CLIMAS

The Climate Assessment for the Southwest

Success Stories

Institute for the Study of Planet Earth
University of Arizona

Institute for the Study of Planet Earth

CLIMAS
Climate Assessment Project for the Southwest

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Integrated Physical and Social Science Research

- Team Integration
- Fire Workshops
- Drought
- Applied Climate Studies
- Water Economics
- Climate Forecast Evaluation
- Vulnerability Assessment
- Team Integrated Project

http://www.ispe.arizona.edu/climas/

Integrated Physical and Social Science Research

- Agricultural Economics
- Tourism Economics
- Fire Ecology
- U.S.-Mexico Border Environment
- Spatially Distributed Snow Estimates
- Streamflow Forecast Evaluation
- Urban Water Resources and Policy
- Institutional and Policy Analysis

http://www.ispe.arizona.edu/climas/

Metrics for Success

- # Stakeholder engagement
- Team integration
- Δ User input ⟶ Change in science
- Increased demand for information/briefings
- ☺ Vulnerability reduced
- NOAA partnerships

Bales et al., 2004 – *Bulletin of the American Meteorological Society*

Success Stories

CLIMAS Team Integration

Team Meetings

- **Communication**
  - Methods
  - Language
- **Collegiality**

Mini-Retreats

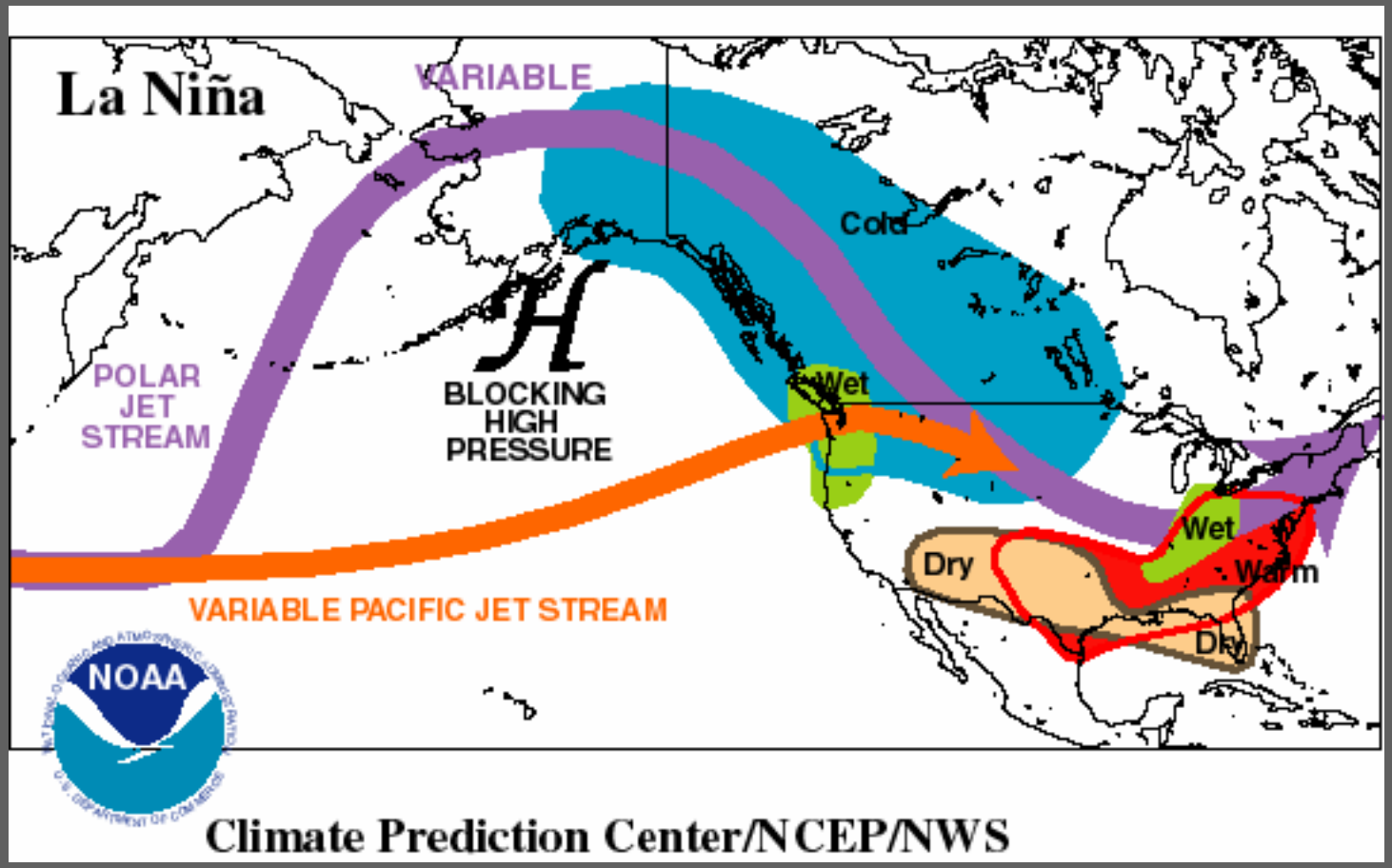
- Introduce new members to the project (Fall)
- Foster greater team/project integration
- Keep CLIMAS on track with regard to meeting short- and long-term goals
- Move forward on Team Integrated Project

PI Retreats

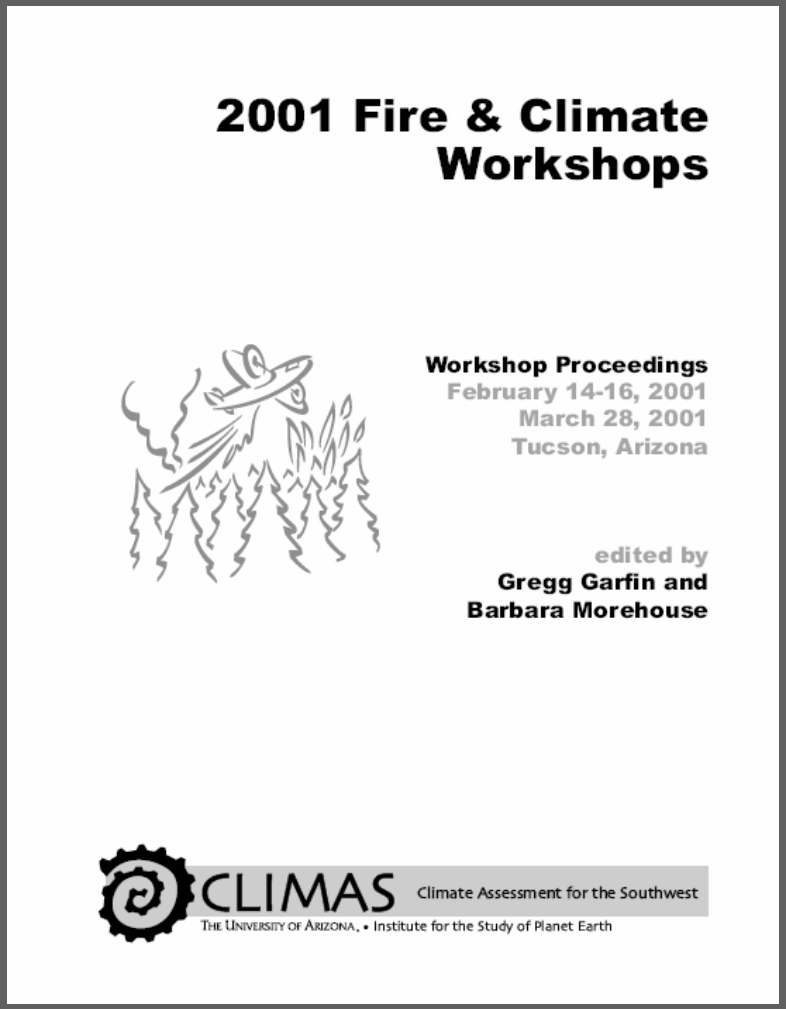
- Evaluate contributions to literature on theory and practice of integrated assessment
- Write multi-author papers on aforementioned
- Brainstorm projects and future directions
- Strengthen collegiality

Process-Based Decision Support

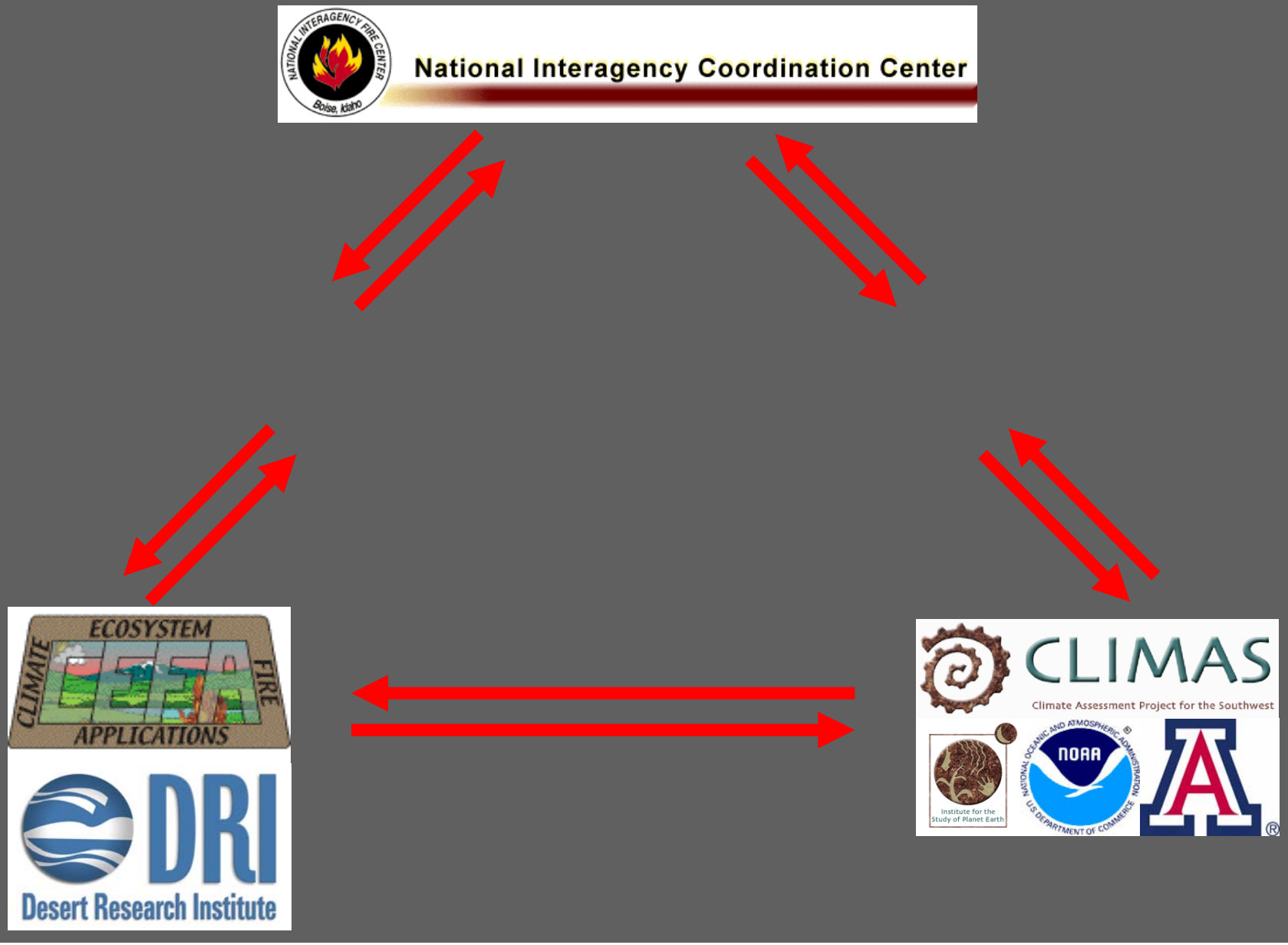
Process: Fire-Climate Workshops



2000-2002: ENSO and Fire Management



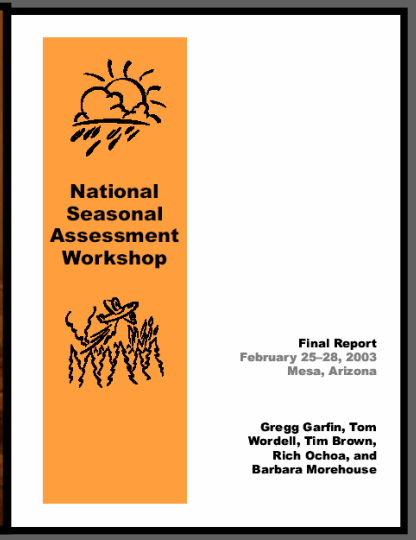
Fostering Agency Partnerships



Process: Fire-Climate Workshops

- 2003-2005: National Seasonal Assessment Workshop

Photo: New York Times

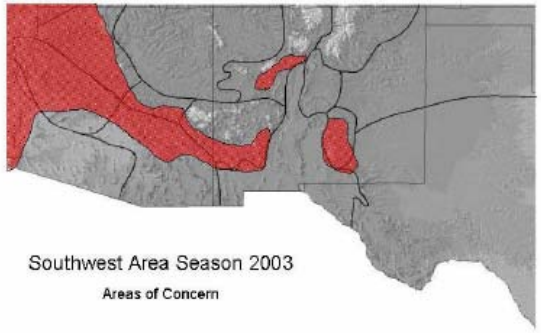


Process: Fire-Climate Workshops

- Fire potential outlooks
- Climate conditions, forecasts
  - explicitly incorporated

E. Management Implications and Concerns

The Southwest Area, over the past 12-year period, has experienced several significant fire seasons, causing tremendous loss of property and wildland resources. The current trend, all things being the same, indicates 2003 will not be on the scale of these seasons. However, with that being said, several concerns still need to be addressed throughout the 2003 fire season.



Southwest Area Season 2003

Areas of Concern

Areas of Greatest Concern

Considering current and predicted weather, fuels and fire danger conditions, the highlighted areas represent those that are most likely to experience a greater then normal number of large fires. In essence, though the overall number of large fires is expected to be near normal on a regional basis, they are more likely to be concentrated in or near the areas marked in red.

