

# Wildfires & Debris Flows, Oh my!

Mike Conway – Ann Youberg



2010 Schultz Fire (Flagstaff)



2011 Wallow Fire (Alpine)



2012 Gladiator Fire (Crown King)



2011 Monument Fire (Huachuca Mtns)



2011 Horseshoe 2 Fire (Chiricahua Mtn)

Photos courtesy of USFS

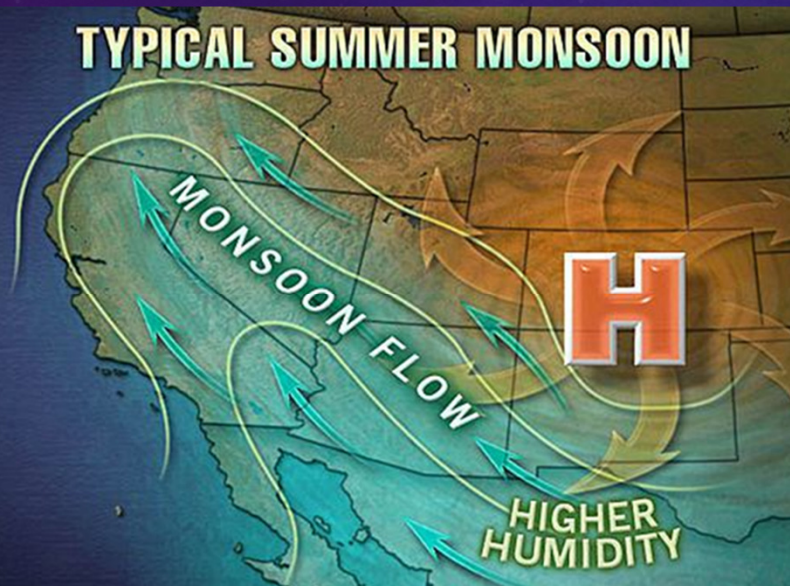
# Debris flow — concrete slurry: the perfect analog



- 60%+ by volume - loose mud, sand, soil, & rock - water and air that travels downslope.
- solids > water (viscous slurry)
- > ½ solids in the mass larger than sand grains;
- Speed – slow to fast up to 100 mph

# Fire and Rain

## DEBRIS FLOWS



Horseshoe 2 Fire Intl Space Station 2011

**Factors influencing how watersheds respond to wildfire:  
precipitation intensity, burn severity, availability of debris, slope  
DROUGHT**



# Tracking wildfires w/ InciWeb Incident Info U.S.A.

<http://inciweb.nwcg.gov/>

## Camillo Fire

[Incident Information](#) [Announcements](#) [Closures](#) [News](#) [Photographs](#) [Maps](#)

### NEWS RELEASE

**Update June 25, 2015**

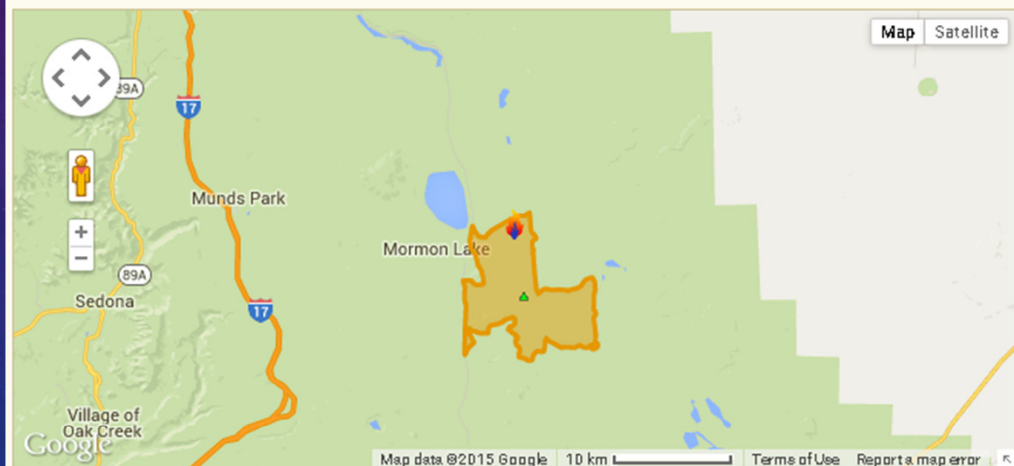
Fire operations will continue on the managed Camillo Fire located 20 miles south of Flagstaff, while the managed Horse Tank Fire moves to patrol status and total acreage concluded at 3,603 acres...

[more](#)

**INCIDENT UPDATED 5 HRS. AGO**

### Approximate Location

34.916 latitude, -111.393 longitude



### Incident Overview

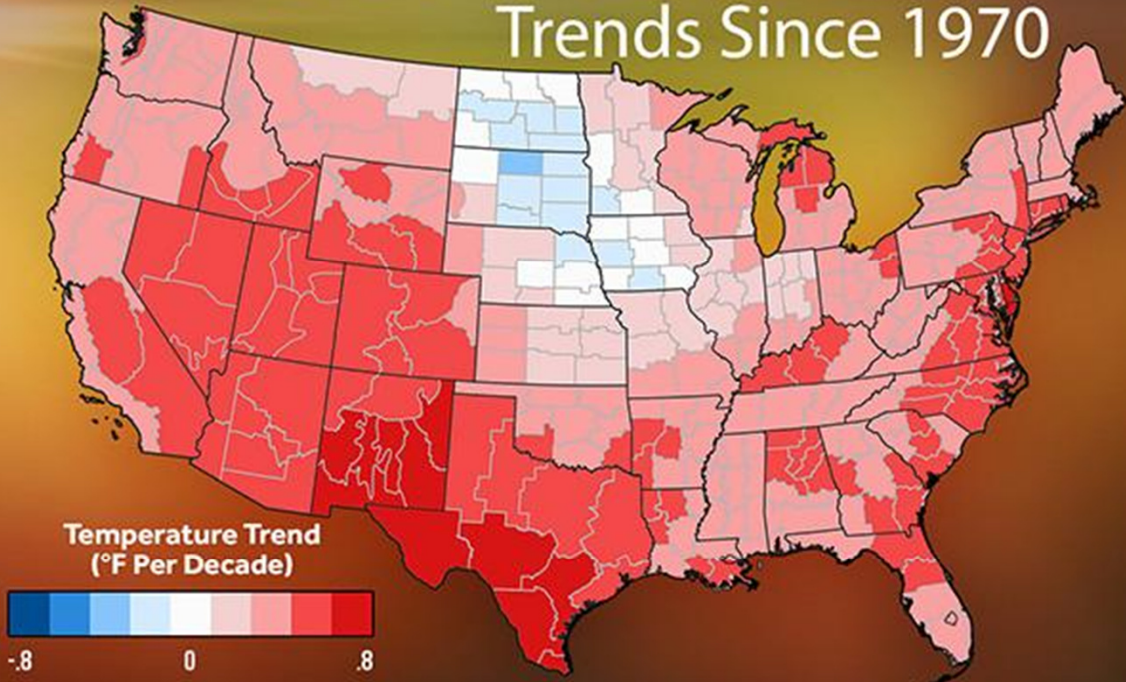
Fire managers on the Coconino National Forest are utilizing the lightning-caused Camillo Fire located approximately 20 miles south of Flagstaff near Mormon Lake. The Camillo Fire is fulfilling its natural and crucial role in forest health and fuels reduction. The forest needs frequent, low severity fire to restore wildlife habitat, promote healthy vegetation, reduce fuels and the risk of severe fire, and create safer conditions for residents, visitors, and firefighters.



Climate

# SUMMER HEAT

Trends Since 1970



June, July, August 1970-2014  
Source: NOAA/NCEI Climate at a Glance

CLIMATE CENTRAL

# Climate at a glance

Got those climate change blues, again!

