Fire-Climate-Society (FCS-1) A Model for Strategic Planning

Wildfire ALTERnatives (WALTER) Project

University of Arizona

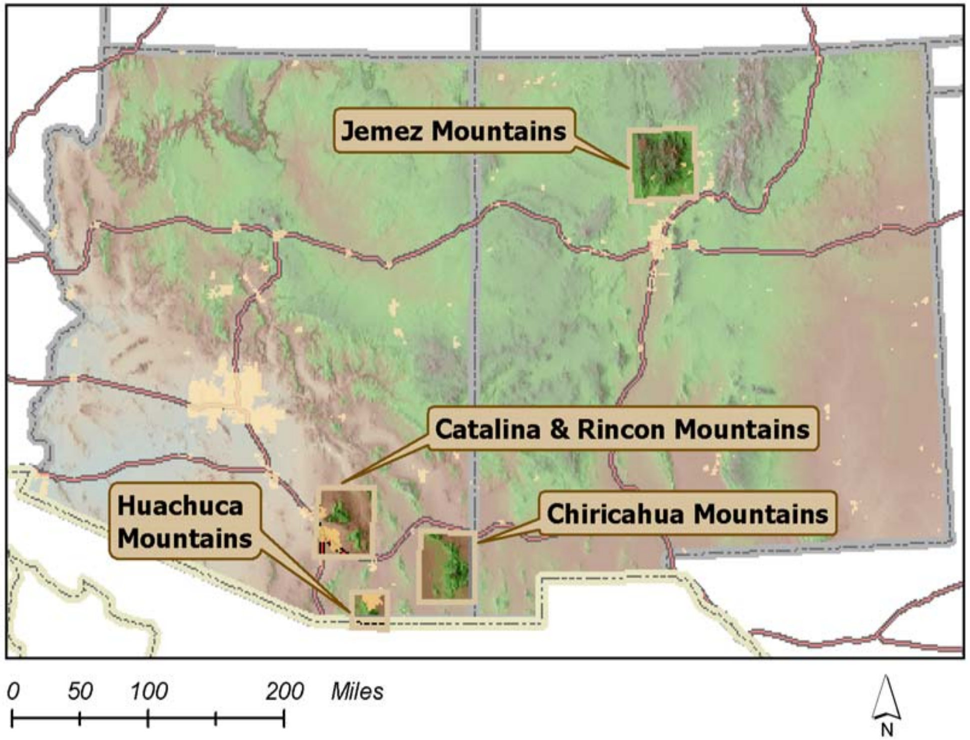
US Environmental Protection Agency - Science to Achieve Results (EPA-STAR)

- Theme of 2001 EPA call for proposals
  - Assessing the Consequences of Interactions between Human Activities and a Changing Climate
    - Consequences for human health, ecosystems, social well-being
    - Human activity as important stressor, and as adaptive response to environmental stresses
    - Development of models for assessing effects
    - Interdisciplinary research initiatives

R-82873201-0

Fire-Climate-Society Model, Version 1 (FCS-1)

- Funded for 3 years, Feb. 2001-July 2004
  - Community *and* fire management orientations
- Produces fire risk maps
  - Catalina-Rincon, Huachuca, Chiricahua, Jemez Mtns
- Provides information for strategic planning
  - Seasonal and longer time frames



Our Fundamental Research Questions

What are the climate and human dimensions of wildfire?

- How do these interact to influence fire *probability* and *risk to landscape values?*

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Our Fundamental Research Questions

How can we represent fire-climate-society interactions to assist strategic planning for wildland fire?

WALTER TEAM

- **Co-Investigators**
  - Barbara Morehouse - human geography (PI)
  - Gary Christopherson - GIS, archeology
  - Barron Orr – geospatial analysis, anthropology
  - Jonathan Overpeck – paleoclimatology, geosciences
  - Thomas Swetnam – fire ecology, dendrochronology
  - StephenYool – remote sensing, GIS, geography
  - Also…Andrew Comrie – applied climatology, geography

- Team

  Mike Crimmins, Susan Taunton

  Jodi Perin, Peter Johnson,

  Sara Jensen, Merrick Richmond,

  Michael Haseltine, Anne Thwaites,

  Wolfgang Grunberg,

  Heather Severson, Noah Lerman,

  Rachel Miller, Carolina deRosas,

  Amanda Cockerham, Jay Miller,

  Pamela Holt, Miguel Villarreal,

  William Wright, Sean Oates,

  Katherine Miskell, Calvin Farris, Derek Honeyman

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

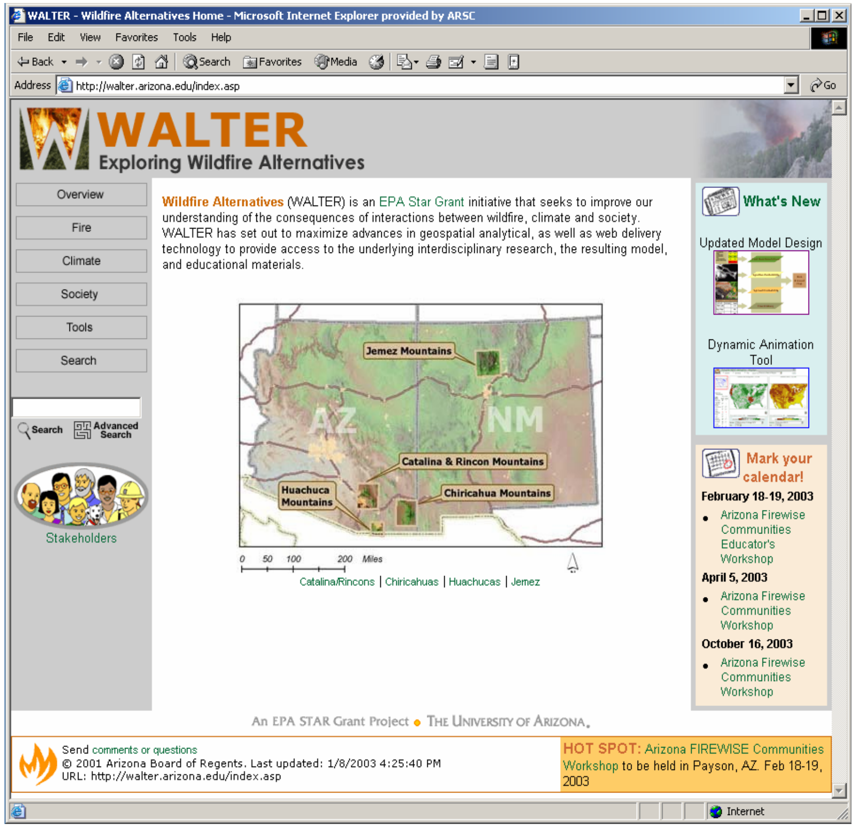
Characteristics of Model

- Tailored to study sites
- Integrates climate
  - Cues vegetation moisture conditions
- Includes fire history
  - Fire return interval departure
- Includes societal values
  - Data bases
  - Map interviews
- Requires user input to weight model components
  - Analytic Hierarchy Process (AHP)
- Features sophisticated web delivery

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Web-based Delivery: WALTER

- Hosts FCS-1
- Provides additional information and tools
- Architecture built to accommodate future product development and delivery



http://walter.arizona.edu

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Lecture Topics

- Overview of model
- Overview of individual model components
- Overview of AHP

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

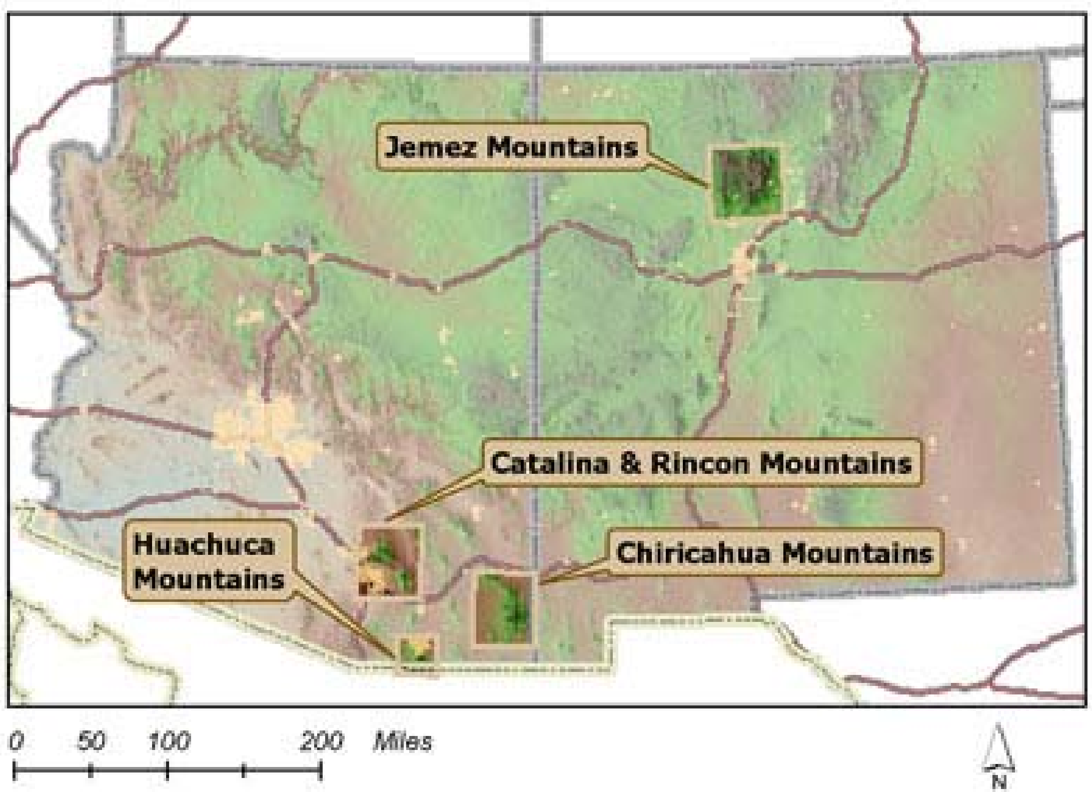
Why This Kind of Modeling is Important

- Huge fuel load buildups
- Impacts of climate variability and change
- Increasing human/wildland interaction
- Changing land use patterns
- Escalating costs
- Escalating vulnerabilities
  - Ecosystems
  - Fire fighters
  - Community members

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

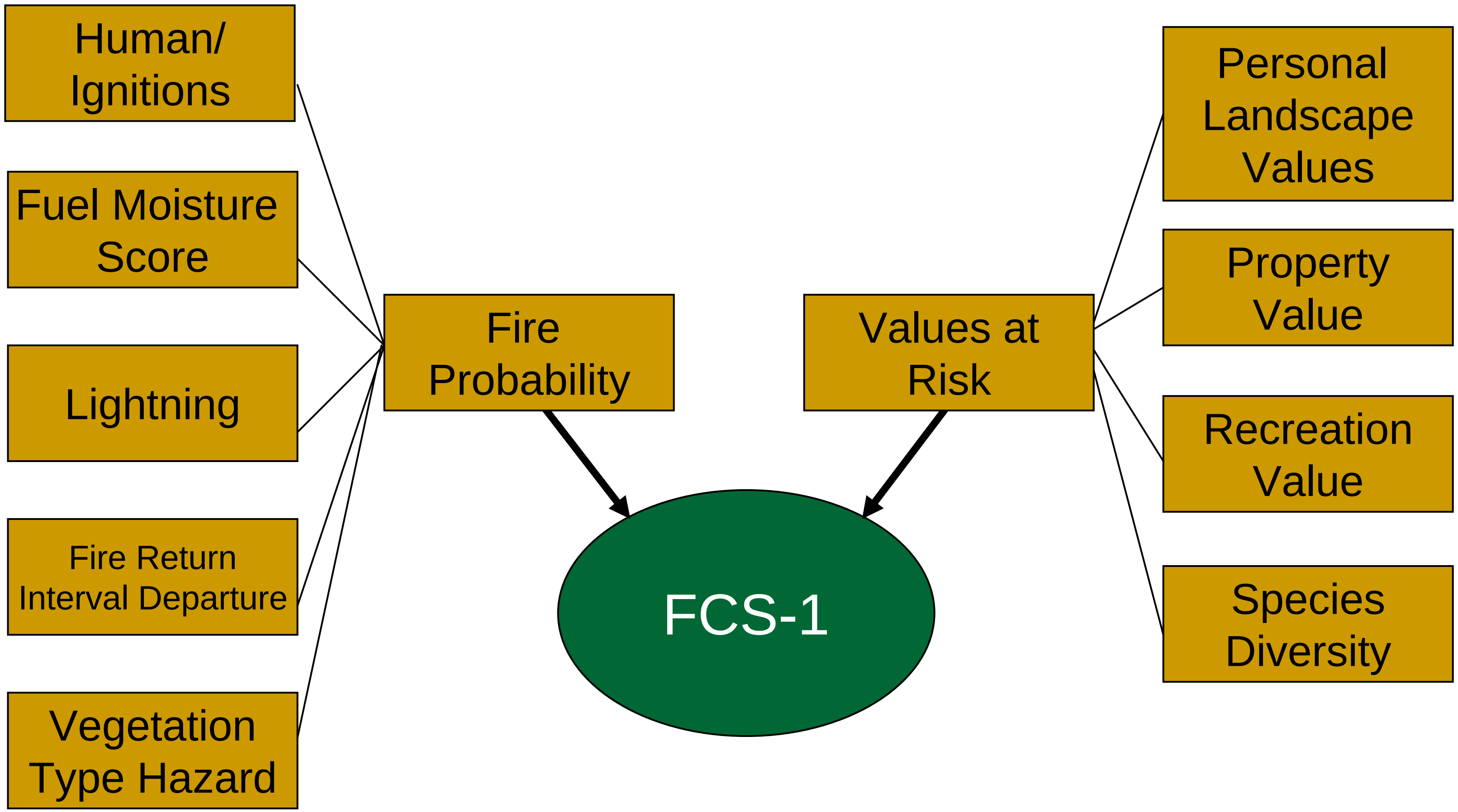
What Areas Does FCS-1 Cover?

- Catalina-Rincon Mountains
  - Tucson, Arizona
- Huachuca Mountains
  - Sierra Vista, Arizona
- Chiricahua Mountains
  - Douglas, Arizona
- Jemez Mountains
  - Los Alamos, New Mexico

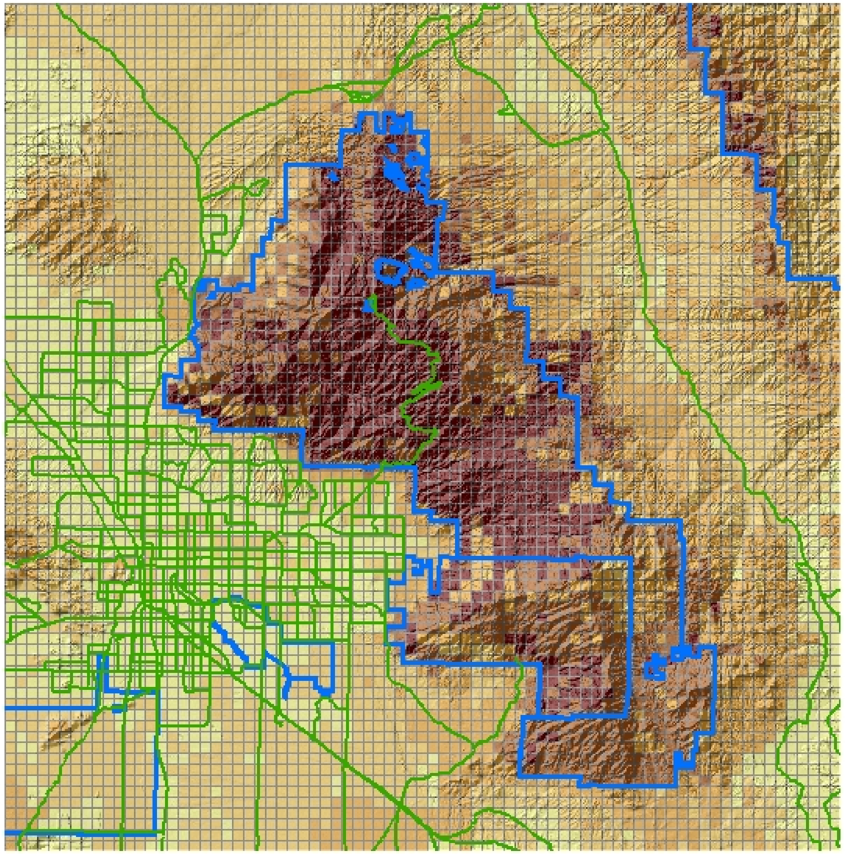


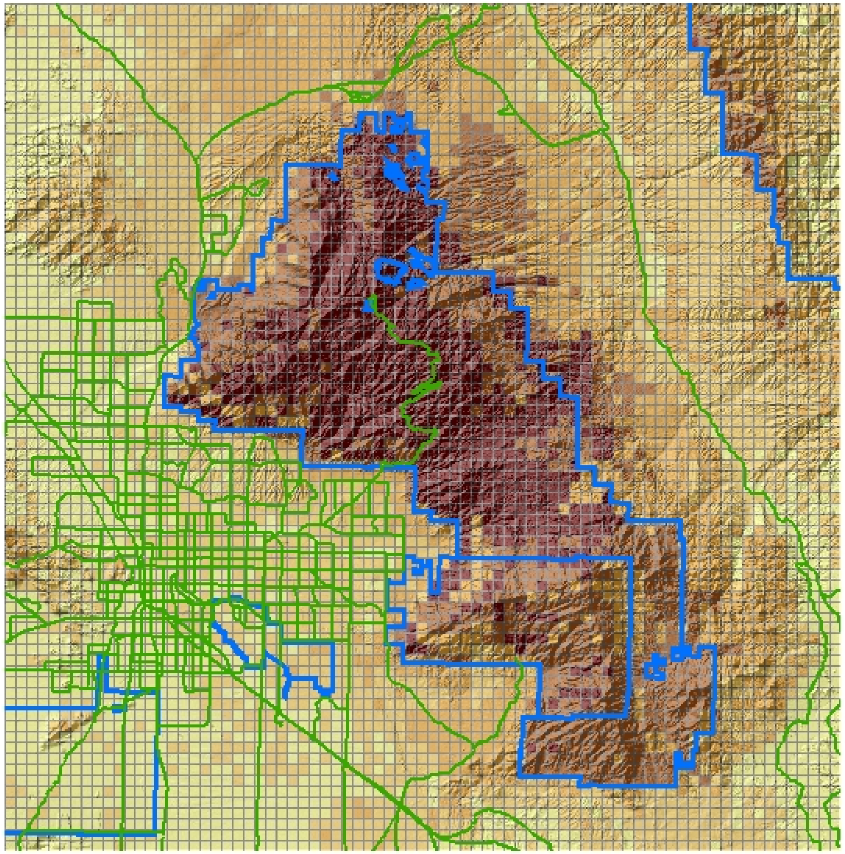
This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

FCS-1 Model Components

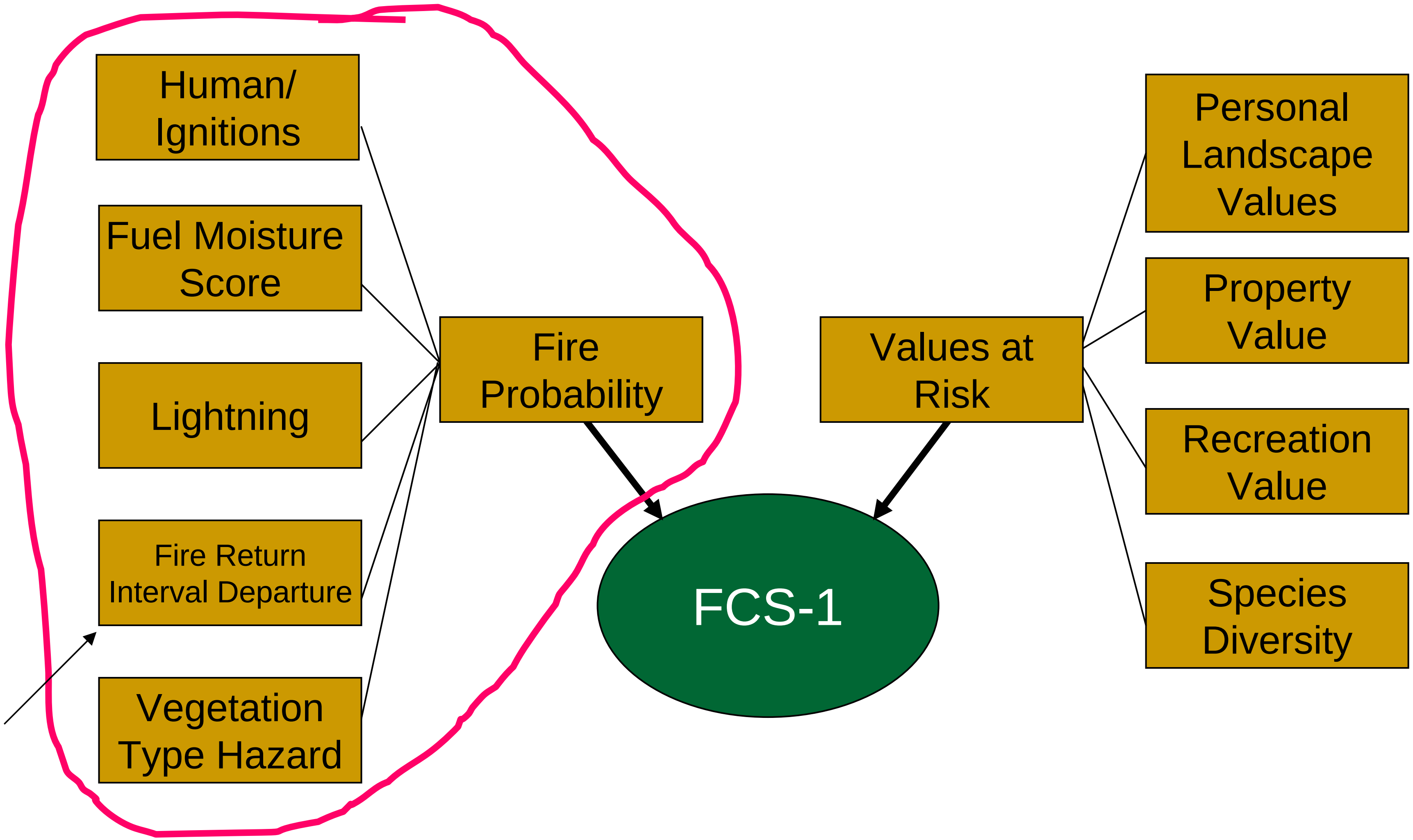


FCS-1 Features Weighted Variables: 1-km Resolution





Spatial Modeling: Fire-Climate-Society-1



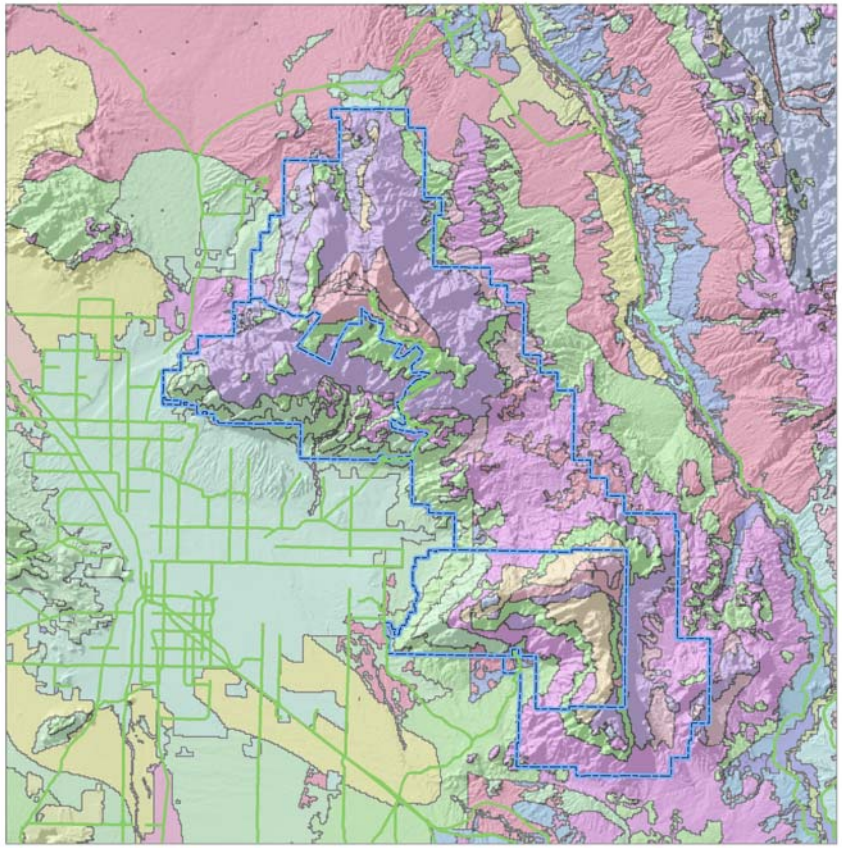
Fire Return Interval Departure

Purpose:

To map an indication of the magnitude of departure from expected fire return interval

Source data

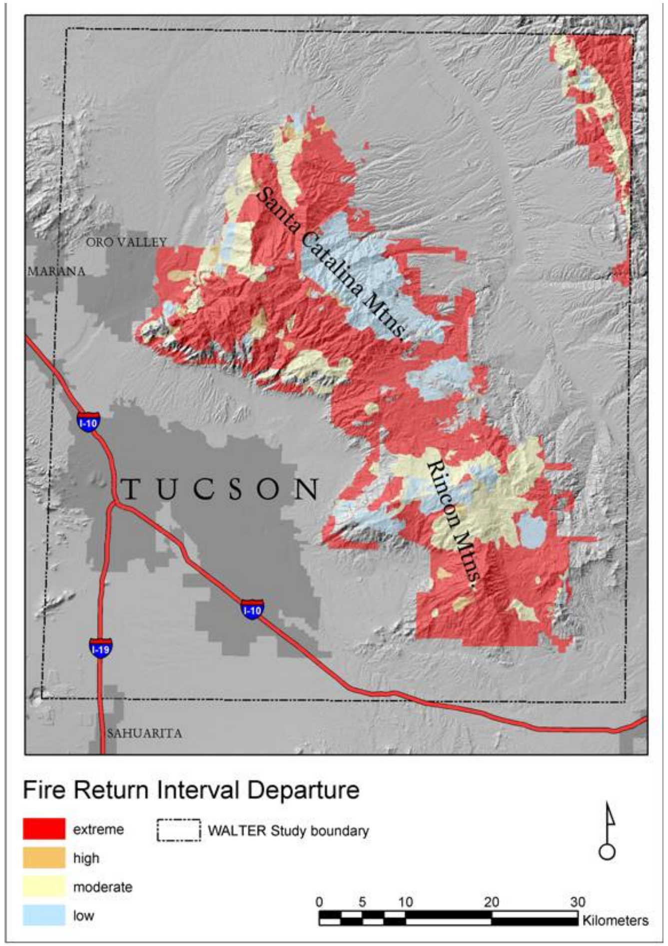
- Fire perimeters
- Vegetation coverages
- Arizona and New Mexico GAP land tenure boundaries



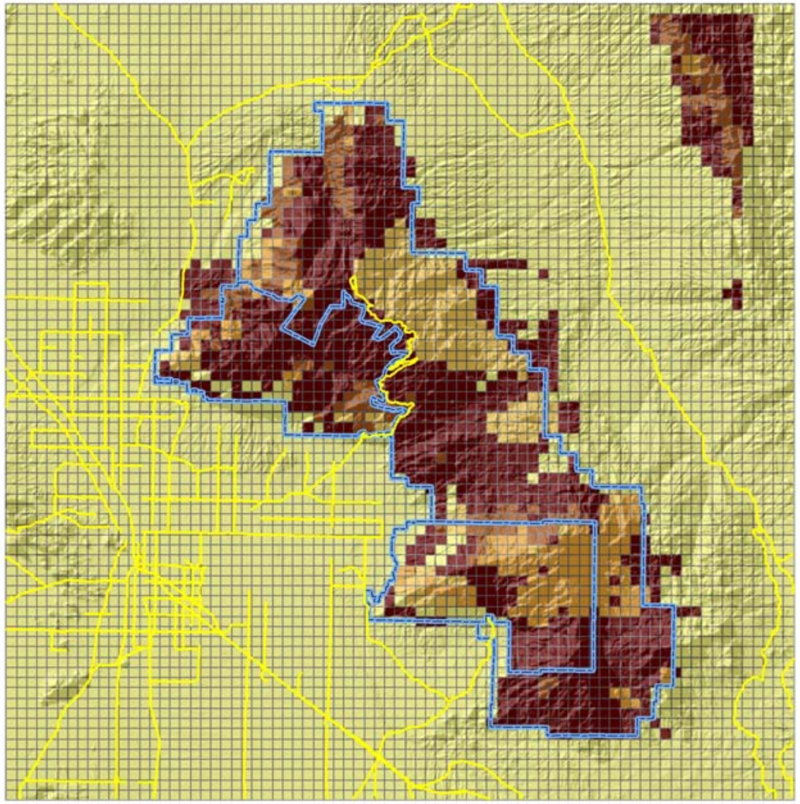
This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Creating the Fire Return Interval Departure Layer

1. Assign fire return intervals to FCS-1 vegetation types.
2. Create coverage for “years since fire” from fire perimeter data.
3. Combine (1) and (2).
4. Calculate FRID: (Number of years since last fire - Fire Return Interval) / Fire Return Interval
5. Clip data to boundaries of Federal agencies
6. Classify FRID values using qualitative groups.



FCS-1 Fire Interval Return Departure Map



Fire Return Interval Departure checklist

- **Scale:** The smallest of the various data sets used is that from the GAP vegetation, 1:100,00
- **Accuracy:** Fire return interval estimates for some vegetation may not be very good due to lack of information. Range of years for which fire perimeters are available vary by WALTER venue.
- **Time to create:** 2 weeks
- **AHP appropriate:** Yes
- **Metadata:** Yes

Fire Return Interval Departure: Concerns

- Scale too coarse for project planning.
- Uncertainty of fire return intervals for non-forest coniferous vegetation types.
- Fire perimeter data does not include all fires
  - Commercial timber
  - Recreation areas

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Fuel Moisture Hazard

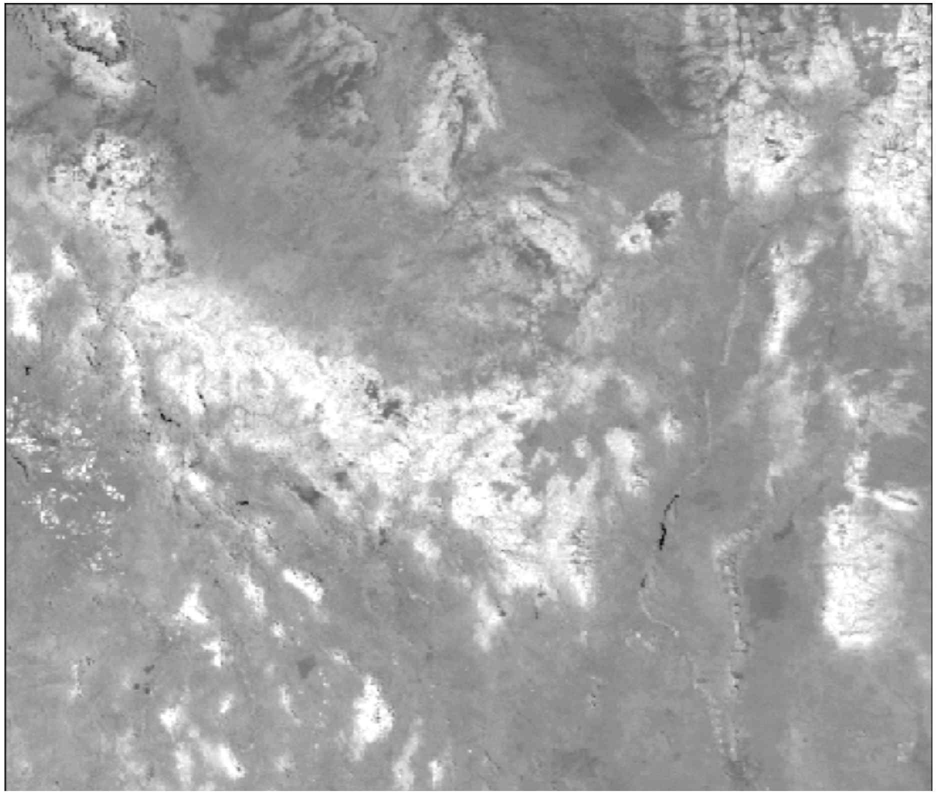
Purpose:

To map fuel moisture hazard relative to time

Source data:

1989-2003 Normalized Difference Vegetation Index (NDVI) time series

- Advanced Very High Resolution Radiometer (AVHRR)

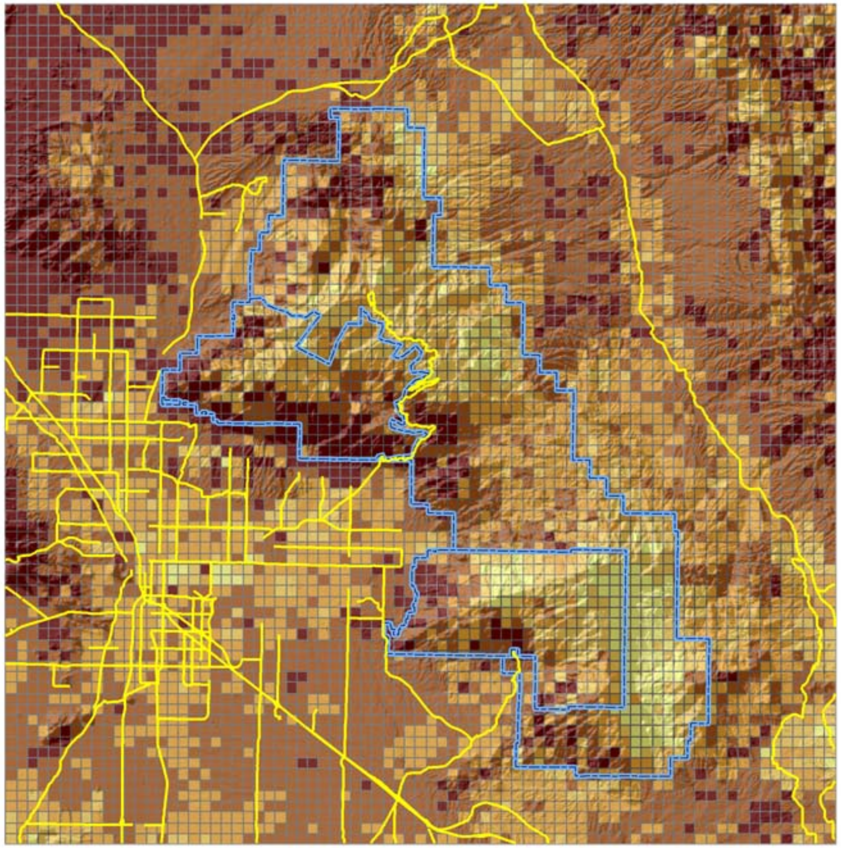


NDVI from AVHRR – Arizona and New Mexico

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Creating the Fuel Moisture Hazard Layer

1. Rescale NDVI data to 0 to 200
2. Standardize NDVI values into Z-scores



Fuel Moisture Hazard checklist

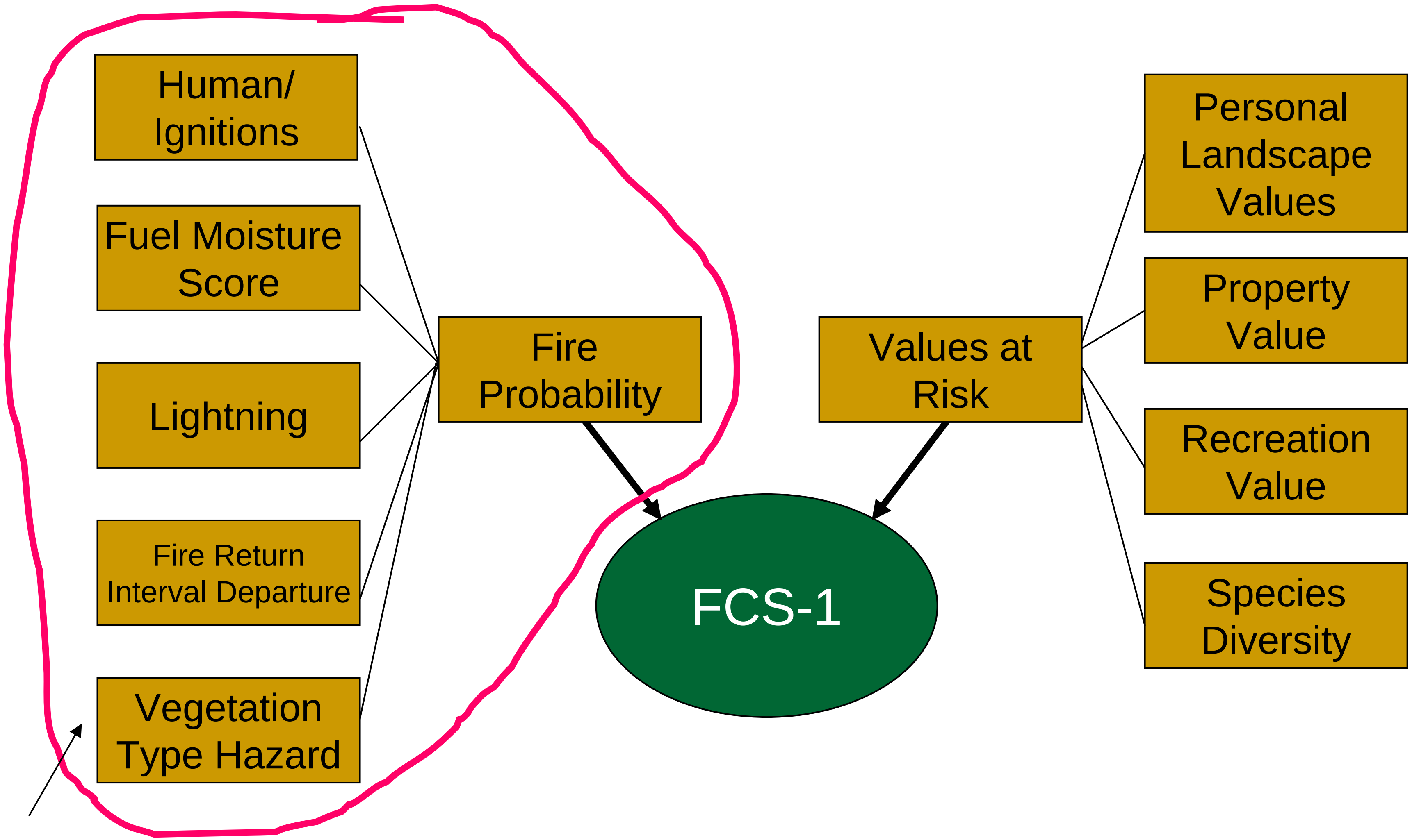
- Scale: Pixel resolution is 1 km^2
- Accuracy: 75%
- Time to create: 1 week
- AHP appropriate: Yes
- Metadata: No

Fuel Moisture Hazard: Concerns

- Field verification of the relationship between NDVI and fuel moisture has not been established.
- Resolution of AVHRR data is not sufficient for 1 km^2 WALTER cell sizes
  - Should be at least 500m
  - Possibly mitigated by spatial autocorrelation

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Spatial Modeling: Fire-Climate-Society-1

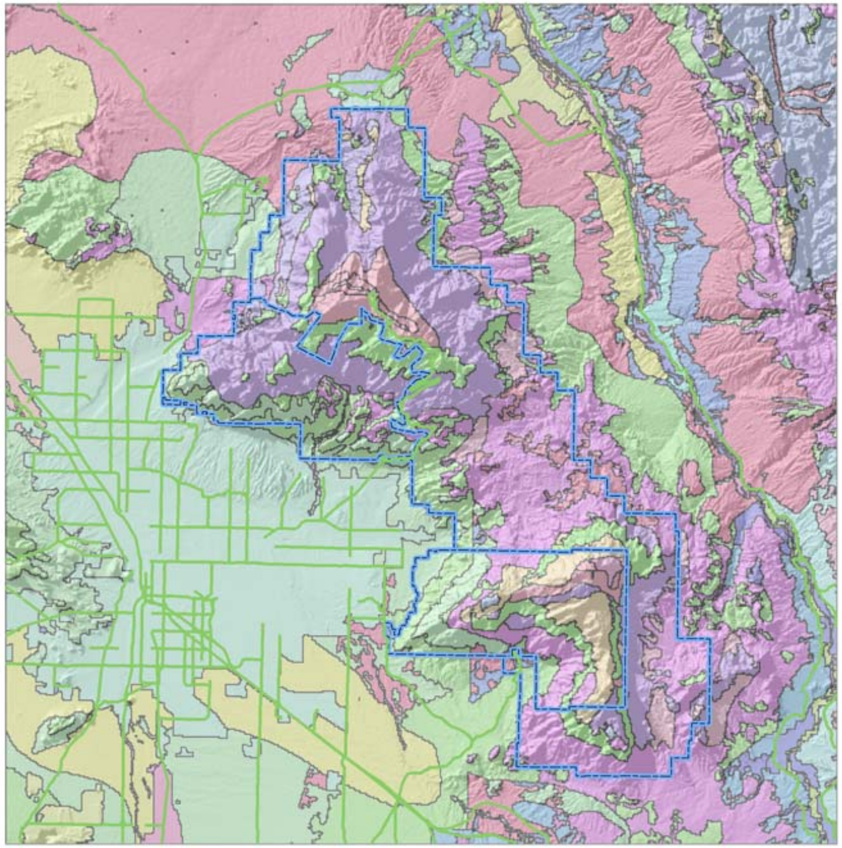


This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Vegetation Type Hazard

Purpose:

Maps, using ordinal scale, hazard level of vegetation, based on inherent fire occurrence within each vegetation type



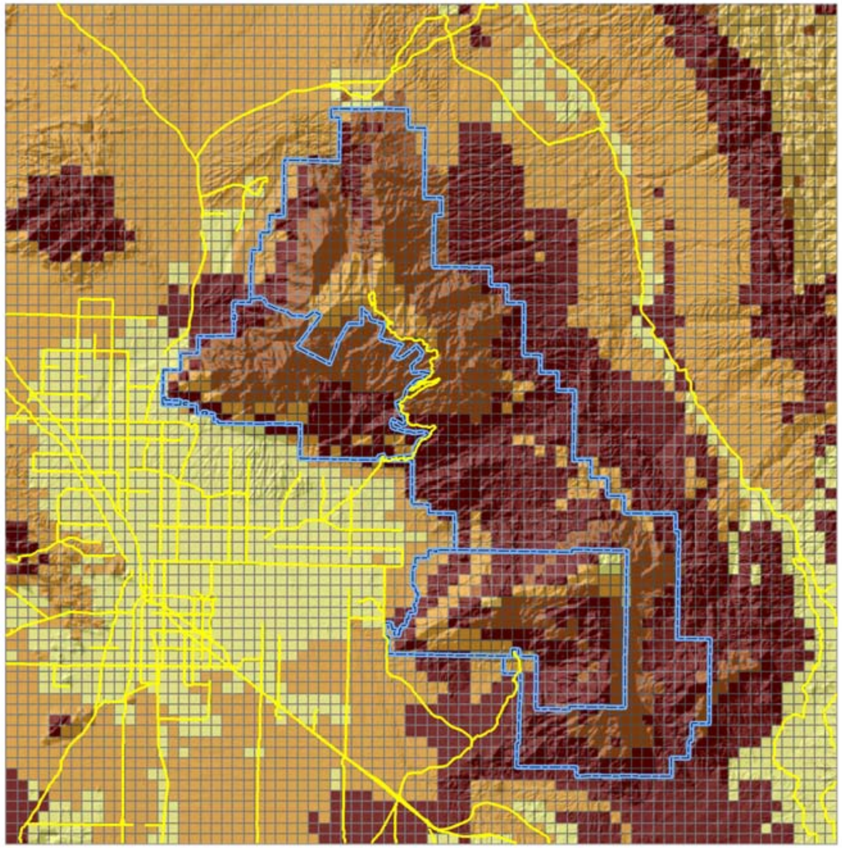
Source data:

- GAP vegetation
- Brown, Lowe and Pace vegetation
- Ignition data
  - Coronado National Forest
  - National Park Service
  - Fort Huachuca Army Base

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Creating the Vegetation Type Hazard Layer

1. Remove duplicated fires
2. Convert data to a single projection
3. Assign a vegetation type to each fire ignition
4. Standardize total ignitions for each vegetation class into a density, based on the total amount of area in each class



Vegetation Type Hazard checklist

- **Scale:** 1:100,000
- **Accuracy:** 50%
- **Time to create:** 3 months
- **AHP appropriate:** Yes
- **Metadata:** No

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant #

Vegetation Type Hazard: Concerns

- Assumes robust relationship between Vegetation Type Hazard and ordinally-ranked fire hazard.
- Accuracy of the vegetation map