Air Resources

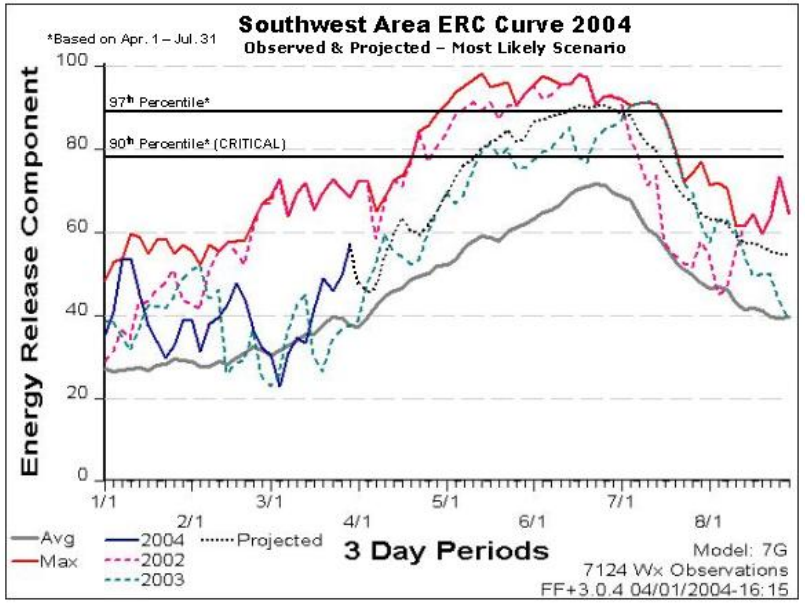
In 2002, the nation lost several heavy air tankers and helicopters to fatal crashes. As a result, all heavy air tankers will be undergoing significant stress level testing through the spring and summer of 2003. This will mean that the number of heavy air tankers may be limited. There will need to be an awareness that some initial attack fires may jump to extended attack because of a lack of heavy air tanker availability.

Fire Behavior

Throughout the drought period 1998-2002, significant vegetative stress, die-back, and

Process: Fire-Climate Workshops

- Resource allocation
- Prescribed fire
- Public education



Process: Fire-Climate Workshops

Requests for new products

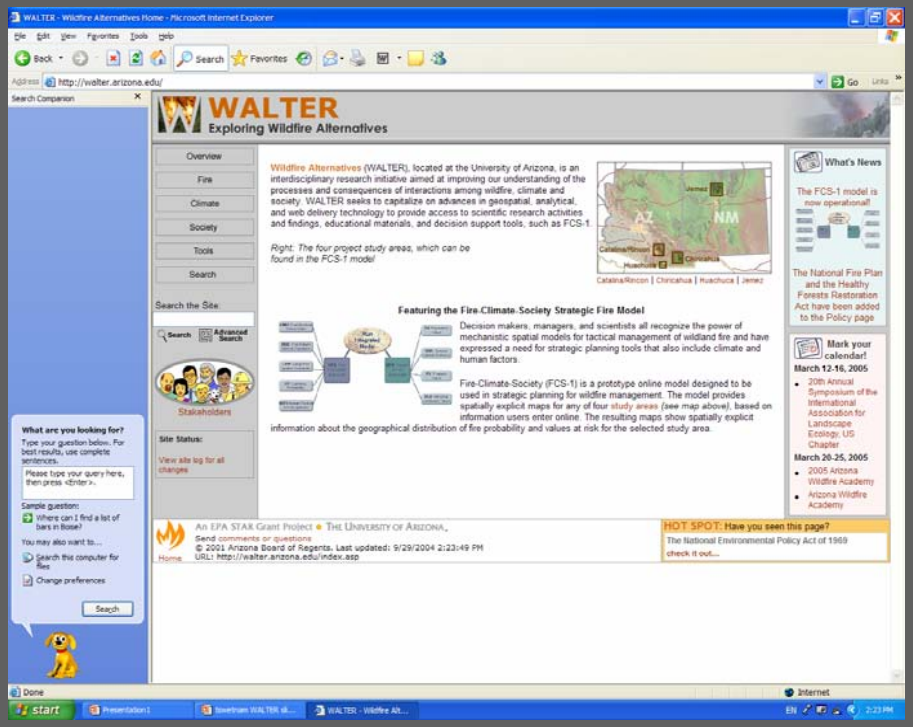
- Eastern
  - Snow water equivalent
    - Historical context
  - Precipitation frequency
  - Blocking
- Western
  - Monsoon onset, breaks

Metrics for Success

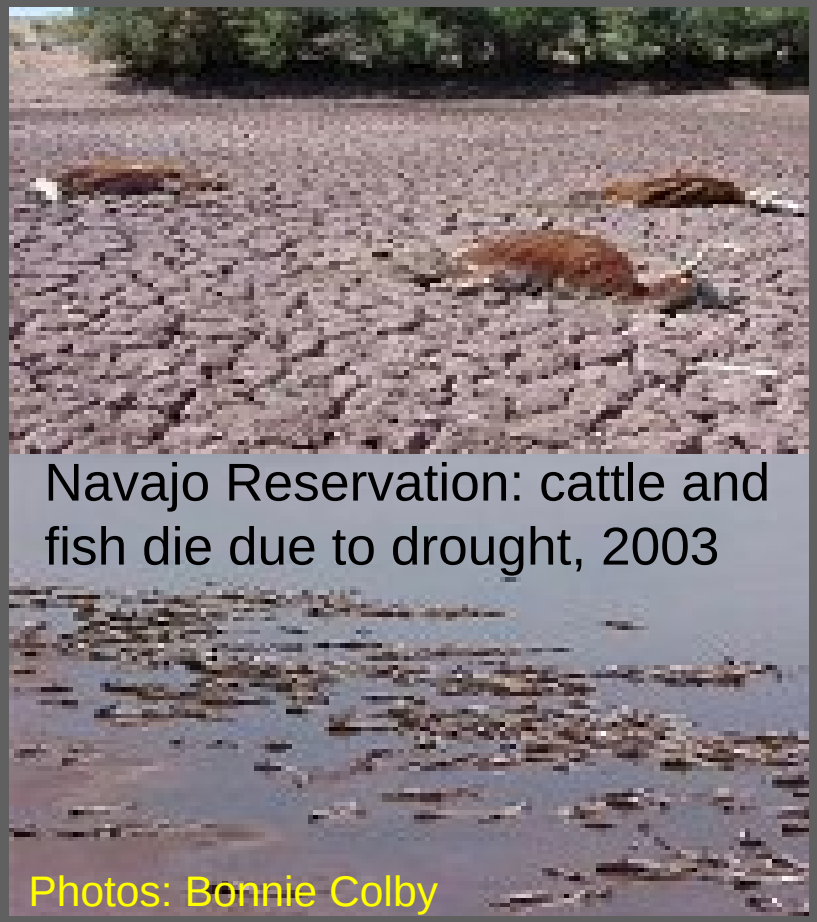
- # States, SRCC, NRCC
- Press briefings, training, international, WALTER
- ☺ ? – NOAA forecasts and products used in management
- CPC, CDC, RCCs, IRI, RISAs

Wildfire Alternatives (WALTER)

- EPA-STAR Funding
  - CLIMAS-Associated Investigators
- Spinoff from first CLIMAS Fire-Climate Workshop
  - Fire risk assessment
  - Scenario generation
  - Climate, Fuels
  - Human Factors



Drought: Process, Product, Policy



Navajo Reservation: cattle and fish die due to drought, 2003

Photos: Bonnie Colby

Photos: John Dohrenwend

El Niño-Drought Initiative

Users CLIMAS Climate Assessment Project for the Southwest **Producers**

Flexibility to Respond

http://www.ispe.arizona.edu/climas/research/END/background.html

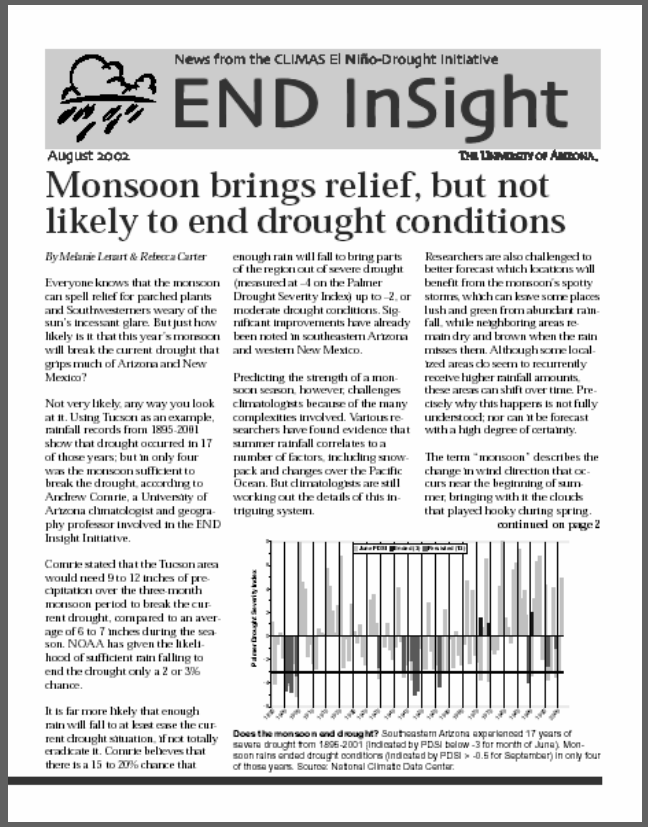
Objectives

- Provide region-specific value-added climate info
- Stakeholder feedback
  - Producers of information
  - Climate Services
- Inform the press

http://www.ispe.arizona.edu/climas/research/END/background.html

Elements of END InSight

- Monthly info packets + Website
- Surveys (initial, monthly, phone, exit)
- Wrap-up workshop



News from the CLIMAS El Niño-Drought Initiative

END InSight

August 2002 — The University of Arizona

Monsoon brings relief, but not likely to end drought conditions

By Melanie Lenart & Rebecca Carter

Everyone knows that the monsoon can spell relief for parched plants and Southwesterners weary of the sun's incessant glare. But just how likely is it that this year's monsoon will break the current drought that grips much of Arizona and New Mexico?

Not very likely, any way you look at it. Using Tucson as an example, rainfall records from 1895-2001 show that drought occurred in 17 of those years; but in only four was the monsoon sufficient to break the drought, according to Andrew Comrie, a University of Arizona climatologist and geography professor involved in the END Insight Initiative.

Comrie stated that the Tucson area would need 9 to 12 inches of precipitation over the three-month monsoon period to break the current drought, compared to an average of 6 to 7 inches during the season. NOAA has given the likelihood of sufficient rain falling to end the drought only a 2 or 3% chance.

It is far more likely that enough rain will fall to at least ease the current drought situation, if not totally eradicate it. Comrie believes that there is a 15 to 20% chance that enough rain will fall to bring parts of the region out of severe drought (measured at -4 on the Palmer Drought Severity Index) up to -2, or moderate drought conditions. Significant improvements have already been noted in southeastern Arizona and western New Mexico.

Predicting the strength of a monsoon season, however, challenges climatologists because of the many complexities involved. Various researchers have found evidence that summer rainfall correlates to a number of factors, including snowpack and changes over the Pacific Ocean. But climatologists are still working out the details of this intriguing system.

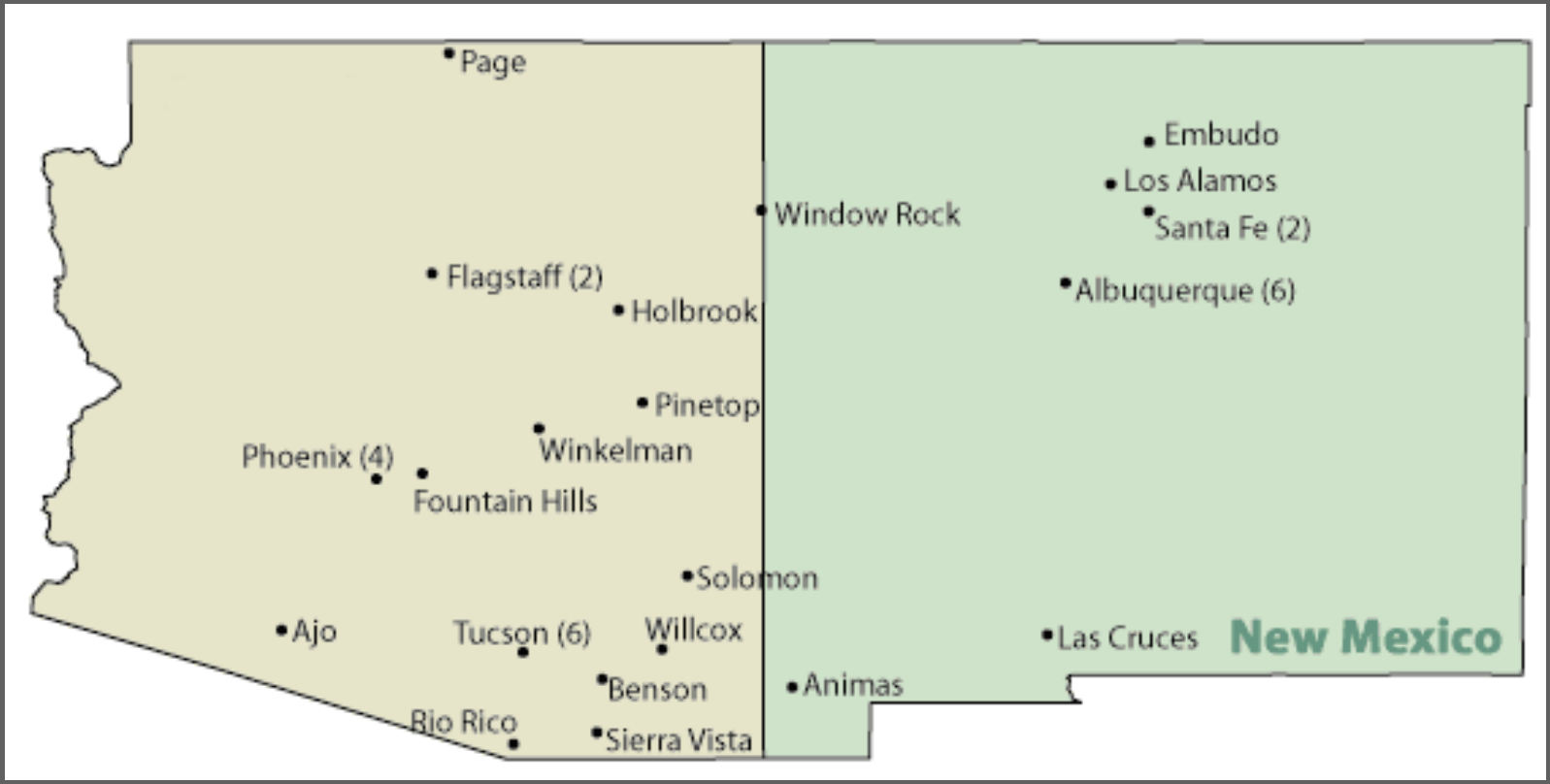
Researchers are also challenged to better forecast which locations will benefit from the monsoon's spotty storms, which can leave some places lush and green from abundant rainfall, while neighboring areas remain dry and brown when the rain misses them. Although some localized areas do seem to recurrently receive higher rainfall amounts, these areas can shift over time. Precisely why this happens is not fully understood; nor can it be forecast with a high degree of certainty.

