Arizona's Earthquakes

Presented by Jeri J. Young, AZGS

&

Dave Brumbaugh, NAU

July 26th, 2012

Arizona Geological Survey

Northern Arizona University

Road Map

- Who is monitoring? And why?
- What counties/Tribal Nations have earthquake hazard?
- Examples of earthquake faults and seismicity.
- What can you do to prepare?
- Why maintain AISN?

Who is monitoring? And Why?

AISN – Arizona Integrated Seismic Network

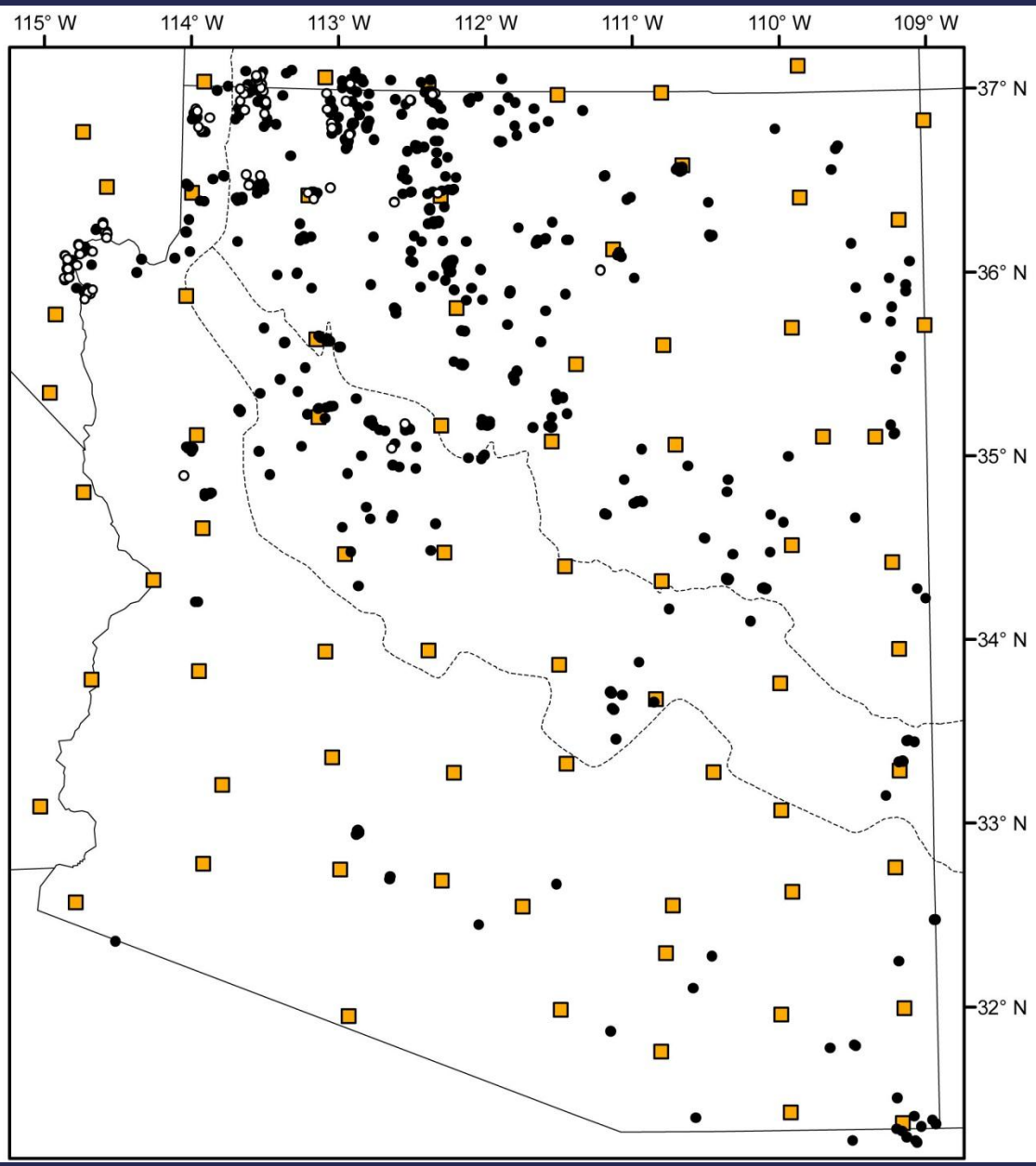
- Purchase of 8 new broadband seismometers
- Better characterize seismicity and young faulting in Arizona, and improve understanding of seismic hazard.
- Collaborative effort between the Arizona Geological Survey and NAU/AEIC.
- Combination of resources and expertise.

Comparison of Coverage

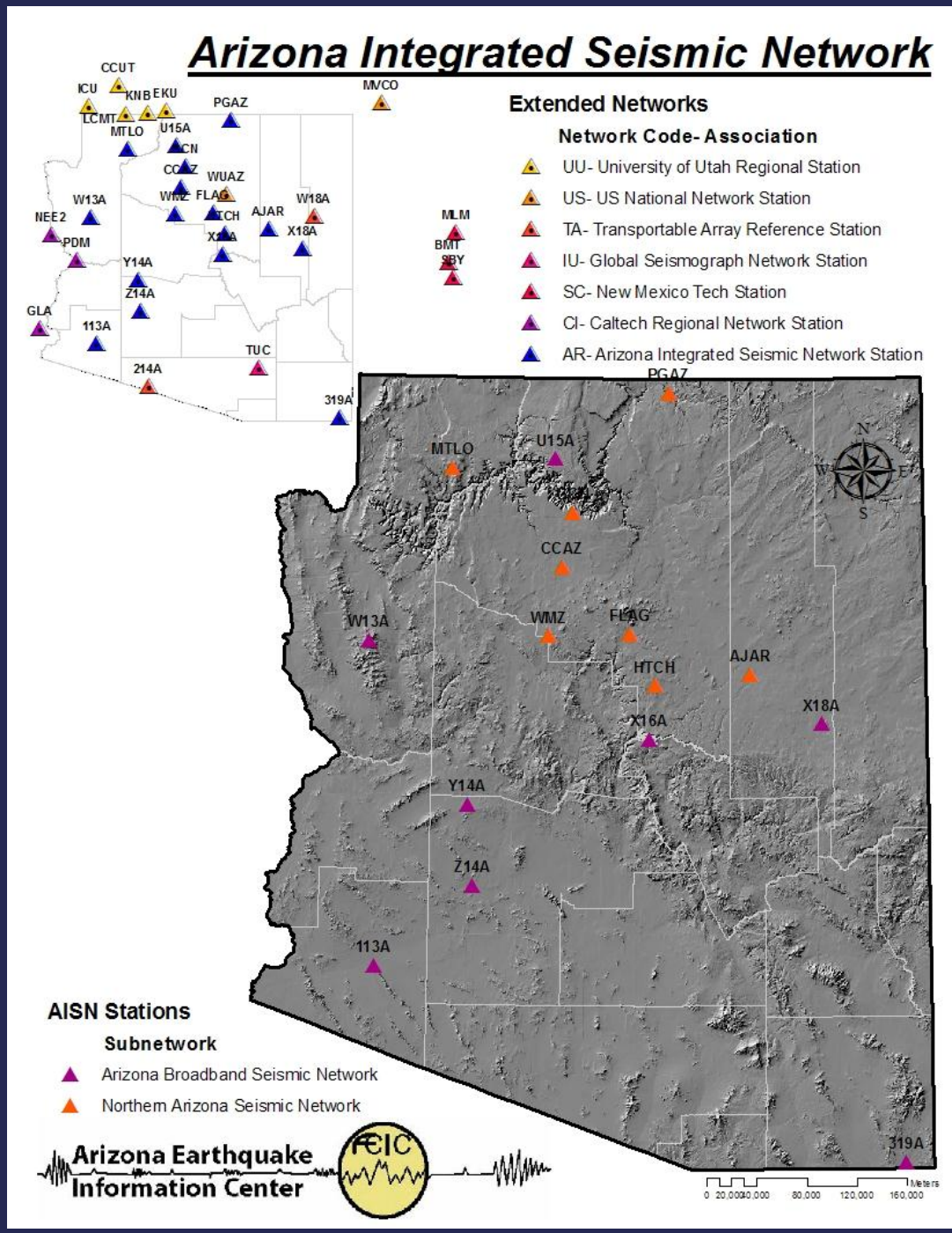
Many more earthquakes detected with more complete seismic network

1200 earthquakes compared to 80 earthquakes for same time period (about 1.5 yrs).