NOAA



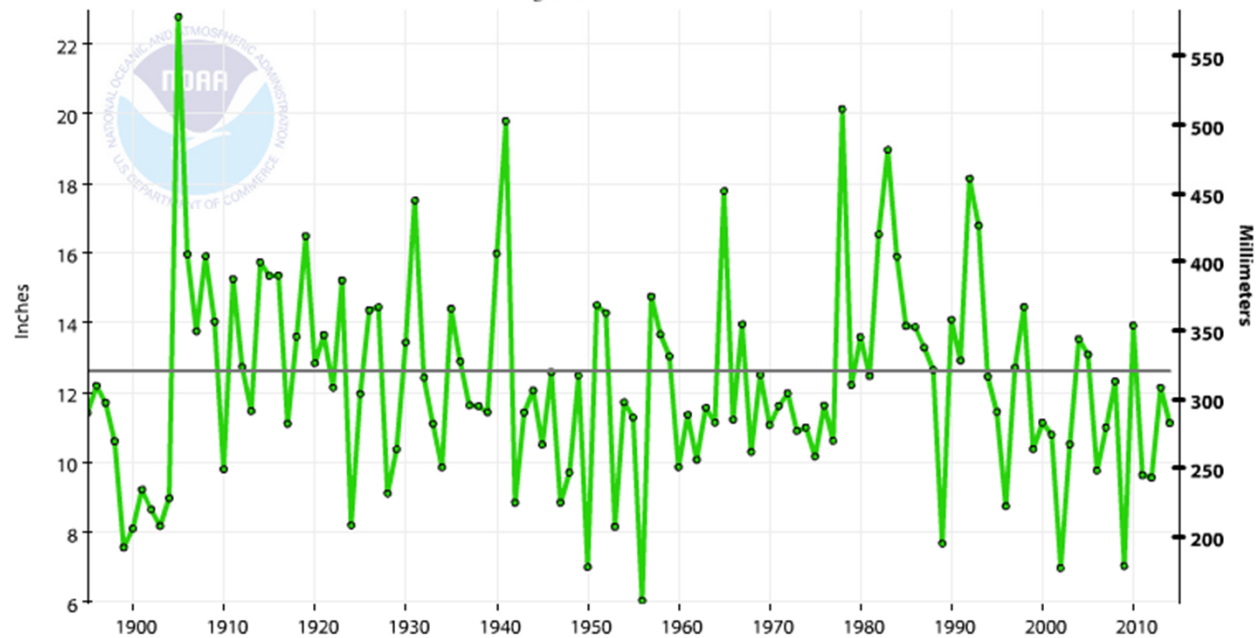
Plot



Move mouse towards an axis until highlighted. Left-click mouse to **pan**. Shift key + left-click to **zoom**.

Arizona, Precipitation, January-December

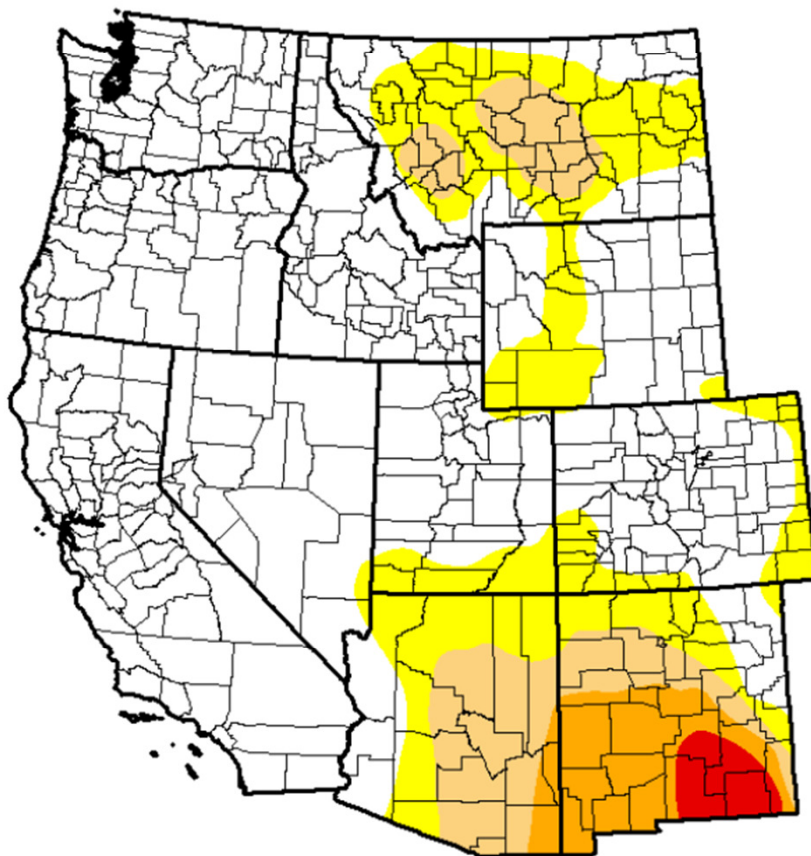
— 1901-2000 Avg: 12.62" — Precip



Download: [XML](#) [PDF](#) [Image](#)

# U.S. Drought Monitor West

**June 6, 2000**  
(Released Thursday, Jun. 8, 2000)  
Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	69.20	30.80	14.30	5.84	1.34	0.00
<b>Last Week</b> 5/30/2000	73.80	26.20	16.04	5.93	1.36	0.00
<b>3 Months Ago</b> 3/7/2000	76.08	23.92	7.90	0.60	0.00	0.00
<b>Start of Calendar Year</b> 1/4/2000	80.42	19.58	0.18	0.01	0.00	0.00
<b>Start of Water Year</b>	-	-	-	-	-	-
<b>One Year Ago</b>	-	-	-	-	-	-

Intensity:

- 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. See accompanying text summary for forecast statements.

**Author:**  
Staff  
National Drought Mitigation Center



<http://droughtmonitor.unl.edu/>

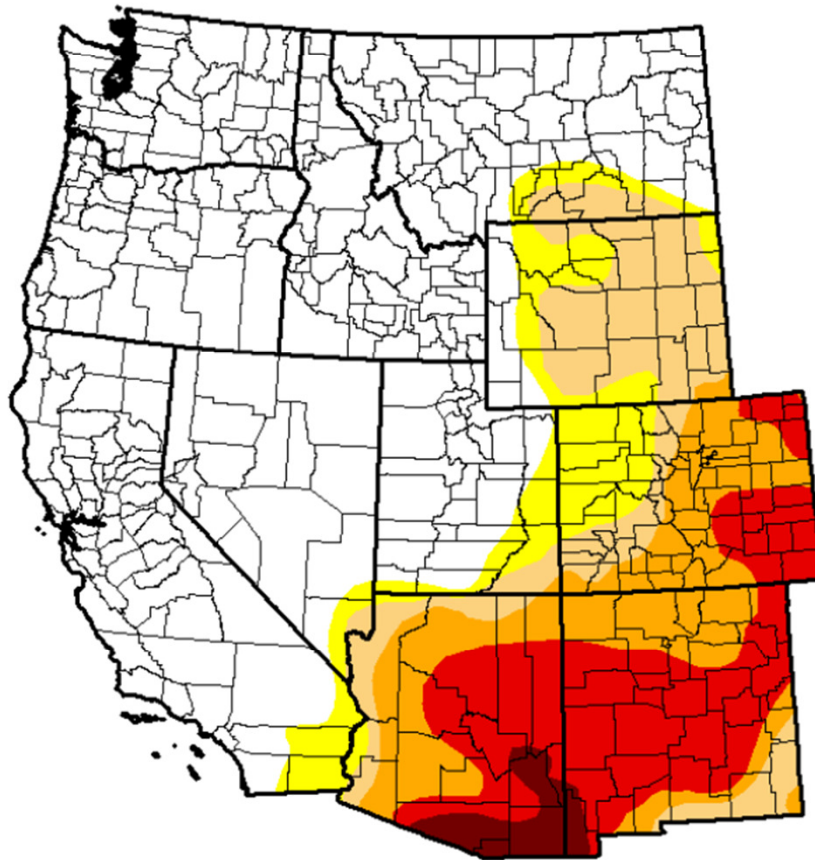


# U.S. Drought Monitor West

**June 13, 2006**

(Released Thursday, Jun. 15, 2006)