The term "monsoon" describes the change in wind direction that occurs near the beginning of summer, bringing with it the clouds that played hooky during spring.

continued on page 2

Does the monsoon end drought? Southeastern Arizona experienced 17 years of severe drought from 1895-2001 (indicated by PDSI below -3 for month of June). Monsoon rains ended drought conditions (indicated by PDSI > -0.5 for September) in only four of those years. Source: National Climatic Data Center.

Participants



- Water, Fire, Land Management
- Energy, Cooperative Extension, Ranching, Media

http://www.ispe.arizona.edu/climas/research/END/background.html

CLIMAS-SAHRA Press Briefings

ARIZONA DIVISION OF EMERGENCY MANAGEMENT

OFFICE OF THE ARIZONA STATE CLIMATOLOGIST

ARIZONA DEPARTMENT OF WATER RESOURCES
SECURING ARIZONA'S WATER FUTURE

New Mexico Drought Planning Team

EARTH AND PLANETARY SCIENCES
UNIVERSITY OF NEW MEXICO

University of New Mexico

NATIONAL WEATHER SERVICE

ARIZONA STATE LAND DEPARTMENT
SERVING ARIZONA'S SCHOOLS AND PUBLIC INSTITUTIONS SINCE 1915

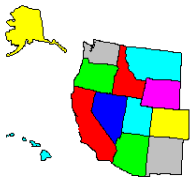
NRCS Natural Resources Conservation Service

SAHRA
Sustainability of semi-Arid Hydrology and Riparian Areas
Ensuring water in a changing world

SRP
Delivering More Than Power

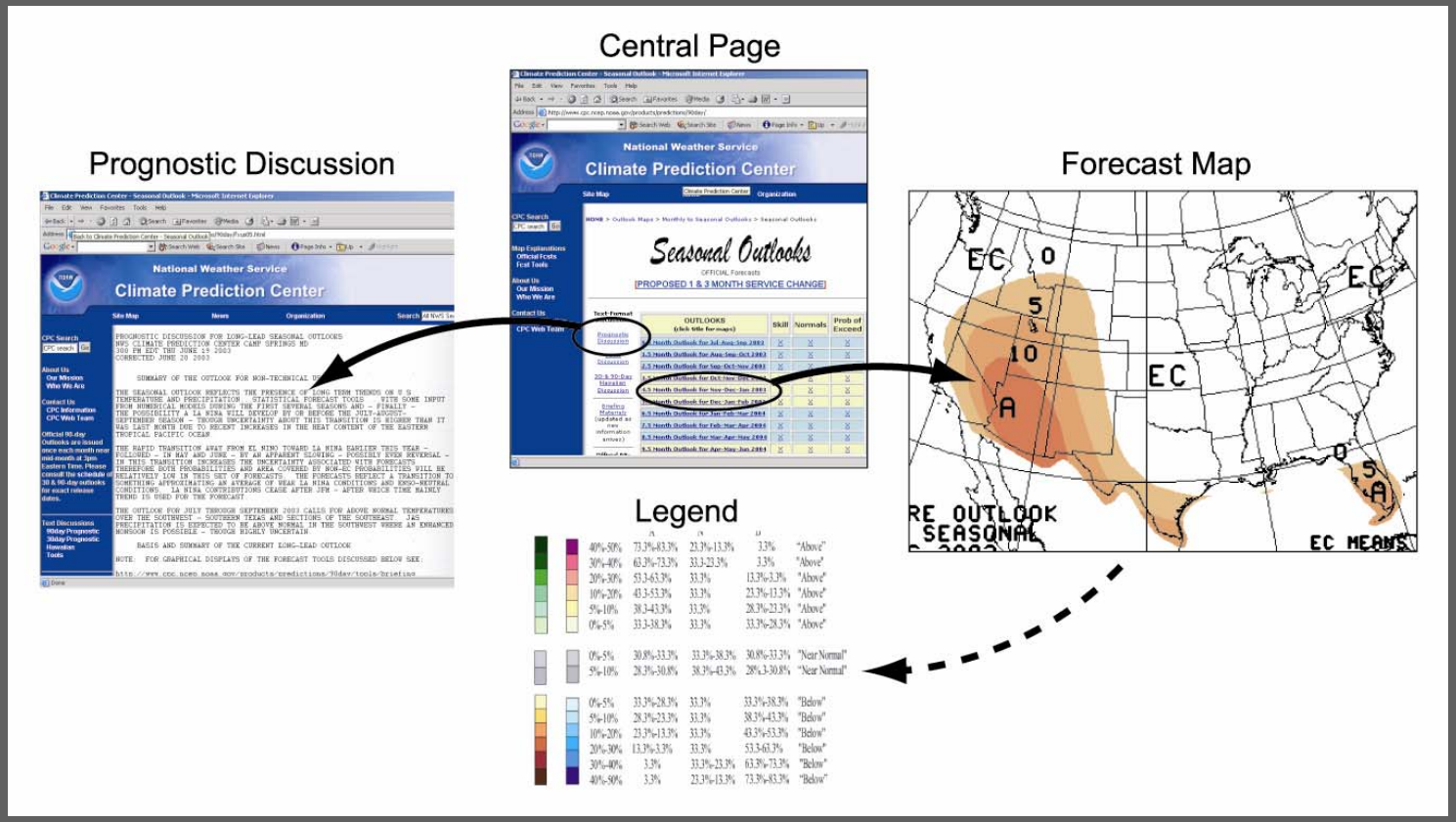
Hydrological Data and Information System
HyDIS
Infomart

CLIMAS



Western Regional Climate Center

Placement of Text and Graphics

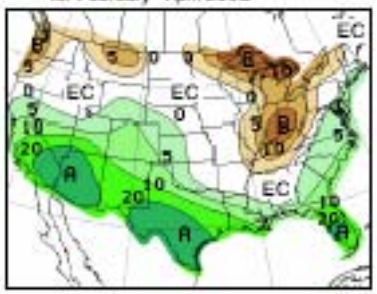


Slide courtesy of Joe Abraham, CLIMAS

11. Precipitation: Multi-season Outlooks ♦ Source: NOAA Climate Prediction Center

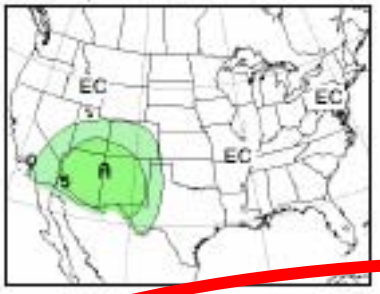
Overlapping 3-month long-lead precipitation forcasts (released 12/19/02).

11a. Long-lead U.S. precipitation forecast for February - April 2003.

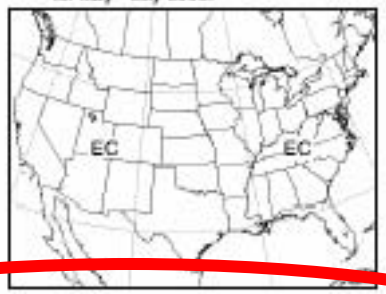


11b. Long-lead U.S. precipitation forecast for March - May 2003.

11c. Long-lead U.S. precipitation forecast for April - June 2003.



11d. Long-lead U.S. precipitation forecast for May - July 2003.



Percent Likelihood of Above or Below Average Precipitation*

20% - 30%	Above
10% - 20%	
5% - 10%	
0% - 5%	
0% - 5%	Below
5% - 10%	
10% - 20%	
20% - 30%	

*EC indicates no forecast due to lack of model skill

Highlights: The effects of a moderate El Niño are indicated by the increased probability of above-average precipitation in the southern United States in the winter and spring (Figures 11a-c). For the Southwest, the greatest confidence in these predictions is centered over much of Arizona during February-April 2003, with probabilities reaching 53.3-63.3% for above-average precipitation (accompanied by only 3.3-13.3% probabilities of below-average precipitation). The probabilities for continued above-average precipitation in Arizona and New Mexico during the spring (Figure 11b) range between 38.3% (southern Arizona) and 43.3-53.3% (southeastern New Mexico). These predictions are based chiefly on the historical tendency for above-average precipitation in the Southwest during an El Niño event, supported by results of trend analysis. Forecasters expect moderate El Niño conditions to continue for at least the next 2-4 months. However, El Niño-related winter precipitation in the Southwest is highly variable. Peak El Niño strength is likely to occur either during December 2002 or January 2003. NOAA CPC climate outlooks are released on Thursday, between the 15th and 21st of each month.

For more information, visit:
http://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/churchill.html
Please note that this website has many graphics and may load slowly on your computer.

Notes:

The NOAA CPC (National Oceanic and Atmospheric Administration Climate Prediction Center) outlooks predict the "excess" likelihood (chance) of above-average, average, and below-average precipitation, but **not** the magnitude of such variation. The numbers on the maps **do not** refer to inches of precipitation.

In a situation where there is no forecast skill, one might look at *average* conditions in order to get an idea of what might happen. Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3% chance of above-average, a 33.3% chance of average, and a 33.3% chance of below-average precipitation.

Thus, using the NOAA CPC excess likelihood forecast, in areas with light green shading (0-5% excess likelihood of above-average) there is a 33.3-38.3% chance of above-average, a 33.3% chance of average, and a 28.3-33.3% chance of below-average precipitation.

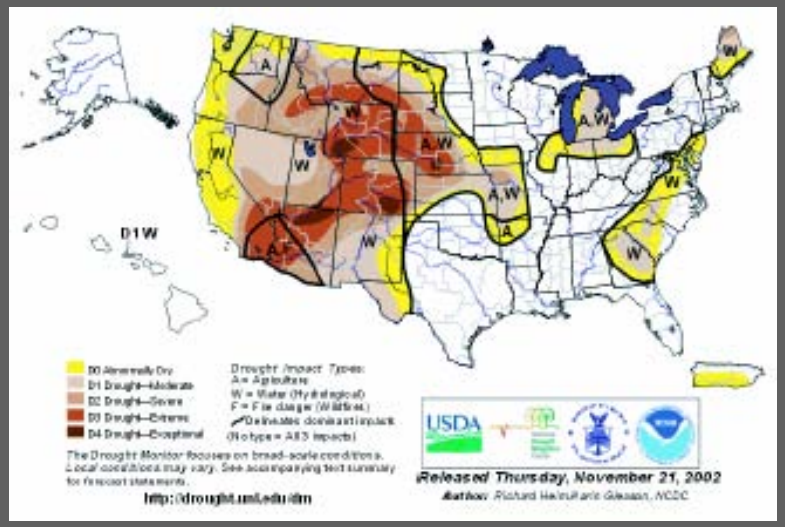
The term *average* refers to the 1971-2000 average. This practice is standard in the field of climatology.

Equal Chances (EC) indicates areas where reliability (i.e., the 'skill') of the forecast is poor and no prediction is offered.

CLIMAS

Quantitative Responses (n=34)

U.S. Drought Monitor

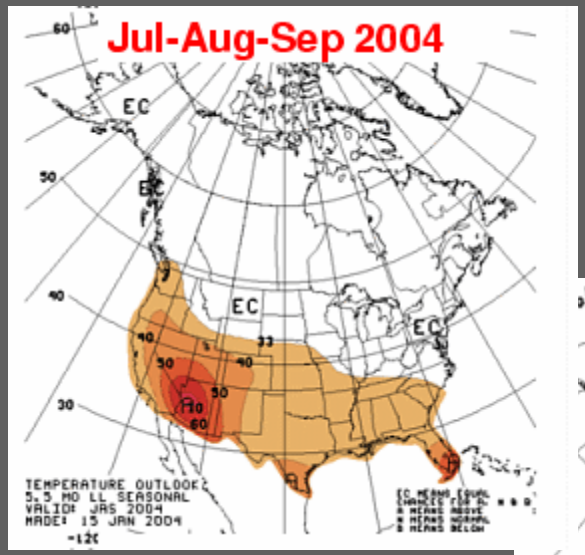


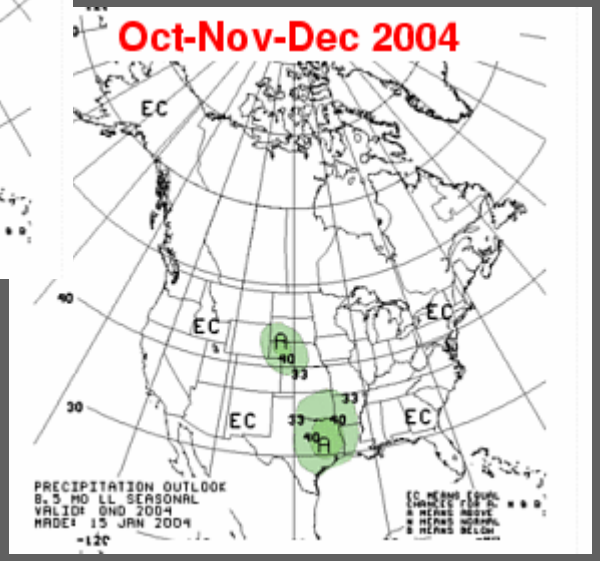
Useful	77%
Interesting	23%
Neither	0%

Need two maps

Qualitative Responses

NOAA-CPC Seasonal Outlook





Regional
Skill +
Verification?