- ○ AEIC+ANSS Events (04/07-11/08)
- ● TA Events (04/07-11/08)
- ■ TA Stations

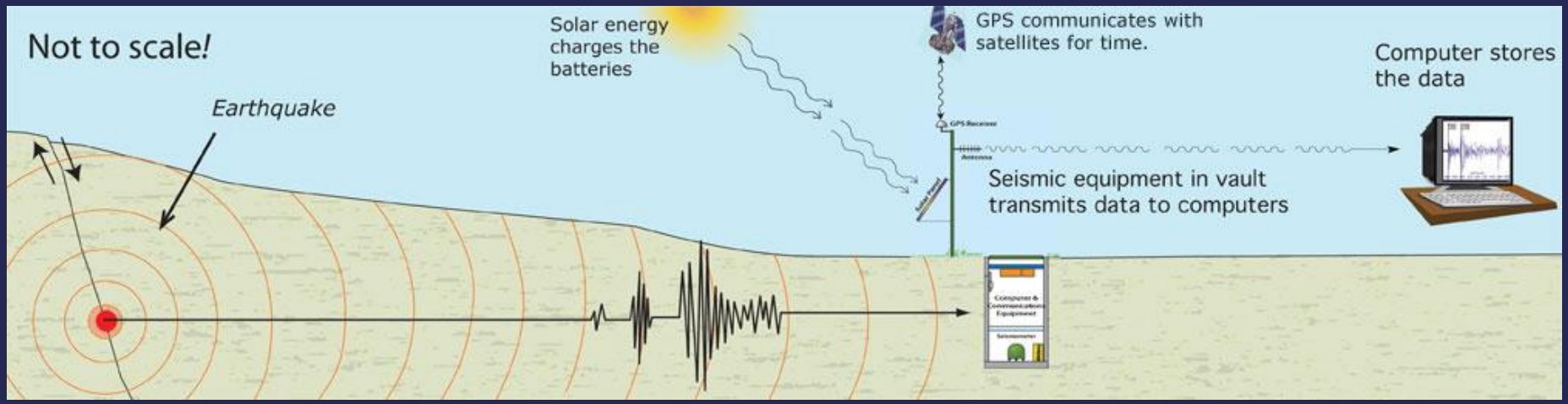


Current state coverage – Includes stations from neighboring networks



Monitoring Efforts

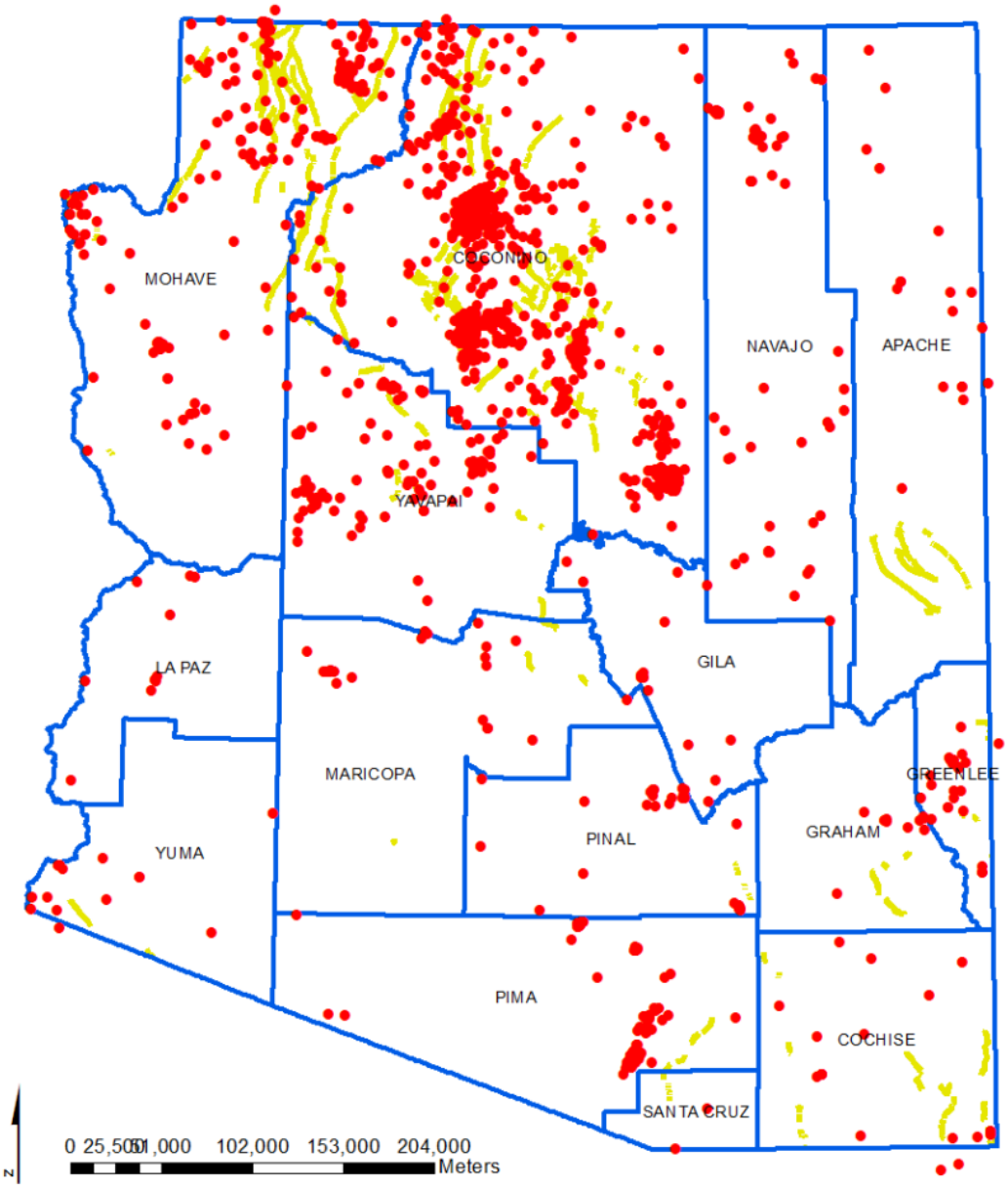
- Broadband Seismometers



Yes, Arizona has earthquakes

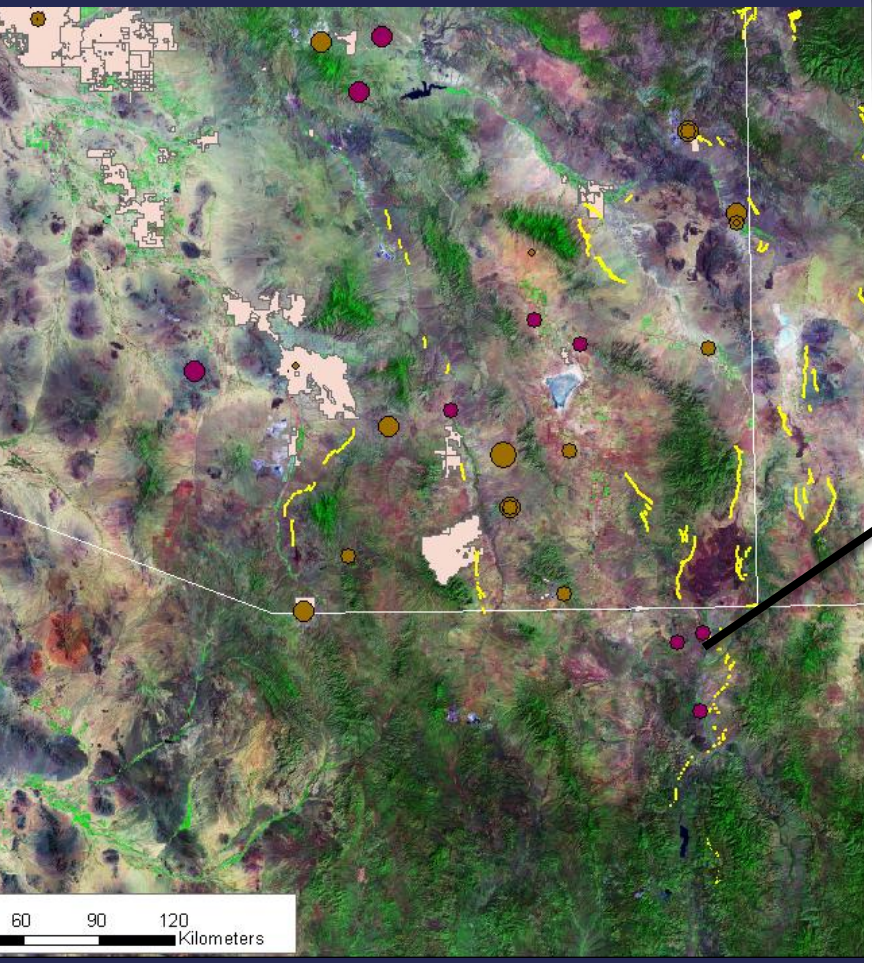
- Arizona's seismic hazard is largely ignored
- Several AZ Counties are at risk:
  - Coconino
  - Yuma
  - Yavapai
  - Mohave
  - Apache
  - Pima
  - Cochise
  - Maricopa – size, exposure
  - All counties should be prepared – no one is immune.

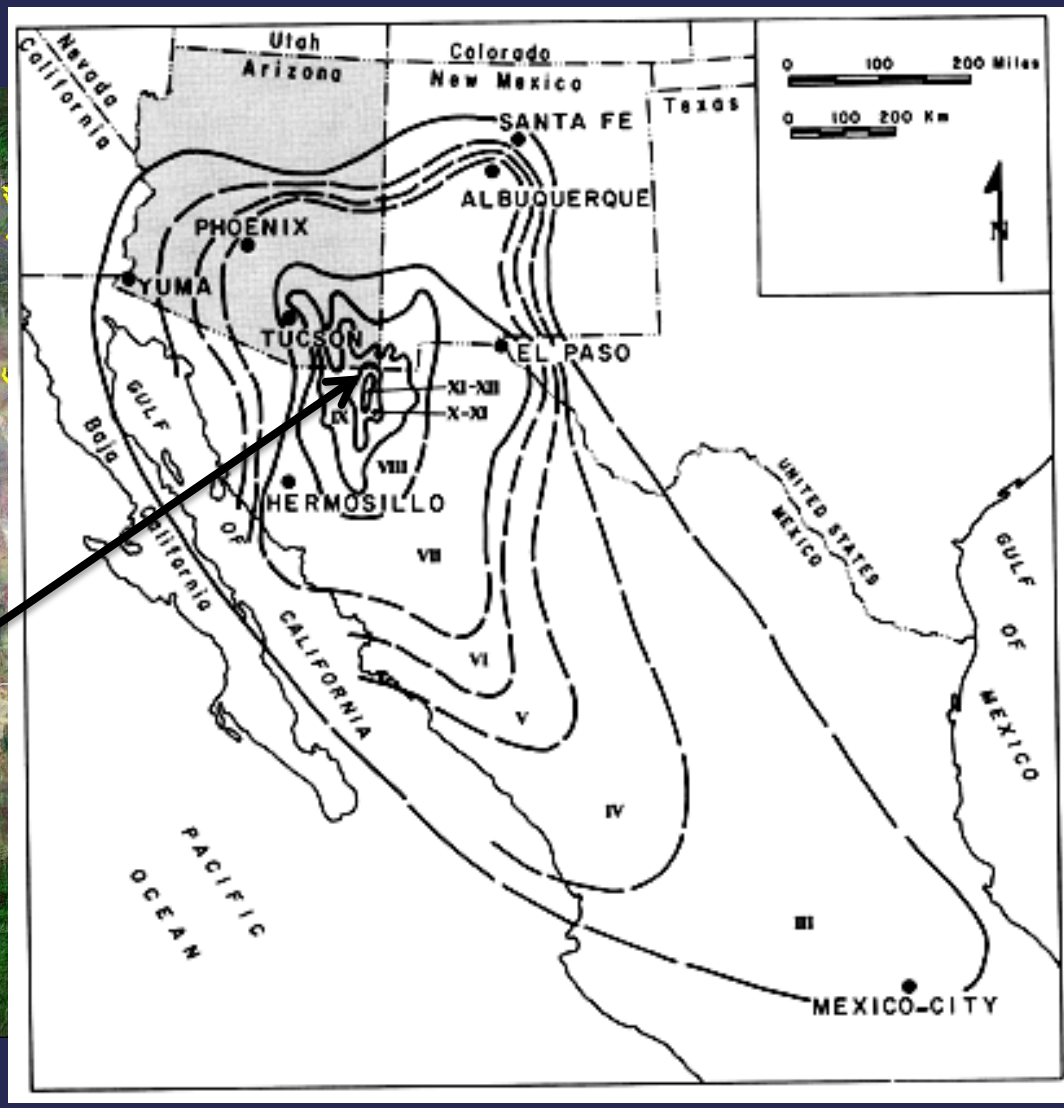
Arizona Counties - Seismicity and known faults



1887 Pitaycachi M 7.5 Event

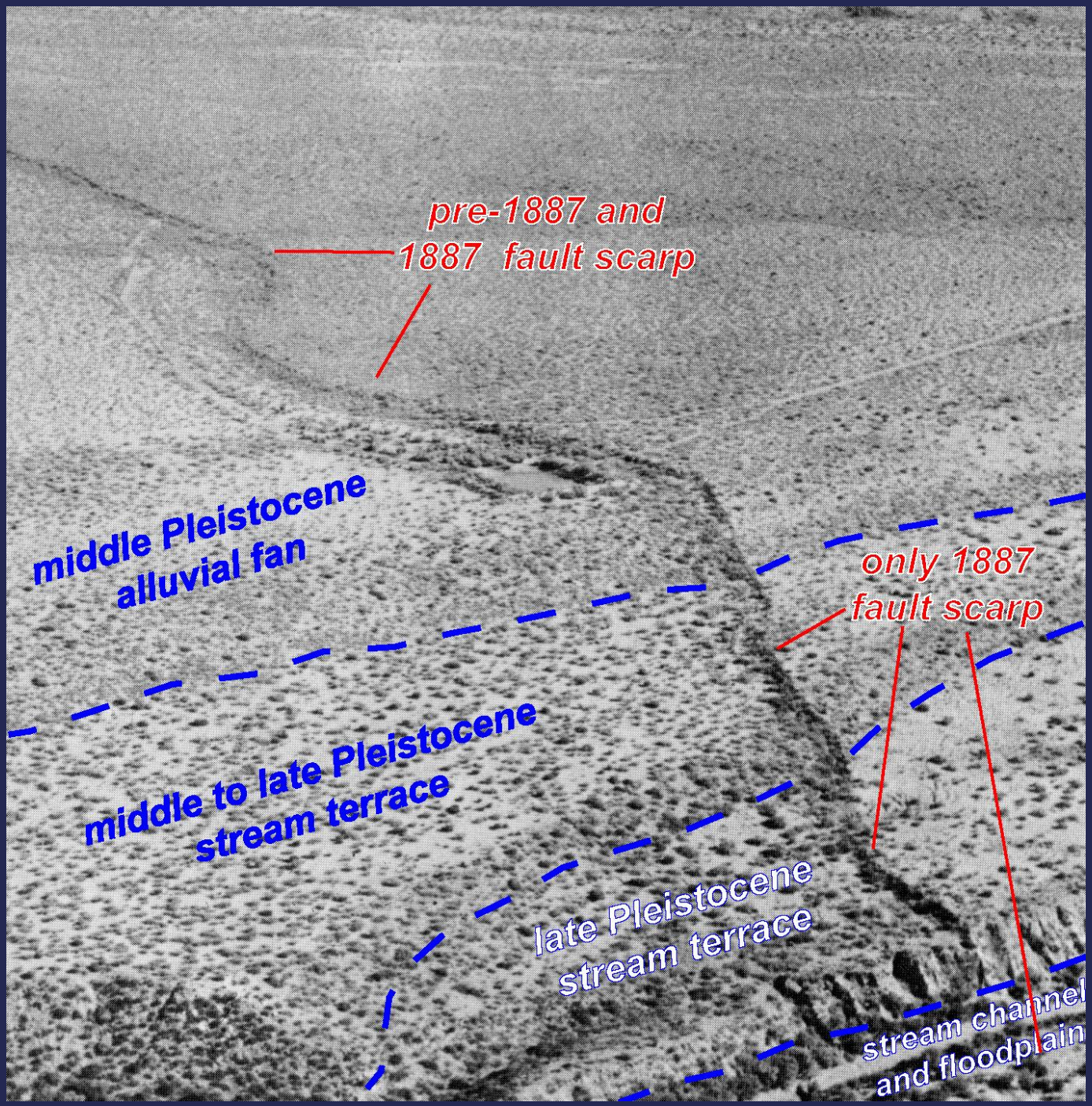
Example of a very long recurrence interval – Reminder to be prepared.