Valid 7 a.m. EST



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	59.74	40.26	32.81	23.10	13.37	1.66
<b>Last Week</b> 6/6/2006	59.97	40.03	30.75	22.85	12.34	1.68
<b>3 Months Ago</b> 3/14/2006	59.82	40.18	25.14	15.33	5.00	0.00
<b>Start of Calendar Year</b> 1/3/2006	57.59	42.41	14.39	0.00	0.00	0.00
<b>Start of Water Year</b> 9/27/2005	45.73	54.27	30.88	11.63	0.96	0.00
<b>One Year Ago</b> 6/14/2005	53.64	46.36	16.46	0.74	0.00	0.00

Intensity:

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

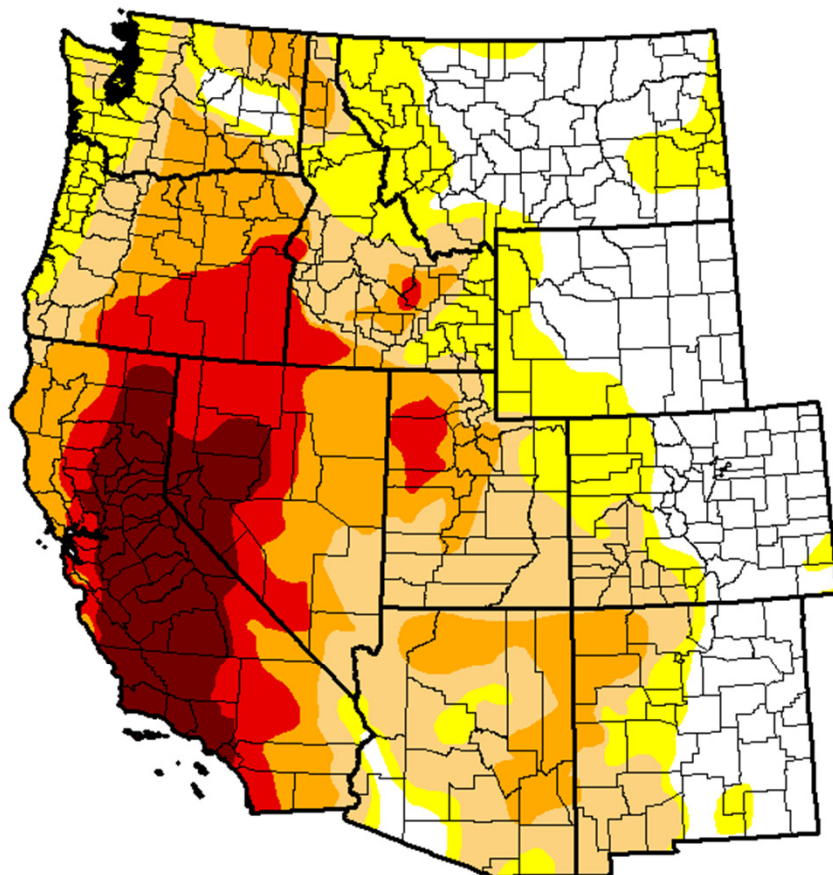
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

**Author:**  
Richard Tinker  
CPC/NOAA/NWS/NCEP



<http://droughtmonitor.unl.edu/>

# U.S. Drought Monitor West



**June 2, 2015**  
(Released Thursday, Jun. 4, 2015)  
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	25.23	74.77	56.98	35.92	17.99	7.94
<b>Last Week</b> <i>5/26/2015</i>	25.37	74.63	57.03	35.92	17.59	7.94
<b>3 Months Ago</b> <i>3/3/2015</i>	29.95	70.05	59.79	29.48	16.62	7.04
<b>Start of Calendar Year</b> <i>12/30/2014</i>	34.76	65.24	54.48	33.50	18.68	5.40
<b>Start of Water Year</b> <i>9/30/2014</i>	31.48	68.52	55.57	35.65	19.95	8.90
<b>One Year Ago</b> <i>6/3/2014</i>	31.84	68.16	60.32	47.21	20.20	4.31

Intensity:

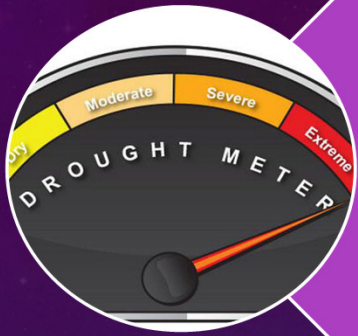


*The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.*

**Author:**  
David Miskus  
NOAA/NWS/NCEP/CPC

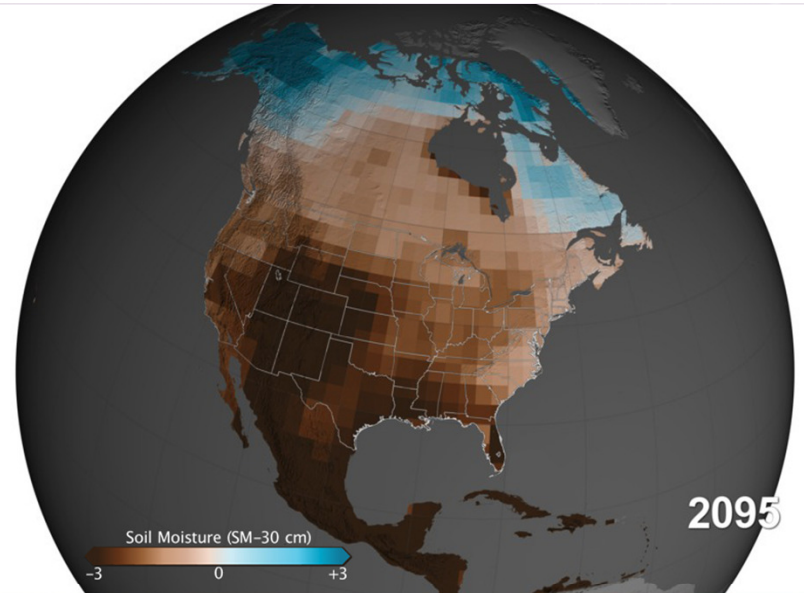


<http://droughtmonitor.unl.edu/>



## Mega-Drought

- Last SW MD ~ 1,000 yrs
- Climate models forecasting MD 2050-2099 (NASA, Cornell, Columbia)