Usefulness

Enhanced decision making ability

- Monitoring, mitigating effects
  - Endangered species
  - Non-native species
- Scheduling activities
  - Prescribed burning
  - Rangeland stocking rates

Lessons Learned

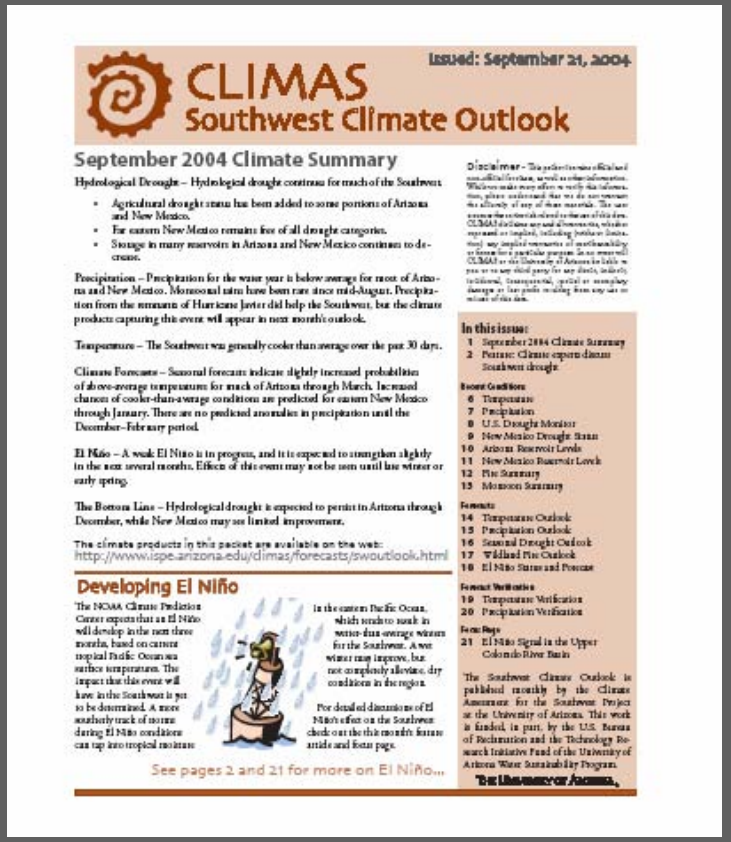
- **Iterative, sustained interaction valued**
  - Trust
  - Workshop
- **Bridge/Translator function valued**
  - Region-specific information
- **One-Stop Shopping**
  - Multi-agency – message neutral

Effective Strategies for Distribution

- **Information brokers are key partners**
  - Target information to appropriate people

Transition to Operations

- **Format change**
- **Information Broker**
  - Cooperative Extension
- **Intermountain West**



CLIMAS
Southwest Climate Outlook

Issued: September 21, 2004

September 2004 Climate Summary

Hydrological Drought – Hydrological drought continues for much of the Southwest

- Agricultural drought status has been added to some portions of Arizona and New Mexico.
- Far eastern New Mexico remains free of all drought categories.
- Storage in many reservoirs in Arizona and New Mexico continues to decrease.

Precipitation – Precipitation for the water year is below average for most of Arizona and New Mexico. Monsoonal rains have been rare since mid-August. Precipitation from the remnants of Hurricane Javier did help the Southwest, but the climate products capturing this event will appear in next month's outlook.

Temperature – The Southwest was generally cooler than average over the past 30 days.

Climate Forecasts – Seasonal forecasts indicate slightly increased probabilities of above-average temperatures for much of Arizona through March. Increased chances of cooler-than-average conditions are predicted for eastern New Mexico through January. There are no predicted anomalies in precipitation until the December–February period.

El Niño – A weak El Niño is in progress, and it is expected to strengthen slightly in the next several months. Effects of this event may not be seen until late winter or early spring.

The Bottom Line – Hydrological drought is expected to persist in Arizona through December, while New Mexico may see limited improvement.

The climate products in this packet are available on the web:
http://www.ispe.arizona.edu/climas/forecasts/swoutlook.html

Developing El Niño

The NOAA Climate Prediction Center expects that an El Niño will develop in the next three months, based on current tropical Pacific Ocean sea surface temperatures. The impact that this event will have in the Southwest is yet to be determined. A more southerly track of storms during El Niño conditions can tap into tropical moisture in the eastern Pacific Ocean, which tends to result in wetter-than-average winters for the Southwest. A wet winter may improve, but not completely alleviate, dry conditions in the region.

For detailed discussions of El Niño's effect on the Southwest check out the this month's feature article and feature page.

See pages 2 and 21 for more on El Niño...

Disclaimer –

In this issue:

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The Southwest Climate Outlook is published monthly by the Climate Assessment for the Southwest Project at the University of Arizona. This work is funded, in part, by the U.S. Bureau of Reclamation and the Technology Research Initiative Fund of the University of Arizona Water Sustainability Program.

http://www.ispe.arizona.edu/climas/forecasts/swoutlook.html

Trust and Recognition Leads to Opportunity

GDTF • Governor's Drought Task Force

ARIZONA DEPARTMENT OF WATER RESOURCES

SECURING ARIZONA'S WATER FUTURE

Governor signed Executive Order at CLIMAS-SAHRA Press Briefing

Drought Research

- **Drought plan chapter co-authors and advisors**
- Climatology and monitoring
- Drought mitigation and vulnerability
- Economic impacts
- Impacts database
    - National Drought Mitigation Center

Targeted Engagements:

Applied Climate Studies

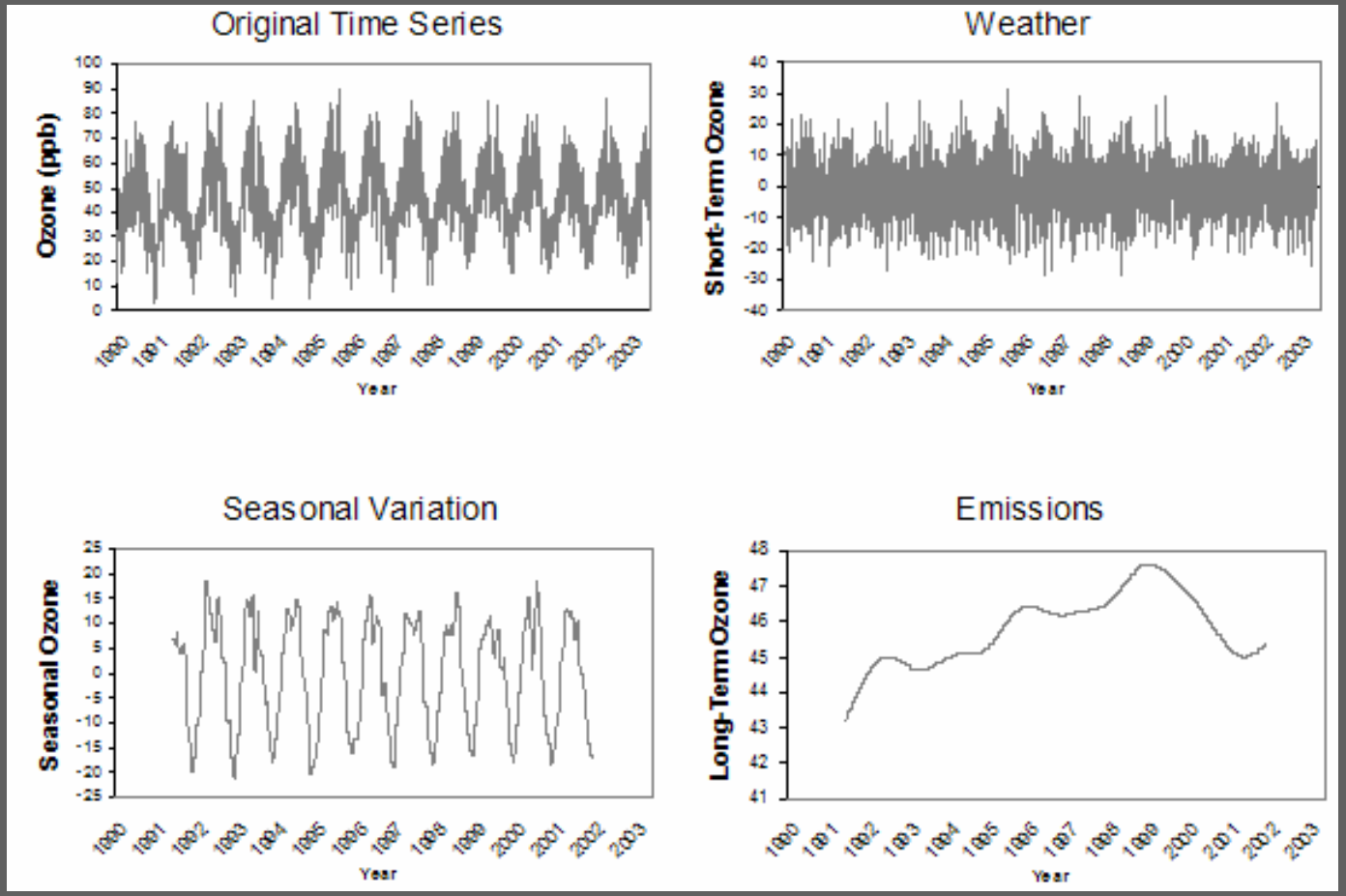
Air Quality

- **Air Quality Managers**
  - Tucson, Phoenix, Las Vegas, El Paso, Albuquerque
  - Isolate climate effects on smog & dust
- **Underlying emission trends**
  - Inform decision-making

Air Quality

- **Regional stakeholder workshops**
- **Stakeholders not aware of latent climate info**
  - Annual-to-decadal variations
  - Inform use of climate forecasts

Air Quality



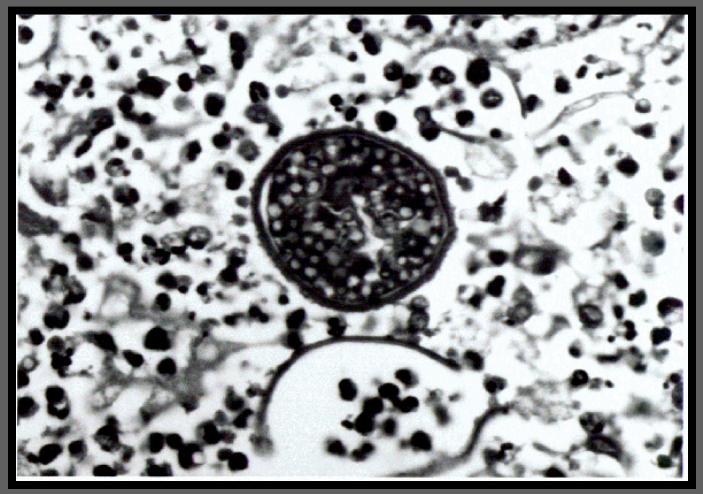
Wise and Comrie, 2005 *Atmospheric Environment* (in press)

Metrics for Success

- # — EPA, WGA, NPS, county, municipal
- Δ — Validation in new region
- — Ongoing workshop series; wildfire, border
- ☺ — ?
- WRCC

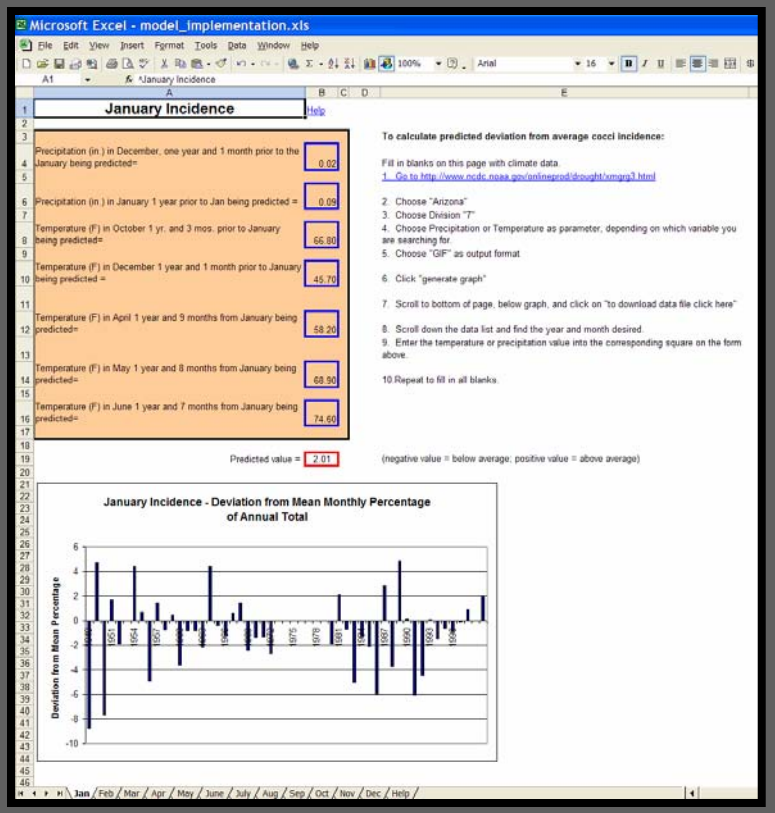
Climate and Health: Valley Fever

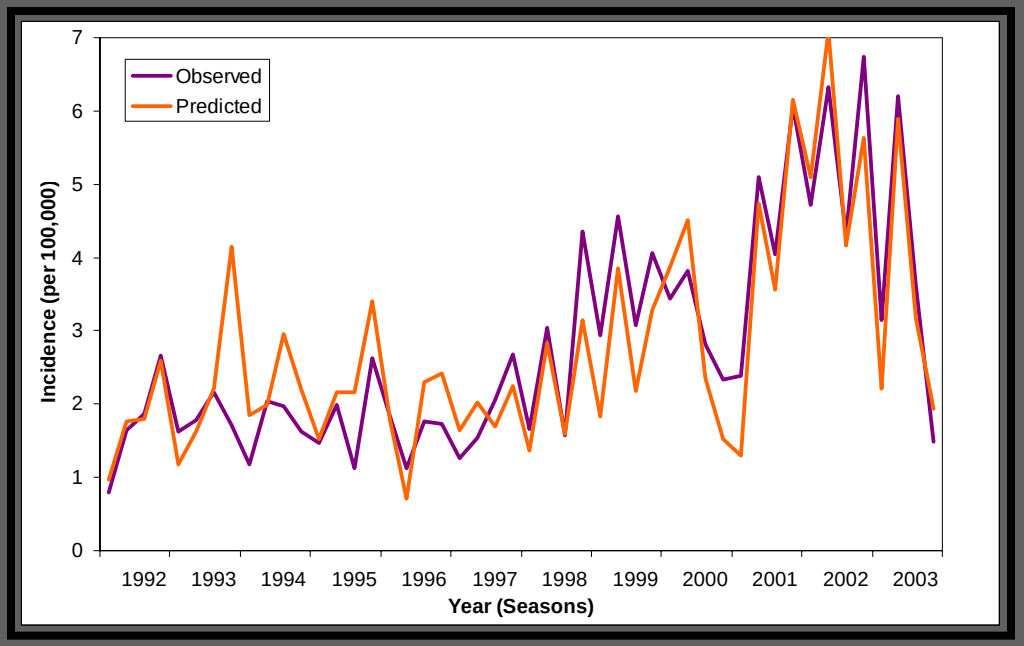
- **Valley Fever** (*coccidioidomycosis*)
  - soil fungus
- **Airborne spores ⟶ infection**
- **Costs**
  - 6,000-8,000 severe cases/year
  - 50-100 deaths/year
  - $60 million/year in medical treament