http://nisee.berkeley.edu/elibrary/index.html

Faulted and unfaulted landforms prior to 1887



Maximum Credible Earthquake

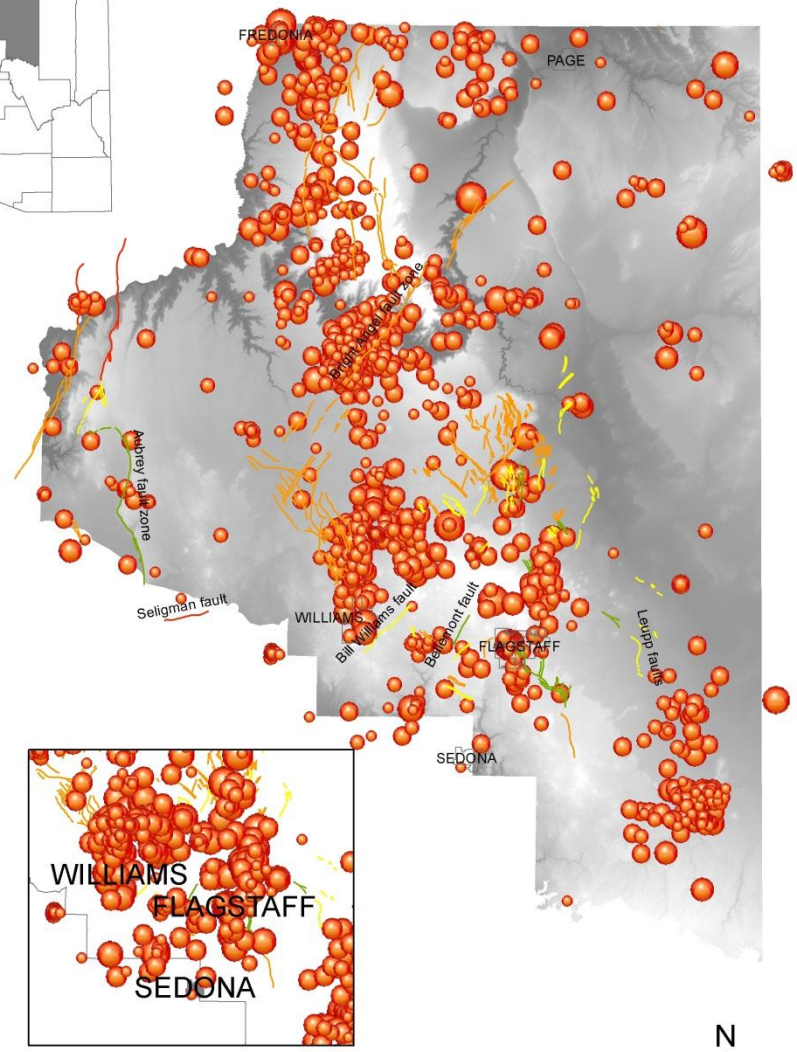
Wells and Coppersmith, 1984

- The largest hypothetical EQ
- Regression compiled from hundreds of EQs & associated databases:

$$M = (\log Mo)/1.5-10.7$$

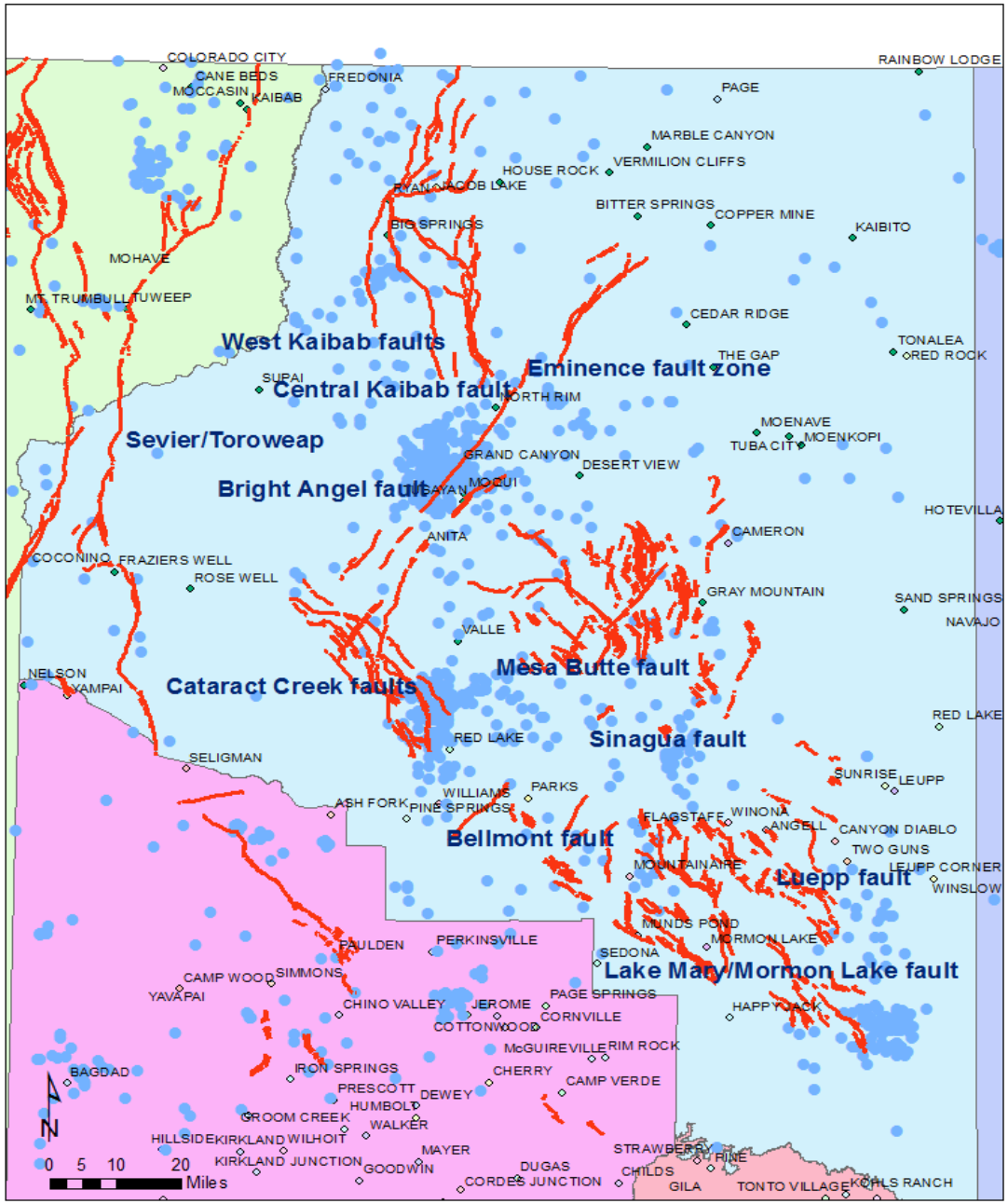
  - Where M is Moment Magnitude
  - Mo is dyne-cm – measure of force

Coconino County Earthquakes 1830-2011



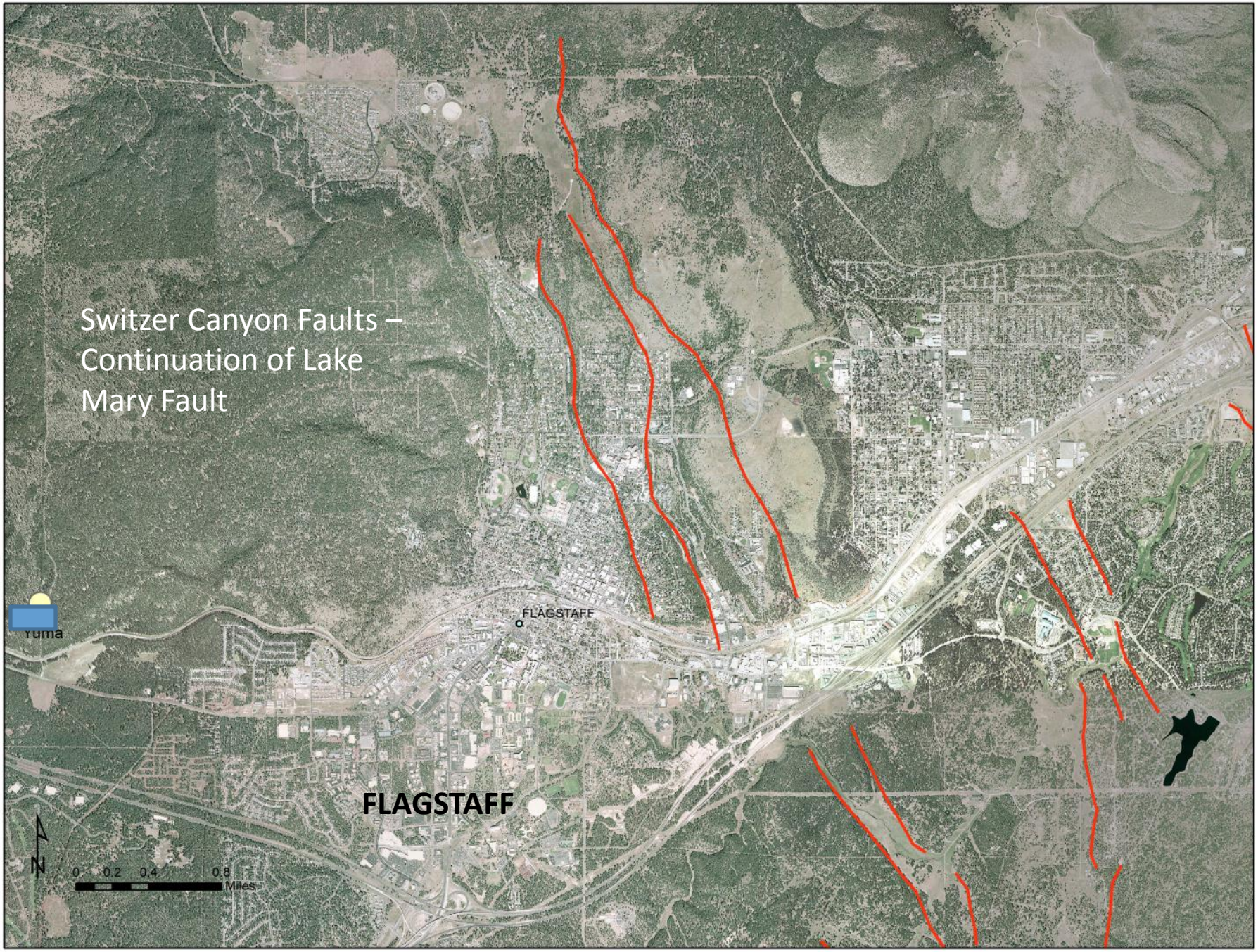
Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database

