Match" of Booster dose:

- CDC's recommendations allow for individuals to choose which type of vaccine they receive as a booster dose regardless of which they received for the primary series.
- This type of mix and match dosing is for booster shots only.

Source: Yavapai County Update October 25, 2021

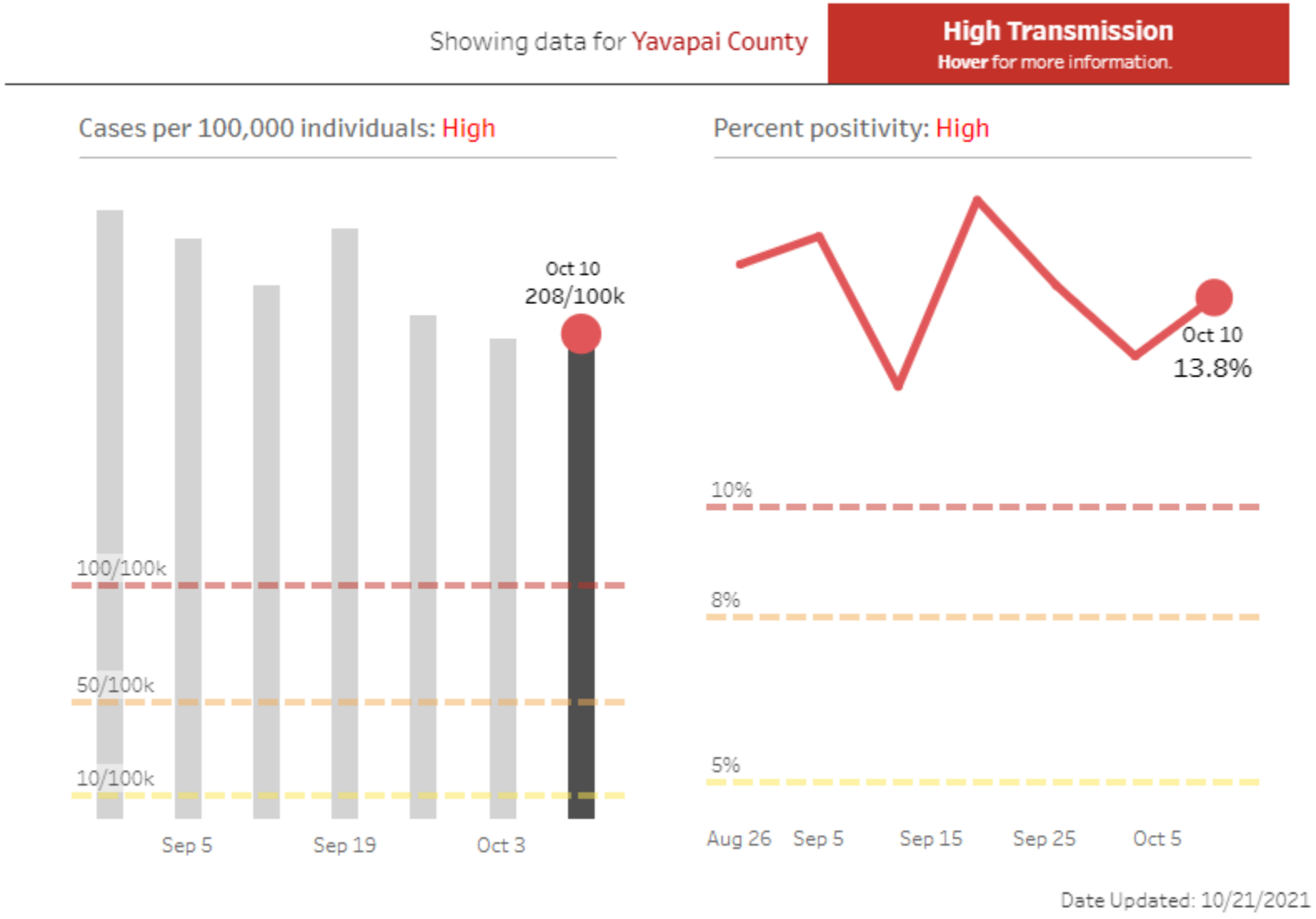
Questions?