Climate and Health: Valley Fever

- Identify climate controls
  - Precipitation, temperature, dust
  - Interactive web-based tool

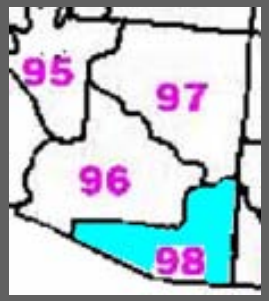


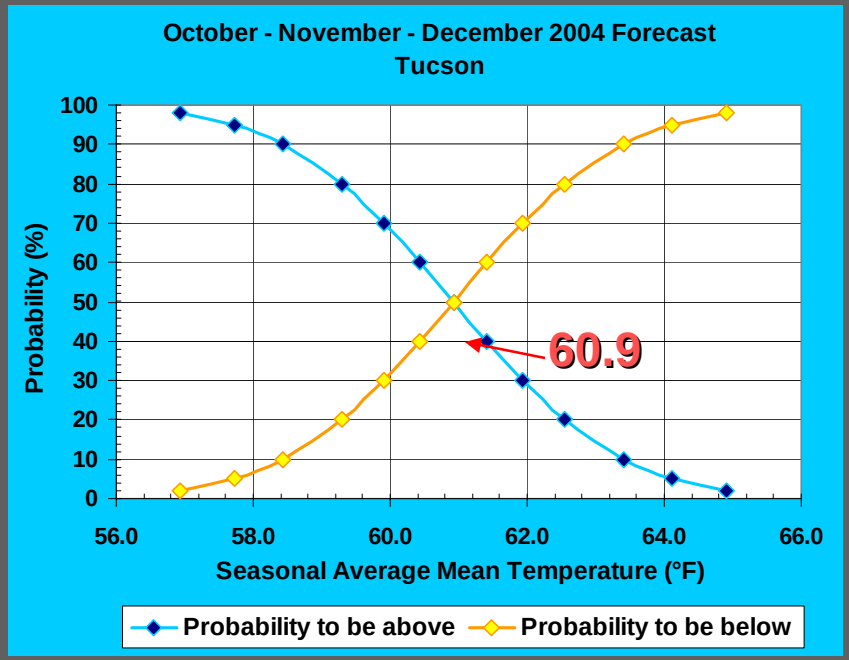


Kolivras and Comrie, 2003 *International Journal of Biometeorology*

Downscaled Climate Forecasts

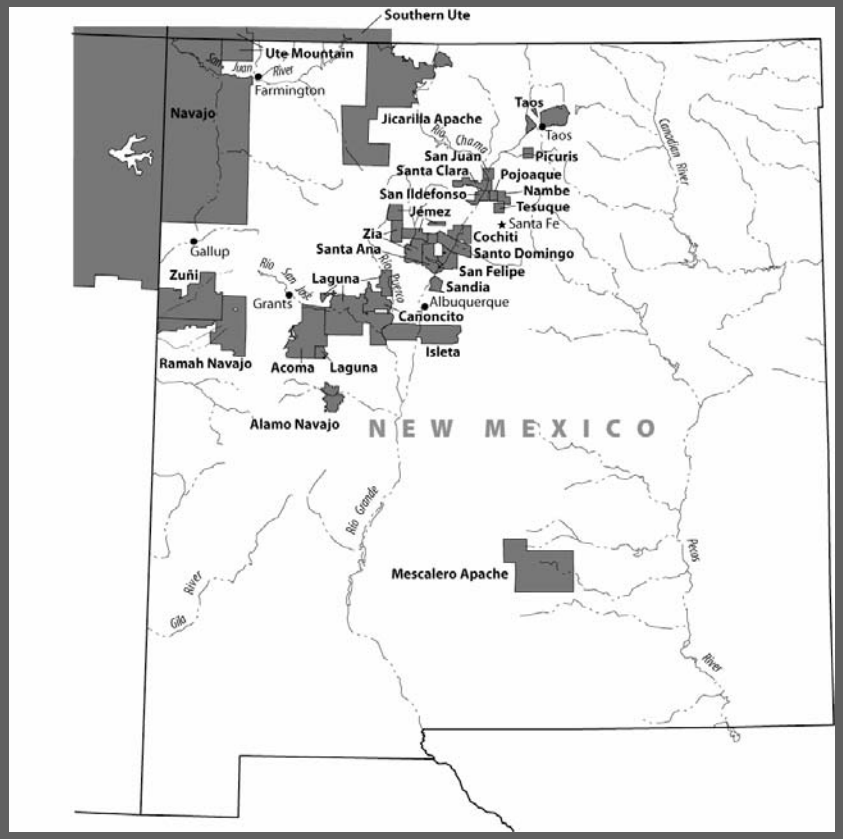
- **CLIMAS-NWS Tucson collaboration meetings**
  - Need for local climate forecast info
  - Constraint: must be official product
- **CLIMAS tests CSD methodology**
  - Precipitation: West
- **NOAA Partners**
  - NWS Tucson
  - NWS Western Reg.
  - NOAA-CSD





Quantifying Impacts:

Economic Risk Analysis



Water Transfer Tradeoffs

- **Conflict**
  - Moving water from traditional uses and rural communities
- **Social & environmental benefits**
  - Restoring watersheds
  - Assuring reliable supplies for homes and businesses

Dry year water reliability: a challenge *throughout* the West!

Hot spots: **recent efforts to acquire water**

Slide courtesy of Bonnie Colby

Water Rights Settlement

- **New Mexico Indian-Urban-Irrigation Settlement**
  - Shortage sharing during drought
    - Pueblos
    - Rural water users
    - Counties & cities
  - **Securing stability**

Water Rights Settlement

- **New Mexico Indian-Urban-Irrigation Settlement**
  - Stakeholder workshop
  - Explicit climate information
  - Regional dialogue on susceptibility to drought
  - Coping strategies and goodwill secured

Economic Risk Analysis

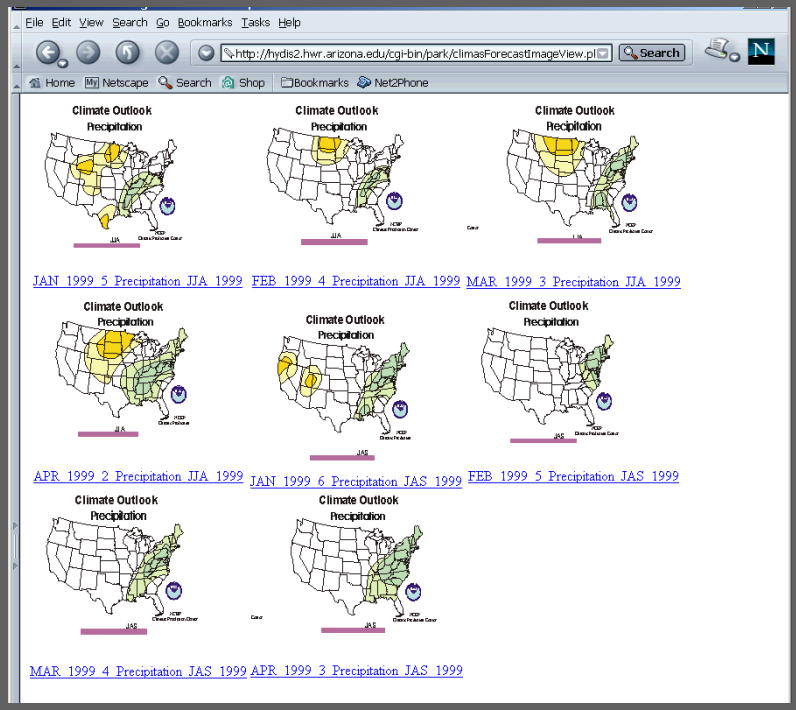
- **Tourism and recreation economy**
  - Snow-based recreation economy
    - Potential climate change effects
  - Park visitation, drought, water
    - NPS model – no climate, no causality
    - CLIMAS attribution

Product:

Forecast Evaluation

Forecast Evaluation

- Unknown forecast skill
- Misinterpretation
- Lack historical context



FET Elements

- Forecast Progression
- Tutorials
- Historical Context
- Forecast Performance

http://hydis4.hwr.arizona.edu/ForecastEvaluationTool

Forecast Evaluation

- **Sub-setting**
  - Seasons, Lead times, Regions, Years
- **Criteria**
  - Simple/Intuitive to Complex/Informative
- **Transparency**
  - Data behind analysis

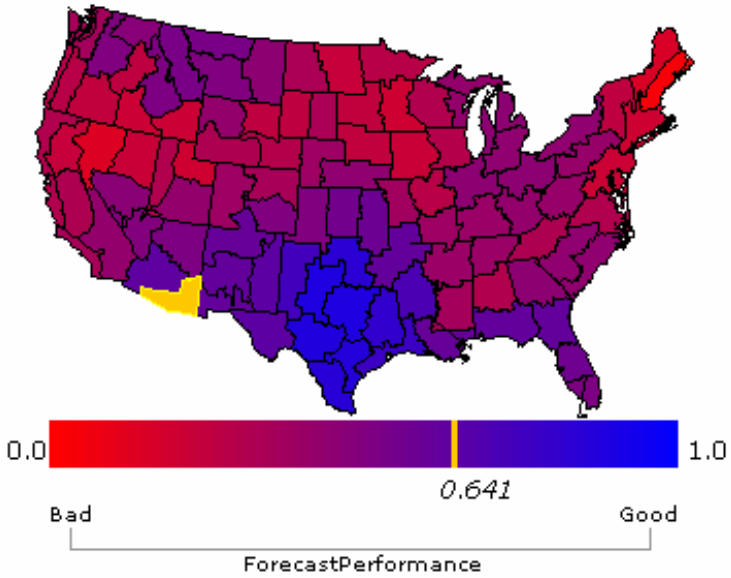
http://hydis4.hwr.arizona.edu/ForecastEvaluationTool

Forecast Evaluation

You chose precipitation forecasts issued August - October covering seasons December - April.

Non Climatology Score Results

To see the data that were used in the evaluations, go to the map that you are interested in and click on the region you are interested in. Then select "Show data behind map".