Coconino County

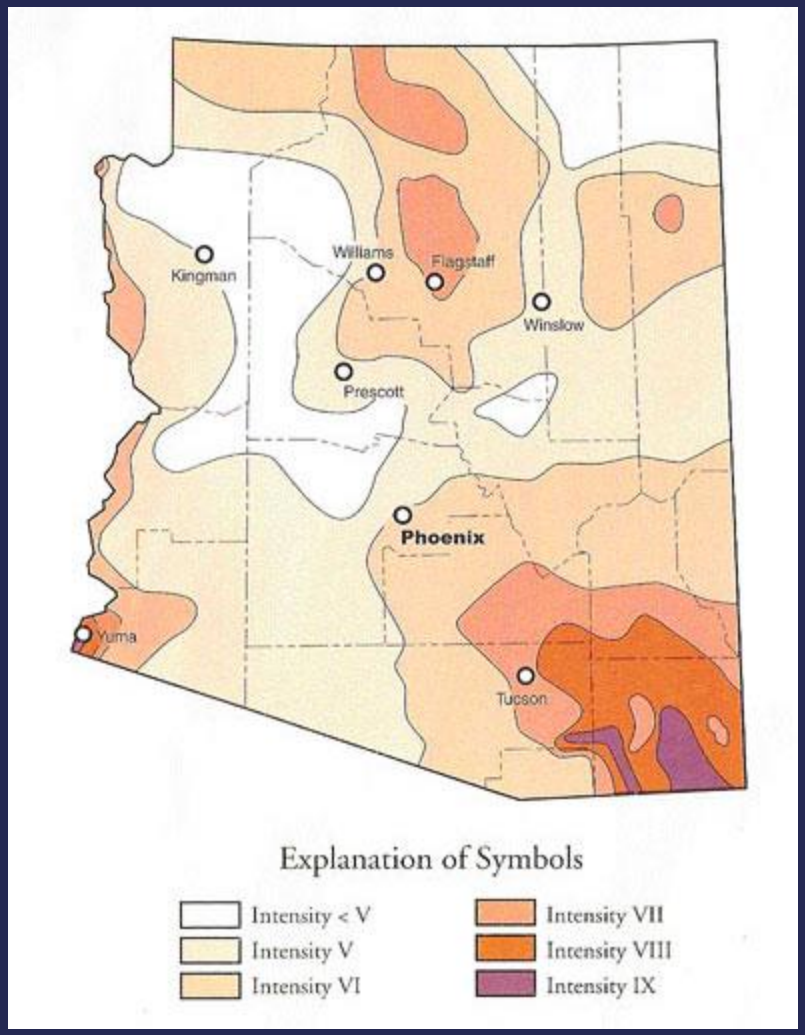


Examples from Coconino Cty

Fault Name	Length (km)	MCE (Mw)
Switzer (longest segment of a splay system)	5.6	5.9
3 Sections- Sevier/Toroweap	250	7.8
Sevier/Toroweap – Northern	60	7.1
Sevier/Toroweap – Central	60	7.1
Sevier/Toroweap – Southern	19	6.6
Lake Mary fault zone	30	6.8
Mormon Lake	15	6.4
Lake Mary and Mormon	45	7.0
Oak Creek North fault zone	7	5.9
Casner Cabin	10	6.2
Bellemont	11	6.3
Metz Tank	7	6.1
Bill Williams	21	6.6
Maverick Butte	4	5.8
Cedar Ranch	10	6.2
Mesa Butte	23	6.6
Cameron Graben	16	6.5
Eminence	36	6.9
Bright Angel	66	7.2
Sinagua	5	5.9
Arrowhead fault	5	5.9


Switzer Canyon Faults –
Continuation of Lake
Mary Fault
FLAGSTAFF
Yuma
FLAGSTAFF
N
0 0.2 0.4 0.8
Miles

Maximum historic (1887-1999) ground shaking intensity in Arizona.



Intensity VII:
Everybody runs outdoors. Damage slight to moderate in well-built structures; considerable in poorly-built/designed structures. Some chimneys broken.

Intensity VIII:
Partial collapse in ordinary built buildings; great in poorly built structures. Panels thrown out of frame structures. Fall of chimneys, monuments, parapets. Heavy furniture overturned.

(Intensity VII-VIII = Magnitudes 6.0-6.9)

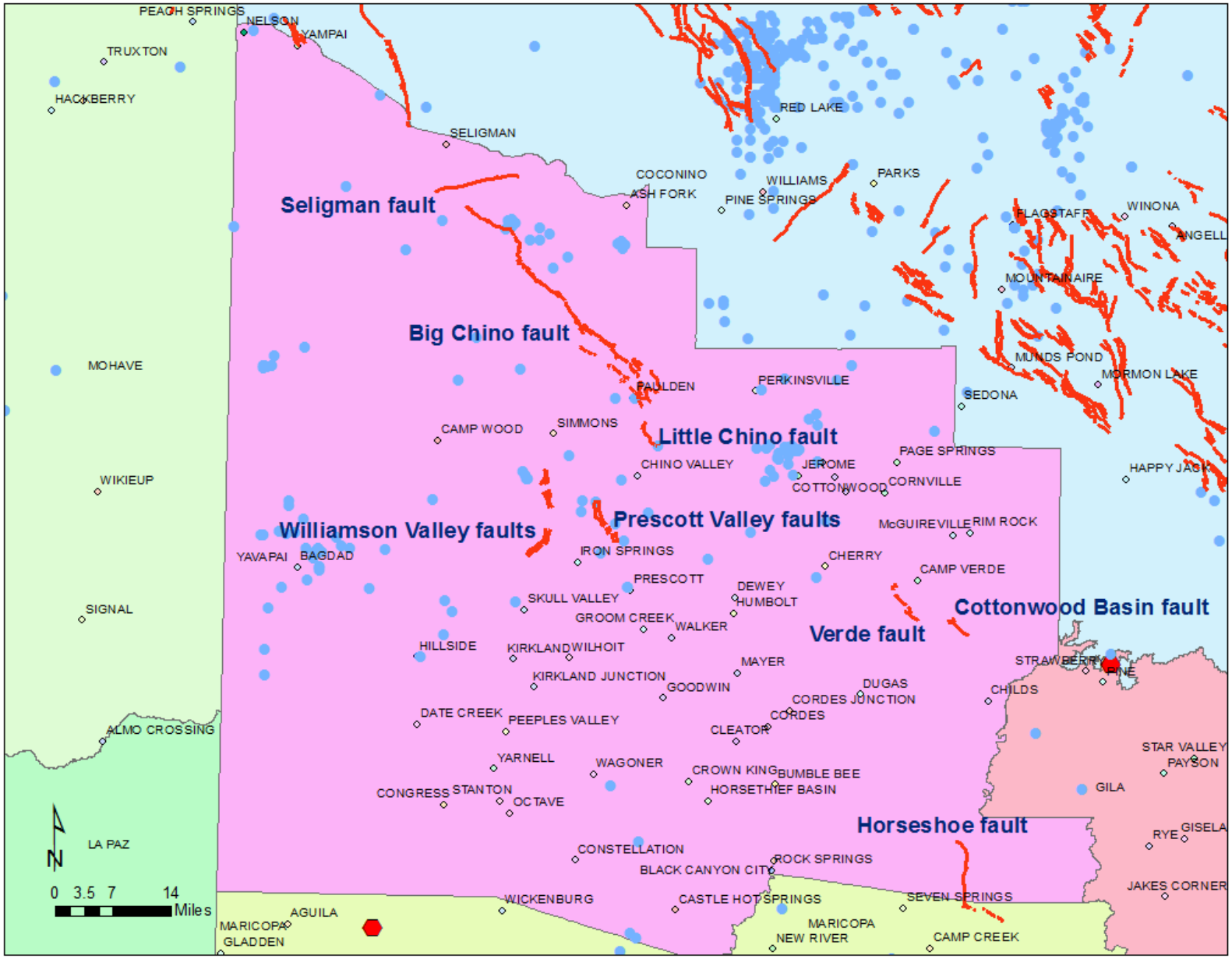
By Dave Brumbaugh

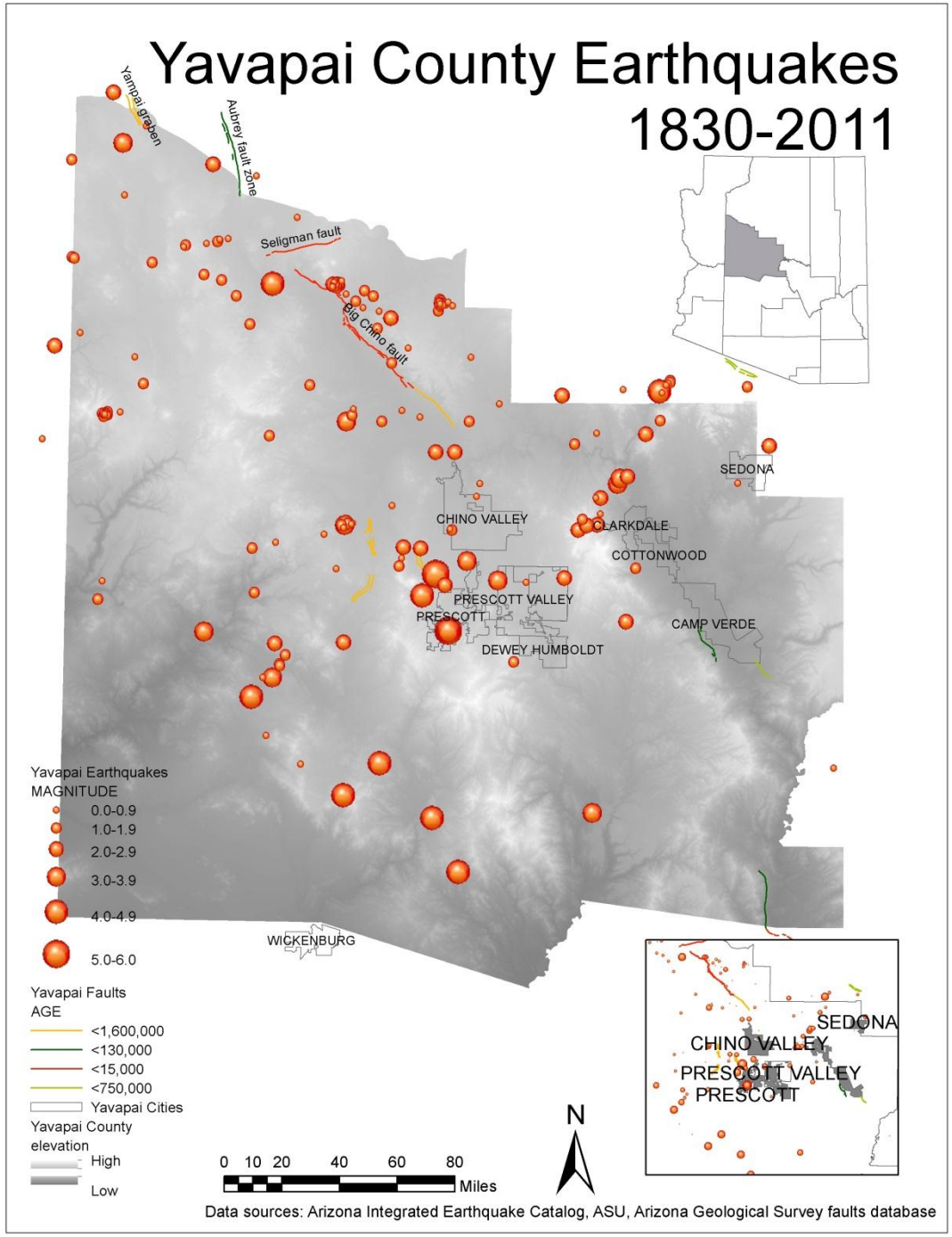
Historic Northern Arizona Earthquakes (≥ VI or 4.9)