Community Transmission: Coconino



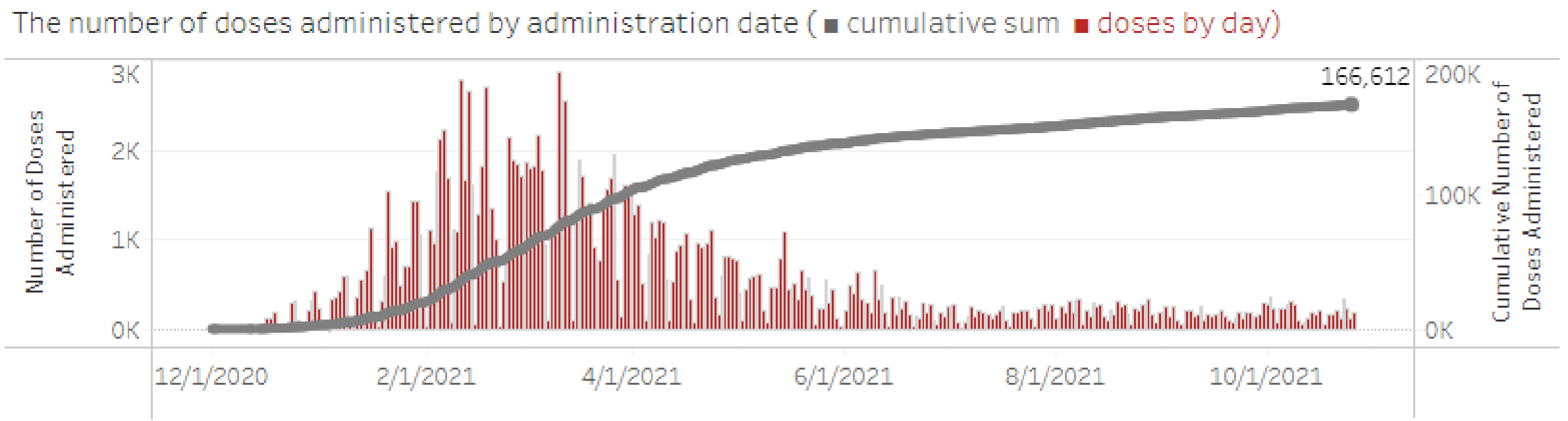
https://www.azdhs.gov/covid19/index.php#schools-dashboard

Community Transmission: Yavapai



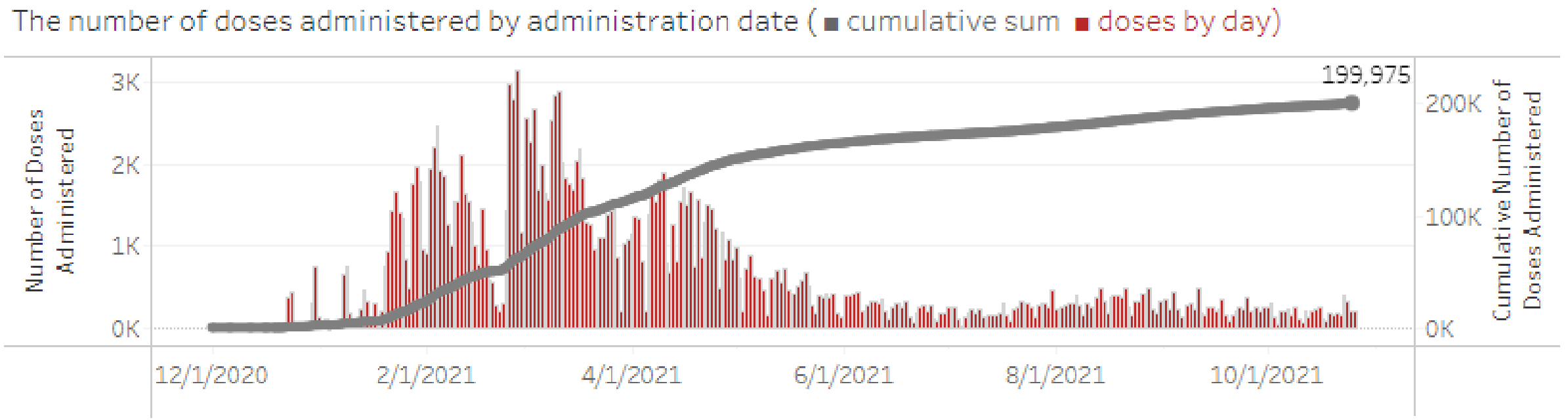
https://www.azdhs.gov/covid19/index.php#schools-dashboard

Vaccinations: Coconino



https://www.azdhs.gov/covid19/data/index.php#vaccine-admin

Vaccinations: Yavapai



https://www.azdhs.gov/covid19/data/index.php#vaccine-admin