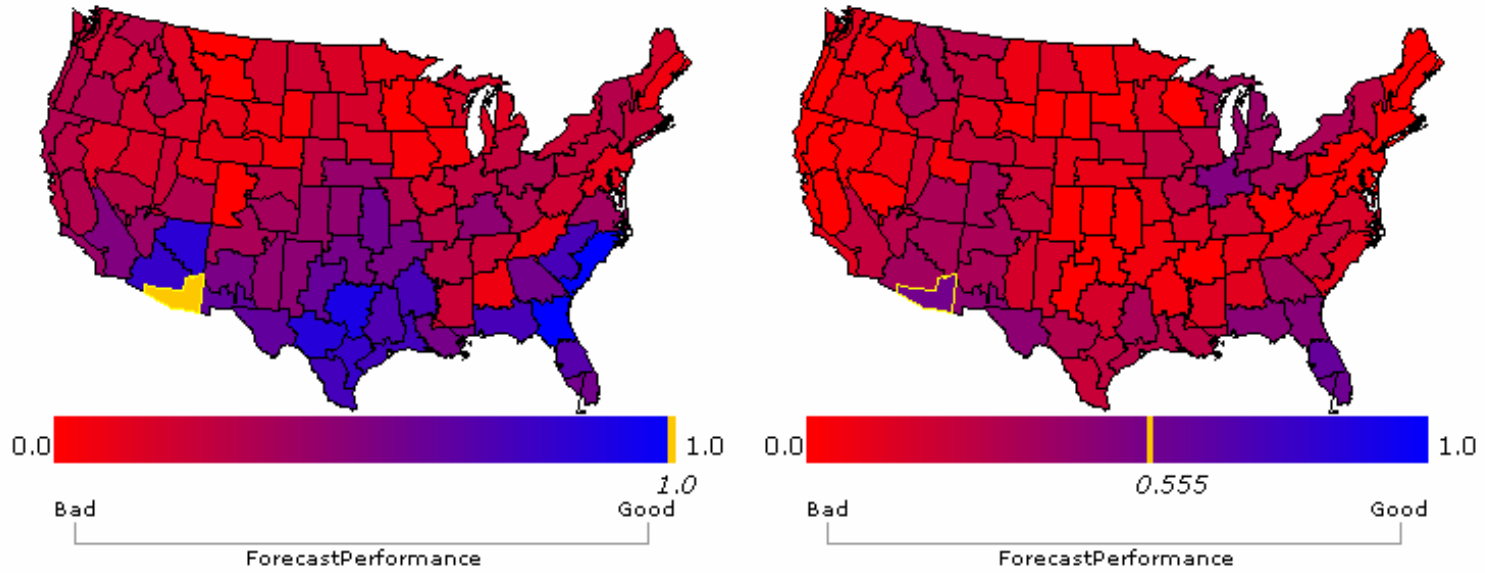


http://hydis4.hwr.arizona.edu/ForecastEvaluationTool

Forecast Evaluation

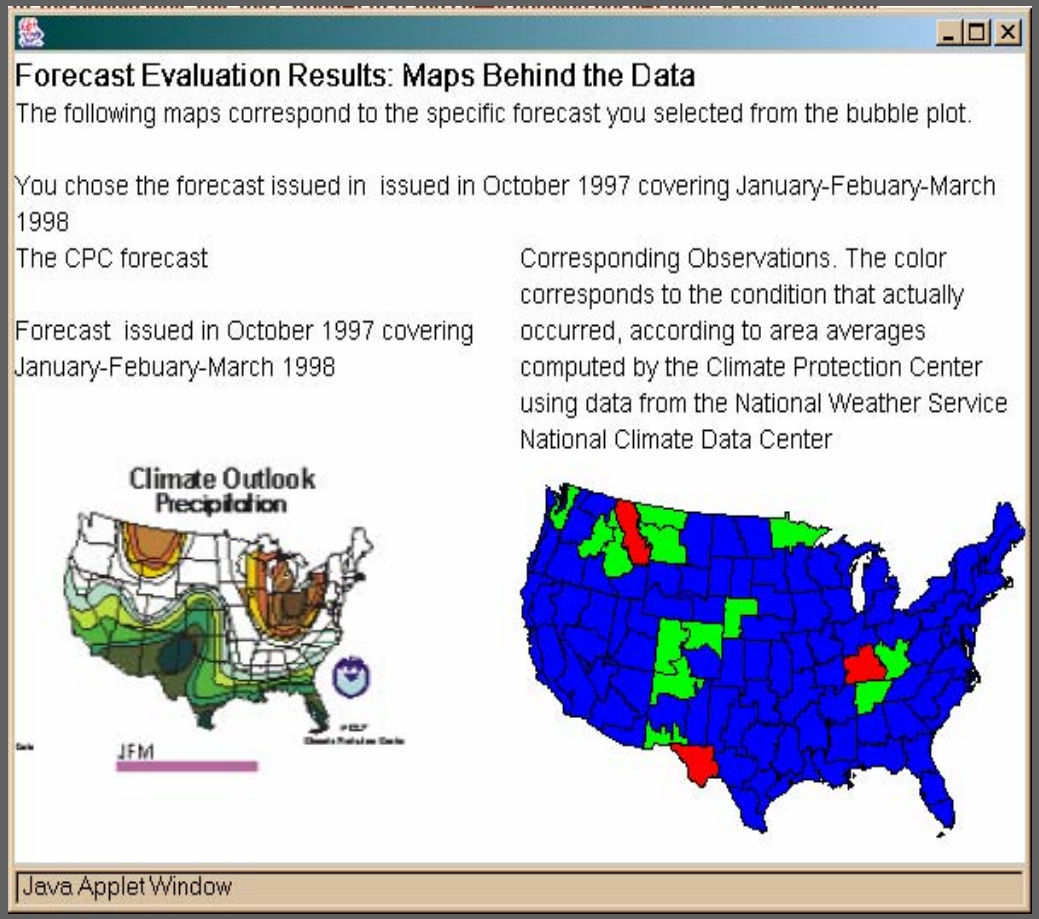
Probability of Detection Skill Score Results

This pair of maps shows the Probability of Detection for wet (left) and dry (right) conditions. The Probability of Detection tracks how often the forecasts say the right category (e.g., wet or dry) is most likely, compared to how often that category has actually occurred. It indicates how well the forecast system has been able to warn about upcoming conditions. The legend shows the Probability of Detection as a percentage.



http://hydis4.hwr.arizona.edu/ForecastEvaluationTool

Forecast Evaluation



http://hydis4.hwr.arizona.edu/ForecastEvaluationTool

Features in Development

- **Profiles and projects**
  - Save project history
  - Built-in usability study
- **Report generation**
  - PDF output

http://hydis4.hwr.arizona.edu/ForecastEvaluationTool

Metrics

- # Ranching, fire, water resources, others
- Hydro-Core Office
- Δ Historical data
- Trainings
- CSD, NWS, CBRFC, RISA, others

Establishing Context:

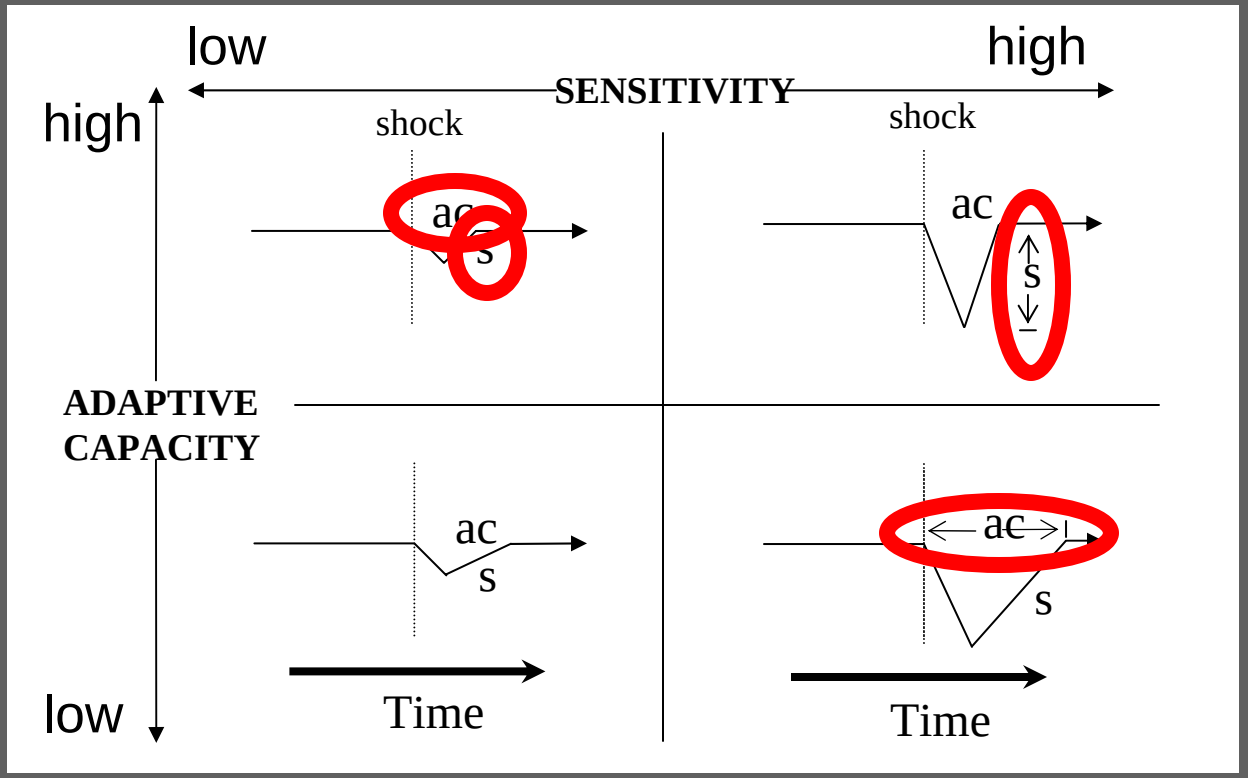
Vulnerability Assessment

Vulnerability Assessment

- Document vulnerability to climate variability
- Historical context
  - Current processes of adaptation
- Identify key stakeholders
  - Climate information: uses, needs, constraints
- Establish a sustained working partnership

http://www.ispe.arizona.edu/climas/research/vulnerability/background.html

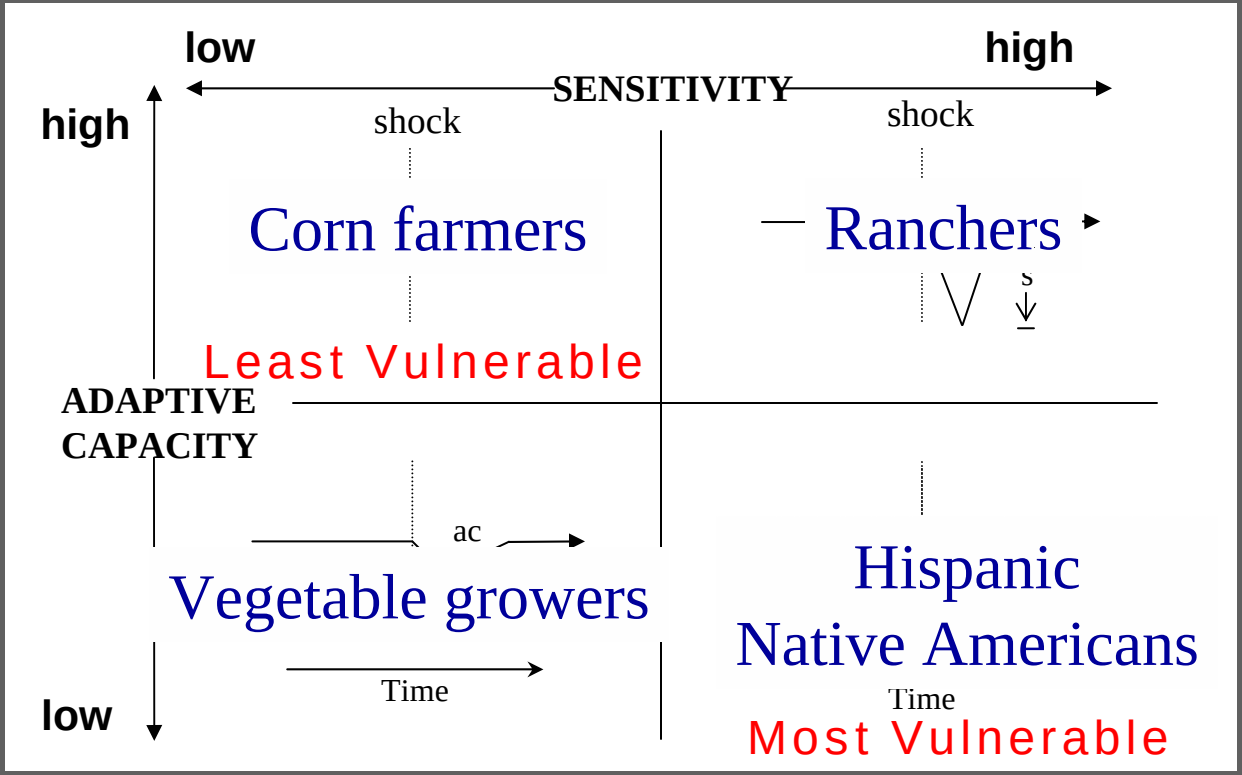
Vulnerability Assessment



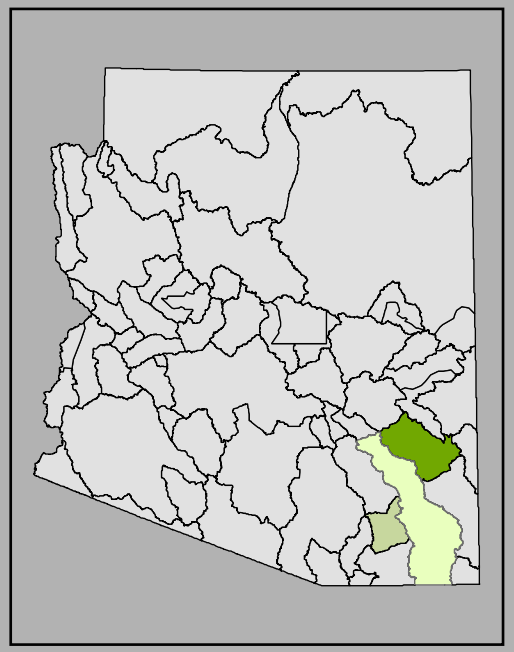
- **Exposure** to climatic variability and change
- **Sensitivity** – degree to which system is affected by climate
- **Adaptive capacity** – ease and time to adjust and recover