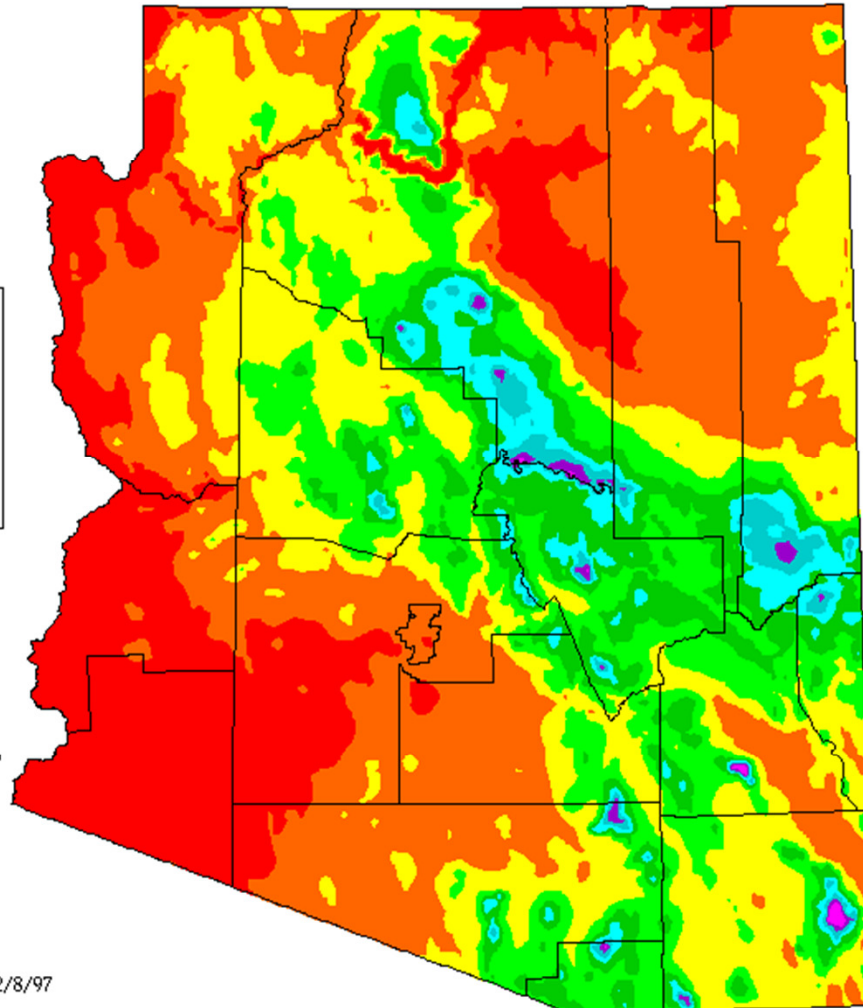


Arizona Monsoon >> South to SE winds bringing moisture  
from Gulf of CA & Gulf of MX



## Average Annual Precipitation

### Arizona



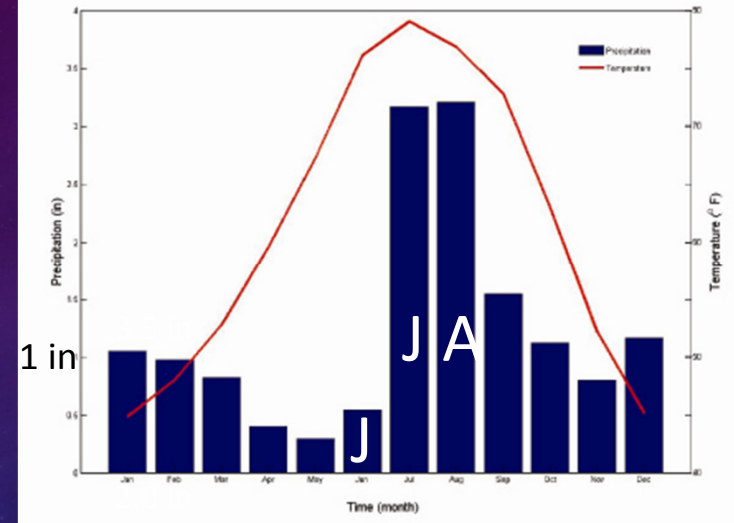
#### Legend (in inches)



Period: 1961-1990

This map is a plot of 1961-1990 annual average precipitation contours from NOAA Cooperative stations and (where appropriate) USDA-NRCS SNOTEL stations. Christopher Daly used the PRISM model to generate the gridded estimates from which this map was derived; the modeled grid was approximately 4x4 km latitude/longitude, and was resampled to 2x2 km using a Gaussian filter. Mapping was performed by Jenny Weisburg. Funding was provided by USDA-NRCS National Water and Climate Center.

12/8/97



SE Arizona

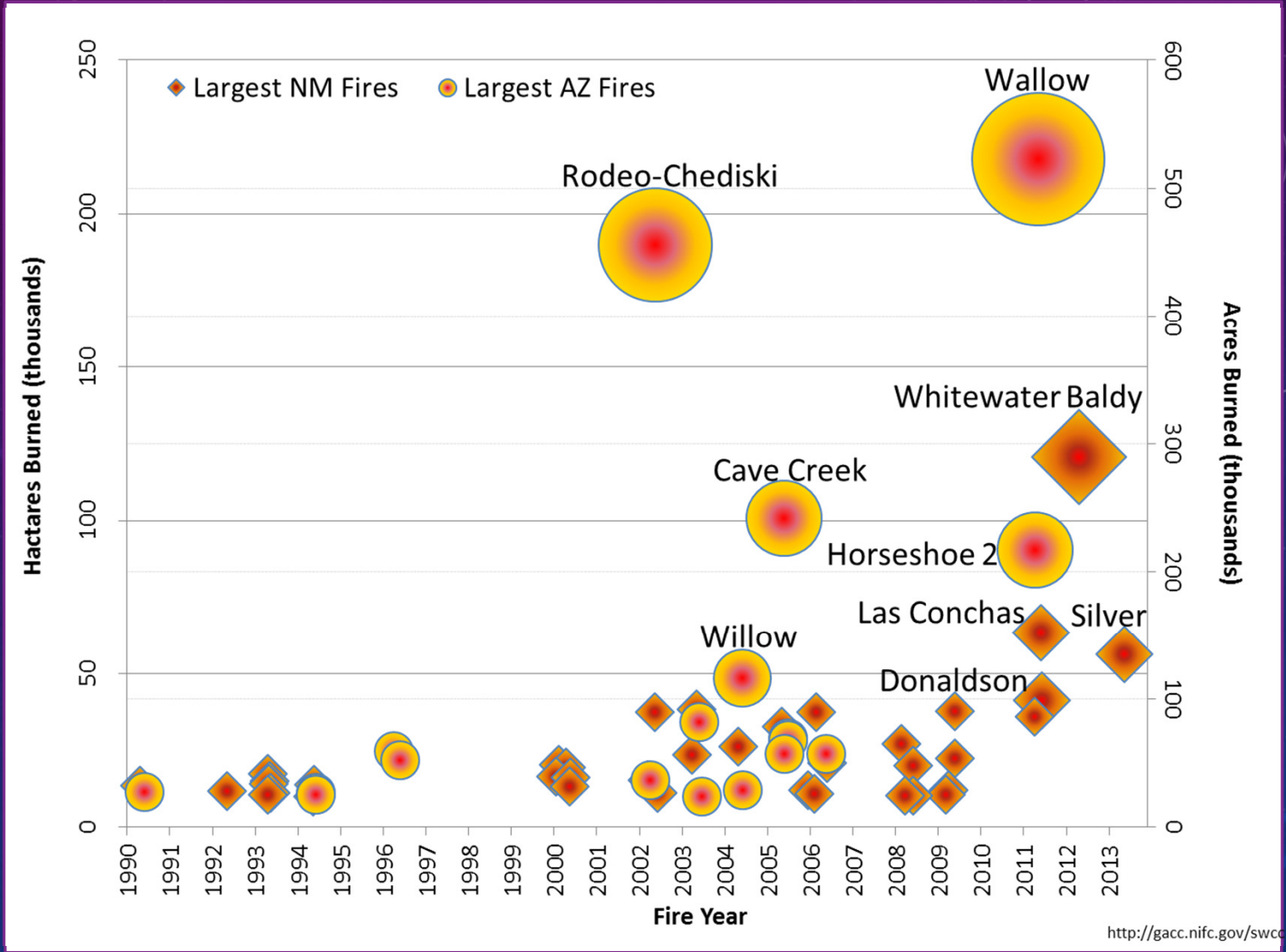
Avg. monthly precipitation

1930-2022

# AZ – NM Wildfires

Higher Temp + Drought

Bigger, badder & more frequent wildfires



# Debris flow event





Debris flow  
deposit  
Grand Canyon, AZ







2005 Florida Fire  
Madera Canyon  
Santa Rita Mtns



2011 Monument Fire  
Miller Canyon/Beatty's  
Debris-flow deposits in  
Foreground, flood damaged  
Cabin in background.



2011 Monument Fire  
Miller Canyon/Beatty's  
Flood-damaged cabin.  
2-yr 60-min storm



2011 Monument Fire  
Miller Canyon/Beatty's  
Grus from this tiny drainage  
put a slug of sediment in and  
around this cabin. Not clear if  
debris flow or  
hyperconcentrated.  
2-yr 60-min storm