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program
Grant #

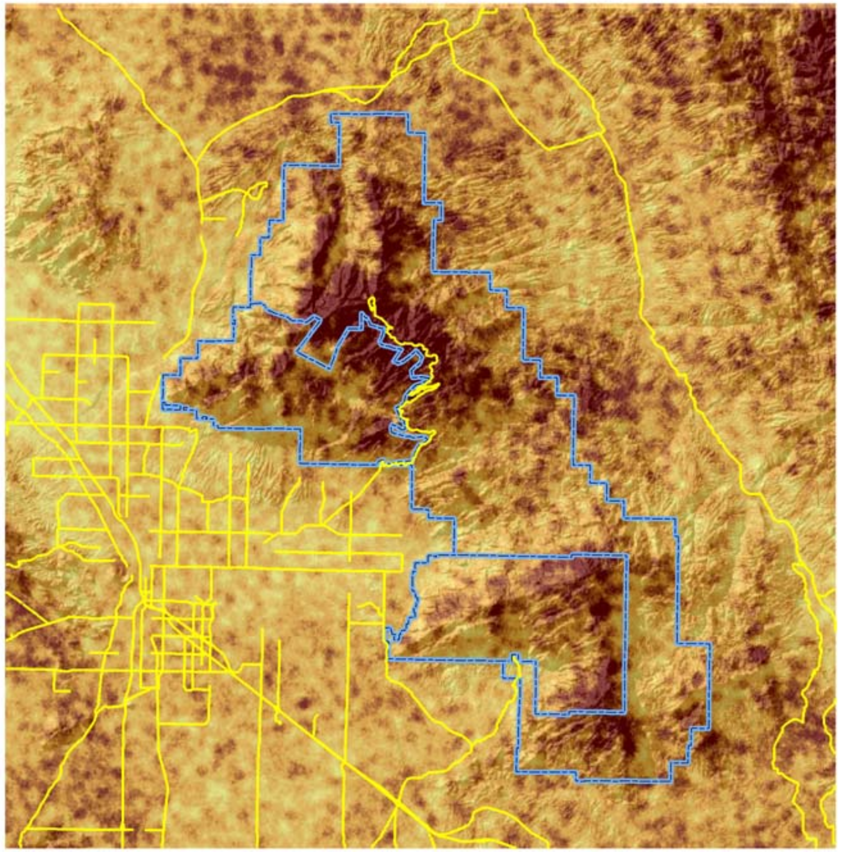
Lightning Ignition Probability

Purpose:

Maps the probability of a lightning-ignited fire

Data Source:

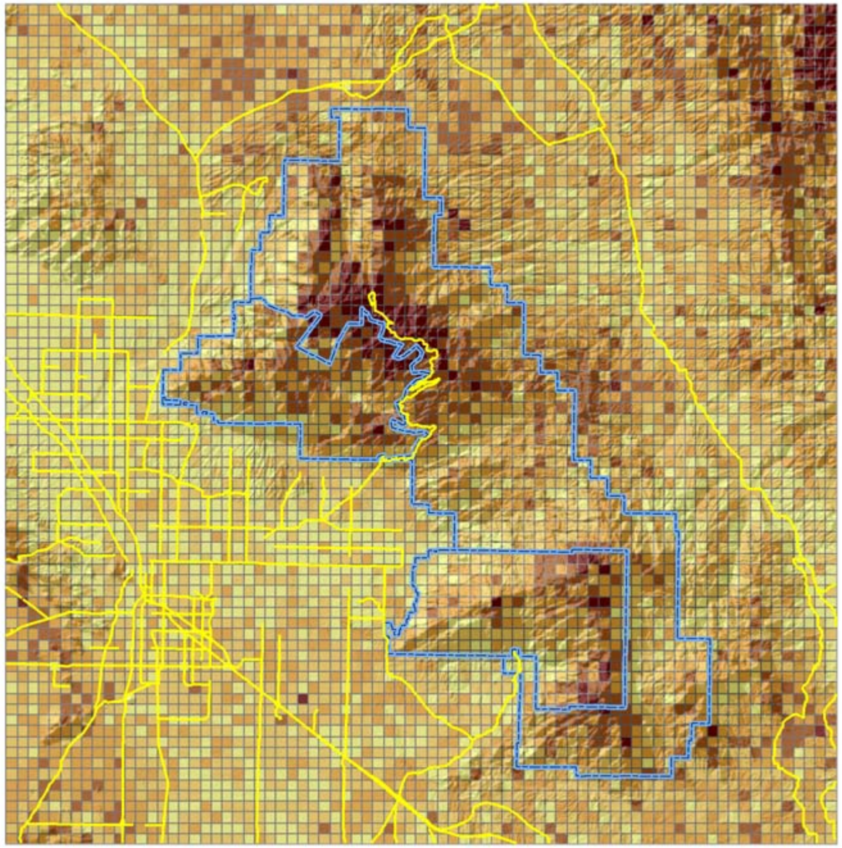
Lightning occurrence data from 1989-1999 from the National Lightning Detection Network (www.lightningstorm.com)



This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Creating the Lightning Ignition Probability Layer

1. Assign each lighting strike a geographical coordinate and a date
2. Convert the data to GIS point coverage
3. Create a density of lighting strikes / 100 ha / year
4. Convert this to an annual density
5. Calculate the probability of lightning strikes per 100ha per year
6. Create categorical probability by classifying the continuous probabilities



This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Lightning Ignition Probability checklist

- **Scale:** Pixel resolution is 1 km^2
- **Accuracy:** 75%
- **Time to create:** 2 weeks
- **AHP appropriate:** Yes
- **Metadata:** No

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Lightning Ignition Probability: Concerns

Resolution of AVHRR data is not sufficient for 1 km^2 WALTER cell sizes

- Should be at least 500m
- Possibly mitigated by spatial autocorrelation

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Human Factors of Fire Ignitions

Purpose:

Map the probability of human-caused fires

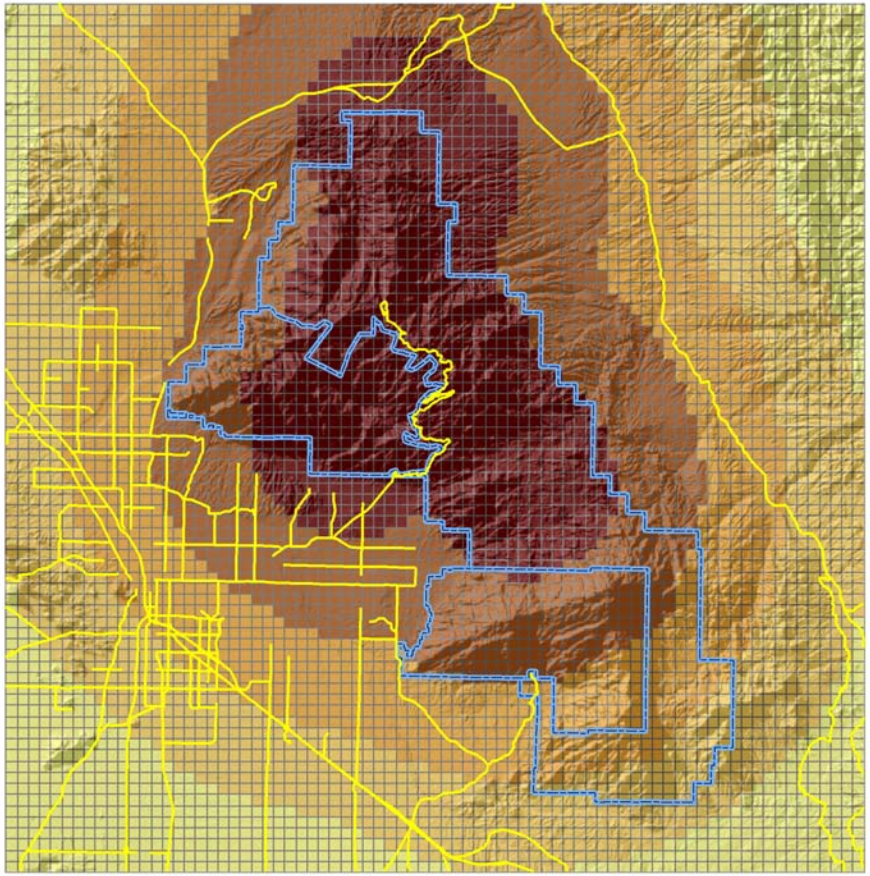
Data sources:

- Roads (US Forest Service)
- Campgrounds/picnic areas (USFS)
- Urban areas (ALRIS)
- Non-forested vegetation layers (GAP)
- Urban-Wildland Border Complexity (ALRIS)
- Other data were examined but were found not to be important

“Firebug” at Parker Canyon Lake, Huachucas

Creating the Human Factors of Fire Ignitions Layer

1. Convert features of interest to raster format
2. Calculate Euclidean distance from those features
3. Capture the value of the variables at the sites of human-caused fires and at random locations
4. Perform logistic regression
5. Use results of the regression to create the sub-model



This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

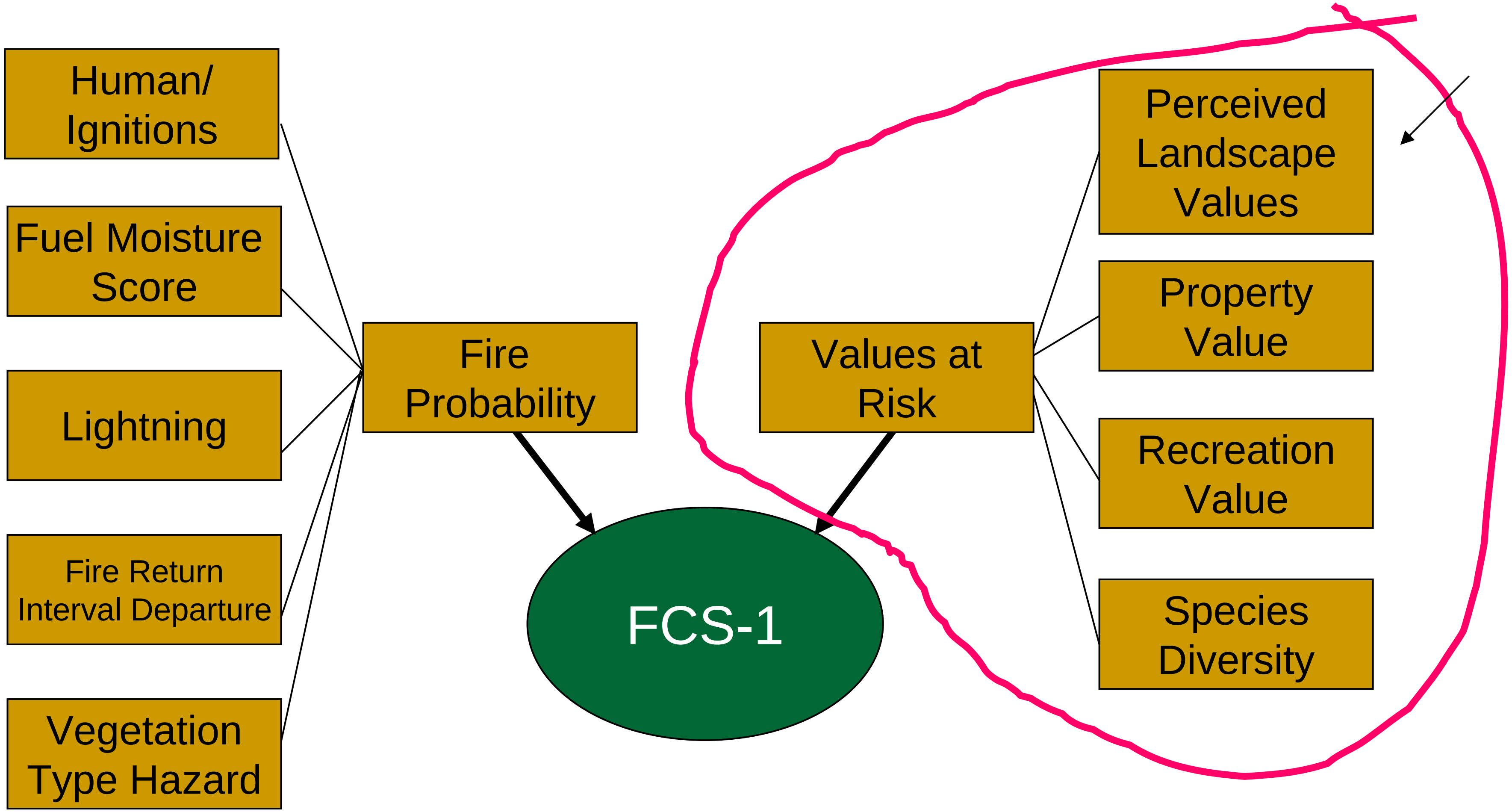
Human Factors of Fire Ignitions checklist

- **Scale**: 1 km polygon – base data is 1:100,000 (GAP), 1:24,000 (USFS & USGS)
- **Accuracy**: Meets federal standards, except for GAP (questionable)
- **Time to create for all study areas**: 1 week/study area (does not include time required to collect and pre-process base data layers)
- **AHP appropriate**: Yes
- **Metadata:** FGDC compliant

Human Factors of Fire Ignitions: Concerns

- Concerns about how GAP source data was collected
- Regression models are very powerful but they are only models, can be overemphasized
- We don't have all of the possible data – there are a lot of variables that we can't model

Spatial Modeling: Fire-Climate-Society-1



This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Perceived Landscape Value

Purpose:

To assess human values placed on landscape

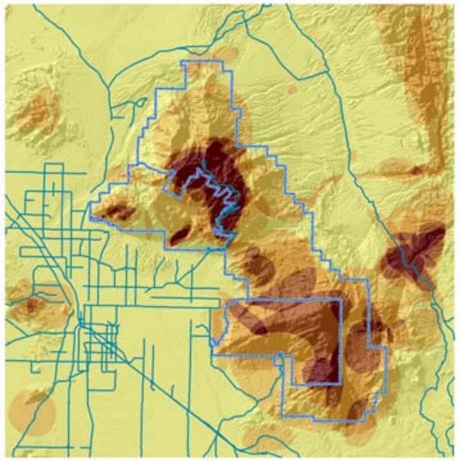
Data source:

- Base maps using data from
  - USGS
  - ESRI
  - Arizona NBII
  - NPS
  - Arizona GAP (land ownership)
- Map-based, in-person interviews by WALTER researchers

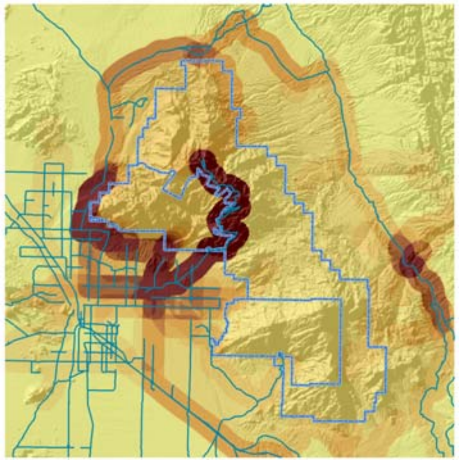
Creating the Perceived Landscape Value Layer

- Create field maps of the project areas & questionnaire
- Conduct interviews (approximately 30 per study area)
- Digitize interview results
- Clean up the polygons
- Turn the polygons into grids
- Reclassify the grids to 1,0
- Add the grids together
- Normalize the grid to 0 - 1
- Resampledto 1km grid cells

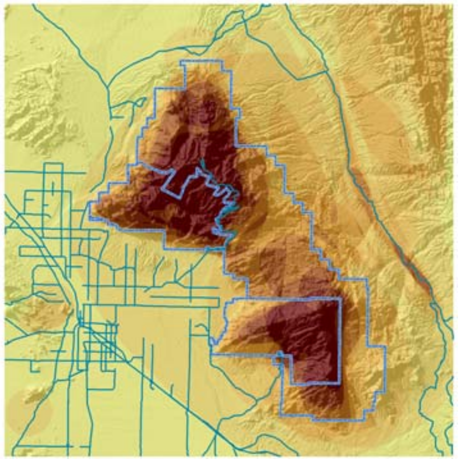
Perceived Landscape Value Layers



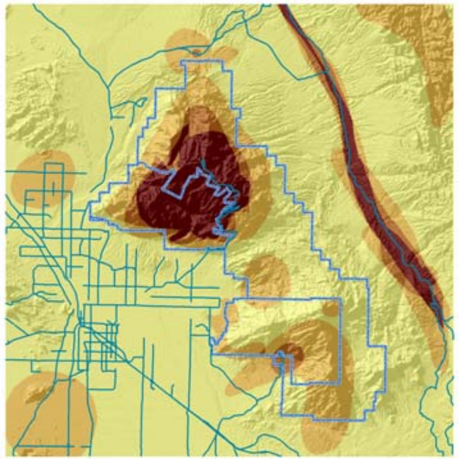
Recreation areas visited



Routes used

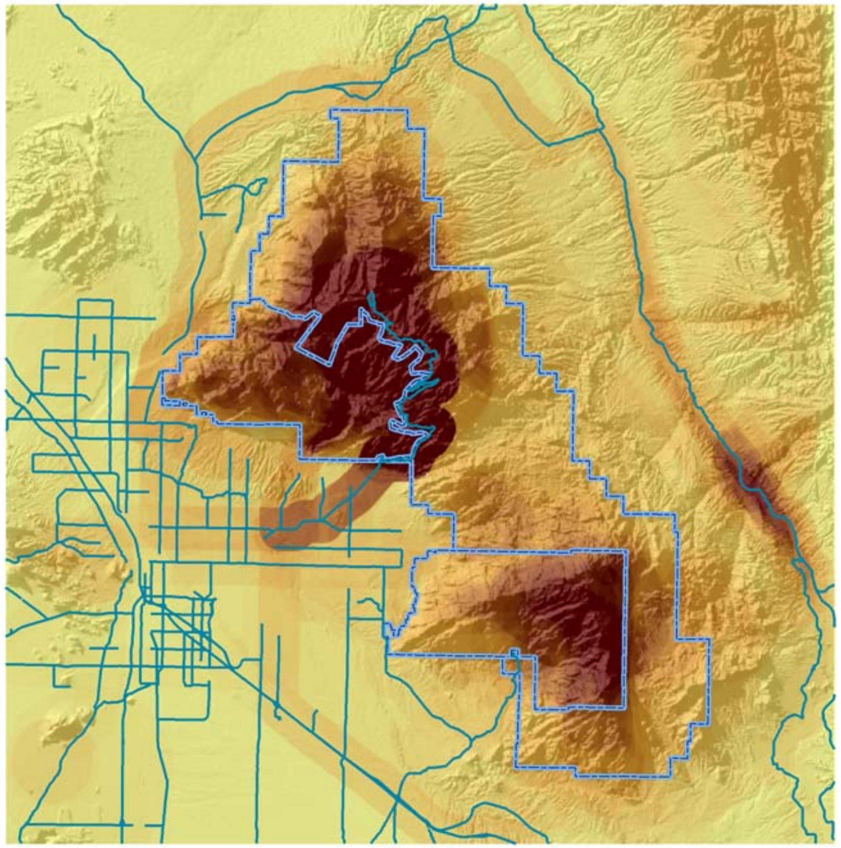


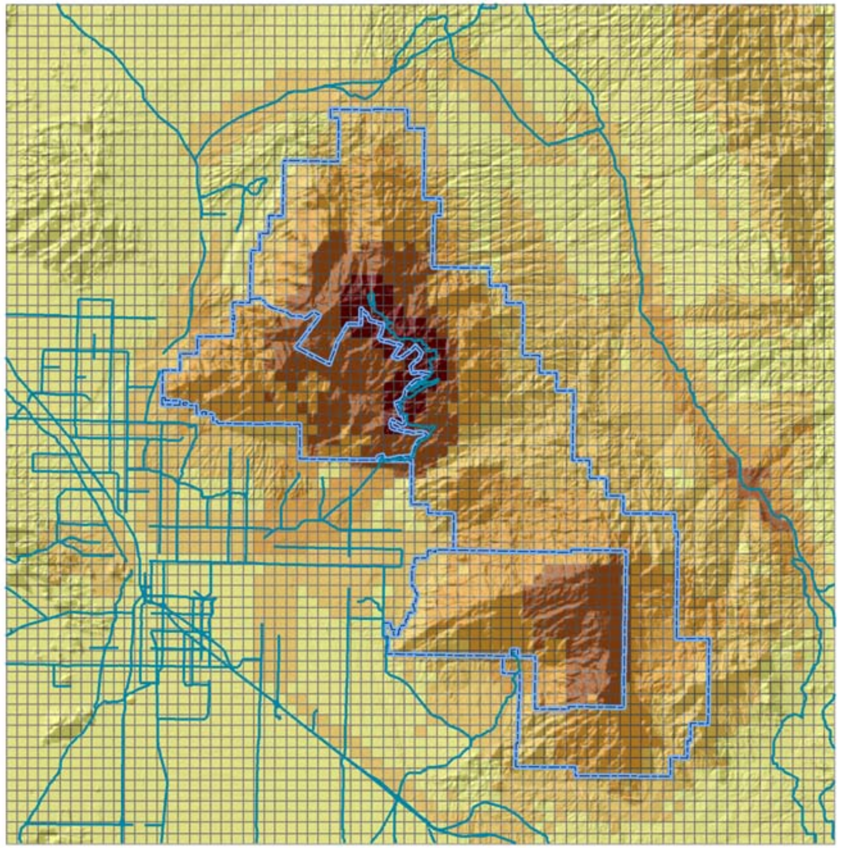
Areas judged to be most at risk



Area would most hate to see burn

Perceived Landscape Value: Aggregation of Interview Results





This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Perceived Landscape Value Checklist

- **Scale**: >= 1:100,000 (base data)
- **Accuracy**: Base data meets federal standards; interview data unknown
- **Time to create** for all study areas: 4 months (does not include time required to collect and pre-process base-map data layers)
- **AHP appropriate**: Yes
- **Metadata**: FGDC compliant