Year	Month/Day	Intensity/Magnitude	Comments
1892	2/2	VI	Felt in Flagstaff
1906	1/25	6.2	Caused minor damage in Flagstaff
1910	9/24	6.0	Minor damage in Flagstaff
1912	8/18	6.2	Rock slides/falls reported
1935	1/1	VI	Strongly felt at Grand Canyon
1959	7/21	5.75	Fredonia: minor damage
1959	10/13	5.0	Felt in Flagstaff
1976	2/4	4.9	Minor damage in Chino Valley
1993	4/25	4.9	Felt in Flagstaff and Grand Canyon
1993	4/29	5.3	Minor damage at Grand Canyon

By Dave Brumbaugh

Examples from Yavapai Cty

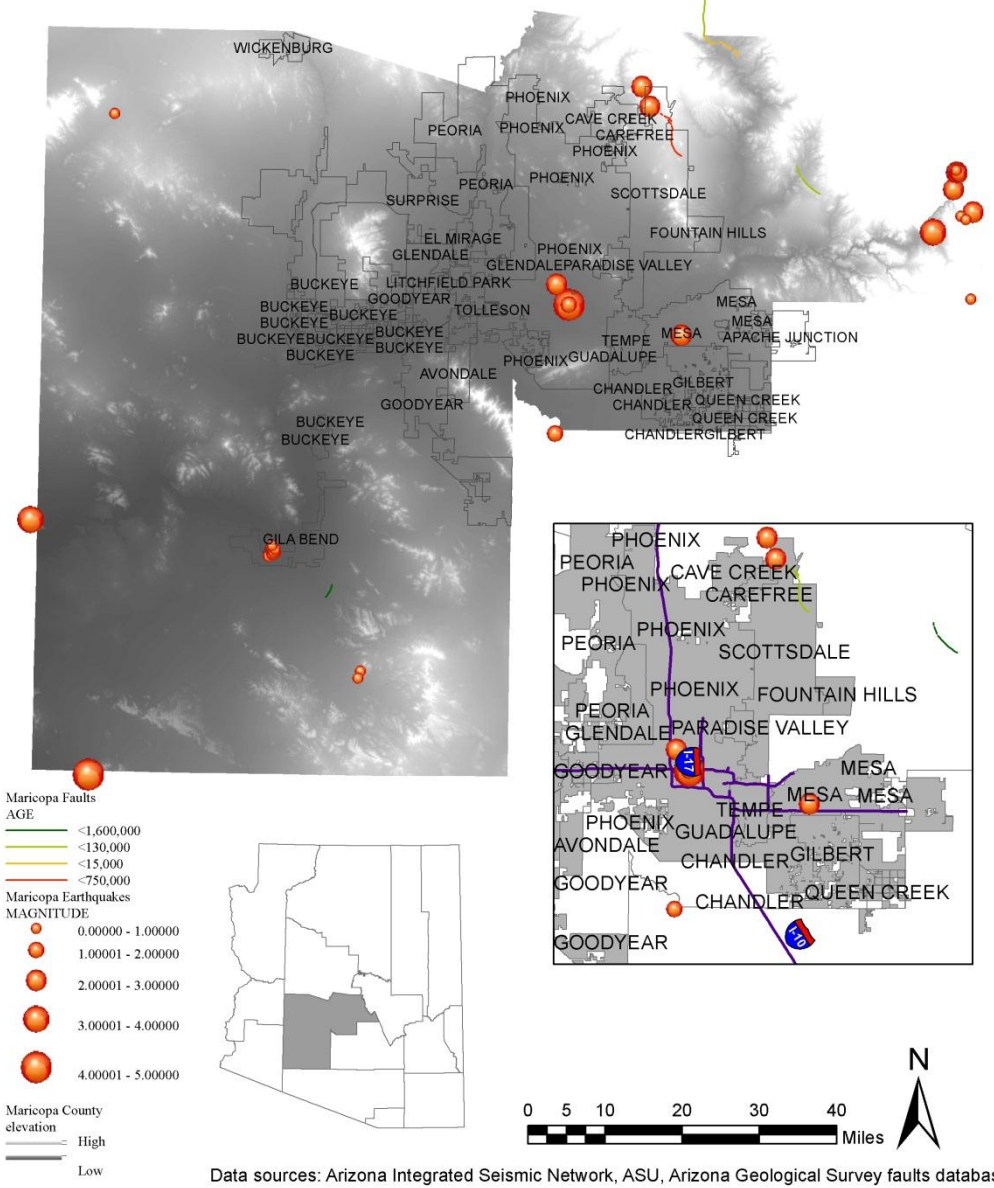



Yavapai County Earthquakes
1830-2011
Yampai graben
Aubrey fault zone
Seligman fault
Big Chino fault
SEDONA
CHINO VALLEY
CLARKDALE
COTTONWOOD
PRESCOTT VALLEY
PRESCOTT
CAMP VERDE
DEWEY HUMBOLDT
WICKENBURG
Yavapai Earthquakes
MAGNITUDE
0.0-0.9
1.0-1.9
2.0-2.9
3.0-3.9
4.0-4.9
5.0-6.0
Yavapai Faults
AGE
<1,600,000
<130,000
<15,000
<750,000
Yavapai Cities
Yavapai County
elevation
High
Low
0 10 20 40 60 80
Miles
N
SEDONA
CHINO VALLEY
PRESCOTT VALLEY
PRESCOTT
Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database

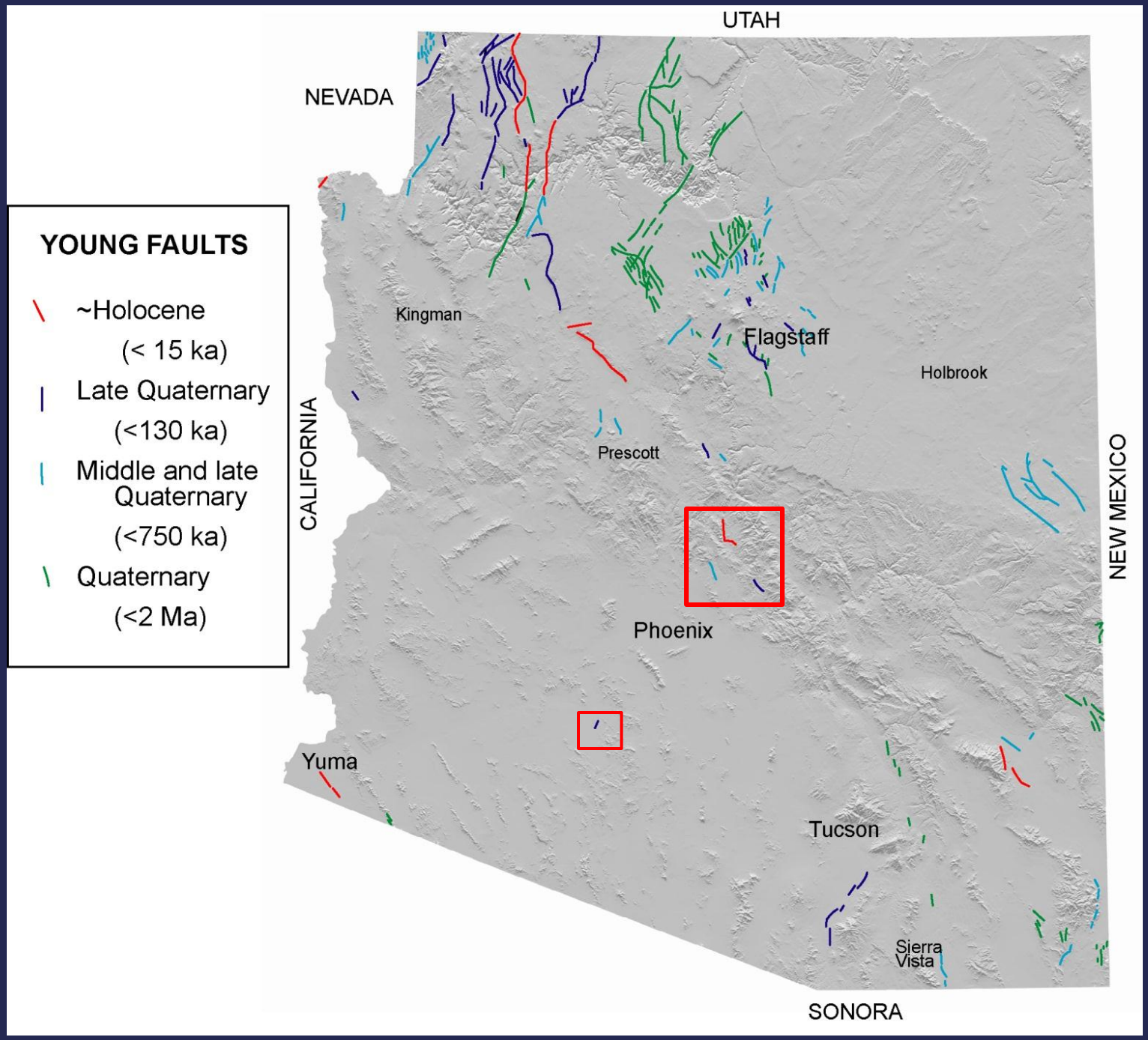
Yavapai Faults - MCE

Fault Name	MCE (Mo)	Slip Rate (mm/yr)
Aubrey	7.1	<0.2
Seligman	6.5	<0.2
Big Chino	7.2	<0.2
Little Chino	6.2	?
Prescott Valley faults	6.2	<0.2
Williamson Valley faults	6.5	<0.2
Verde Valley	6.1	<0.02
Cottonwood Basin	5.9	<0.02
Horseshoe	6.6	<0.2

Maricopa County Earthquakes 1830-2011



Data sources: Arizona Integrated Seismic Network, ASU, Arizona Geological Survey faults database