Sabino Canyon, July 2006  
Debris flow event





## Geodatabase of Post-Wildfire Study Basins

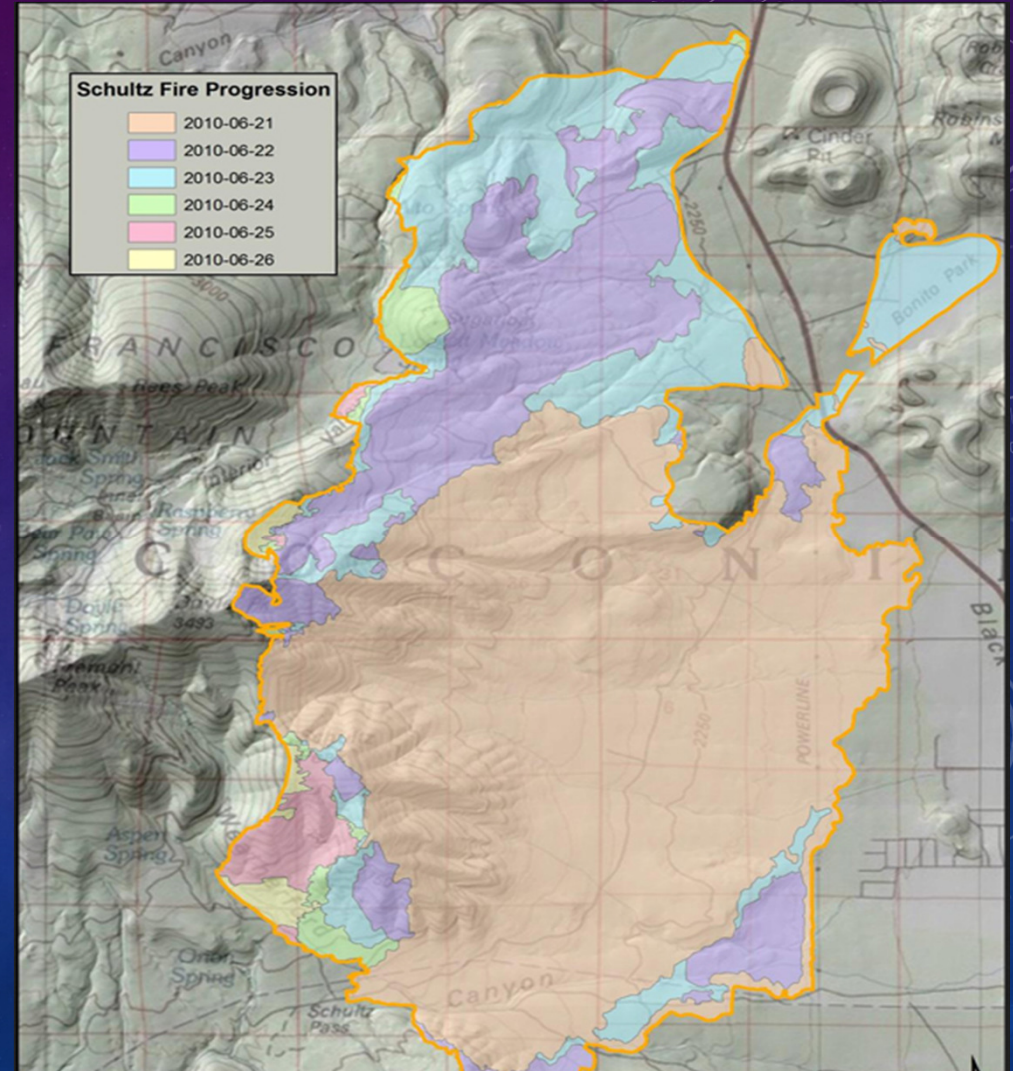
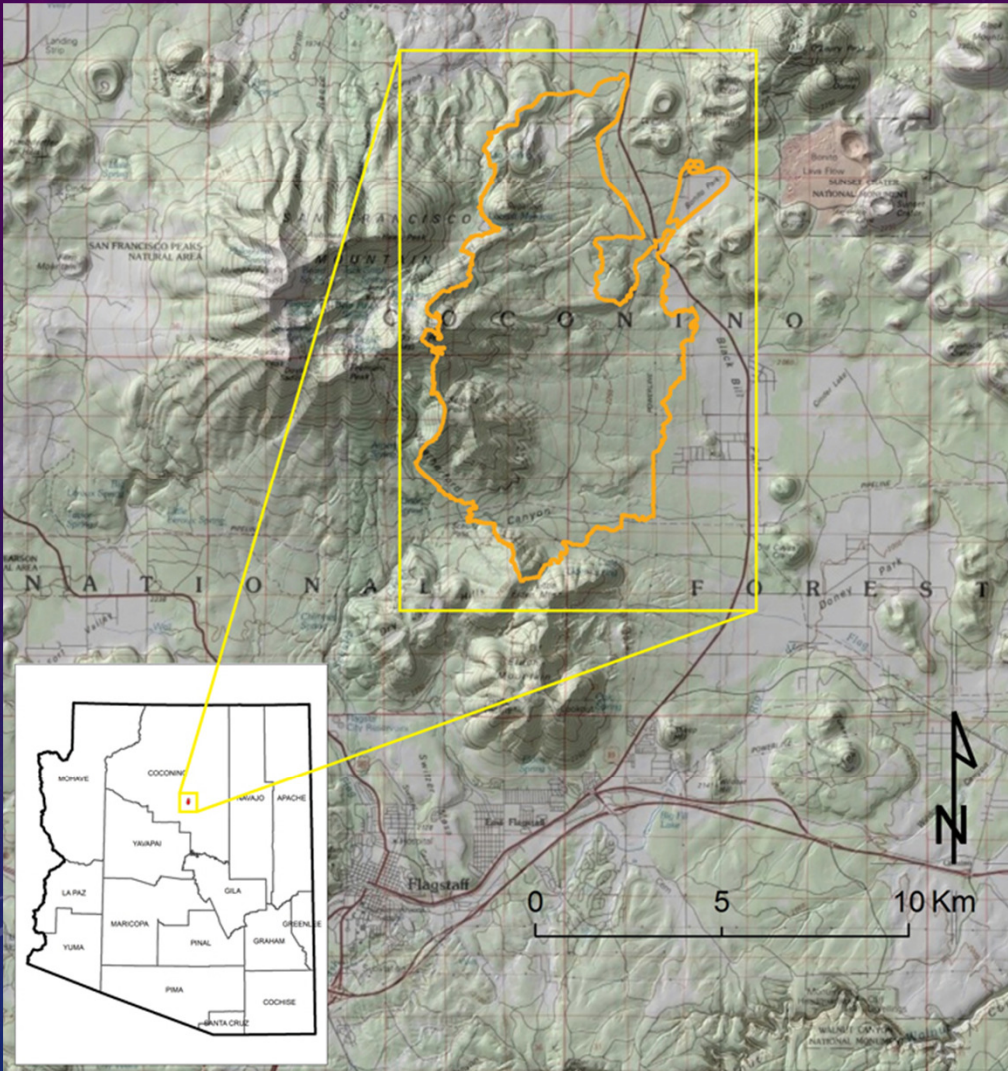
Assessing the predictive strengths of post-wildfire debris-flow models in Arizona and defining rainfall intensity-duration thresholds for initiation of post-fire debris flow