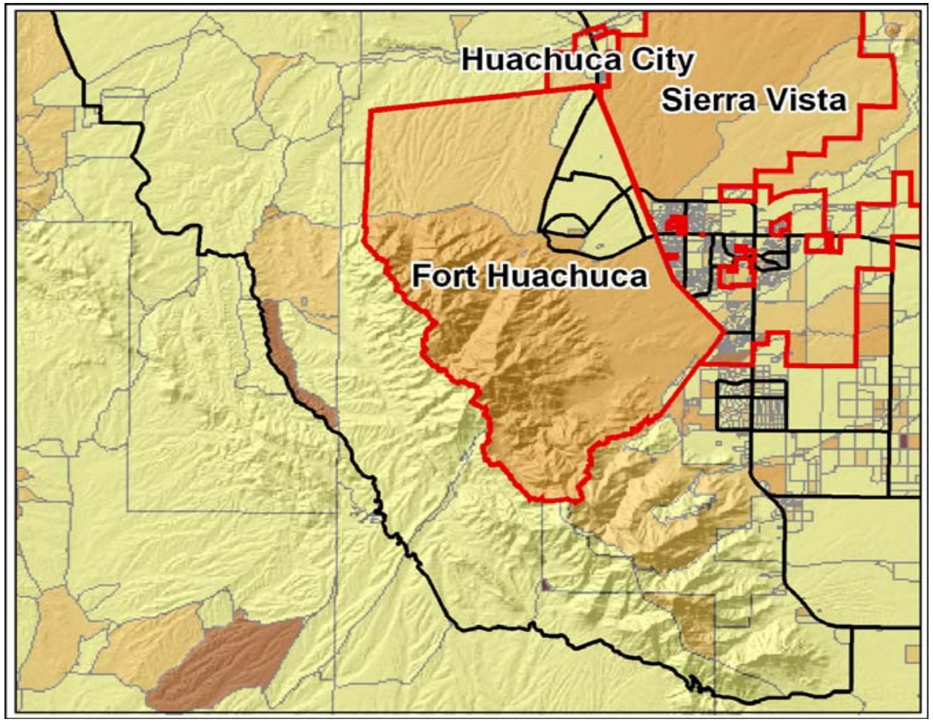
Perceived Landscape Value: Concerns

- Sample was designed to be representative of local populations, but was small and non-random
- Questions about accuracy of marking on maps
- Question of validity in using graphic representations to elicit responses on landscapes (Daniel and Meitner 2001)

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant #

Property Value

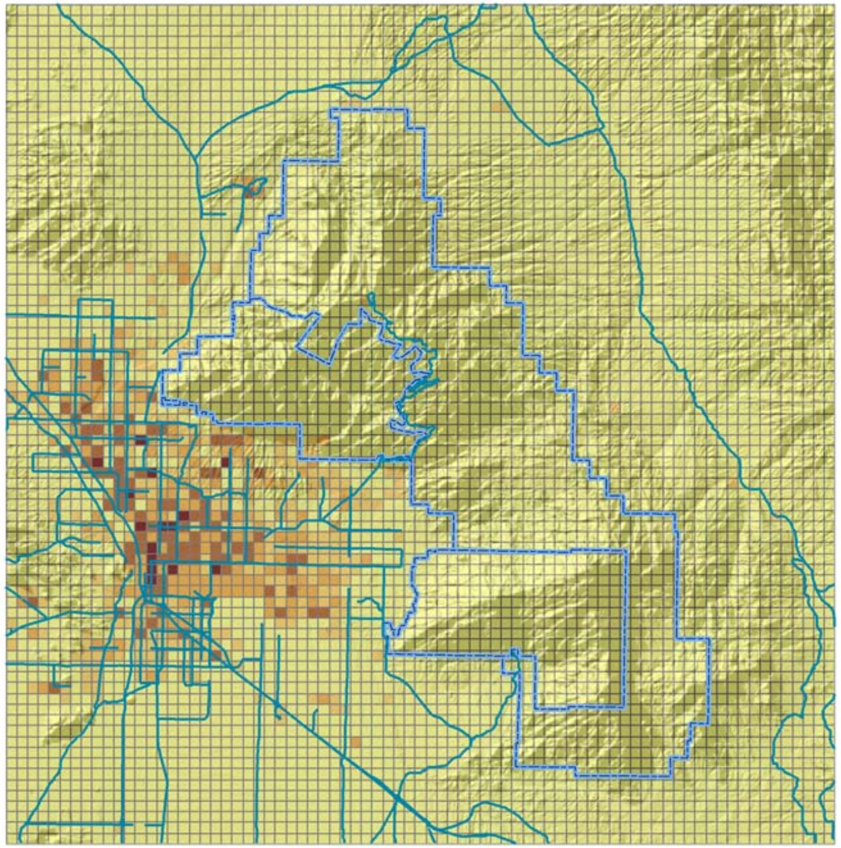
- Purpose: Determine property values in study areas
- Base data source:
- US Census Bureau
  - TIGER block-level data
  - SF 3 table of population and housing



Median price of owner occupied housing

Creating the Property Value Layer

- Join tabular housing data to Census block-level data
- Assign total housing value proportionally, based on area of intersection with the 1-km project grid



Property Value Checklist

- **Scale**: 1:100,000
- **Accuracy**: Meets federal standards
- **Time to create** for all study areas: 1 week
  (does not include time required to collect and pre-process base data layers)
- **AHP appropriate**: Yes
- **Metadata:** FGDC compliant

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Property Value: Concerns

- Only owner-occupied housing is valued, so it may not reflect value of non-residential property very well

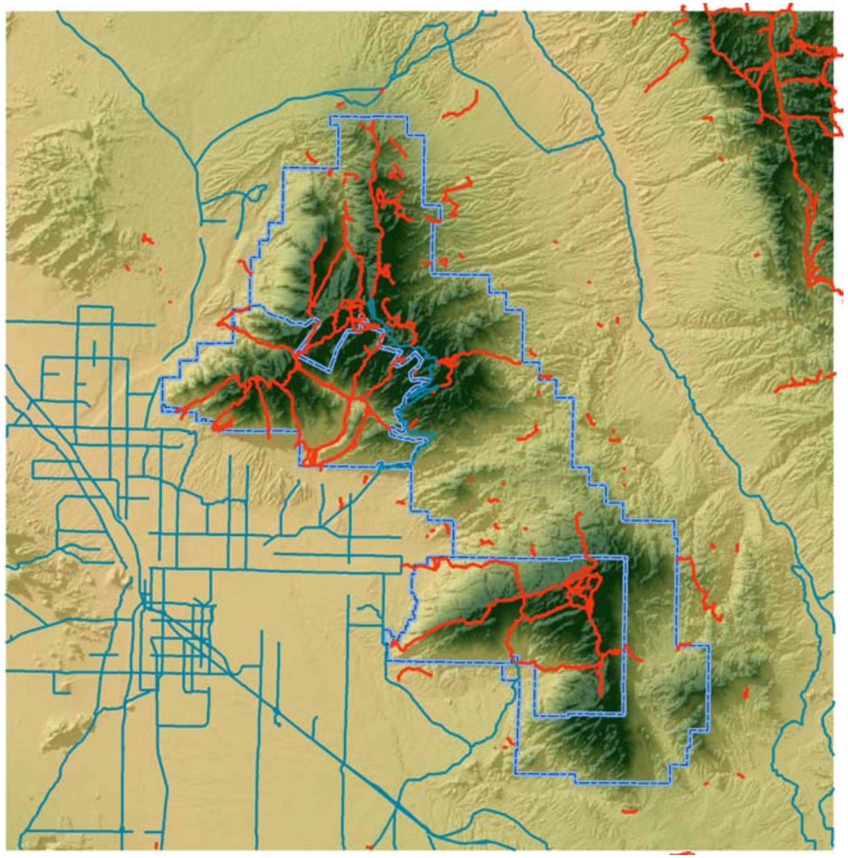
Recreation Value

Purpose:

To determine the importance of recreation in each polygon cell

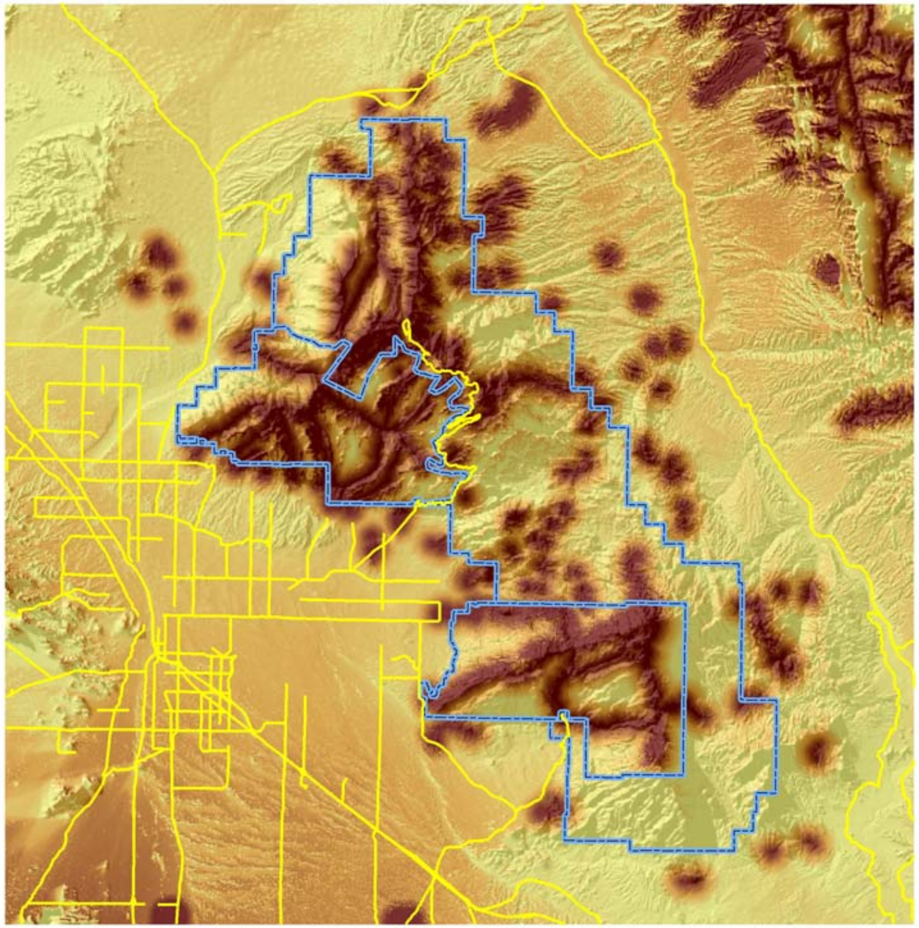
Base data source:

- USFS
  - Campgrounds
  - Hiking trails
  - Roads
  - Picnic areas
  - Lakes
  - Historical sites
  - Visitor centers
  - National Visitor Use Monitoring Results Table
- GAP Hunting areas



Creating the Recreation Value Layer

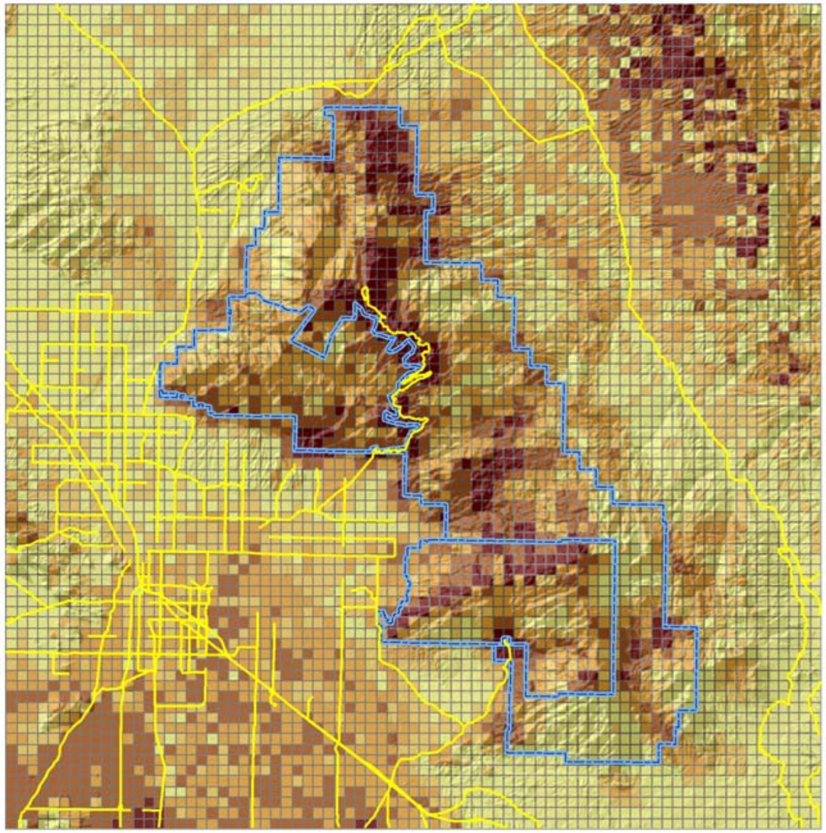
- For each recreation type, calculate the Euclidean distance grids and visibility surface grids from features of interest
- Rescale grids to 0 – 1
- Add them together
- Resample to 1km grids
- Rescale data from 0 – 1
- Multiply by the proportion of visitors who participated in particular activities
- Sum all recreation types to create map layer



This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Recreation Processing 2:
Total Recreation

Individual recreation variables (10)



Recreation Values

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Recreation Value Checklist

- **Scale**: 1:24,000
- **Accuracy**: Meets federal standards
- **Time to create** for all study areas: > 6 months (does not include time required to collect and pre-process base data layers)
- **AHP appropriate**: Yes
- **Metadata:** FGDC compliant

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Recreation Value: Concerns

- Uncertain that this is the best methodology for calculating recreational usage
- Uncertain that the proxies chosen really represent the recreational activities of interest
- May be some overlap between some of these data and some of ‘personal value’ data

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant #

Species Habitat Richness

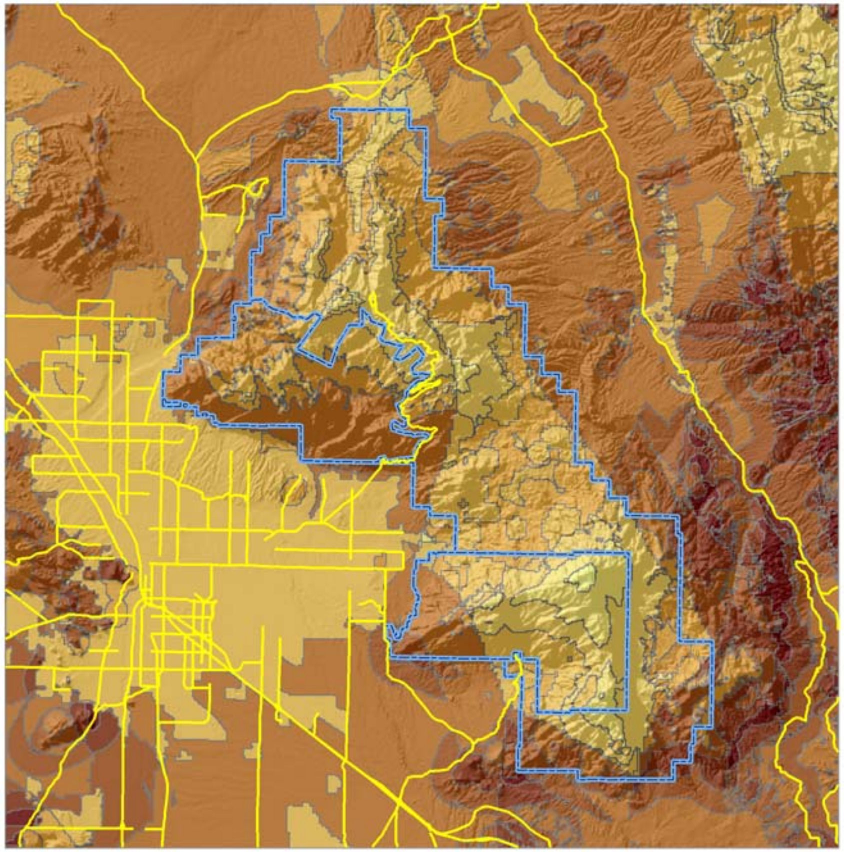
Purpose:

Proxy for animal species diversity

Base data source:

GAP habitat richness models for:

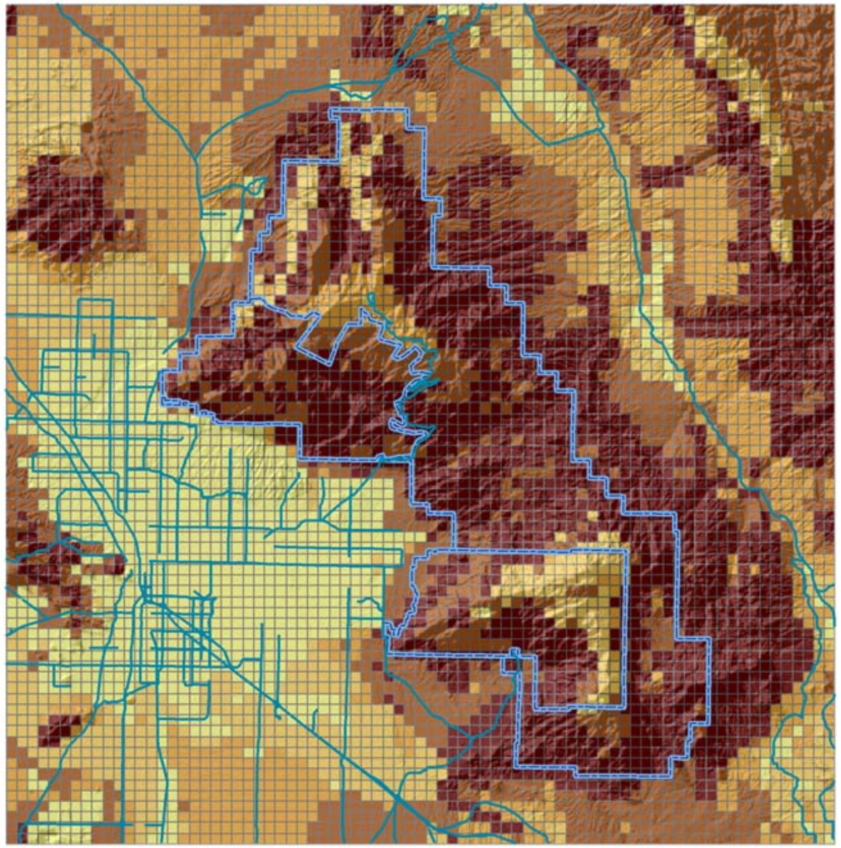
- Mammals
- Amphibians
- Reptiles
- Birds



This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

Creating the Species Habitat Richness Layer

- Download data from AZ/NM GAP
- Clip project areas to be used
- Sum the four animal types
- Scale the data 0, 1
- Resample data to fit the 1km raster
- Join the raster data to the 1km polygon grid



Species Habitat Richness checklist

- **Scale**: 1 km polygon – base data is 1:100,000
- **Accuracy**: Questionable but best that is available
- **Time to create** for all study areas (approx.): 1 week
  (does not include time required to collect and pre-process base data layers)
- **AHP appropriate**: Yes
- **Metadata:** FGDC compliant

Species Habitat Richness: Concerns

- Concerns about how GAP source data was collected
- Concerns about whether habitat can be used to model species diversity
- Concerns about issues of scale

Using AHP to construct FCS-1

The Analytic Hierarchy Process (AHP) is a … “decision making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered.”

Complex decisions are reduced to a series of one-to-one comparisons.

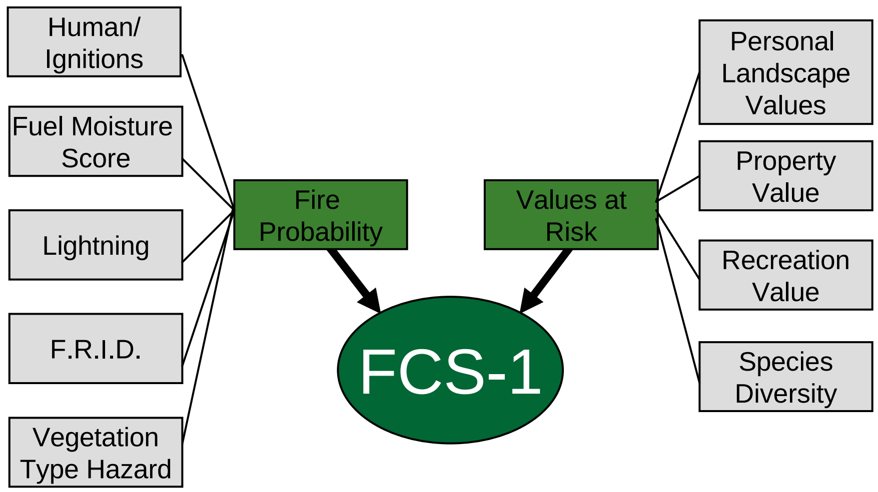
Results are then synthesized

AHP not only helps decision makers arrive at the best decision, but also provides a clear rationale for stating it is the best. (www.expertchoice.com)

Using AHP to Construct FCS-1

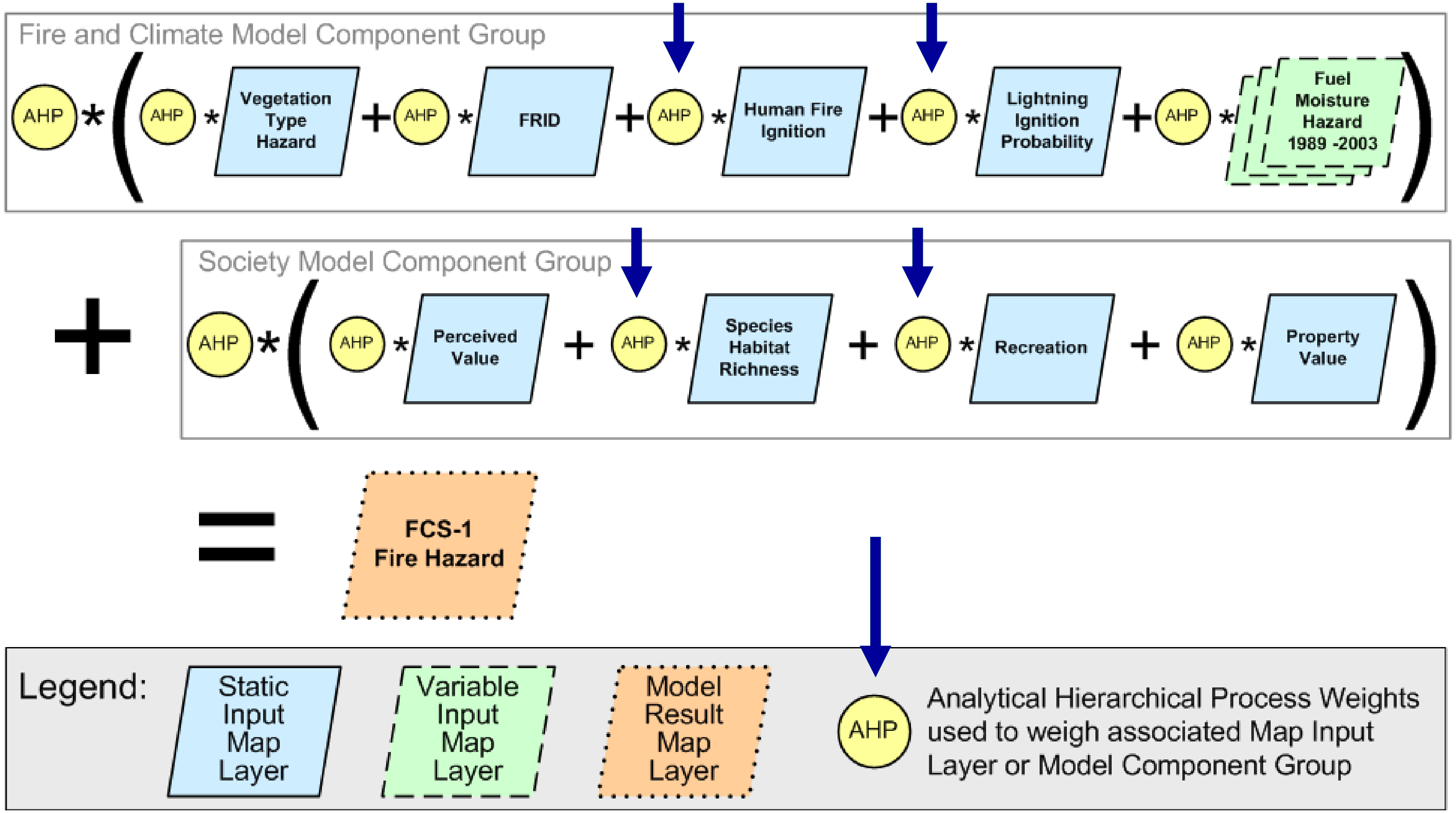
To create output from the model:

- Make pairwise comparisons between variables and between fire probability and fire risk submodels
- AHP assigns weights based on the comparisons
- AHP multiplies the variables by their corresponding weights
- A linear combination of weighted variables creates the sub-models
- A linear combination of sub-models creates model



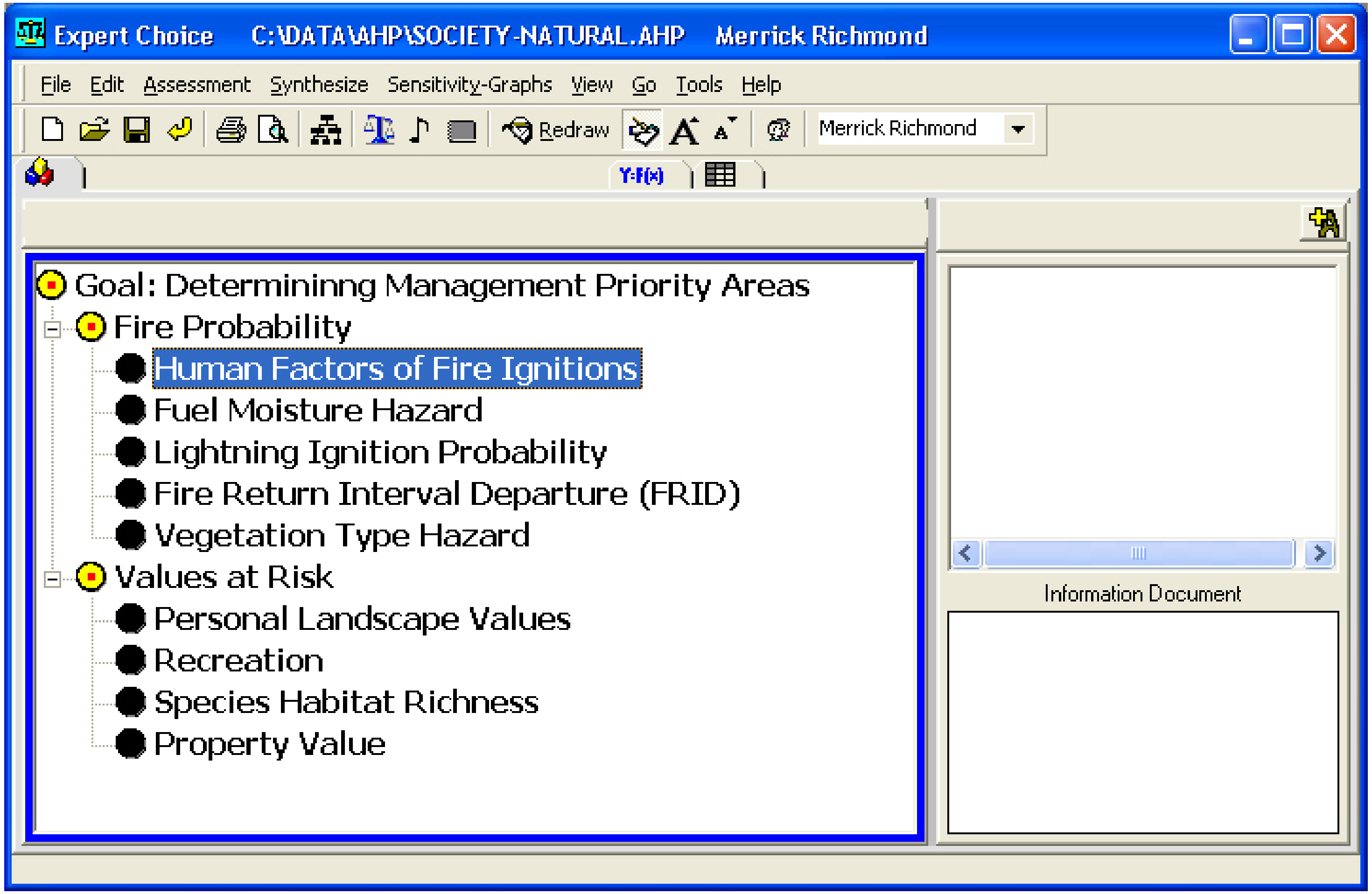
This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

FCS-1 Model Formula



FCS-1 also can "capture" your knowledge, experience and expertise relative to *all* model inputs using AHP

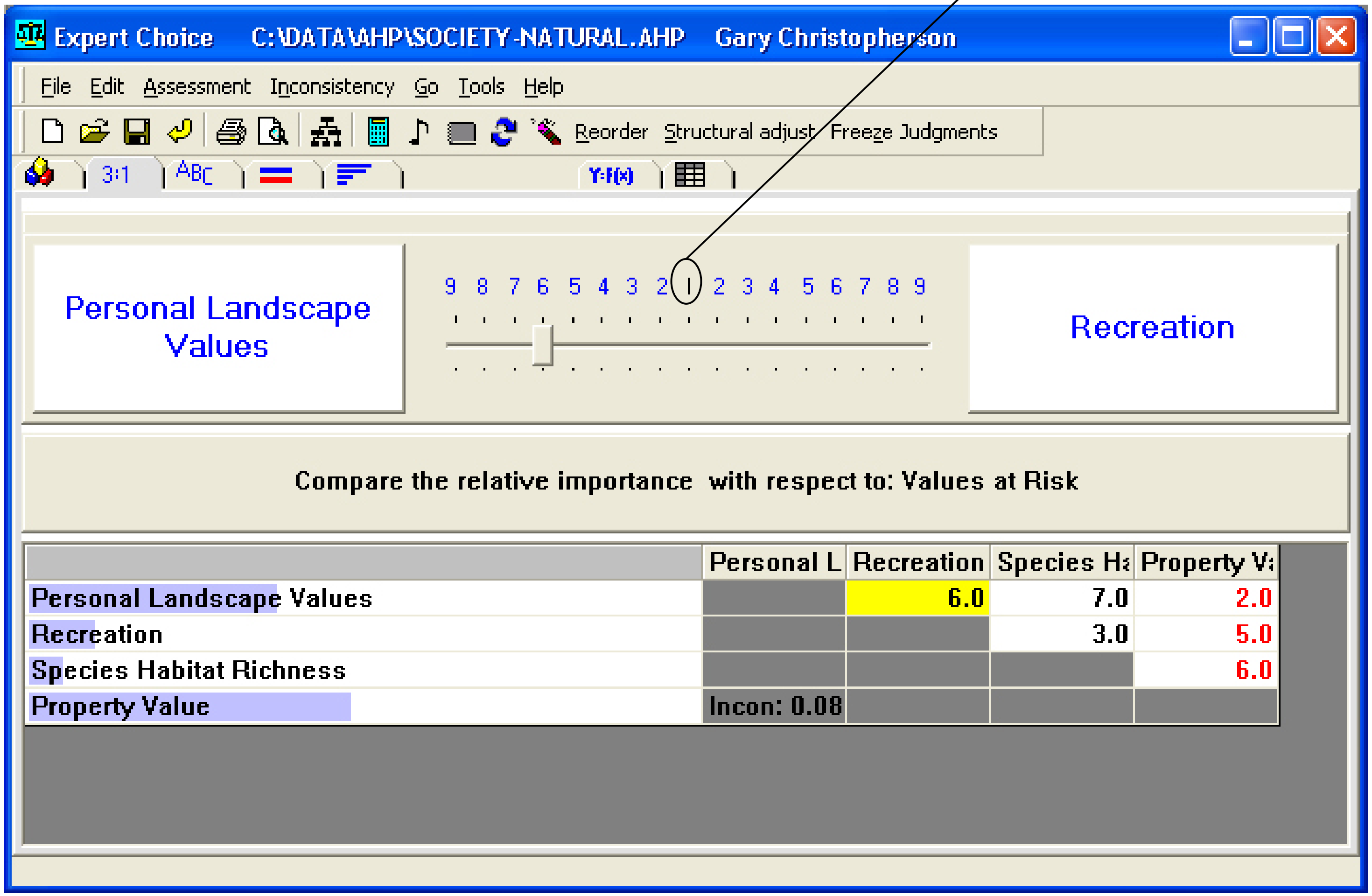
Variables in Expert Choice



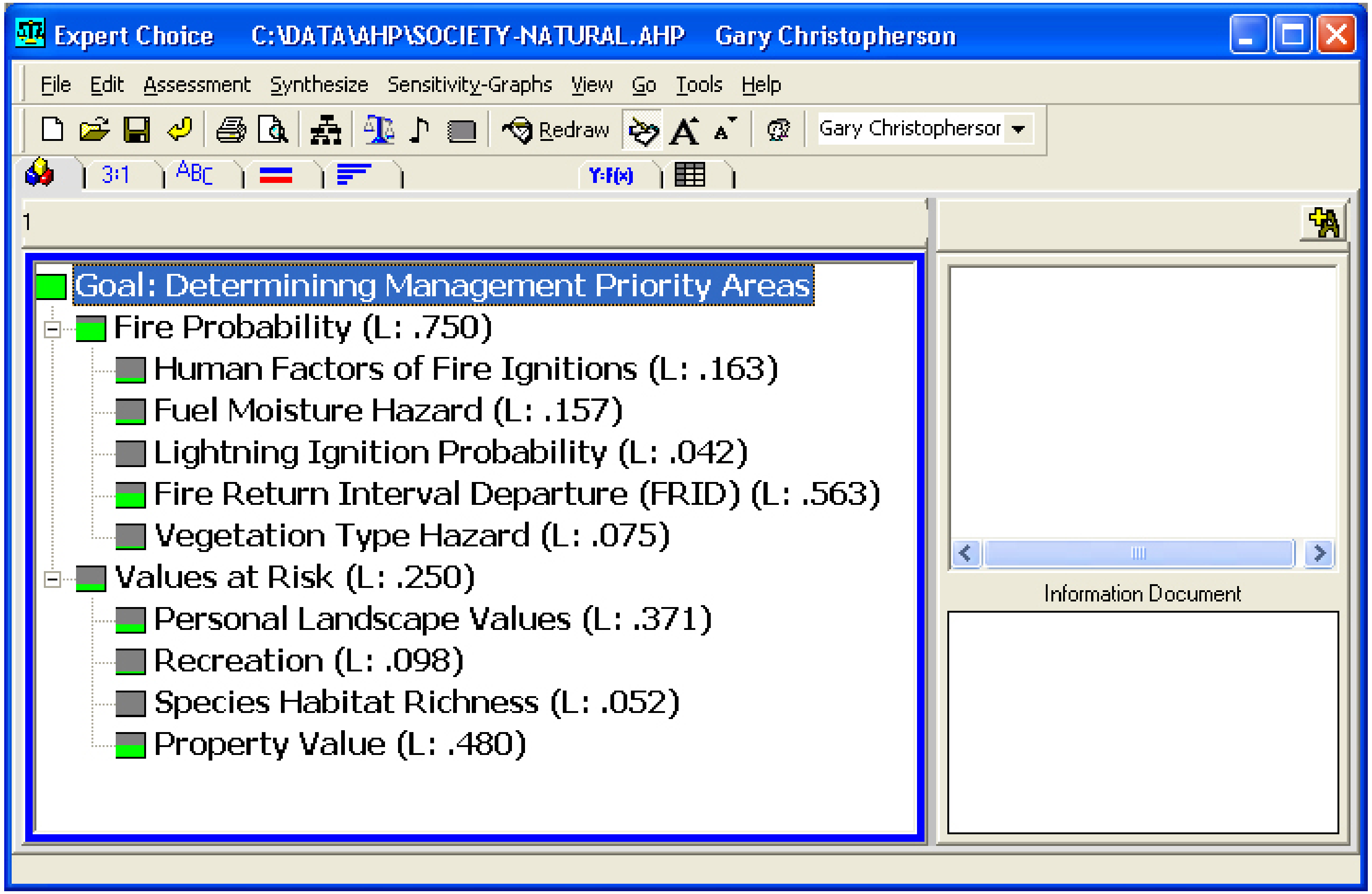
This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant #

How Pairwise Comparisons are Made

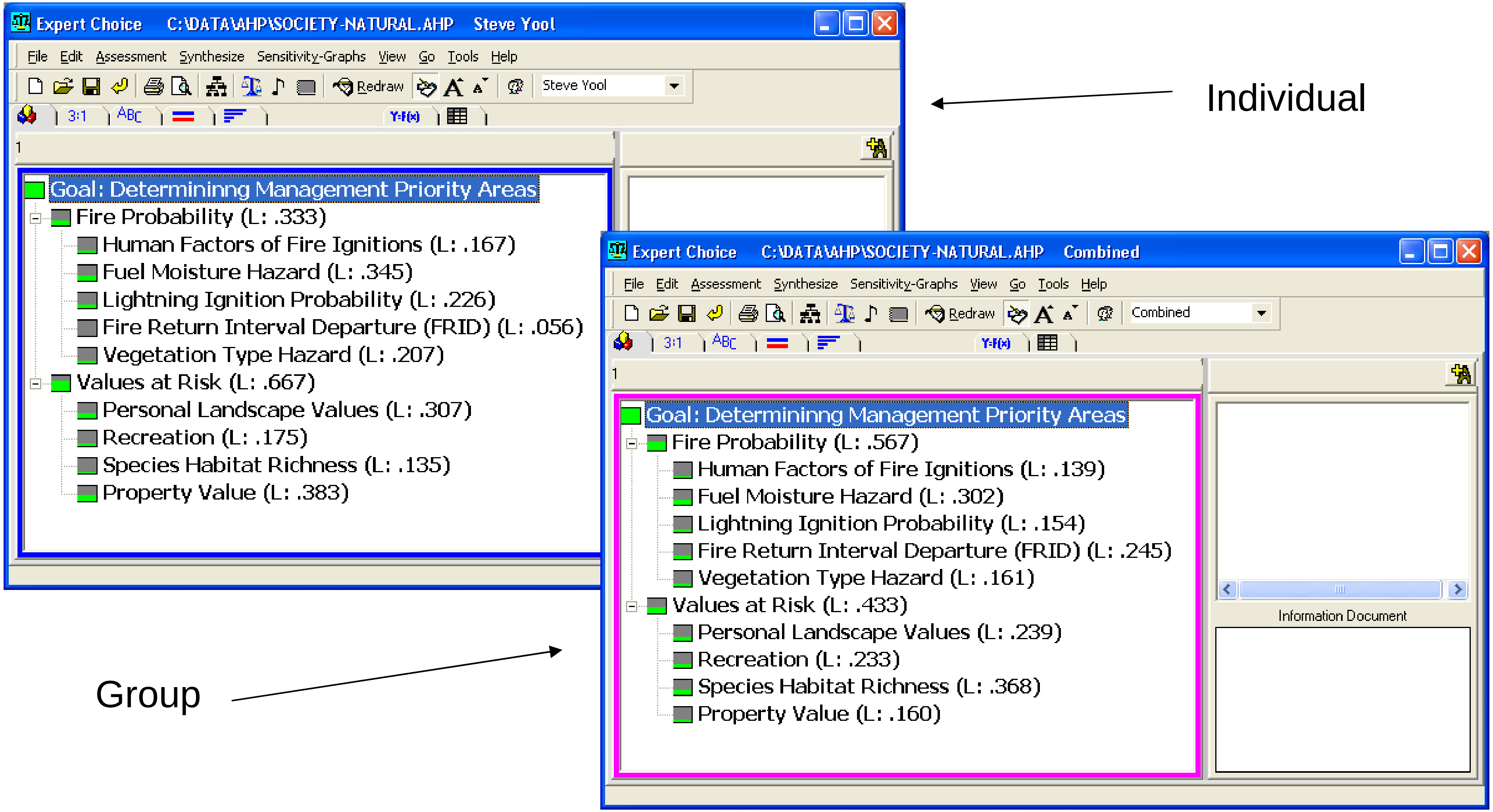
Variables have equal importance (“weight”)



How the Weighted Variables are Displayed



Weighted Variables: Individual & Group



AHP Math = Matrix Mathematics

- Original matrix

1.000	0.500	3.000
2.000	1.000	4.000
0.333	0.250	1.000

- Squared (matrix algebra)

3.000	1.750	8.000
5.333	3.000	14.000
1.167	0.667	3.000

More Matrix Mathematics

3.000	1.750	8.000
5.333	3.000	14.000
1.167	0.667	3.000

= 12.750

= 22.333

= 4.833

39.9165

Row Totals

12.750/39.9165 = 0.3194

22.333/39.9165 = 0.5595

4.833/39.9165 = 0.1211

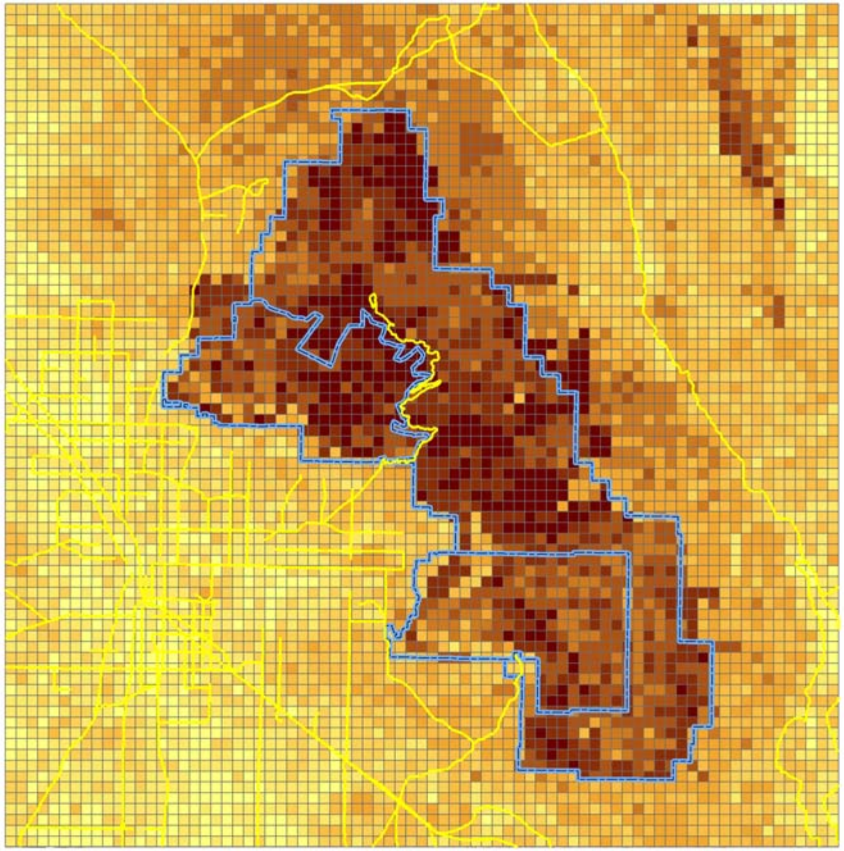
Priorities

(eigenvector)

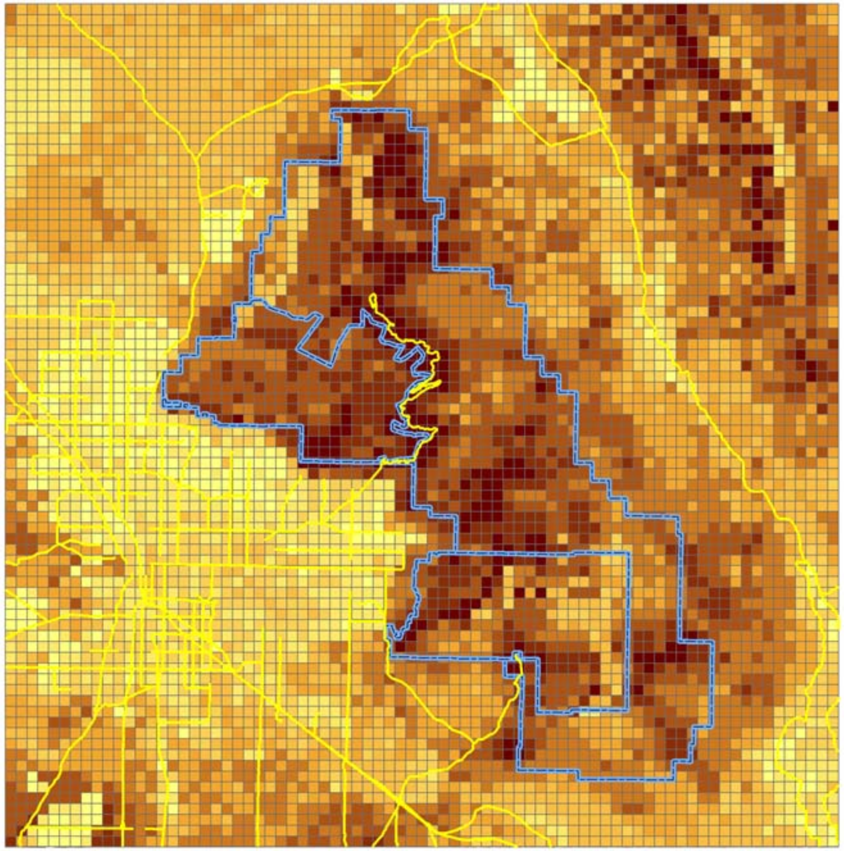
How Results are Obtained

- Repeat this process until the differences in the priorities are zero, to the ten-thousandths position