Based on Davies 1996 *Adaptable Livelihoods*

Vulnerability Assessment



Based on Davies 1996 *Adaptable Livelihoods*



SAFFORD

WILLCOX

BENSON

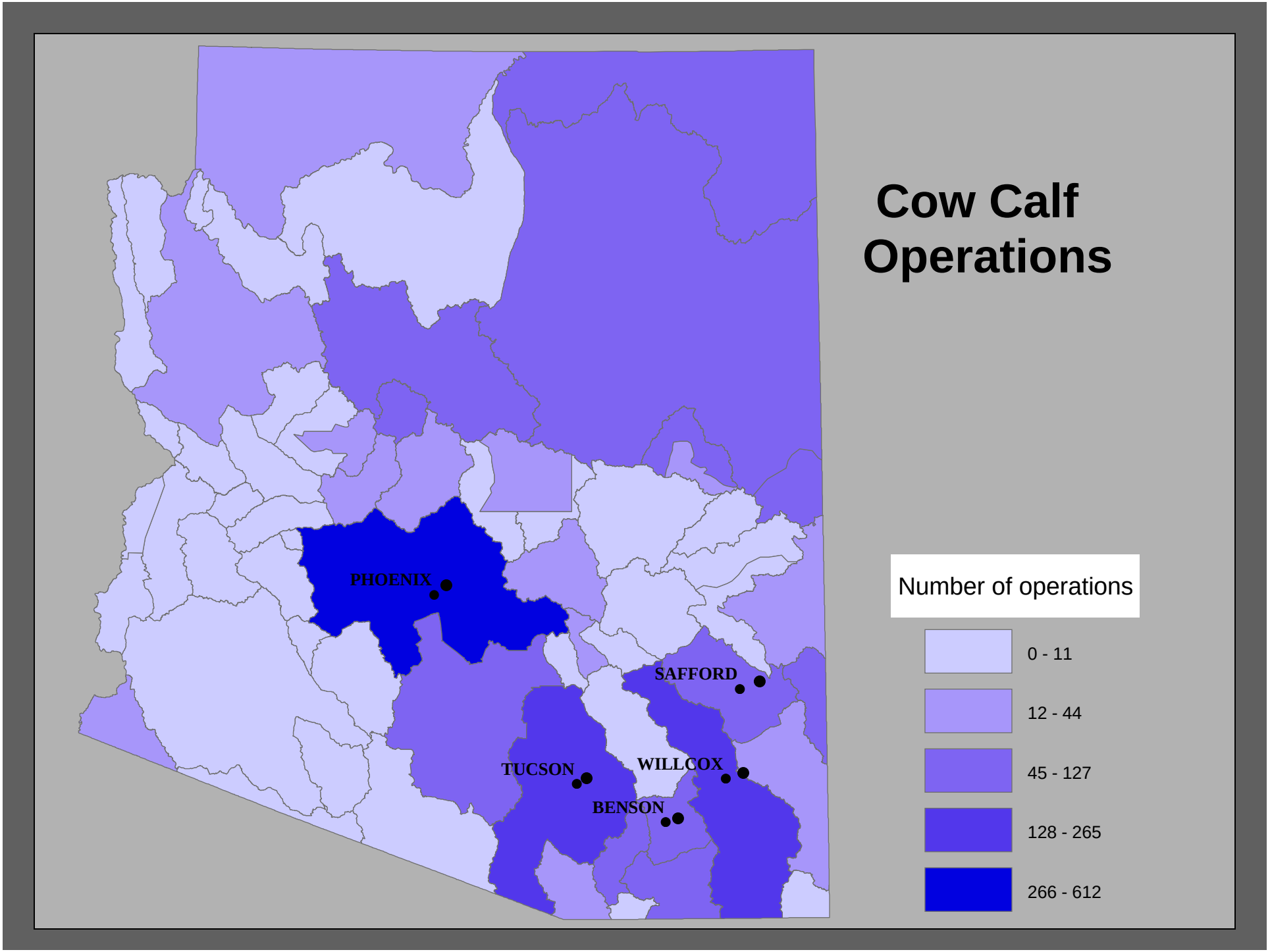
Case Study Regions

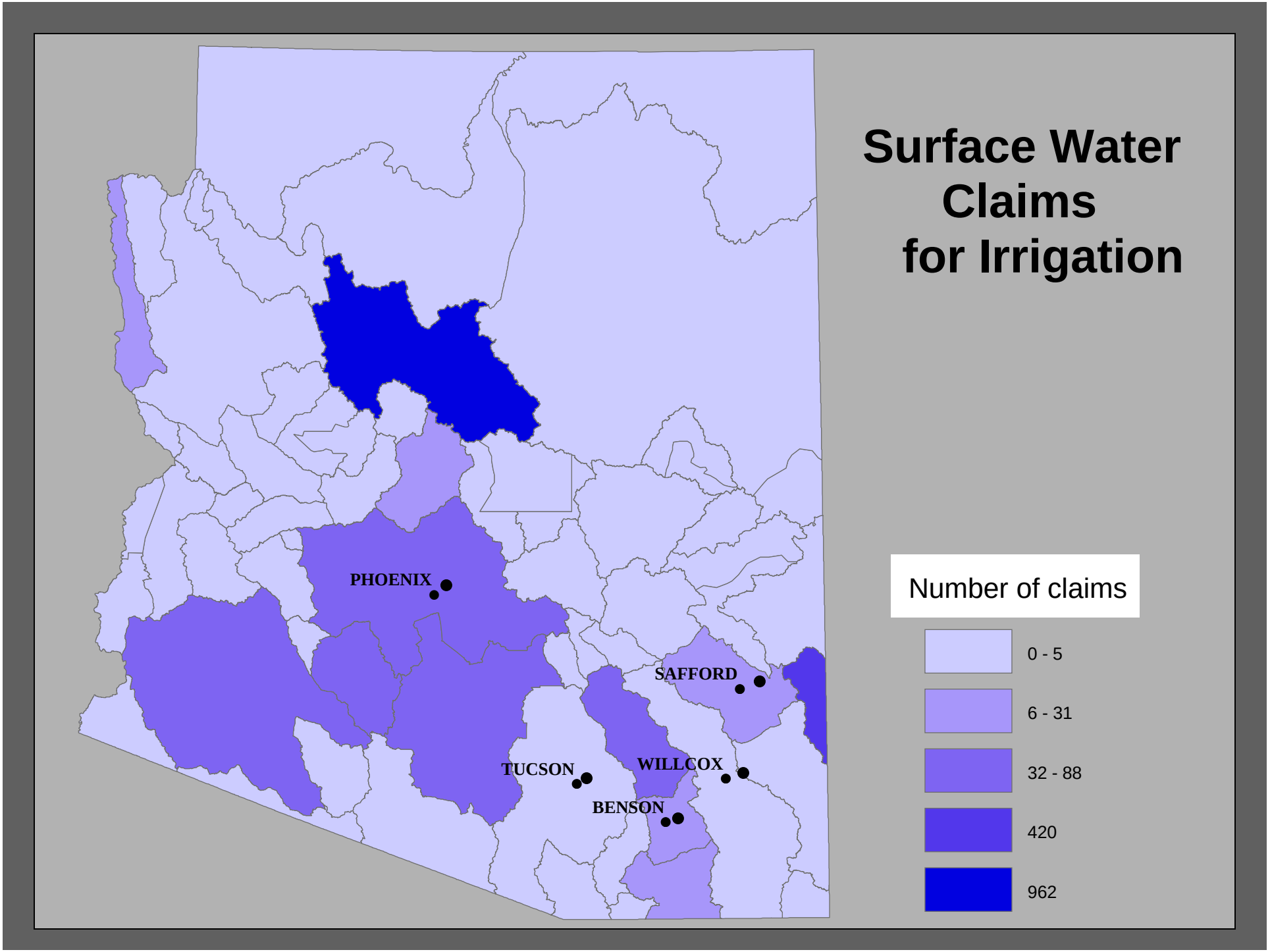
- Middle San Pedro River Valley
- Sulphur Springs Valley
- Upper Gila River Valley

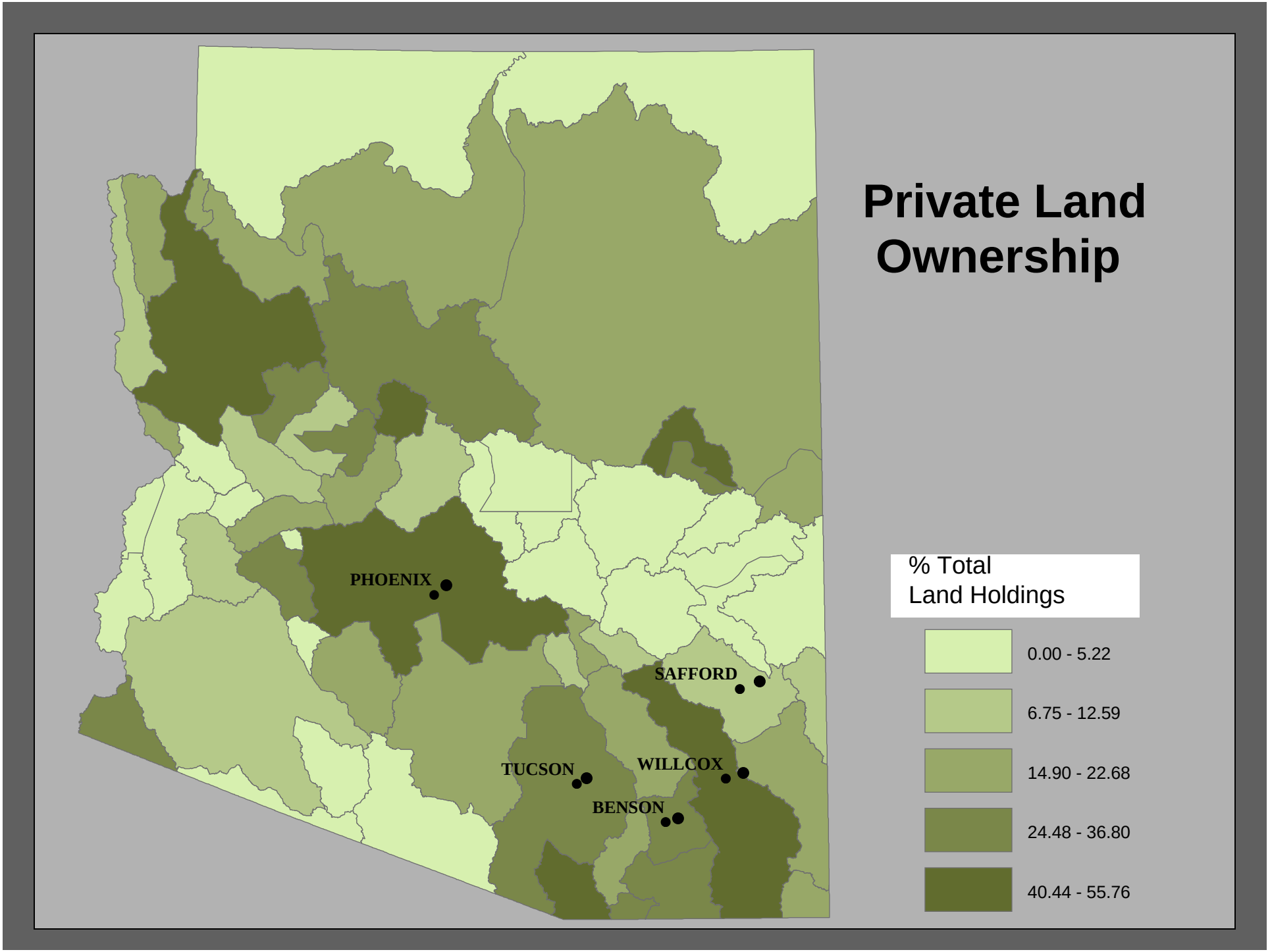
GIS-based Vulnerability Mapping

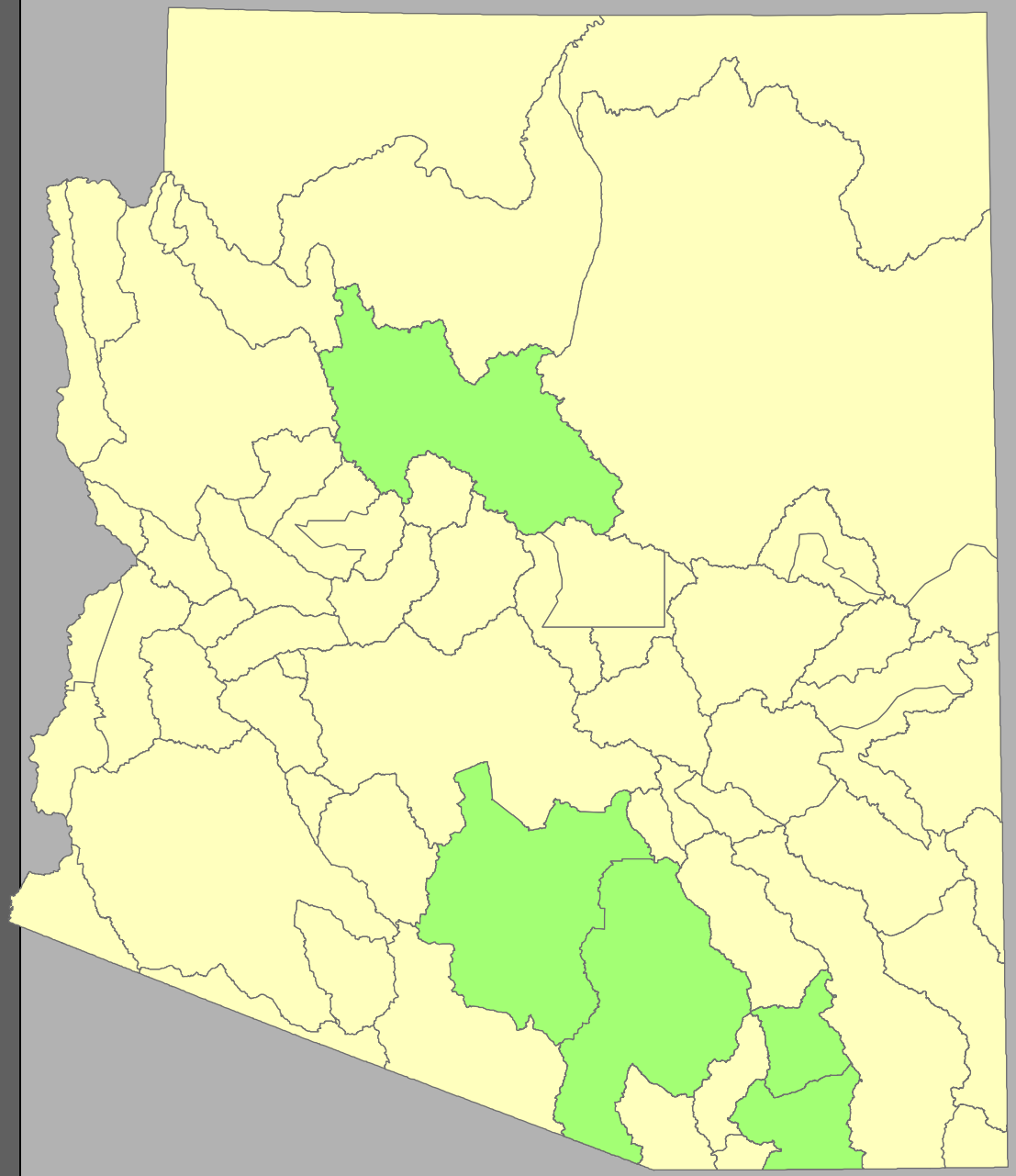
- Locate matches
- Qualitative – Quantitative

- **Partners in helping refine the product:**
- Upper San Pedro Partnership
- Arizona Department of Water Resources
- Cooperative Extension