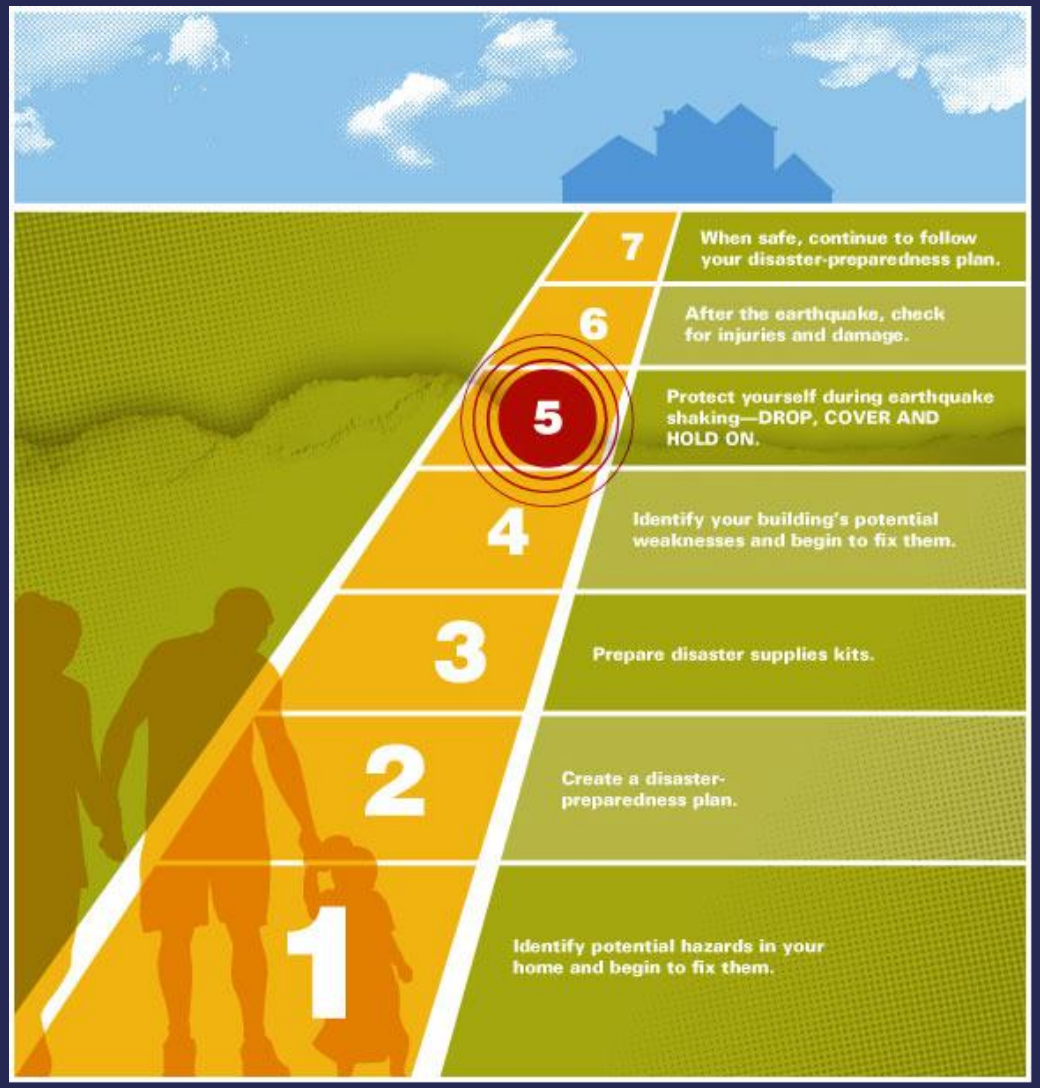

YOUNG FAULTS
~Holocene
(< 15 ka)
Late Quaternary
(<130 ka)
Middle and late Quaternary
(<750 ka)
Quaternary
(<2 Ma)
UTAH
NEVADA
CALIFORNIA
NEW MEXICO
SONORA
Kingman
Flagstaff
Holbrook
Prescott
Phoenix
Yuma
Tucson
Sierra Vista

Maricopa Cty - MCE

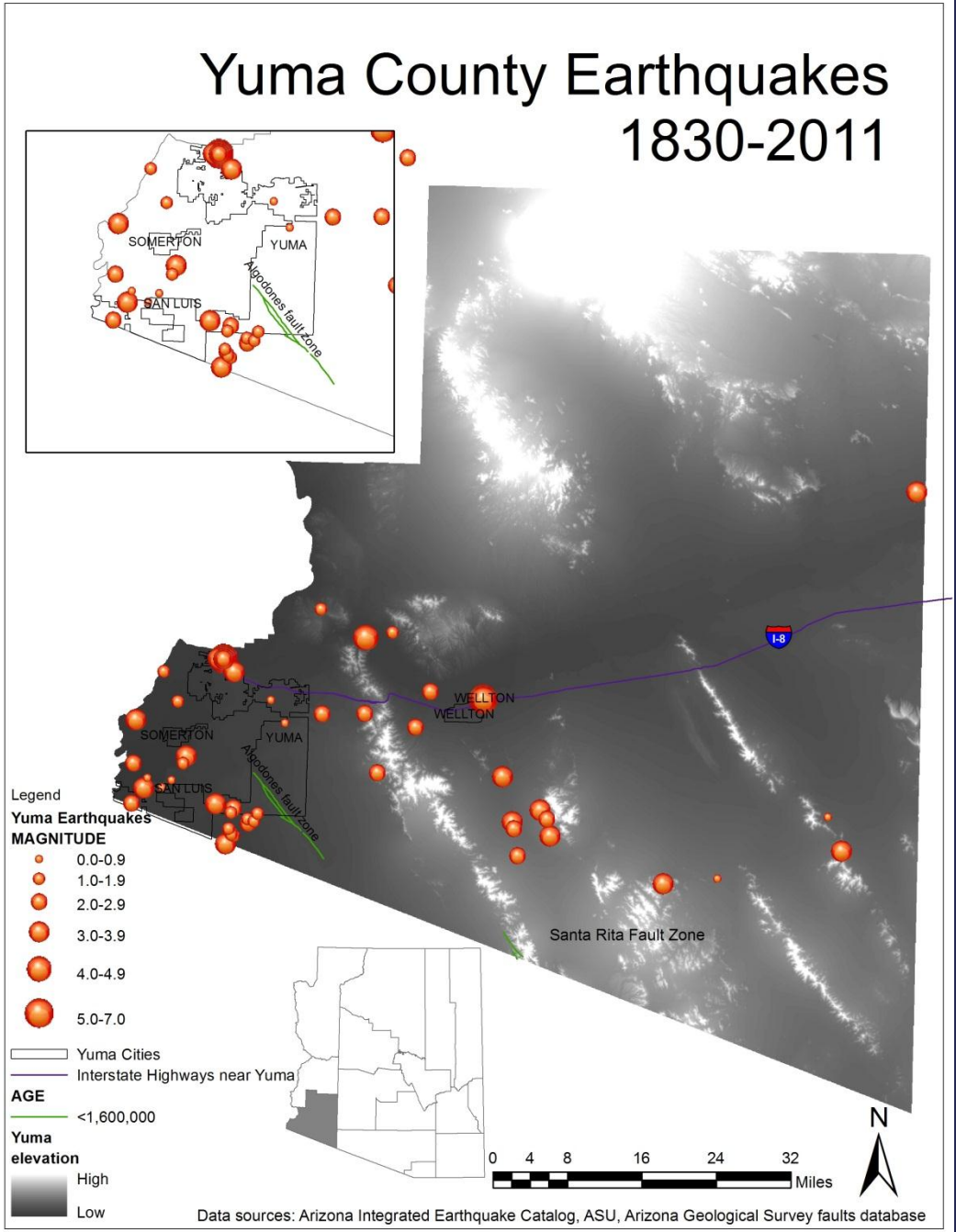
Horseshoe fault	**21 km**	**M 6.6**
Carefree fault	**11 km**	**M 6.3**
Sugarloaf fault	**8 km**	**M 6.1**
Sand Tank	**5 km**	**M 5.9**