Fire Probability and Values at Risk Sub-Model Results



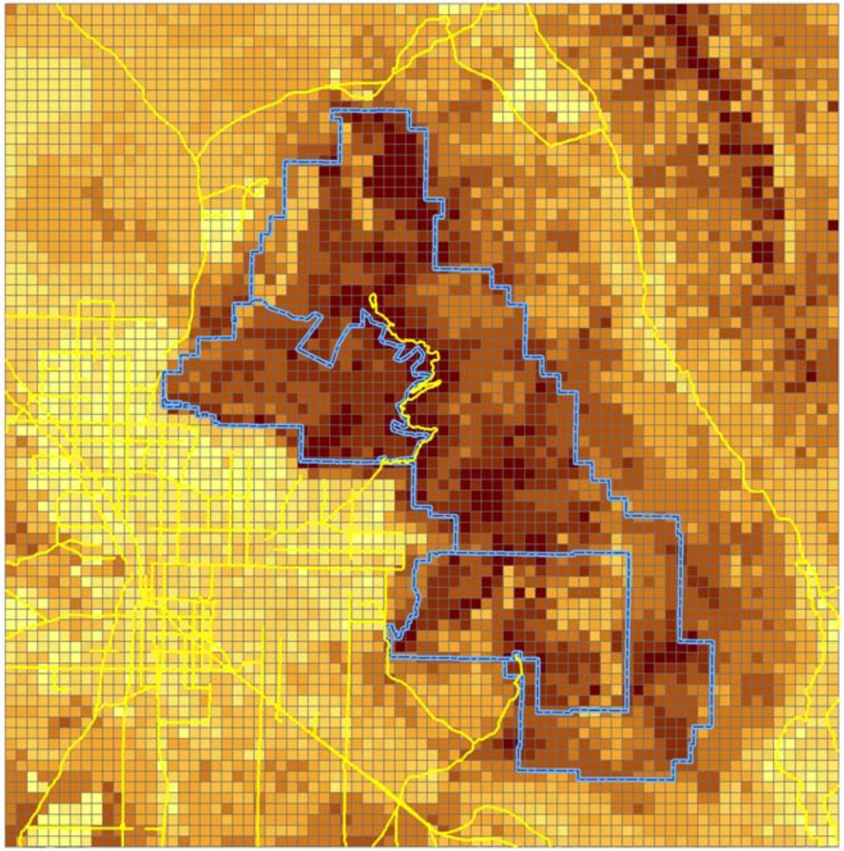
Fire Probability

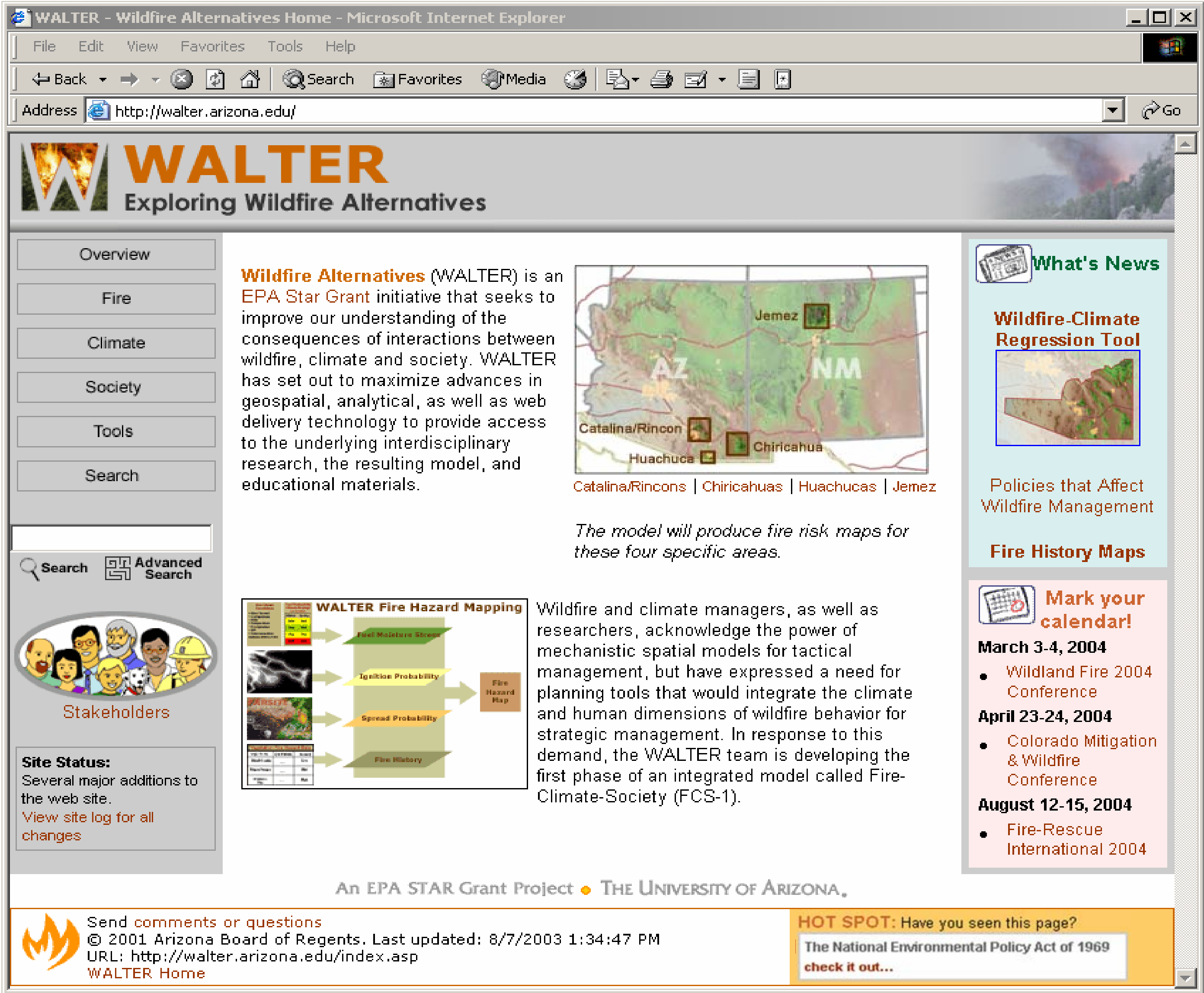


Values at Risk

Combined FCS-1 Model Result

- The combined model includes weighted values from both the fire probability and values at risk models
- In this particular case, the values at risk sub-model was weighted higher than the fire probability sub-model




WALTER - Wildfire Alternatives Home - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://walter.arizona.edu/
Go
WALTER
Exploring Wildfire Alternatives
Overview
Fire
Climate
Society
Tools
Search
Search
Advanced Search
Stakeholders
Site Status:
Several major additions to the web site.
View site log for all changes
Wildfire Alternatives (WALTER) is an EPA Star Grant initiative that seeks to improve our understanding of the consequences of interactions between wildfire, climate and society. WALTER has set out to maximize advances in geospatial, analytical, as well as web delivery technology to provide access to the underlying interdisciplinary research, the resulting model, and educational materials.
Jemez
AZ
NM
Catalina/Rincon
Chiricahua
Huachuca
Catalina/Rincons | Chiricahuas | Huachucas | Jemez
The model will produce fire risk maps for these four specific areas.
WALTER Fire Hazard Mapping
Fire Hazard Map
Wildfire and climate managers, as well as researchers, acknowledge the power of mechanistic spatial models for tactical management, but have expressed a need for planning tools that would integrate the climate and human dimensions of wildfire behavior for strategic management. In response to this demand, the WALTER team is developing the first phase of an integrated model called Fire-Climate-Society (FCS-1).
What's News
Wildfire-Climate Regression Tool
Policies that Affect Wildfire Management
Fire History Maps
Mark your calendar!
March 3-4, 2004
Wildland Fire 2004 Conference
April 23-24, 2004
Colorado Mitigation & Wildfire Conference
August 12-15, 2004
Fire-Rescue International 2004
An EPA STAR Grant Project • The University of Arizona
Send comments or questions
© 2001 Arizona Board of Regents. Last updated: 8/7/2003 1:34:47 PM
URL: http://walter.arizona.edu/index.asp
WALTER Home
HOT SPOT: Have you seen this page?
The National Environmental Policy Act of 1969
check it out...

Fuel Moisture Hazard Climate Scenario Chooser

There are three different ways to select the desired climate scenario:

Option 1:
Year

2002 ▾ [Submit]

Each year in this list (1989-2003) returns the Fuel Moisture Hazard, based on temperature and precipitation, of the April through June fire season of that year.

Option 2:

Temperature of Fire Season

Far Above Avg ▾

First, choose a temperature level for a hypothetical fire season.

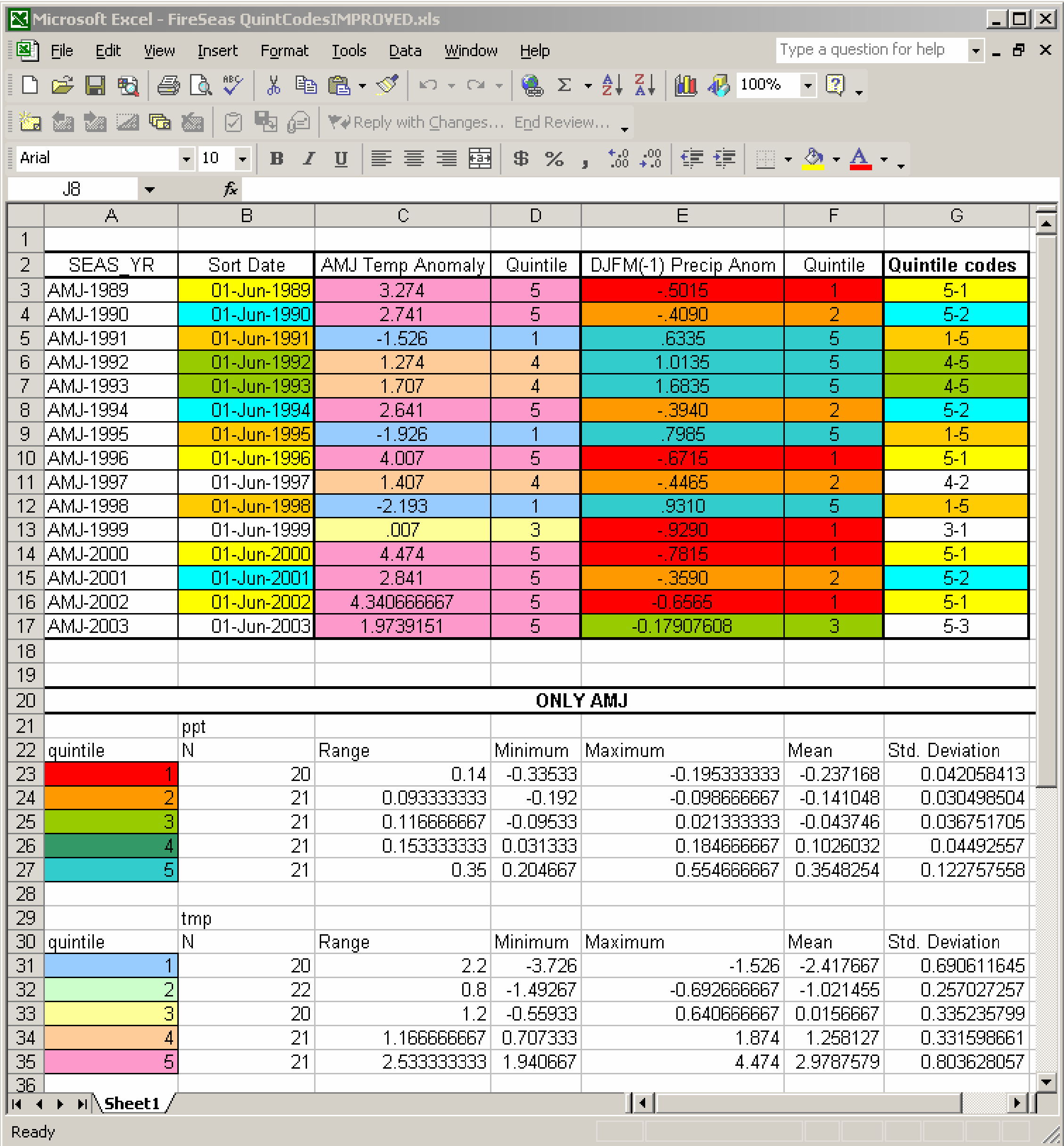
Precipitation Antecedent to Fire Season

Far Below Avg ▾ [Submit]

Second, choose a precipitation level for a hypothetical season just prior to the fire season.

Option 3:
Select Fuel Moisture Hazard from among these historical fire seasons.

Temperature of Current Fire Season \ Precipitation of Season Antecedent to Fire Season	far below average	below average	average	above average	far above average
far above average	1989 1996 2000 2002	1990 1994 2001	2003		
above average		1997			1992 1993
average	1999				
below average					
far below average					1991 1995 1998


Microsoft Excel - FireSeas QuintCodesIMPROVED.xls

SEAS_YR	Sort Date	AMJ Temp Anomaly	Quintile	DJFM(-1) Precip Anom	Quintile	**Quintile codes**
AMJ-1989	01-Jun-1989	3.274	5	-.5015	1	5-1
AMJ-1990	01-Jun-1990	2.741	5	-.4090	2	5-2
AMJ-1991	01-Jun-1991	-1.526	1	.6335	5	1-5
AMJ-1992	01-Jun-1992	1.274	4	1.0135	5	4-5
AMJ-1993	01-Jun-1993	1.707	4	1.6835	5	4-5
AMJ-1994	01-Jun-1994	2.641	5	-.3940	2	5-2
AMJ-1995	01-Jun-1995	-1.926	1	.7985	5	1-5
AMJ-1996	01-Jun-1996	4.007	5	-.6715	1	5-1
AMJ-1997	01-Jun-1997	1.407	4	-.4465	2	4-2
AMJ-1998	01-Jun-1998	-2.193	1	.9310	5	1-5
AMJ-1999	01-Jun-1999	.007	3	-.9290	1	3-1
AMJ-2000	01-Jun-2000	4.474	5	-.7815	1	5-1
AMJ-2001	01-Jun-2001	2.841	5	-.3590	2	5-2
AMJ-2002	01-Jun-2002	4.340666667	5	-0.6565	1	5-1
AMJ-2003	01-Jun-2003	1.9739151	5	-0.17907608	3	5-3

ONLY AMJ

ppt

quintile	N	Range	Minimum	Maximum	Mean	Std. Deviation
1	20	0.14	-0.33533	-0.195333333	-0.237168	0.042058413
2	21	0.093333333	-0.192	-0.098666667	-0.141048	0.030498504
3	21	0.116666667	-0.09533	0.021333333	-0.043746	0.036751705
4	21	0.153333333	0.031333	0.184666667	0.1026032	0.04492557
5	21	0.35	0.204667	0.554666667	0.3548254	0.122757558

tmp

quintile	N	Range	Minimum	Maximum	Mean	Std. Deviation
1	20	2.2	-3.726	-1.526	-2.417667	0.690611645
2	22	0.8	-1.49267	-0.692666667	-1.021455	0.257027257
3	20	1.2	-0.55933	0.640666667	0.0156667	0.335235799
4	21	1.166666667	0.707333	1.874	1.258127	0.331598661
5	21	2.533333333	1.940667	4.474	2.9787579	0.803628057

Sheet1

Using FCS-1 (Examples of Potential Uses)

- Check climate outlooks
- Run model
- Use outputs for seasonal and long-range planning
  - Managers
    - Budgeting
    - Allocation of resources
    - Decisions about forest treatment strategies (where, when, how)
      - Prescribed burns
      - Thinning
    - Public awareness campaigns
  - Public
    - Cleaning up around homes and other structures
    - Planning development and construction activities
    - Anticipating impacts on businesses and livelihoods

Future Research & Development

- Determine best ways to adapt the model to other areas
- Transition to MODIS data
- Make model dynamical
  - Allow interactive updating of data
  - Integrate fire-climate forecasts
  - Add vegetation modeling function
- Continue developing WALTER web site
  - Add map-drawing exercise to Website
  - Add AHP to Website
  - Continue adding information & tools

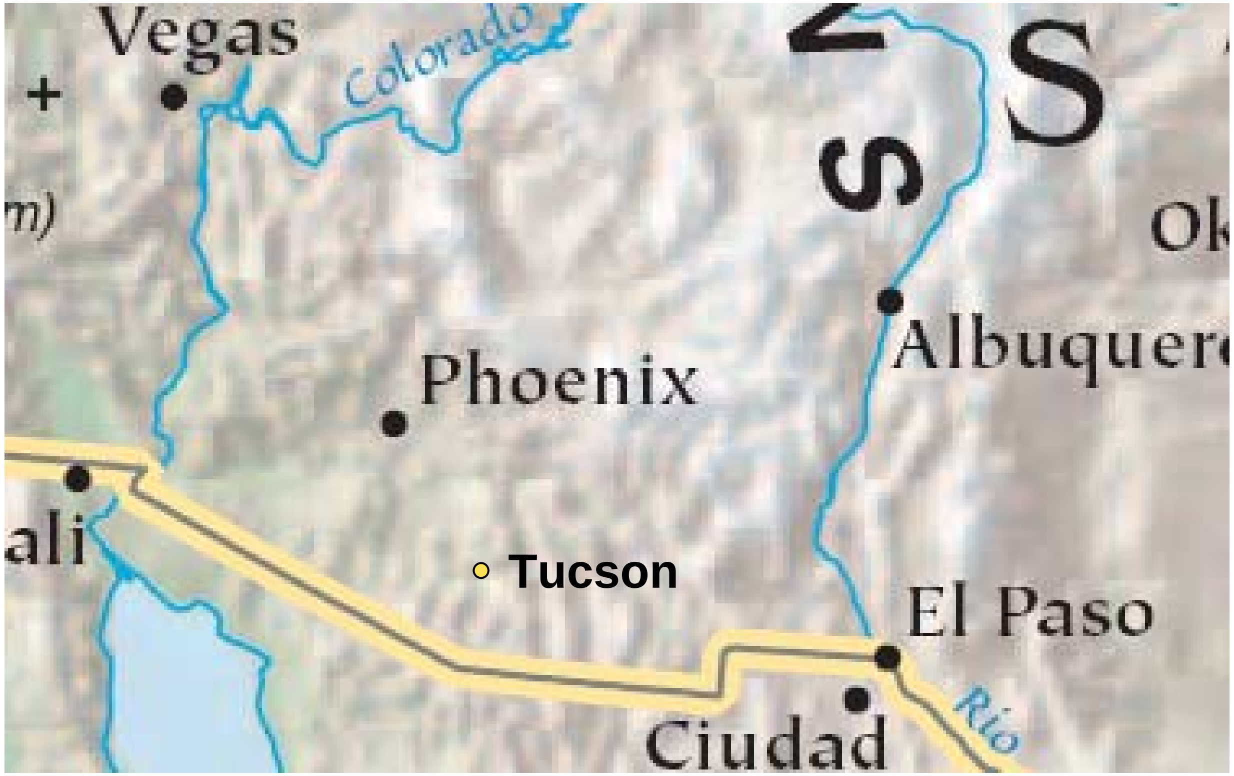
Future Research & Development

- Improve understanding of how this model is adopted and used
  - By whom, when, where, for what purposes
- Improve understanding of how (and if) the use of this model changes decisions and policies
- Improve basic scientific knowledge
  - Fire history, fuels assessment, climatology, vegetation dynamics, human factors

Background Information for the US Southwest

Physical Geography of Southwest

- Physical geography
  - Semi-arid to arid climate
  - Mountains, plateaus, basins, deserts



Population of Southwest

- Demography
  - Relatively sparsely populated
  - Large population concentrations in a relatively few large cities
  - Retirement destination (“snowbirds”)
  - Large migrant population from Latin America
  - Native American population

Economy

- Services
  - Health, retail, tourism, recreation, etc.
- Military and related activities
  - Military bases, national laboratories
- High technology firms
  - Information technology, biotechnology, optical science, etc.
- Primary sector activities
  - Agriculture, mining
- Some manufacturing

Implications for Forests and Forest Fire Management

- Large number of homes being built in forests
  - Expanding wildland-urban interface
- Heavy recreational use of forests
  - Summer: escape heat
  - Winter: skiing
  - Other: hunting, fishing, etc.
    - Native Americans: religious uses, gathering plants
- Conflicts between ranching and other land uses
- High in-migration rates = little knowledge or understanding of forests and fire dynamics in the region

Climate of US Southwest

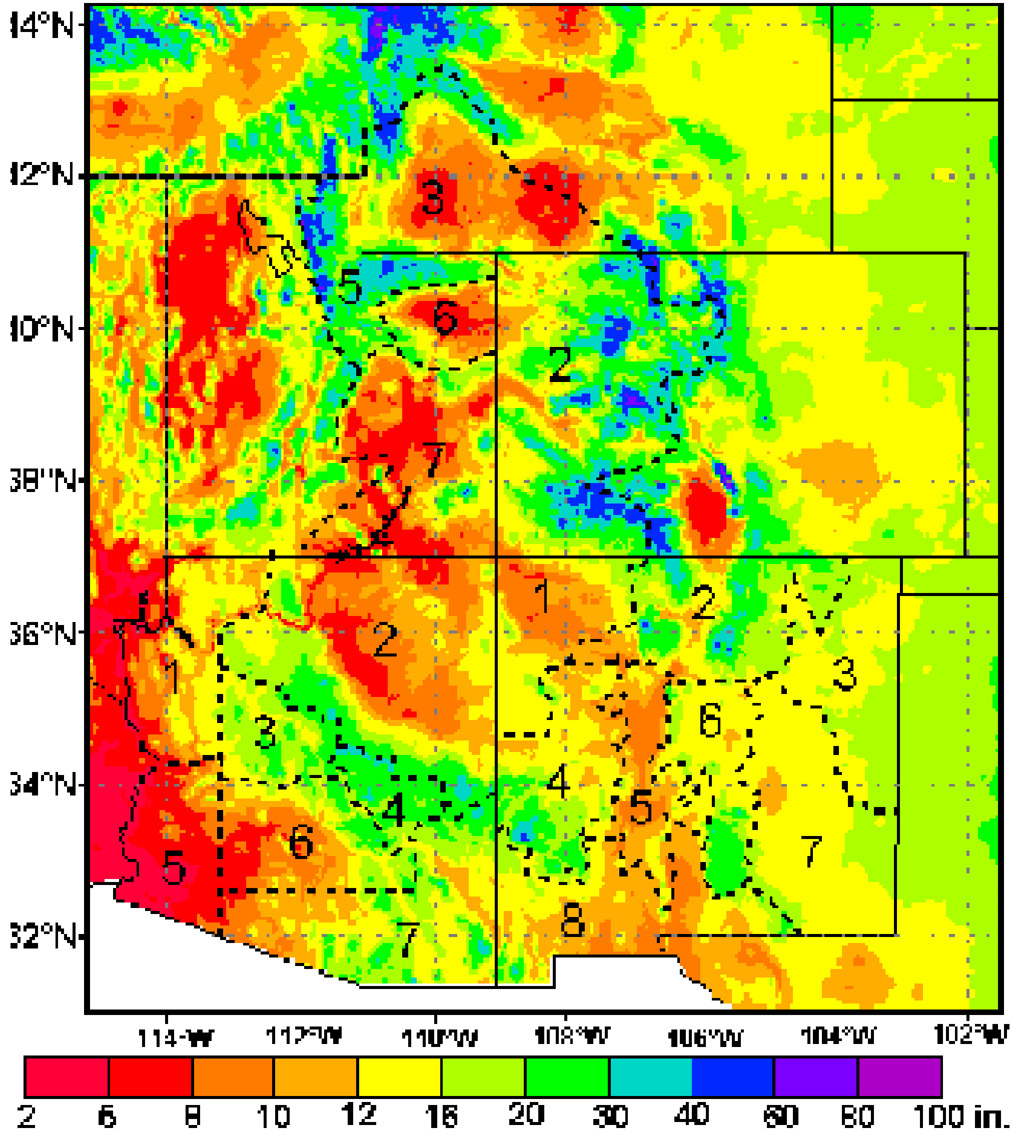
- Arid to semi-arid
- Two wet seasons per year
  - Winter (widespread frontal systems)
  - Summer (North American monsoon and tropical storms)
- Two dry seasons per year
  - Spring (largest fire season)
  - Fall (in dry years, may have secondary fire season)