Cow Calf Operations
PHOENIX
SAFFORD
TUCSON
WILLCOX
BENSON
Number of operations
0 - 11
12 - 44
45 - 127
128 - 265
266 - 612


Surface Water Claims for Irrigation
PHOENIX
TUCSON
SAFFORD
WILLCOX
BENSON
Number of claims
0 - 5
6 - 31
32 - 88
420
962


Private Land Ownership
PHOENIX
SAFFORD
TUCSON
WILLCOX
BENSON
% Total Land Holdings
0.00 - 5.22
6.75 - 12.59
14.90 - 22.68
24.48 - 36.80
40.44 - 55.76



Areas Similar to Middle San Pedro River Valley

Private Land - High
Crop Diversification - High
Large Scale
Production - Low

Metrics

- # Primary contacts, NRCDs, Cooperative Extension
- Hydro, Core Office, Climate, Border, Economics
- Drought Plan: Irrigated agriculture chapter; Arizona Department of Water Resources

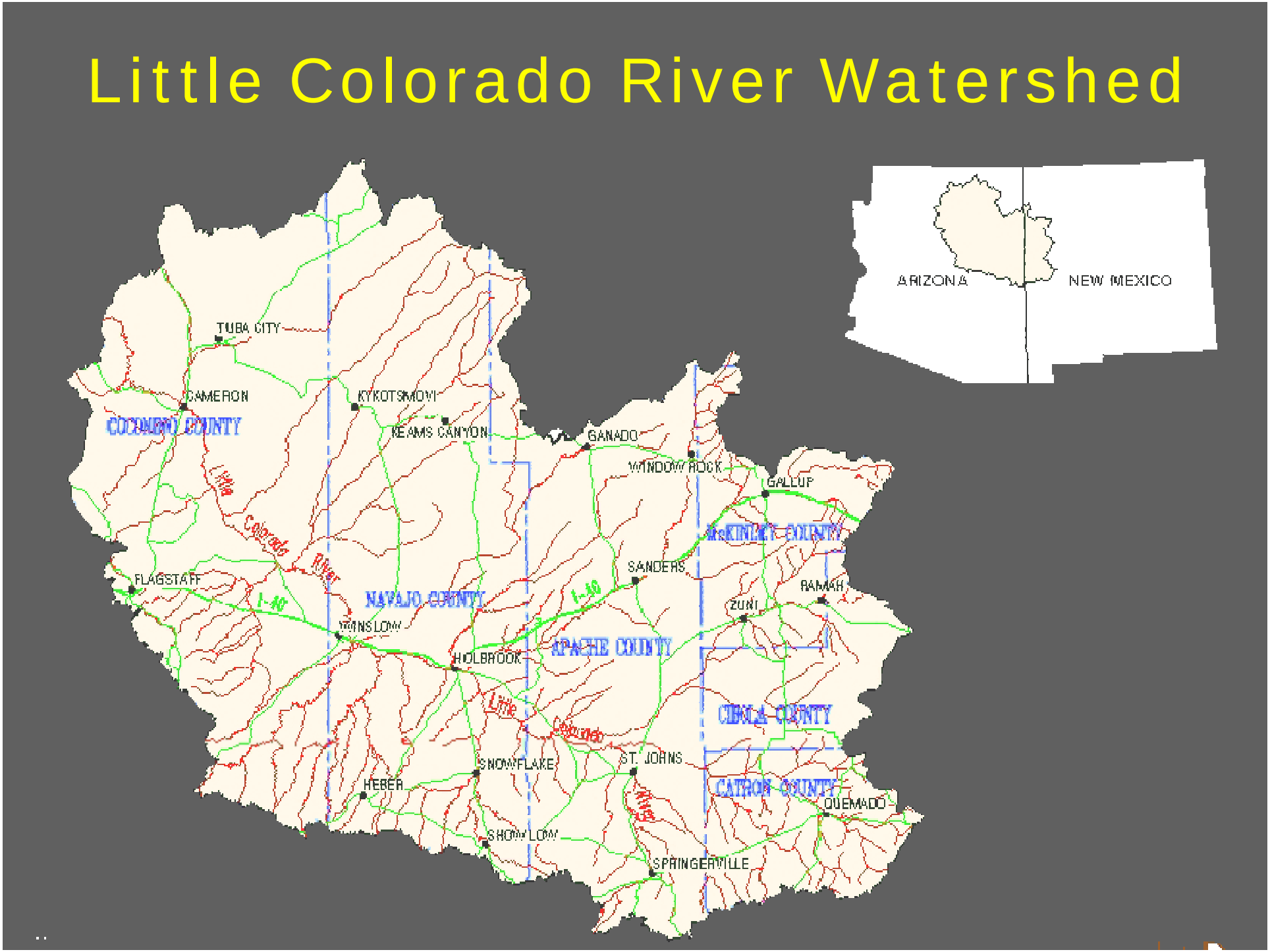
TIP:
Team Integrated Project

TIP Goals

- **Advance integrated assessment**
- **More complete CLIMAS integration**
- **Test methodologies**
  - Principles and objectives
  - Collaborative groups, adaptive research

Photo: Craig Allen

Little Colorado River Watershed



Upper Little Colorado Watershed

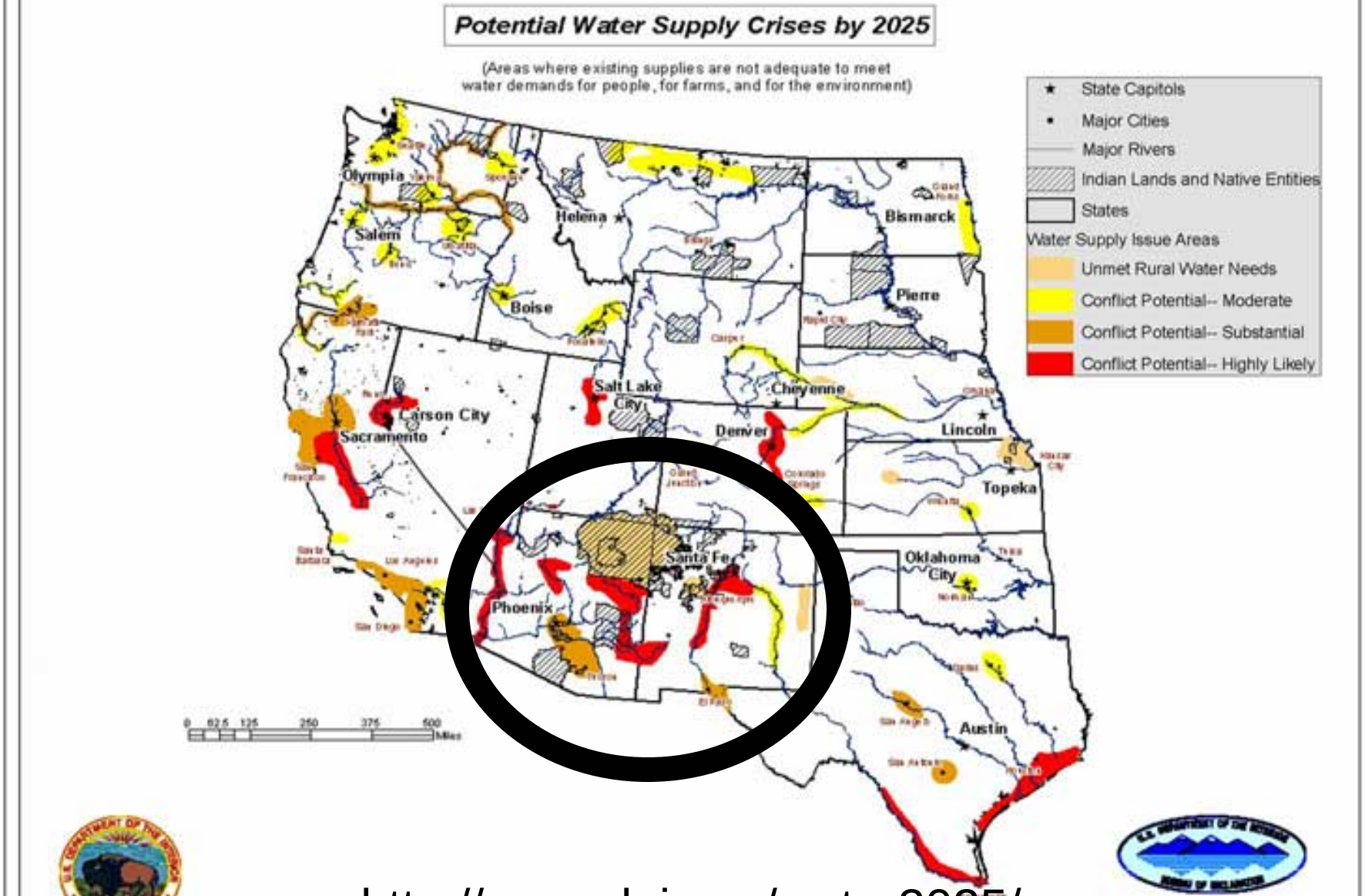
Why this region?

- Ethnic and cultural diversity
- Climate-dependent rural lifestyles
  - urban expansion
- Variety of ecosystems

Photo:USDA-FS

Photo: USDA-FS

Photos: UA Cooperative Extension



http://www.doi.gov/water2025/

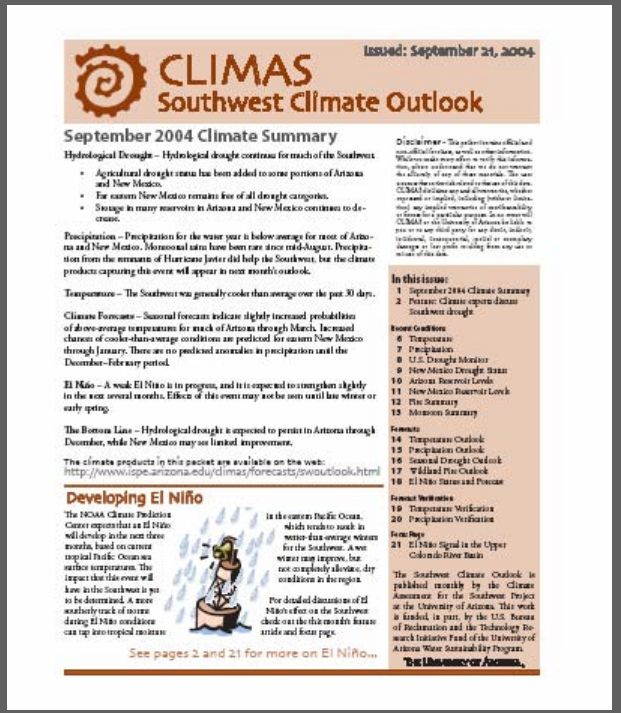
TIP Goals

- **Expand horizontally into other areas**
  - Sectorally
    - Forest health, wildlife, NGOs
    - Tourism and recreation
    - County and municipal

Climate and Water Resources Extension

Climate Extension

- **Information Broker**
  - Improved use
  - Improved demand
  - Re-survey
  - Improved knowledge transfer



CLIMAS
Southwest Climate Outlook

Issued: September 21, 2004

September 2004 Climate Summary

Hydrological Drought – Hydrological drought continues for much of the Southwest

- Agricultural drought status has been added to some portions of Arizona and New Mexico.
- Far eastern New Mexico remains free of all drought categories.
- Storage in many reservoirs in Arizona and New Mexico continues to decrease.

Precipitation – Precipitation for the water year is below average for most of Arizona and New Mexico. Monsoonal rains have been rare since mid-August. Precipitation from the remnants of Hurricane Javier did help the Southwest, but the climate products capturing this event will appear in next month's outlook.

Temperature – The Southwest was generally cooler than average over the past 30 days.

Climate Forecasts – Seasonal forecasts indicate slightly increased probabilities of above-average temperatures for much of Arizona through March. Increased chances of cooler-than-average conditions are predicted for eastern New Mexico through January. There are no predicted anomalies in precipitation until the December–February period.

El Niño – A weak El Niño is in progress, and it is expected to strengthen slightly in the next several months. Effects of this event may not be seen until late winter or early spring.

The Bottom Line – Hydrological drought is expected to persist in Arizona through December, while New Mexico may see limited improvement.

The climate products in this packet are available on the web:
http://www.ispe.arizona.edu/climas/forecasts/swoutlook.html

Developing El Niño

The NOAA Climate Prediction Center expects that an El Niño will develop in the next three months, based on current tropical Pacific Ocean sea surface temperatures. The impact that this event will have in the Southwest is yet to be determined. A more southerly track of storms during El Niño conditions can tap into tropical moisture in the eastern Pacific Ocean, which tends to result in wetter-than-average winters for the Southwest. A wet winter may improve, but not completely alleviate, dry conditions in the region.

For detailed discussions of El Niño's effect on the Southwest check out the this month's feature article and front page.

See pages 2 and 21 for more on El Niño...

In this issue:

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7 Precipitation
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9 New Mexico Drought Status
10 Arizona Reservoir Levels
11 New Mexico Reservoir Levels
12 Fire Summary
13 Monsoon Summary
Forecasts
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15 Precipitation Outlook
16 Seasonal Drought Outlook
17 Wildland Fire Outlook
18 El Niño Status and Forecast
Forecast Verification
19 Temperature Verification
20 Precipitation Verification
Focus Days
21 El Niño Signal in the Upper Colorado River Basin

The Southwest Climate Outlook is published monthly by the Climate Assessment for the Southwest Project at the University of Arizona. This work is funded, in part, by the U.S. Bureau of Reclamation and the Technology Research Initiative Fund of the University of Arizona Water Sustainability Program.

http://cals.arizona.edu/climate/

Water Resources Extension

- **Climate and water resource management**
  - Improved access to stakeholders
  - Emphasis: climate variability and change
  - Critical rural water use assessment

Enhancing Water Supply Reliability Through Use of Climate Information

- State-funded multidisciplinary study
- Partnership: U.S. Bureau of Reclamation
- Incorporating climate information into USBR modeling
- PIs: Jacobs (water policy), Colby (economics)
  Meko (climate), Nijssen (hydrology)

http://www.uawater.arizona.edu/programs/grants04.html