EQ Preparedness

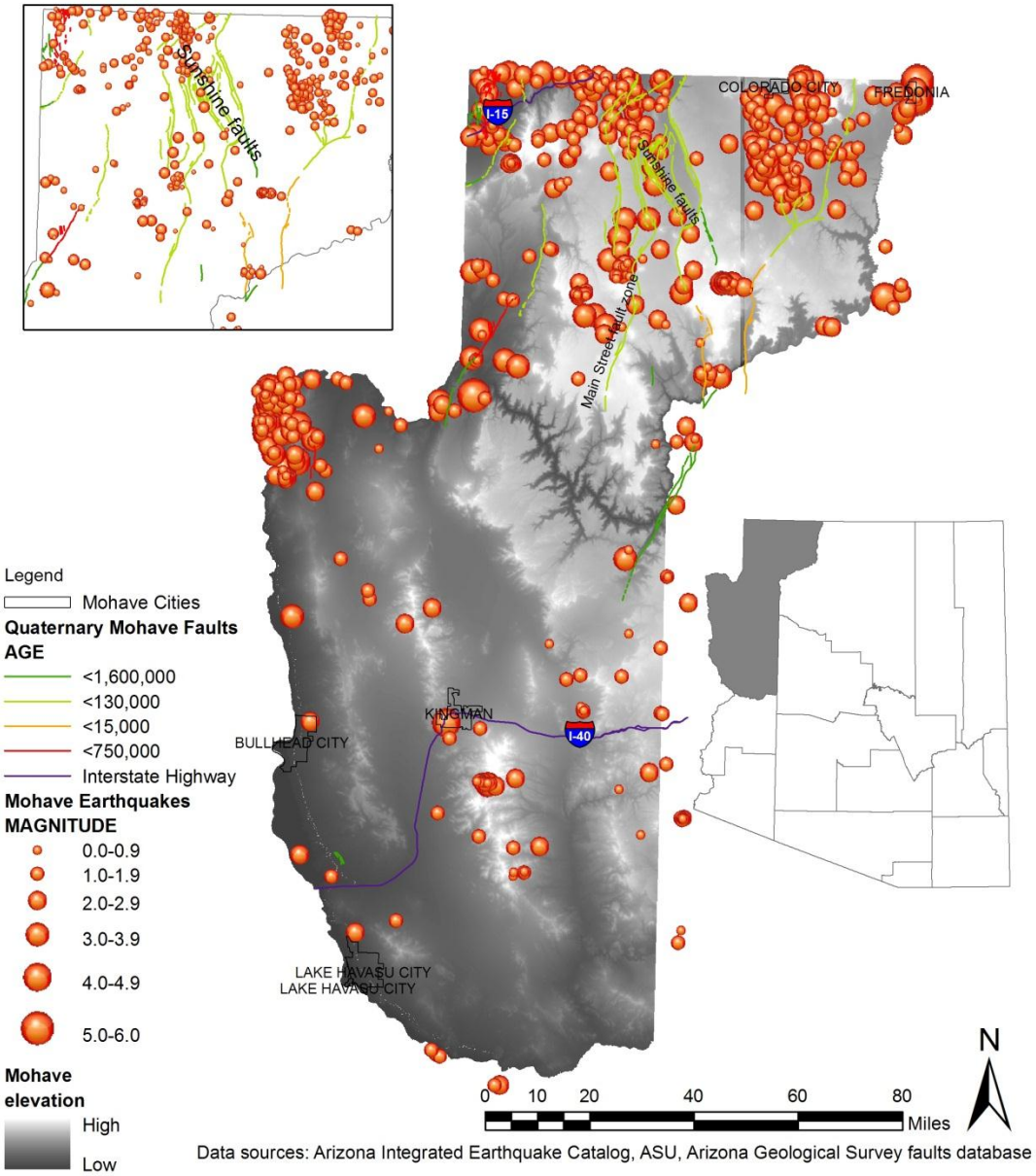
- Educate residents – The Seven Steps



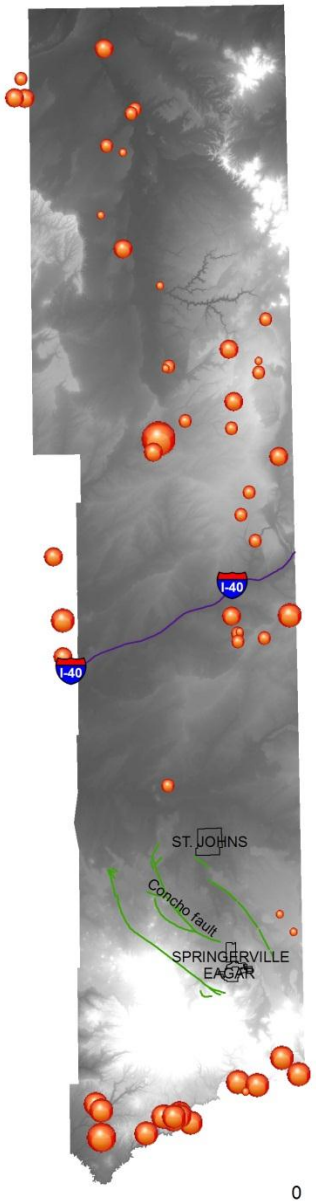
Yuma County Earthquakes 1830-2011

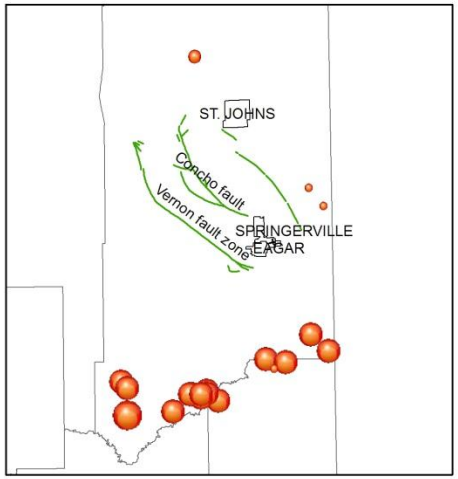


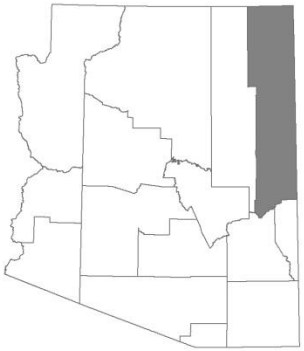
Mohave County Earthquakes 1830-2011



Apache County Earthquakes 1830-2011







Legend

Apache Earthquakes

MAGNITUDE

- 0.0-0.9
- 1.0-1.9
- 2.0-2.9
- 3.0-3.9
- 4.0-4.9
- 5.0-6.0

Interstate Highway

Quaternary Apache Faults

<1,600,000

Apache Cities

Apache elevation

High

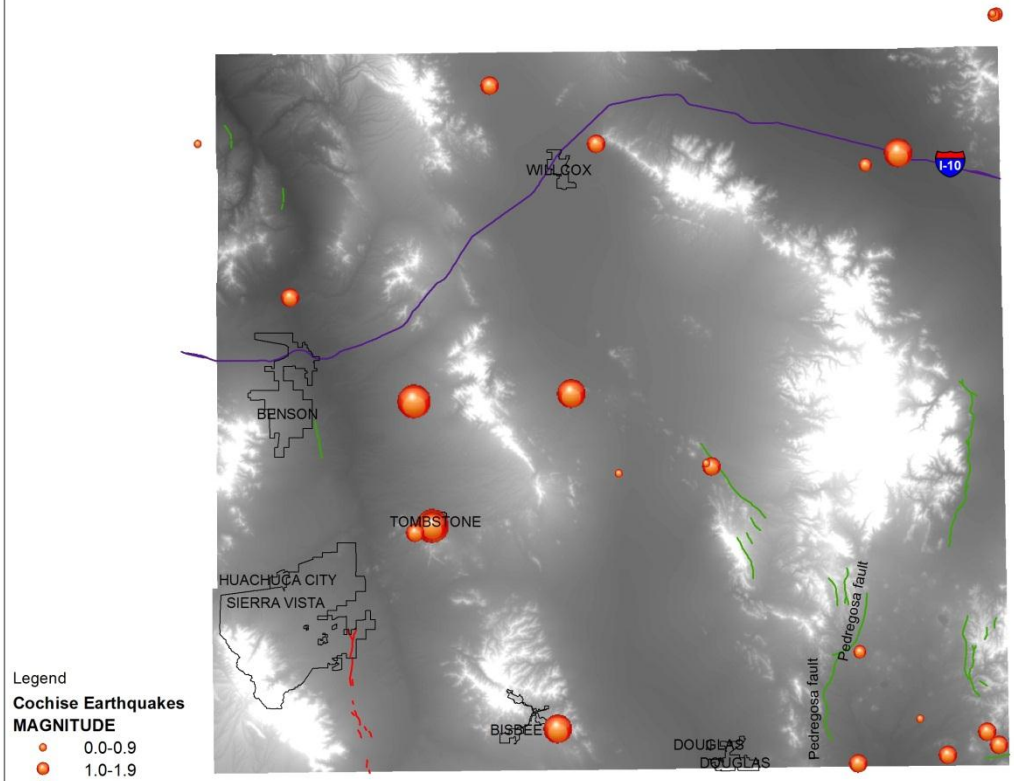
Low

0 10 20 40 60 80 Miles

N

Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database

Cochise County Earthquakes 1830-2011



Legend

Cochise Earthquakes

MAGNITUDE

- 0.0-0.9
- 1.0-1.9
- 2.0-2.9
- 3.0-3.9
- 4.0-4.9
- 5.0-6.0

Cochise Cities

Interstate in Cochise County

Quaternary Cochise faults

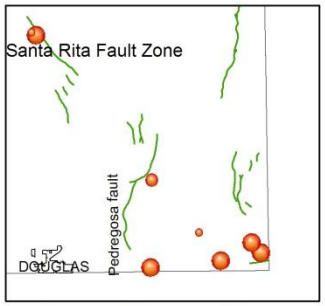
AGE

- <1,600,000
- <750,000

Cochise elevation

High

Low

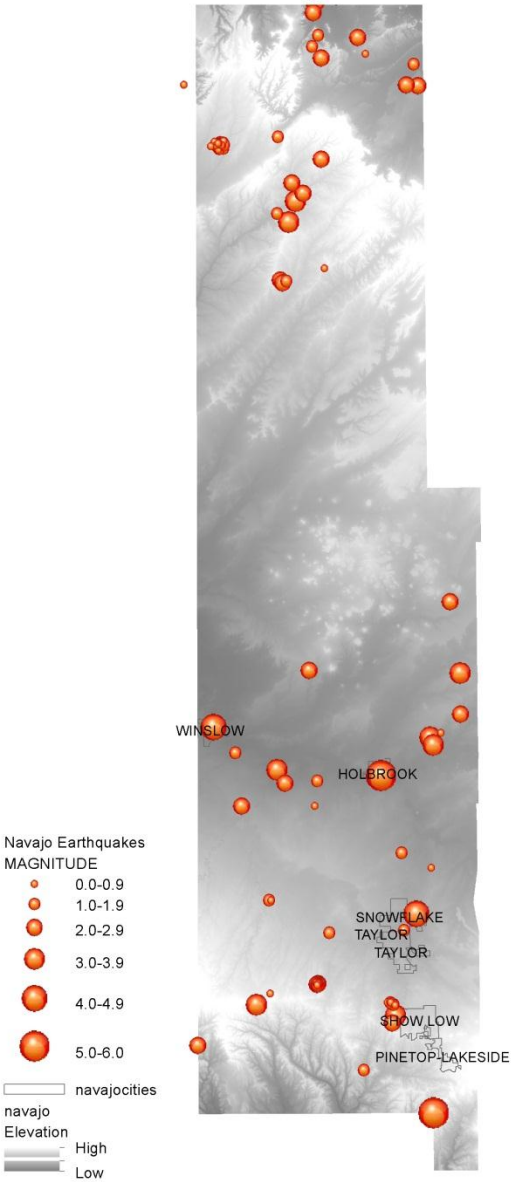


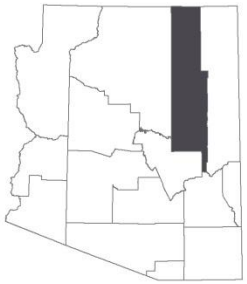
0 5 10 20 30 40 Miles

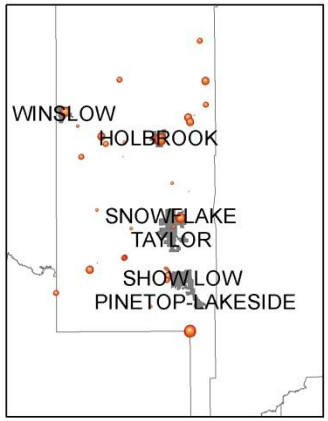
N

Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database

Navajo County Earthquakes
1830-2011







Navajo Earthquakes
MAGNITUDE
- 0.0-0.9
- 1.0-1.9
- 2.0-2.9
- 3.0-3.9
- 4.0-4.9
- 5.0-6.0