Ann Youberg



cisco Peaks 2010

# Schultz Fire 2010 – 15,070 acres Coconino NF



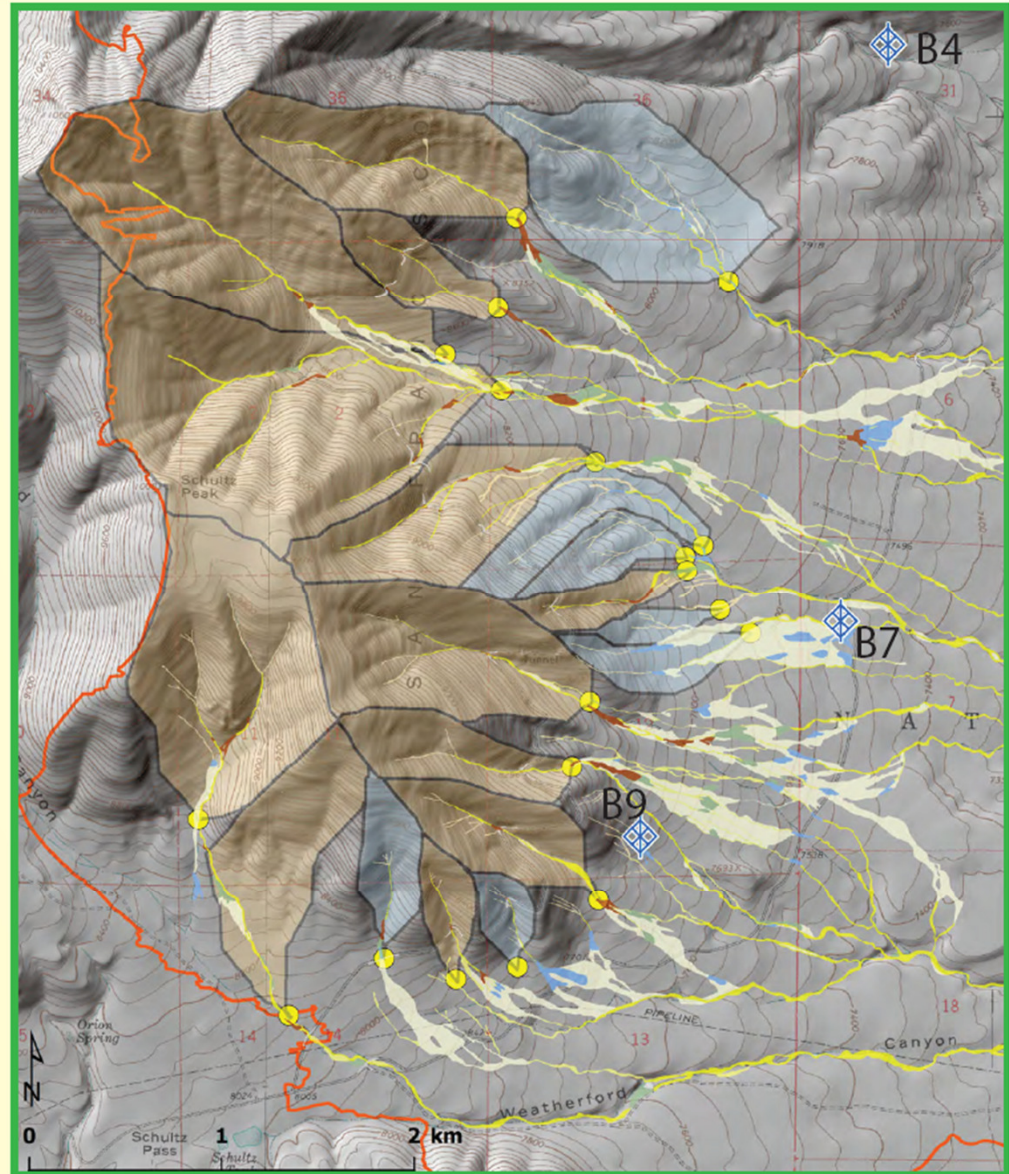




# San Francisco Peak, Arizona Schultz Fire 2001

Opportunities for flooding &  
debris flows abound (basins  
 $n=19$ )

Schultz Fire Basins ( $n = 19$ ) with  
outlets based on flood and debris flow  
deposit locations at or just  
below the base of the steep, upper  
slopes.



# 2011 Schultz Fire chars San Francisco Peaks



Burned slopes of the Schultz Fire. (D. Neary, RMRS)



June 29, 2010  
Flagstaff Water



August 17, 2010  
AZGS

Basin condition in the Schultz Fire  
burned area: post-fire, pre-storm  
(above), post-storms (right).  
(Numbers match trees between  
photos)





July 25, 2010:  
San Francisco Peaks  
FR146 - drainage  
where the waterline  
was severed and  
removed by debris  
flows on July 20th.

Roadbed demolished  
by the August 16th  
debris flows.

Photo: D. Fleishman, USFS.

*'Watersheds subject to moderate to high severity burns are prone to much greater runoff – both in volume and velocity - due to decreased interception and infiltration.'*

Hillslope erosion along FR146, San Francisco Peaks.  
August 17, 2010. Photo: A. Youberg, AZGS.





We can expect more wildfires  
in the future ...

Over the past two decades,  
several communities  
throughout Arizona have dealt  
with post-wildfire flooding,  
rapid erosion, and sediment  
remobilization.

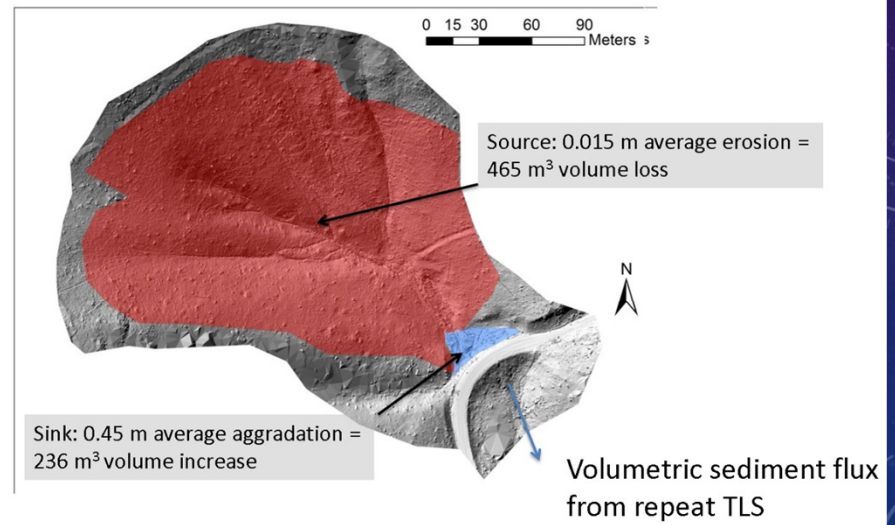
(Youberg, Koestner and Neary, 2011)