Length of Data Records

- Climate
  - 100 years (instrumental record)
  - 1,000+ years (tree-ring records, other paleo records)
- Society
  - ~300 years of written history
  - ~100-150 years of data

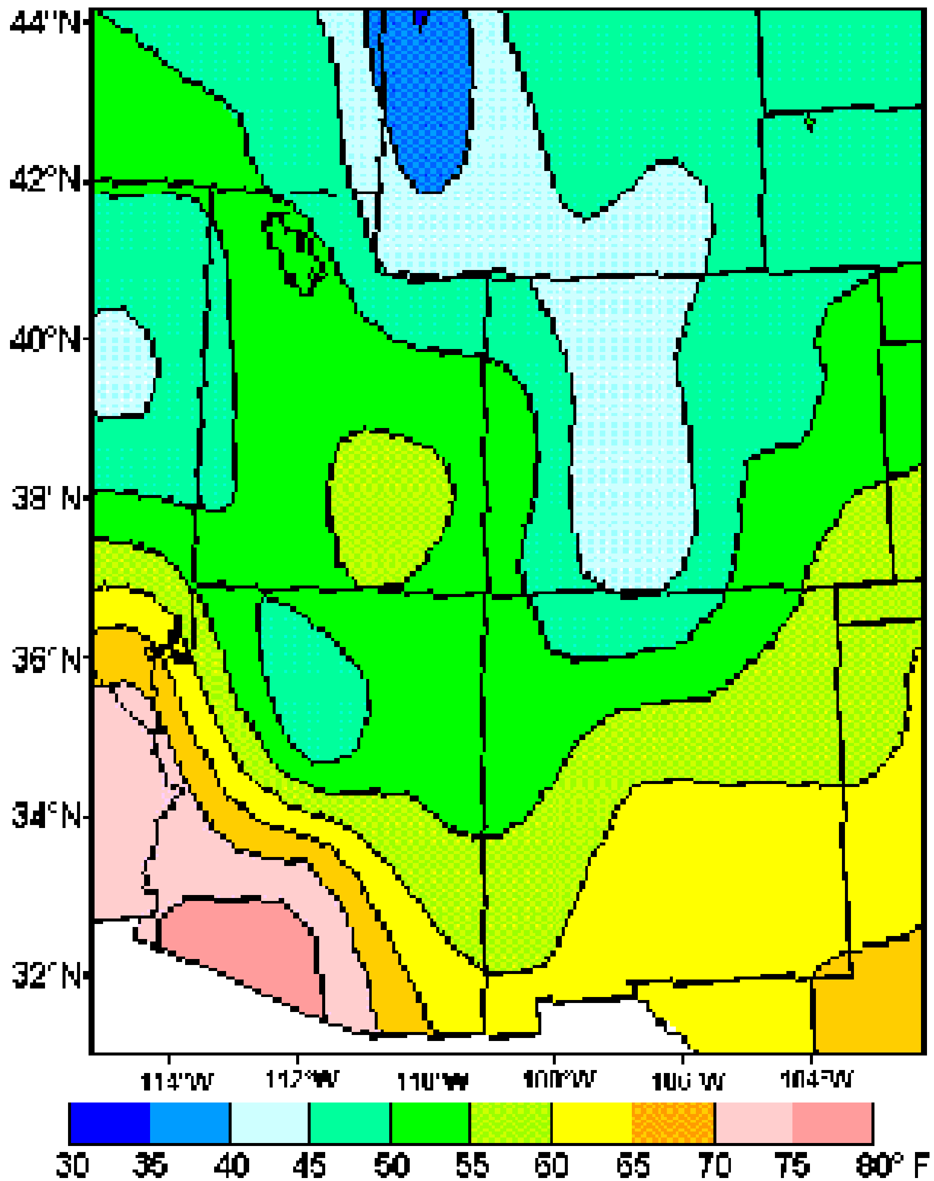
Annual Precipitation

Complex topography



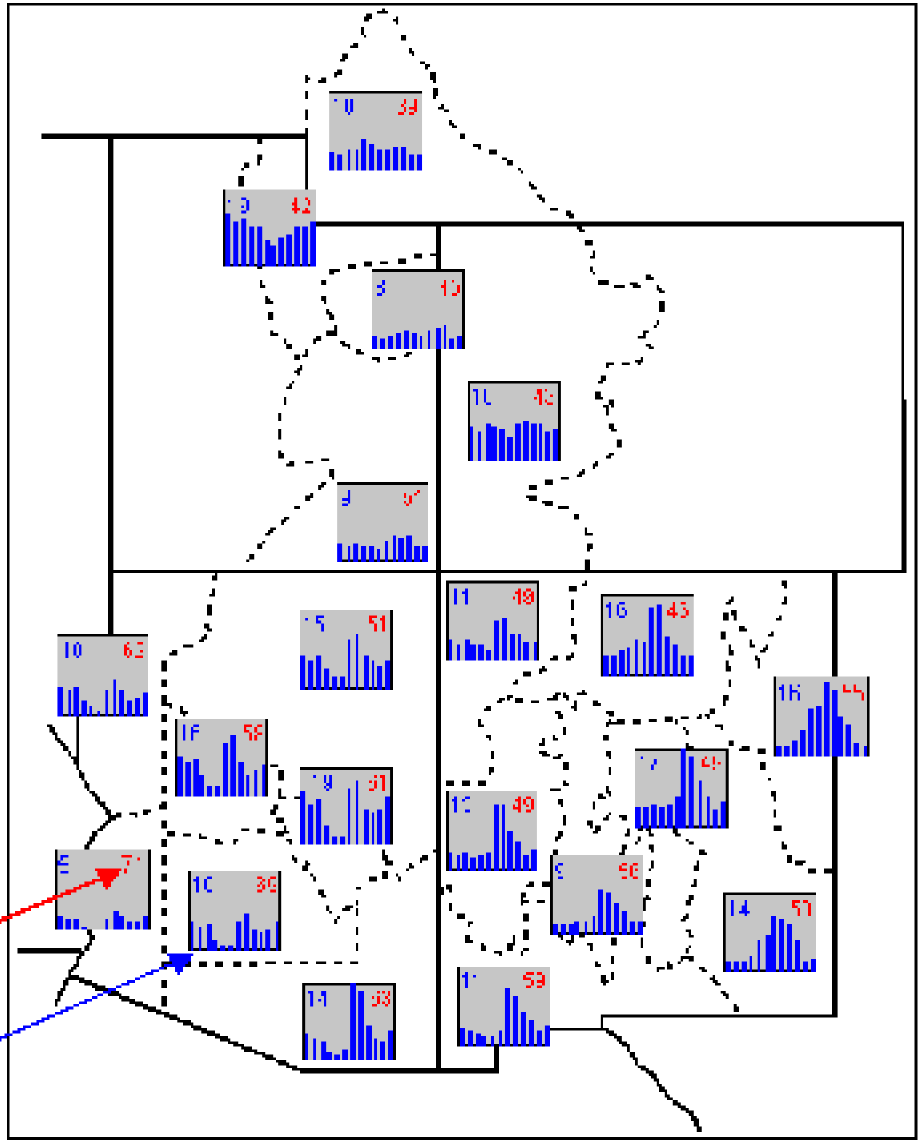
Annual Temperature

Temperature varies with elevation



Basic Climate Characteristics

- Precipitation
  - Annual Means
  - Monthly Scale
    - primary maximum in summer ~ 50% of total
    - secondary maximum in winter ~30%



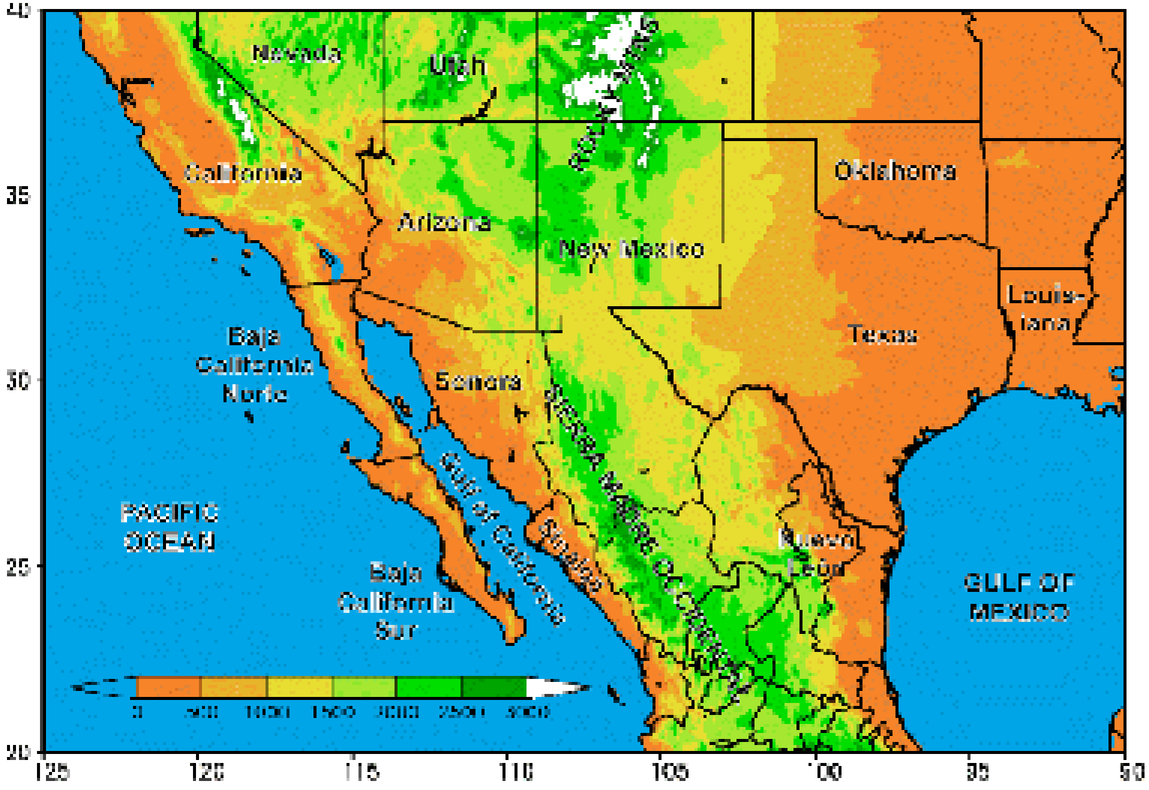
Map legend:

Mean Annual Temp.

Monthly Precipitation (3” scale)

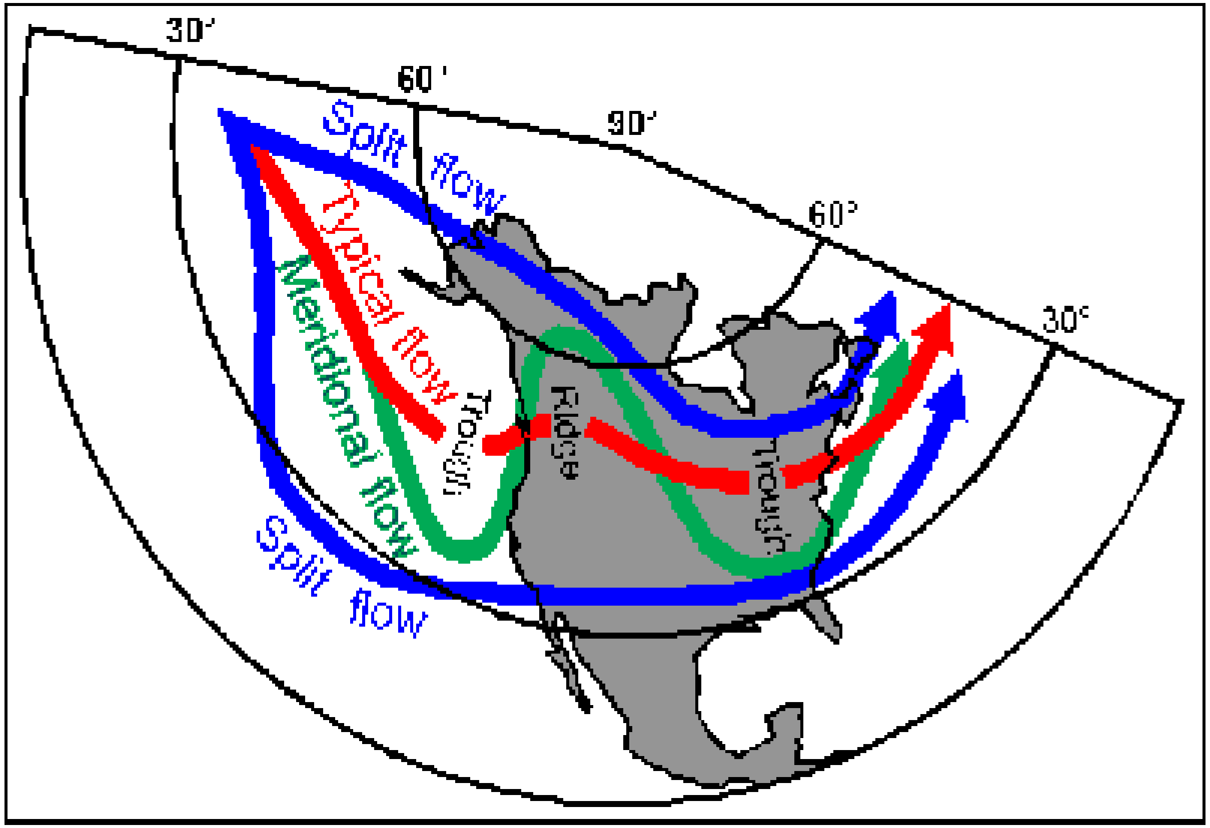
Atmospheric Controls on Climate

- Subtropical high-pressure ridge
  - low precipitation, clear skies, warm weather
- Topography
  - Induces spatial variation
- Proximity to moist air mass sources
  - Gulf of California, Gulf of Mexico, Eastern Pacific Ocean
- Aridity
  - High temperatures & rates of evapotranspiration
  - Rainshadow effects of mountain ranges



Winter Storm Tracks

- Typical= 700 mb jet, N of the Southwest.
- Dry winters= Typical flow to N, or zonal. Enhanced during La Niña.
- Wet winters=
  - Meridional Pacific/North American (PNA) pattern
  - Southwestern Troughing (ridge/trough/ridge)
  - El Niño can lead to PNA or Split flow

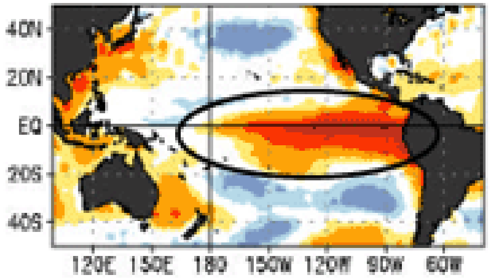


El Nino and La Nina

• El Nino and La Nina are changes in Ocean Temperatures along Equator, near Peru

•Warmer than usual ocean temperatures indicate El Nino, whereas colder indicates La Nina

• It occurs every 2-5 years or so. Scientists are getting better at predicting it



Where El Nino happens: If there are warm ocean temperatures in the oval it is El Nino. If the waters are cold, it's La Nina.

Do you remember any recent winters that were dry or wet? Check and see if they were El Nino or La Nina:

Past El Nino winters since 1950:

1957-59, 63-64, 65-66, 68-70, 72-73, 82-83, 86-87, 90-95, 97-98

Past La Nina winters since 1950:

1949-51, 54-57, 64-65, 70-72, 73-76, 83-85, 88-89, 95-96, 98-?? ← 98-00

Notice how some events (especially La Nina events) can last for more than one year.

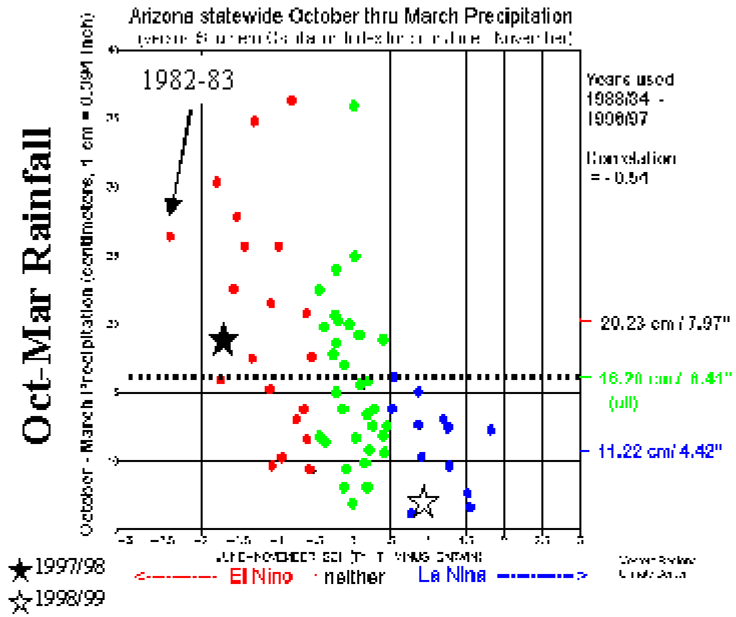
El Nino events have been happening for several thousand years and are a natural part of the earth's system. However, for many years, El Nino was not well understood or monitored. Now, with satellites, buoys, and high power computer simulations of the atmosphere and ocean, we are able to make predictions of El Nino that could not have been made 10 to 15 years ago.

Which forecasts are reliable? Currently, forecasts for El Nino are very good about **6 months in advance**. So, if you would like to know whether it will be El Nino or not in the upcoming winter, you can place high confidence in the forecasts produced the summer before. Forecasts are produced out to two years, and, while there is currently some skill that far in advance, don't take them too seriously. For example, **the current forecast predicts that La Nina will continue through the winter 1999-2000** and it will switch back to El Nino sometime during the summer of 2000. I believe the forecast for this winter, but am taking a "wait and see" attitude towards next winter. Also, while other parts of the ocean can affect climate (e.g. the Atlantic or the North Pacific), forecasts for these regions are currently relatively primitive.

Some web sites about El Nino: http://www.wrcc.dri.edu/enso/
http://www.wrh.noaa.gov/wrhq/EL-LA/el-la.html

ENSO Dry vs. Wet Year Patterns

El Nino & Arizona Precipitation



- **El Niño winters may be very wet.**
- **Very wet winters are typically El Niño winters, but not always...**
- **La Niña winters are reliably dry, and <u>almost never wet</u>.**

At left is a plot comparing Arizona state-wide winter precipitation during El Nino (left), "Non-Nino" (middle) and La Nina (right) years. Southern Oscillation Index (SOI) is a measure of the strength of the El Nino/La Nina event (so very strong El Nino events are to the far left).

El Nino implies wet conditions, whereas La Nina implies drier conditions. While the left side of the plot may look dramatic, keep in mind that the second strongest El Nino event had near average precipitation in Arizona, whereas one of the wettest years on record was "Non-Nino". What is more interesting is the right half of the plot <u>there have been no wet La Nina winters in Arizona since (at least) 1933</u>. Some parts of Yavapai county were wet in winter 1975-76, but during 1973-77 (an extended La Nina), much of the Southwest experienced prolonged drought.

Precipitation in your region:

Walnut creek, AZ (1950-98) Sept-March Rainfall	El Nino	neither	La Nina
# yrs w/ > 10.5 inches (**wet**)	10	5	**1** (in 1976)
in between (**normal**)	4	7	5
# yrs w/ < 7 inches (**dry**)	**2**	4	11

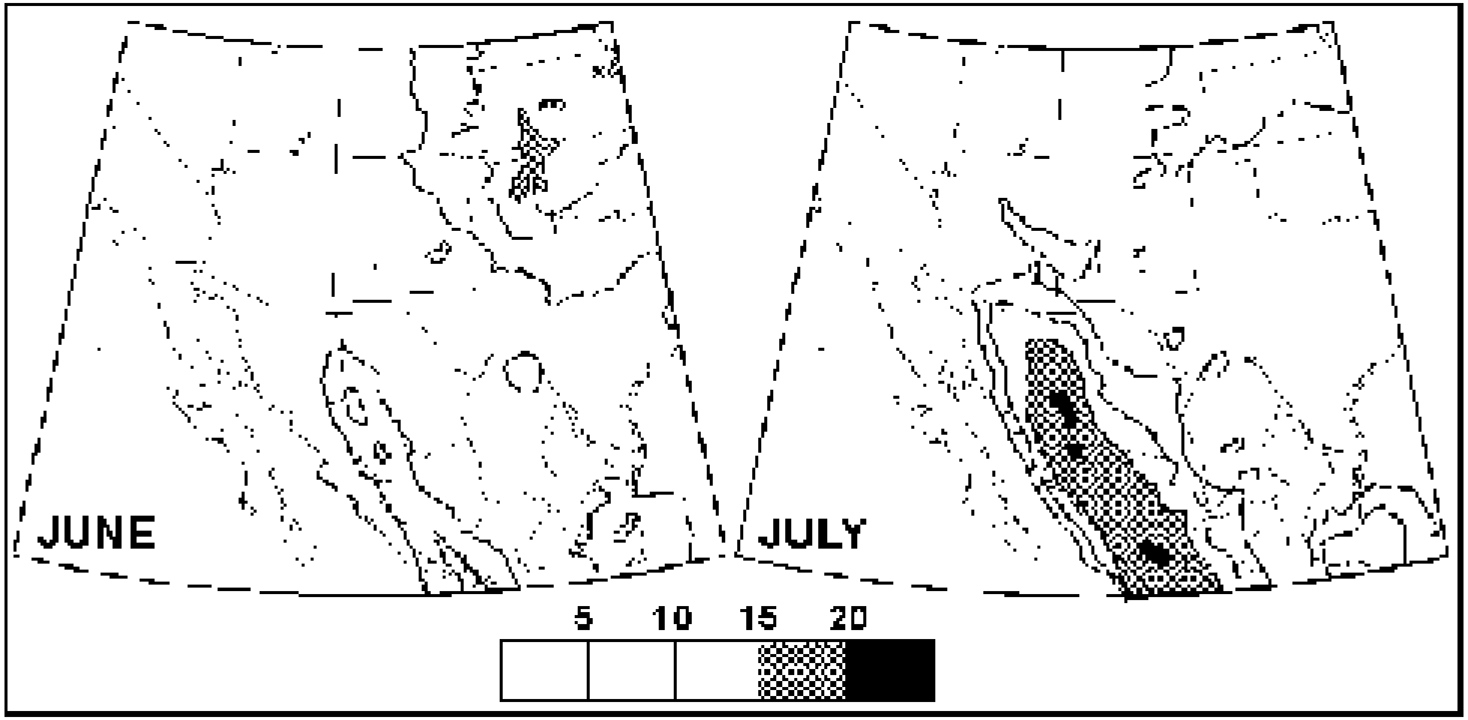
Shown to the bottom left is a table of what winters have been wet/normal/dry at Walnut Creek, AZ (south of Seligman). The upper left box shows that **1 out of the past 16 La Nina years has been wet** (more than 10.5 inches), whereas in the lower right, 2 of the last 16 El Nino years have been dry (less than 7 inches). This is typical of other locations around Arizona and gives us confidence in forecasting a dry winter.