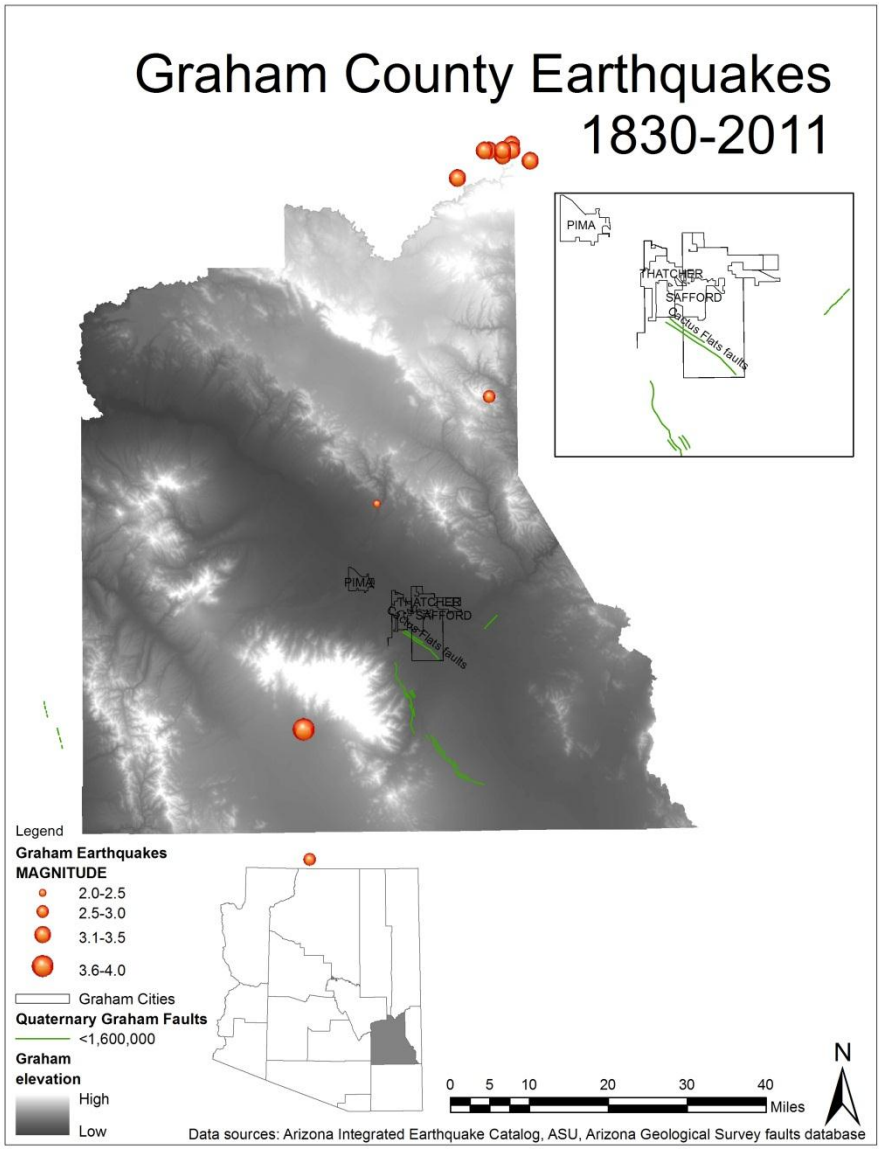
navajocities

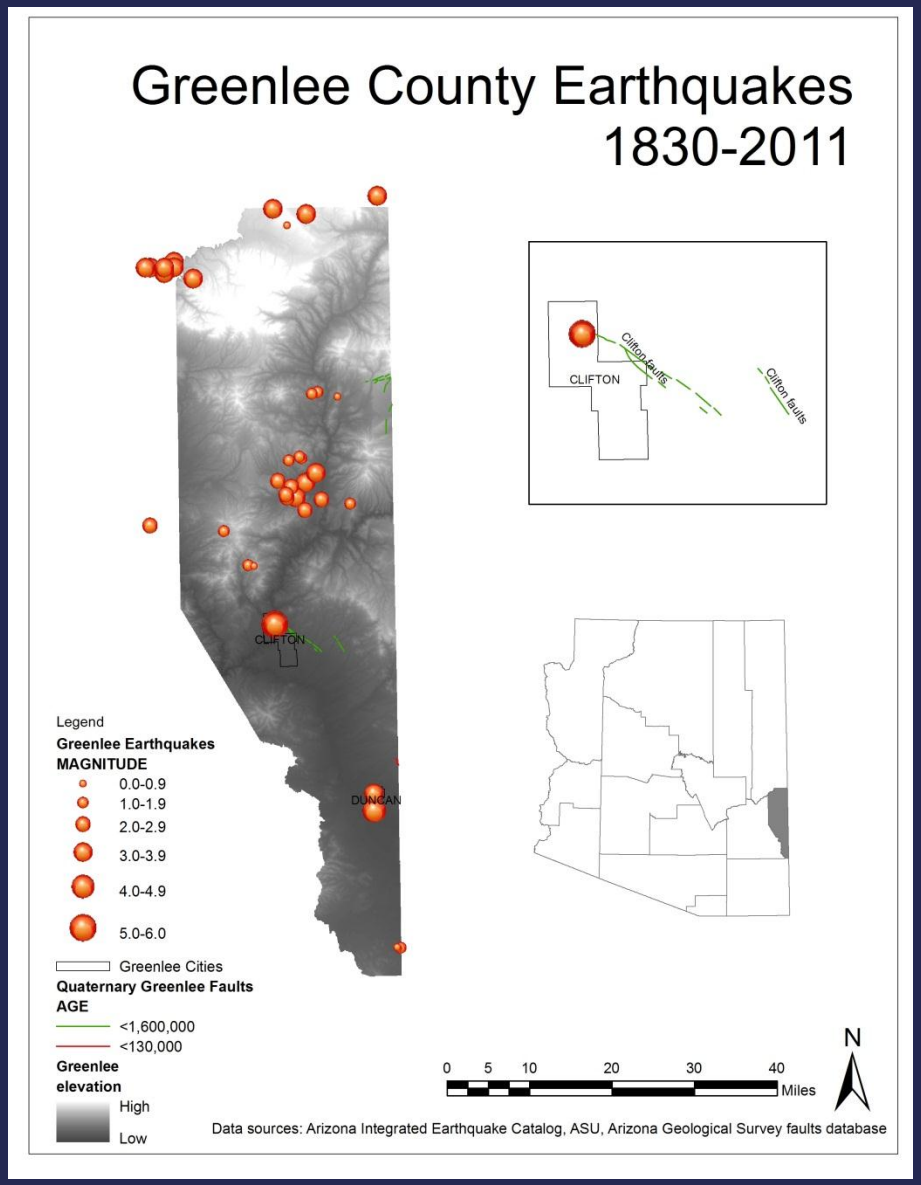
navajo
Elevation
- High
- Low

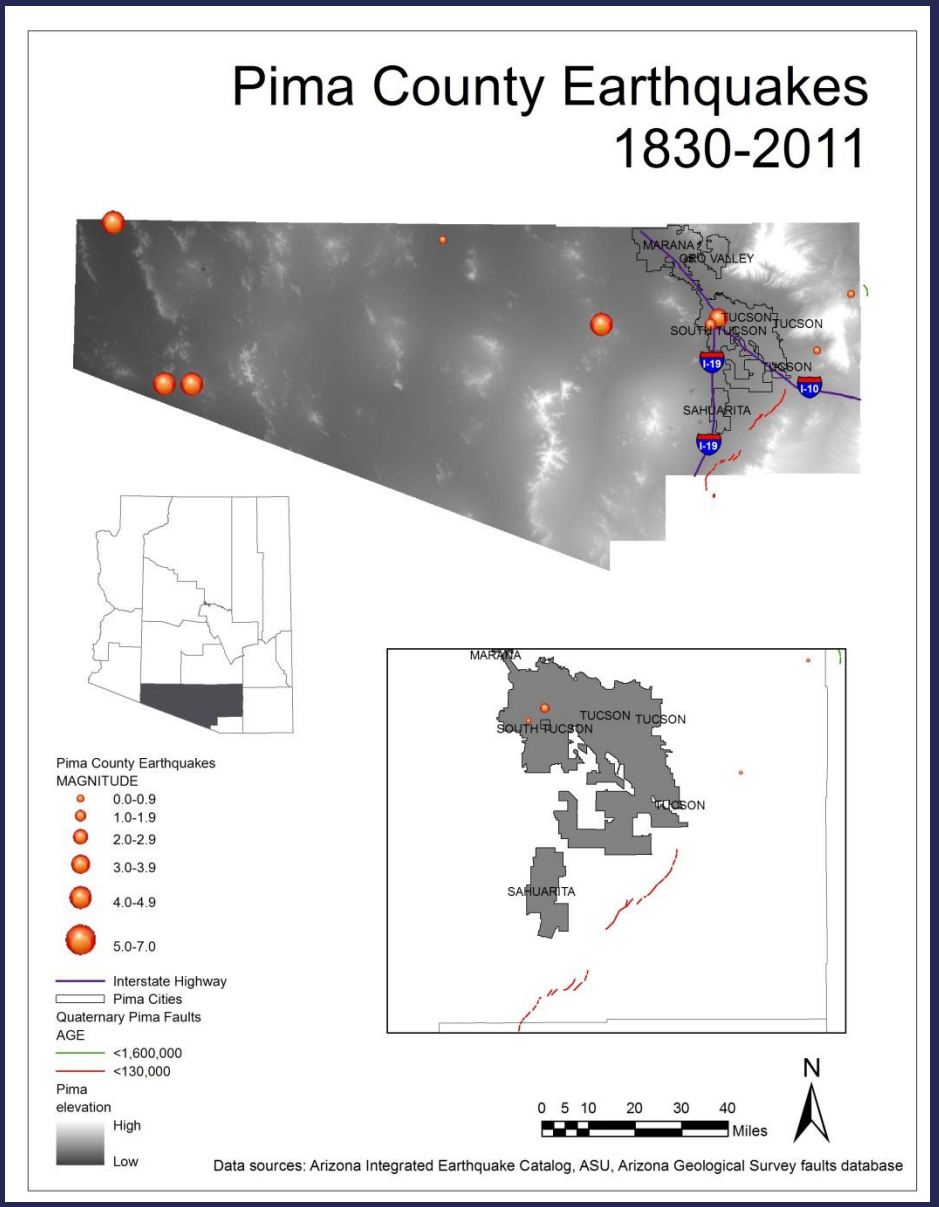
0 5 10 20 30 40 Miles

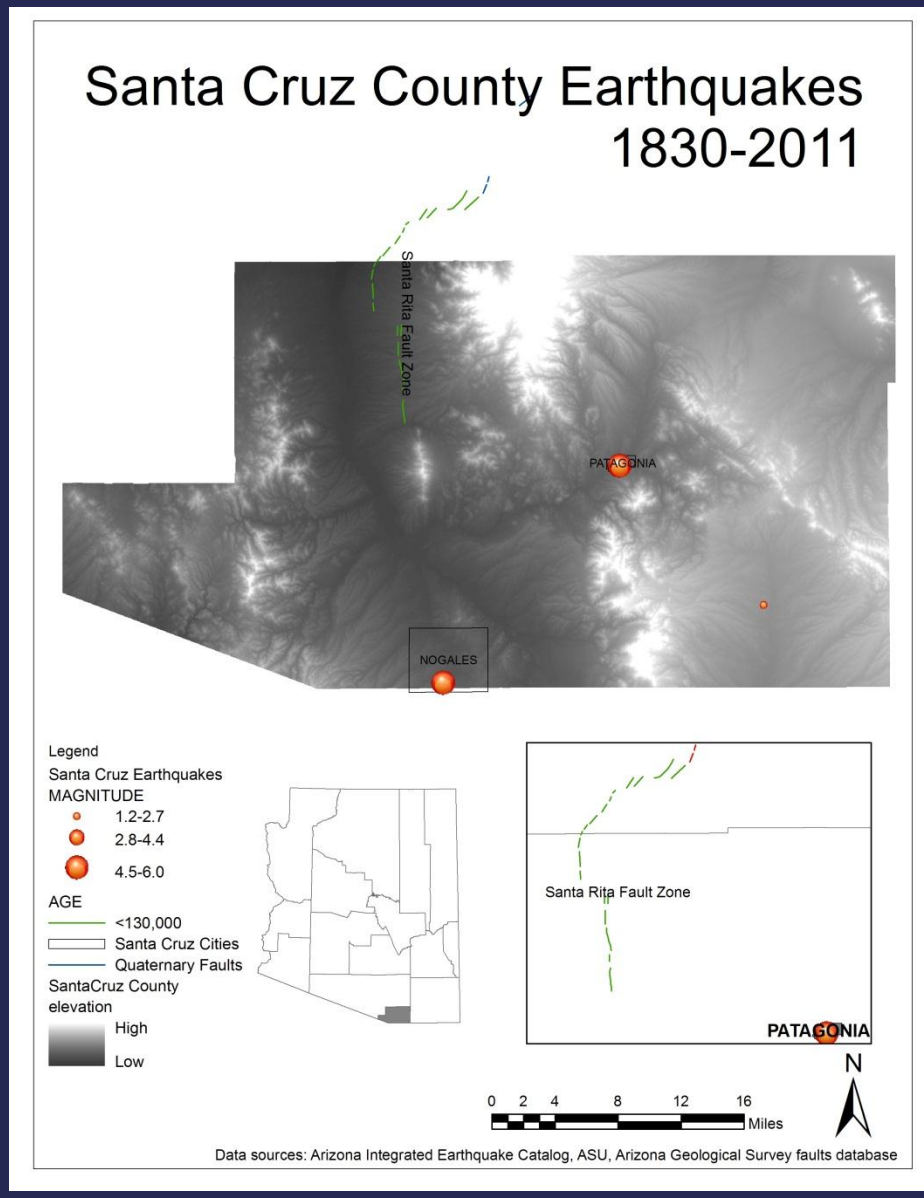
N

Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database


Graham County Earthquakes
1830-2011
PIMA
THATCHER
SAFFORD
Gila Flats faults
Legend
Graham Earthquakes
MAGNITUDE
2.0-2.5
2.5-3.0
3.1-3.5
3.6-4.0
Graham Cities
Quaternary Graham Faults
<1,600,000
Graham
elevation
High
Low
0 5 10 20 30 40
Miles
N
Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database


Greenlee County Earthquakes
1830-2011
CLIFTON
Clifton faults
Clifton faults
DUNCAN
Legend
Greenlee Earthquakes
MAGNITUDE
0.0-0.9
1.0-1.9
2.0-2.9
3.0-3.9
4.0-4.9
5.0-6.0
Greenlee Cities
Quaternary Greenlee Faults
AGE
<1,600,000
<130,000
Greenlee
elevation
High
Low
0 5 10 20 30 40
Miles
N
Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database


Pima County Earthquakes
1830-2011
MARANA
ORO VALLEY
TUCSON
SOUTH TUCSON
TUCSON
TUCSON
I-19
I-10
SAHUARITA
I-19
Pima County Earthquakes
MAGNITUDE
0.0-0.9
1.0-1.9
2.0-2.9
3.0-3.9
4.0-4.9
5.0-7.0
Interstate Highway
Pima Cities
Quaternary Pima Faults
AGE
<1,600,000
<130,000
Pima
elevation
High
Low
MARANA
TUCSON
TUCSON
SOUTH TUCSON
TUCSON
SAHUARITA
0 5 10 20 30 40
Miles
N
Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database


Santa Cruz County Earthquakes
1830-2011
Santa Rita Fault Zone
PATAGONIA
NOGALES
Legend
Santa Cruz Earthquakes
MAGNITUDE
1.2-2.7
2.8-4.4
4.5-6.0
AGE
<130,000
Santa Cruz Cities
Quaternary Faults
SantaCruz County
elevation
High
Low
Santa Rita Fault Zone
PATAGONIA
0 2 4 8 12 16
Miles
N
Data sources: Arizona Integrated Earthquake Catalog, ASU, Arizona Geological Survey faults database

Why maintain AISN?

- Maintaining the seismic network and associated studies
  - Will help us characterize potential seismic zones with more coverage.
  - Provide insight into fault activity – Are we missing faults?
  - Improve our estimation of shaking.
  - Increase awareness of AZ's earthquake hazards through counties, cities and the general public.
  - Provide EQ information to neighboring networks.

Questions or want to support AISN?

Email Jeri.Young@azgs.az.gov