0.05 m DEM slopeshade June 21, 2011 then July 18, 2011



Volumetric sediment flux

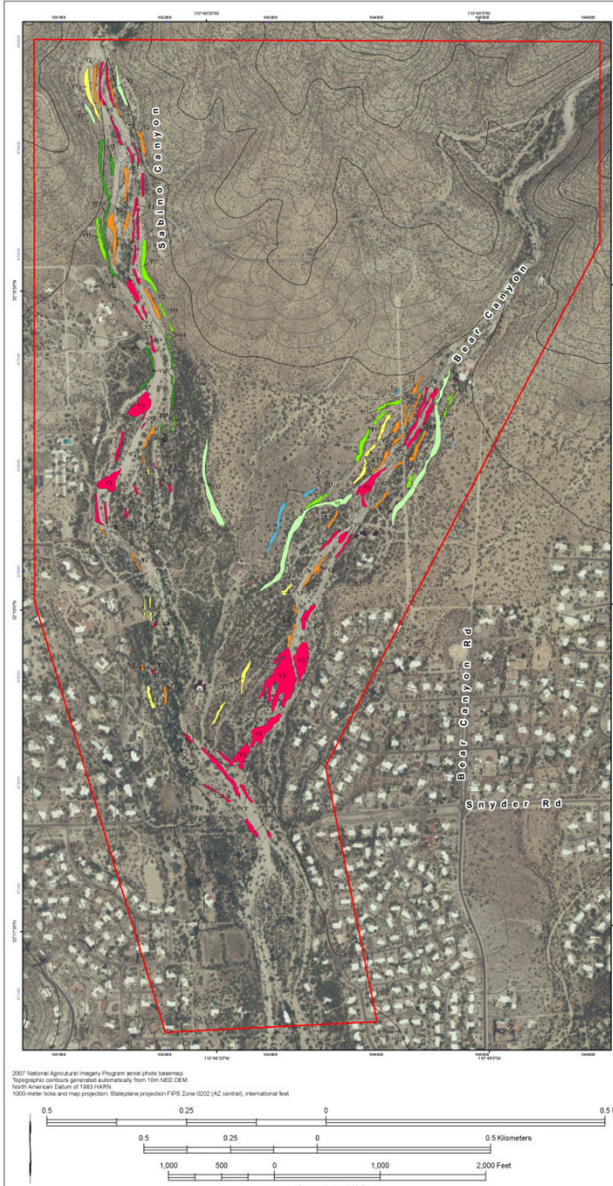


Terrestrial (lasar) Lidar Scanning  
- Monitoring landscape changes

# Mapping Pleistocene debris flow deposits

Youberg and other, 2008

Ancient debris flow deposits in Santa Catalina Mtns.

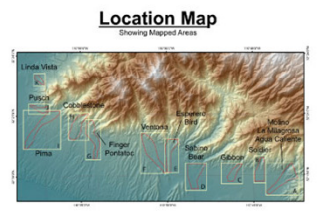


**Debris-Flow Deposits at the Mouths of Sabino and Bear Canyons, Pima County, AZ**  
 by Ann Youberg, Michael L. Cline, Joseph P. Cook and Philip A. Pearthree  
 Cartography by Ryan J. Clark  
 September 2008  
 Arizona Geological Survey Digital Map Series  
 Debris Flow Map 1D (DM-DF-1D)

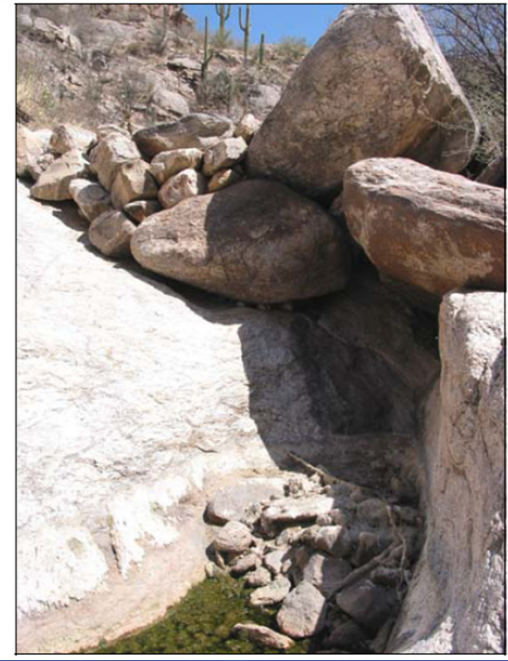
- Generalized Map Unit Descriptions**
- In deposits that are identified as either levees or snouts, the type of deposit is denoted by subscripted letter:  
 L = Debris-flow levee  
 S = Debris-flow snout
- Y1** Very young debris-flow deposits (latest Holocene to modern). Debris-flow deposits found in an alluvial active channel, near the mountain front and upper portions of active alluvial fans. Clasts are fresh and unweathered. Y1 deposits commonly are of intermediate adjacent to stream channels and are subject to incision by fluvial processes, so the extent and characteristics of deposits may change with flow events.
  - Y2** Young debris-flow deposits (middle to late Holocene). Debris-flow deposits found along banks and terraces of active reaches (about 1-2 miles above channel heads). Fine-grained matrix sediments are generally absent from Y2 deposits leaving only clasts that appear fresh and unweathered. Vegetation typically is sparse on banked terraces and snouts.
  - Y11** Intermediate debris-flow deposits (early to middle Holocene). Debris-flow deposits found 2-3 miles above active reaches near the mountain front and 1-2 miles above active reaches farther from the mountain front. Y11 deposits typically are fairly extensive on the upper portions of alluvial fans, but are confined to the valley bottom along limited drainage farther out from the mountain front. Clasts are generally slightly weathered, with light surface oxidation and fine rock faceting. Clasts in Y11 deposits may be slightly sorted from initial deposition and subsequent reworking, but unconsolidated, or weakly consolidated. Soil color varies from gray (Y11L) to brown (Y11S).
  - Y12** Older debris-flow deposits (early Pleistocene to early Holocene). Debris-flow deposits that are sparsely reworked from active reach deposits, often high standing by locally moderately stable vegetation, and commonly exhibit a planed faceting. Distinctions between faceting are slightly enhanced (Y12L), and in some areas clasts and pebbles to almost completely buried by fine deposits. Clasts from disintegrated deposits often have fine, discontinuous subvertical etching. In some areas Y12 deposits can be further classified into five levels.
  - Y111** Highest standing debris-flow deposits.
  - Y121** Debris-flow deposits of similar ages about 1-2 miles below Y11 deposits.
  - Y122** Debris-flow deposits of similar ages about 1-2 miles below Y11 deposits.
  - I** Pleistocene debris-flow deposits, un differentiated - Debris-flow deposits that are either the highest and most extensive in the Sabino and Bear Canyons and have clearly unsorted and (Y12L) or are individual deposits that have been buried by younger debris-flow flows and exposed through subsequent erosion.

**Description of Debris-Flow Deposit Boundaries**

- Contact, accurately located
- - - Contact, approximately located
- Contact, concealed beneath development



**Arizona Geological Survey**  
 416 W. Congress Street, Suite 100  
 Tucson, AZ 85701  
 (520) 773-3500  
 www.azgs.gov



2007 National Geographic Imagery Program aerial photo base map.  
 Topographic contours generated automatically from 10m NED DEM.  
 North arrow based on 1983 datum.  
 1000-meter UTM and map projection. Stateplane projection FIPS Zone 1000 (AZ central), International feet.

This map is part of AZGS Open-File Report 08-06, Suggested Citation: Youberg, Ann, Cline, M. L., Cook, J. P., Pearthree, P. A., and Clark, R. J., 2008, Geologic Map of Pleistocene Debris Flow Deposits in the Santa Catalina Mountains, Pima County, Arizona: Arizona Geological Survey Open-File Report 08-06, 47 p., 1:50,000 scale. DOI: 10.1061/(ASCE)1082-1724(2008)3:1(08).  
 Suggested citation for this cartographic map sheet: Youberg, Ann, Cline, M. L., Cook, J. P., Pearthree, P. A., and Clark, R. J., 2008, Geologic Map of Debris Flow Deposits at the Mouths of Sabino and Bear Canyons, Pima County, Arizona: Arizona Geological Survey Open-File Report 08-06, 47 p., 1:50,000 scale. DOI: 10.1061/(ASCE)1082-1724(2008)3:1(08).

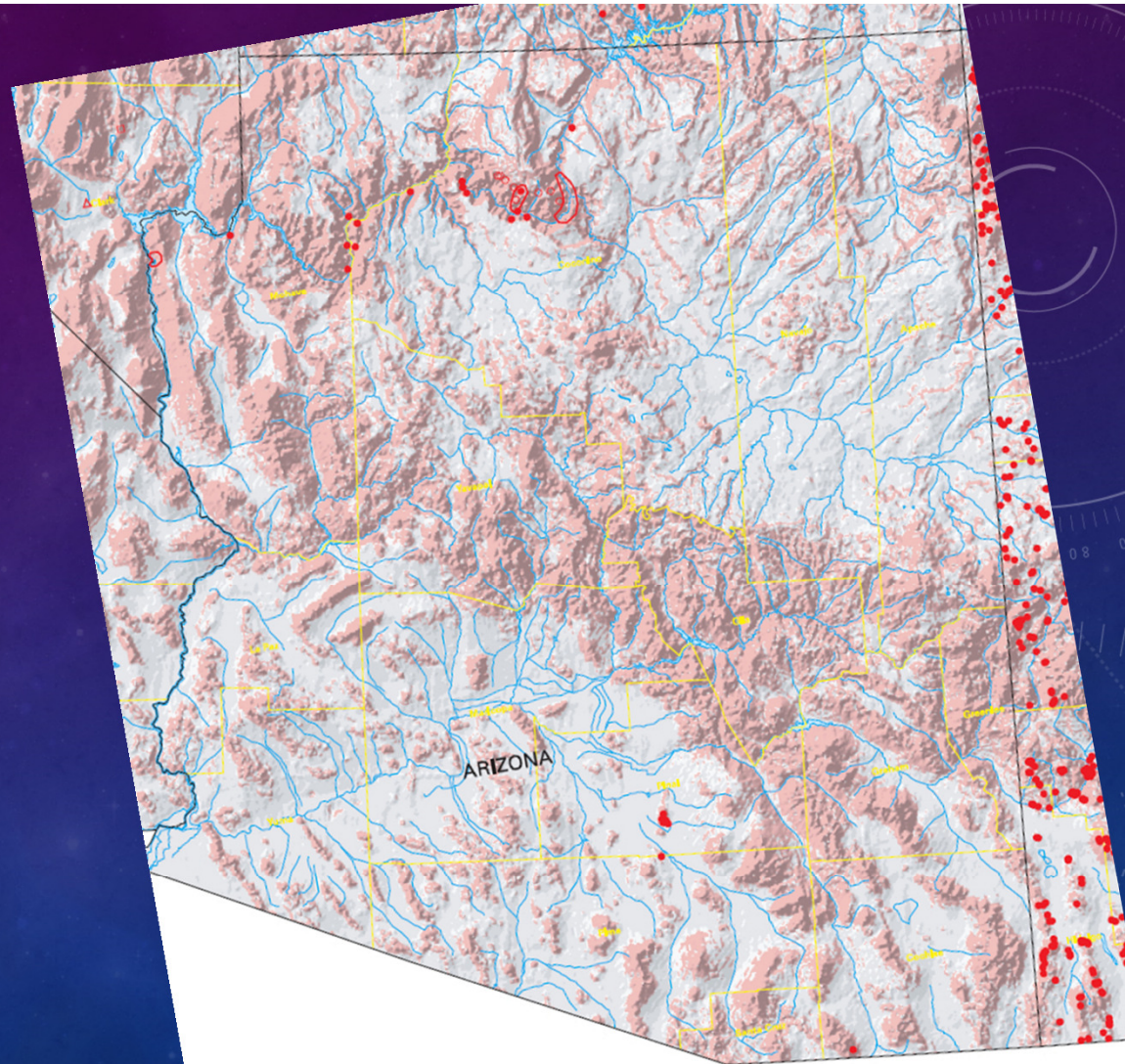


<http://pubs.usgs.gov/mf/1999/2329/>

# USGS Inventory of Holocene Debris Flows (1999): Arizona

● Debris flows

US Geological Survey National  
Landslide Program  
~ \$3.5 million annually



DLESE

Educational Resources ▾

Earth Science Literacy Maps ▾

For Developers ▾

## Digital Library for Earth System Education

Getting started with DLESE ▶

Browse the library ▶

debris flows

Educational resources

Grade Level ▶

Resource Type ▶

Collections ▶

Standards ▶

Clear selections

Search

News & opportunities

Tips

A free service for learners of all ages

<http://www.dlese.org/>

- K to gray
- Classroom, field & lab activities
- Simple search & retrieval
- Free & no registration

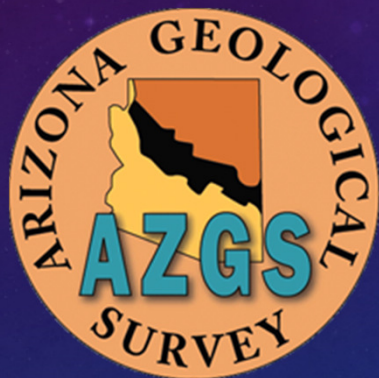


# Some online resources

InciWeb - <http://inciweb.nwcg.gov/>

Climate at a glance - <http://www.ncdc.noaa.gov/cag/>

AZGS Floods & Debris Flows - [http://www.azgs.az.gov/hazards\\_floods.shtml](http://www.azgs.az.gov/hazards_floods.shtml)



Michael Conway

Michael.Conway@azgs.az.gov

[AZGS.AZ.GOV/map\\_services](http://www.azgs.az.gov/map_services)

- ✓ Geologic map of Arizona
- ✓ Geologic map of Grand Canyon
- ✓ Natural Hazards in Arizona viewer

Story maps

- ✓ Geologist in Grand Canyon
- ✓ Arizona's San Pedro River



Schultz Fire 2010 – June 29 (top) Aug 9 (bottom)





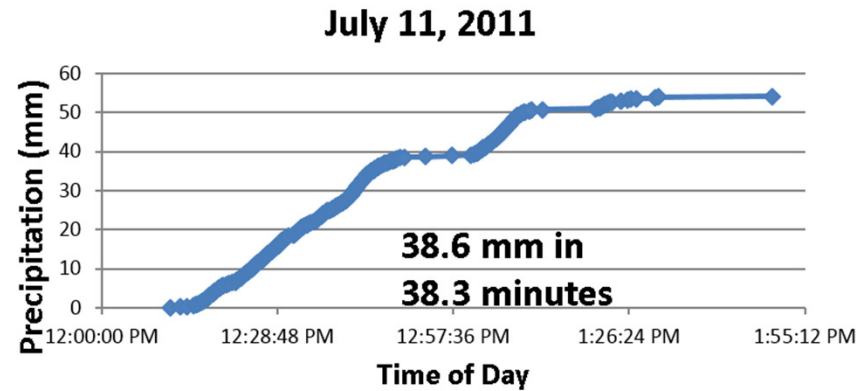
Biosphere 2  
Landscape Evolution Observatory

11:43 AM

# July 11 runoff



Biosphere 2  
THE UNIVERSITY OF ARIZONA



3:43 PM





*Debris in channel near Visitor's Center looking downstream from well site and downstream at 9 ft culverts*

Montezuma Creek – Coronado National forest  
Disturbed by fire in 1988, 2006, 2011.

Stephanie Yard and Allen Haden (2011)