Summer Climate Features

North American Monsoon

Seasonal change in wind direction.

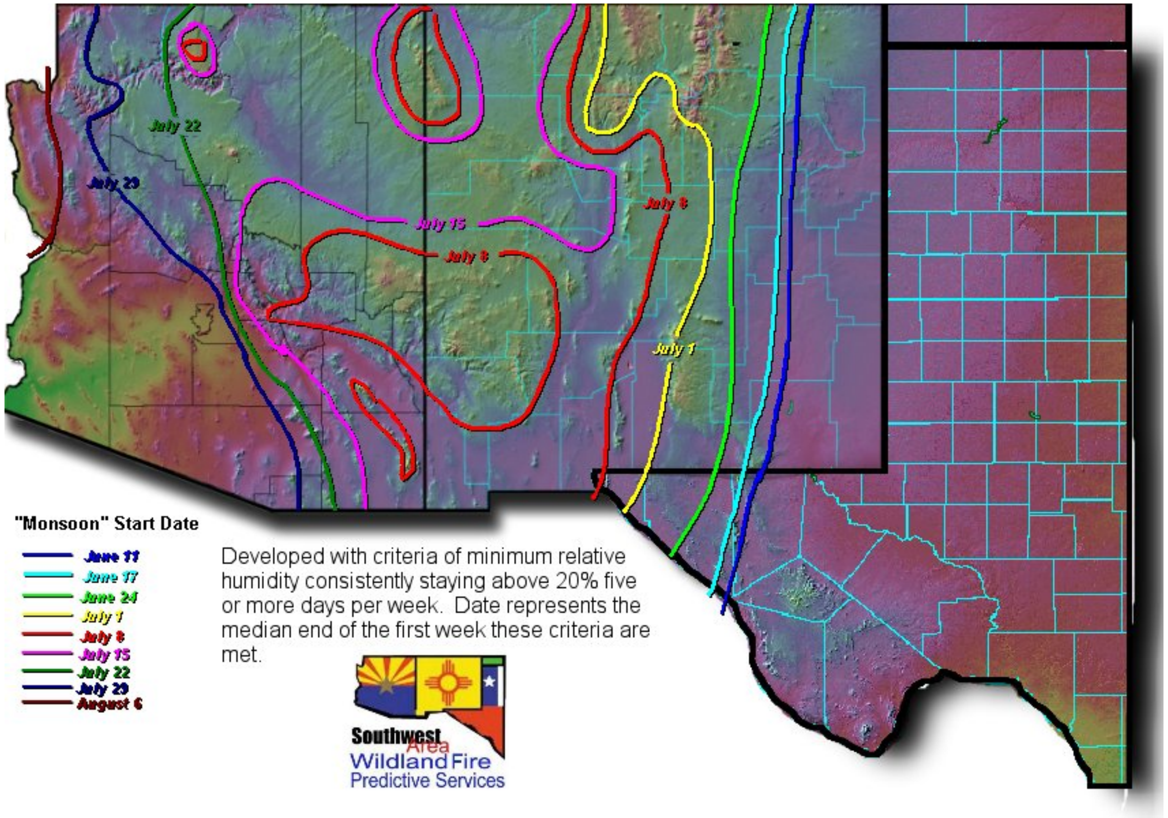
Seasonal rains: July through early September in SW.



Sources: Gulfs of California and Mexico, eastern Pacific Ocean.

Part of larger circulation pattern over Mexican highlands.

Summer Monsoon Pattern for Southwest



http://www.fs.fed.us/r3/fire/swapredictive/swaoutlooks/archived/map_swa_monsoon.jpg

Climate Change Over Time

- Instrumental record

  Extends back ~100 years.

- Paleoclimatology

  SW record extends back in time for 1000 years or more.

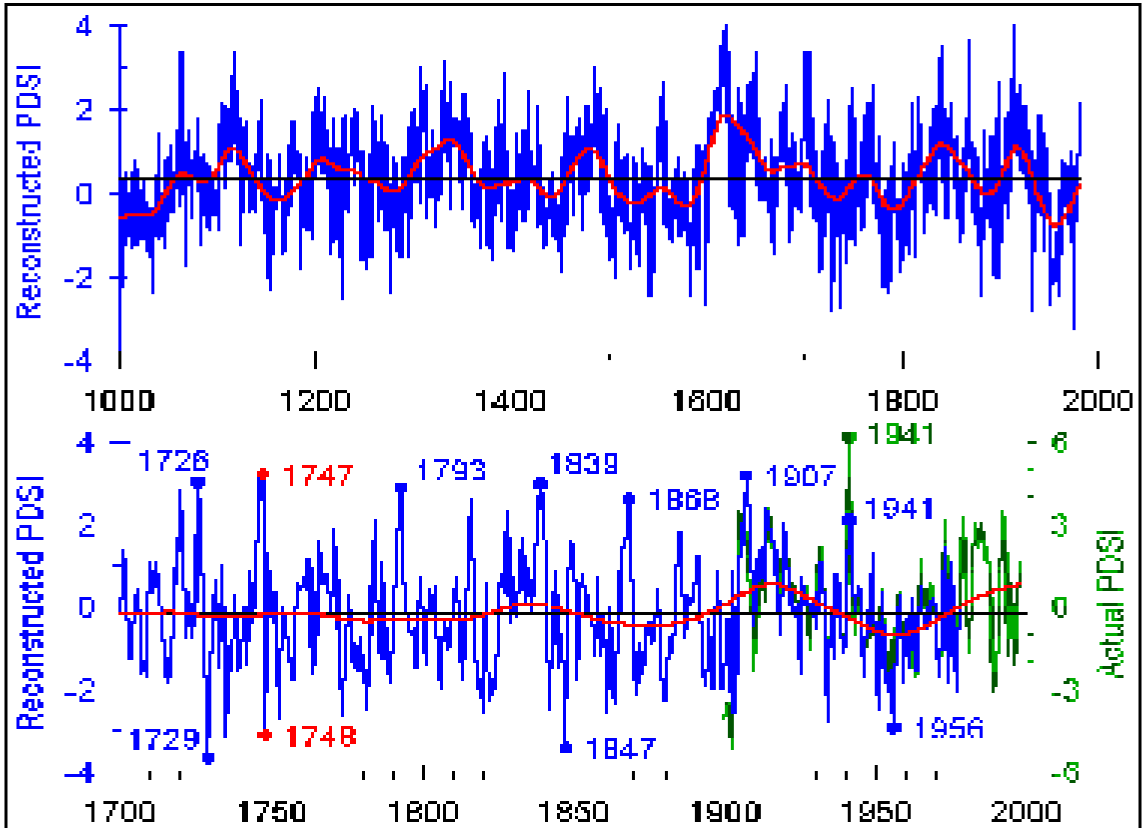
  Dendrochronology: the study of tree-ring variation.

  Palmer Drought Severity Index (PDSI):

  - Single variable derived from variation in precipitation and temperature.
  - For SW, June-August PDSI strongly represents precipitation and, to a lesser extent, temperature of the year prior to the growing season.

Short-Term Moisture Variability

- Frequent dry and wet periods (>10 each) in instrumental record.
- Vary widely in intensity and timing.
- 1950s (sustained) drought among worst in last 1000 years.
- Wet periods: 1726, 1793, 1839, 1868, 1907.
- Greatest annual wet-dry switch 1747-1748.

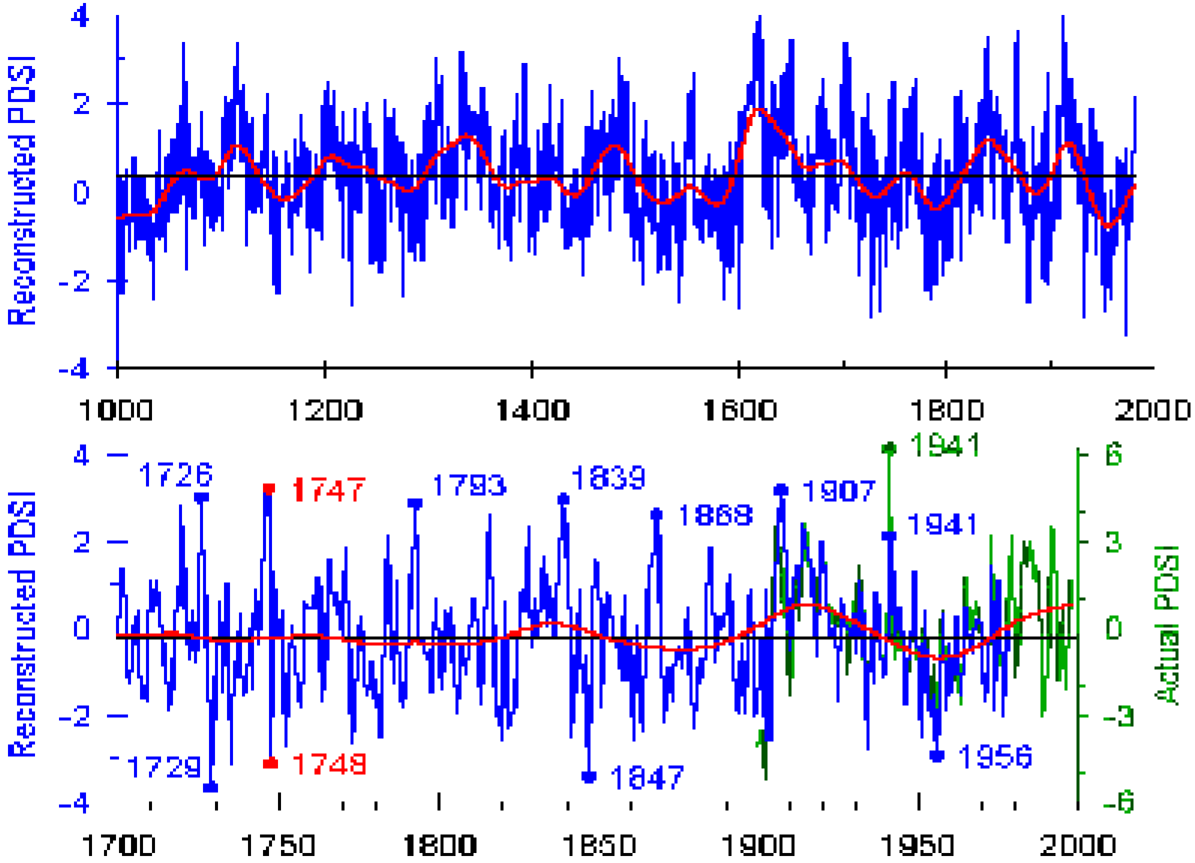


Occurrences ~80-Year-Period Variation in Southwest PDSI

Occurrence	Below Average	Above Average	Length (yrs)
antepenultimate	1770-1825	1825-1840	70
penultimate	1840-1905	1905-1925	85
ultimate	1925-1980	1980-present	~75

Long-Term Moisture Variability

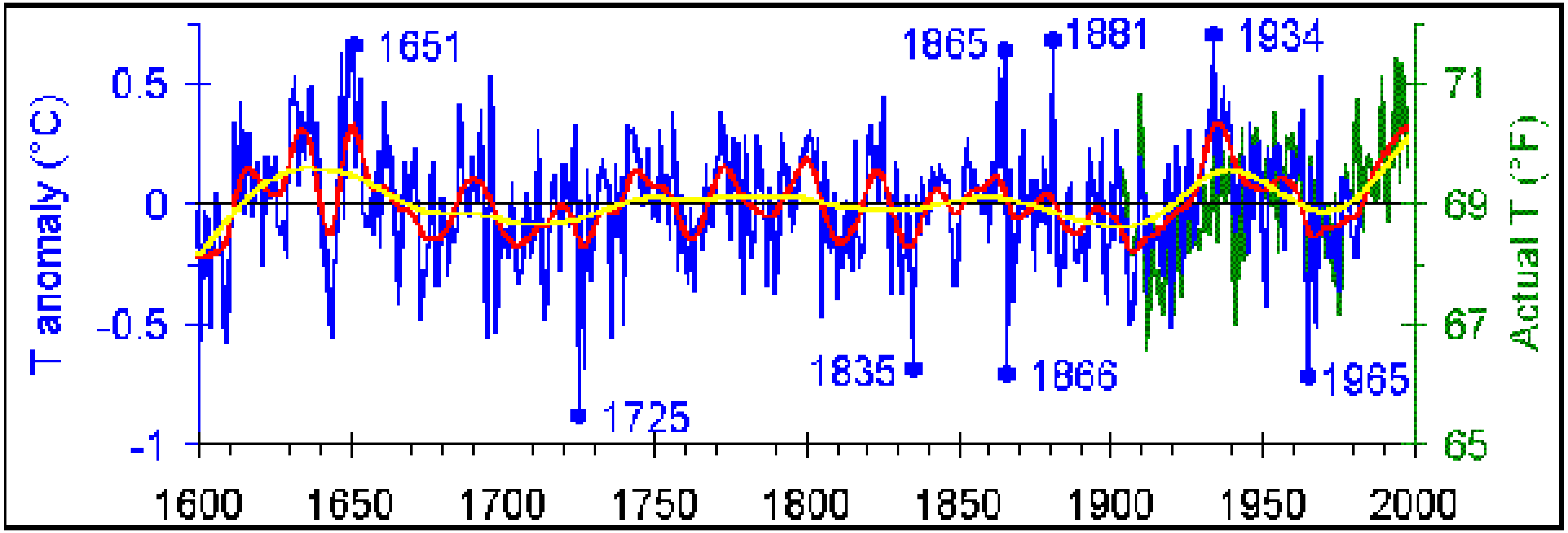
- 20 year early 1900s wet period exceeded only in early 1600s.
- Longest drought of millennium in 1500s.
- ~80 year pattern of variation, alternating below to above average PDSI (Gleissberg solar cycle?)



Occurrences ~80-Year-Period Variation In Southwest PDSI.

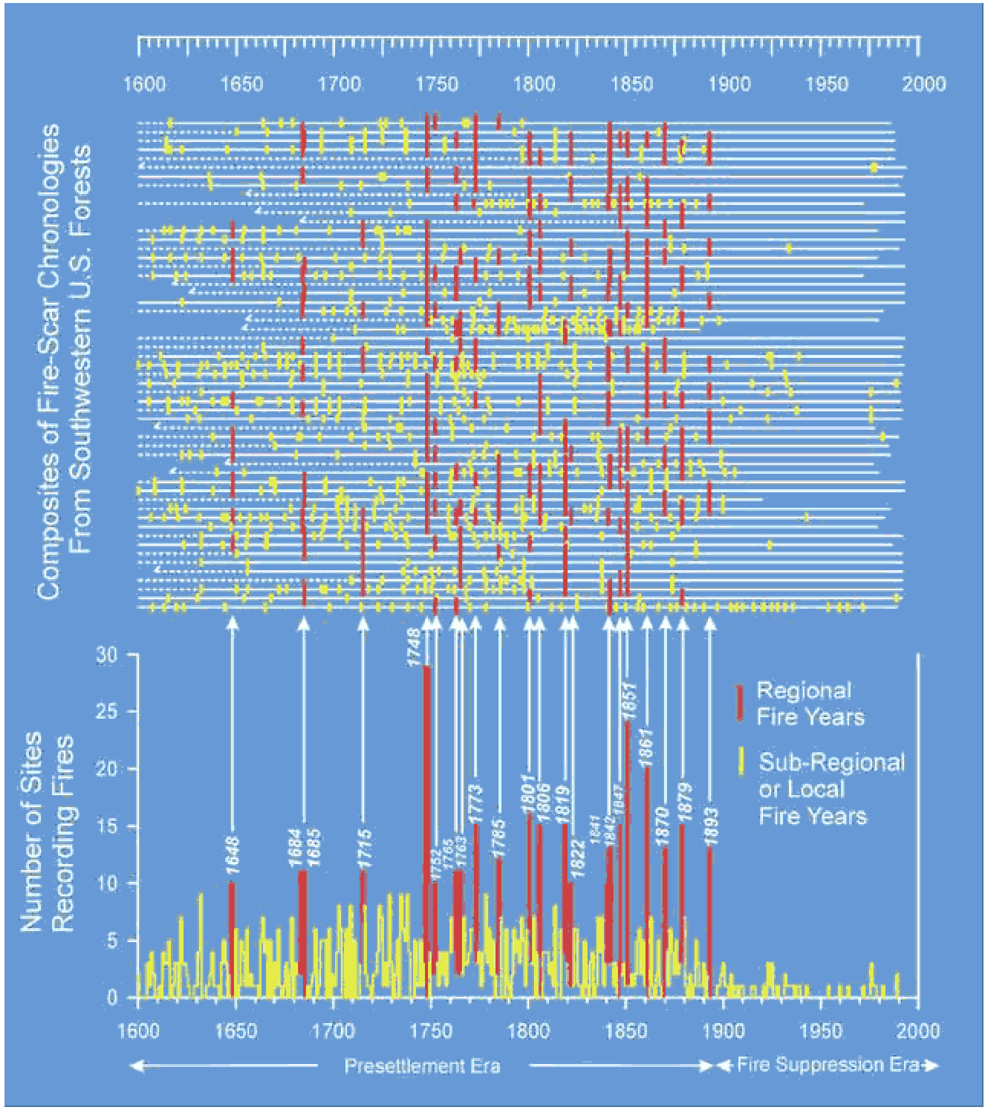
Occurrence	Below Average	Above Average	Length (yrs)
antepenultimate	1770-1825	1825-1840	70
penultimate	1840-1905	1905-1925	85
ultimate	1925-1980	1980-present	>75

Temperature Variability



- **Recent temperatures unprecedented in last 400 years.**
- ~20 year variability: warm mid-1600s & 1930s, cold 1907 & 1600.
- ~80 year pattern weak 1700-1900 (as for precipitation).
- **Extremes are recent** and short-term temporal variability also varies:
  - warm in 1865, 1881, 1934, equaled around 1651.
  - cool in 1725, 1835, 1866 and 1965.

Fire History from Tree-Ring Records

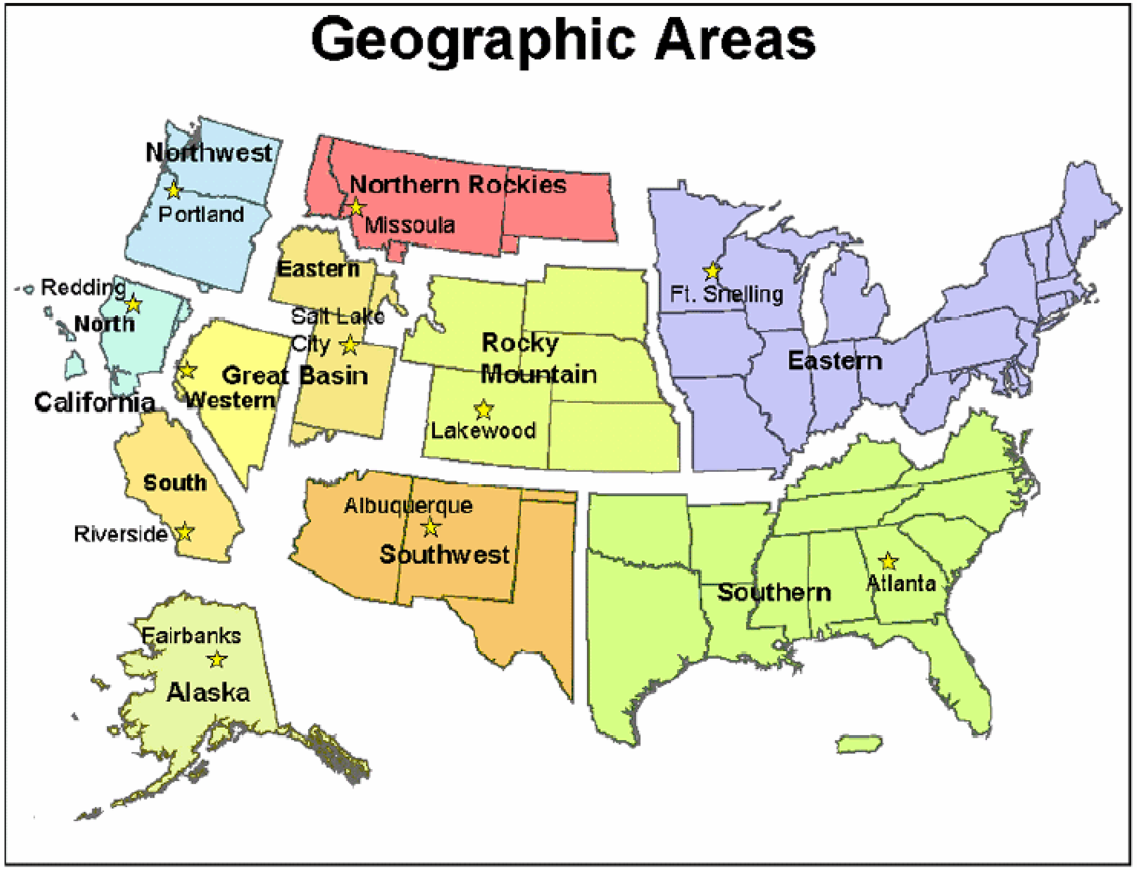


Climate and Fire Forecasting in the United States

National Interagency Fire Center (NIFC)

- Coordinates all wildland fire operations in the United States
  - US Forest Service
  - Bureau of Land Management
  - National Park Service
- Headquartered in Boise, Idaho
- Funds fire research through Joint Fire Science Program

National Interagency Fire Center (NIFC) Management Regions

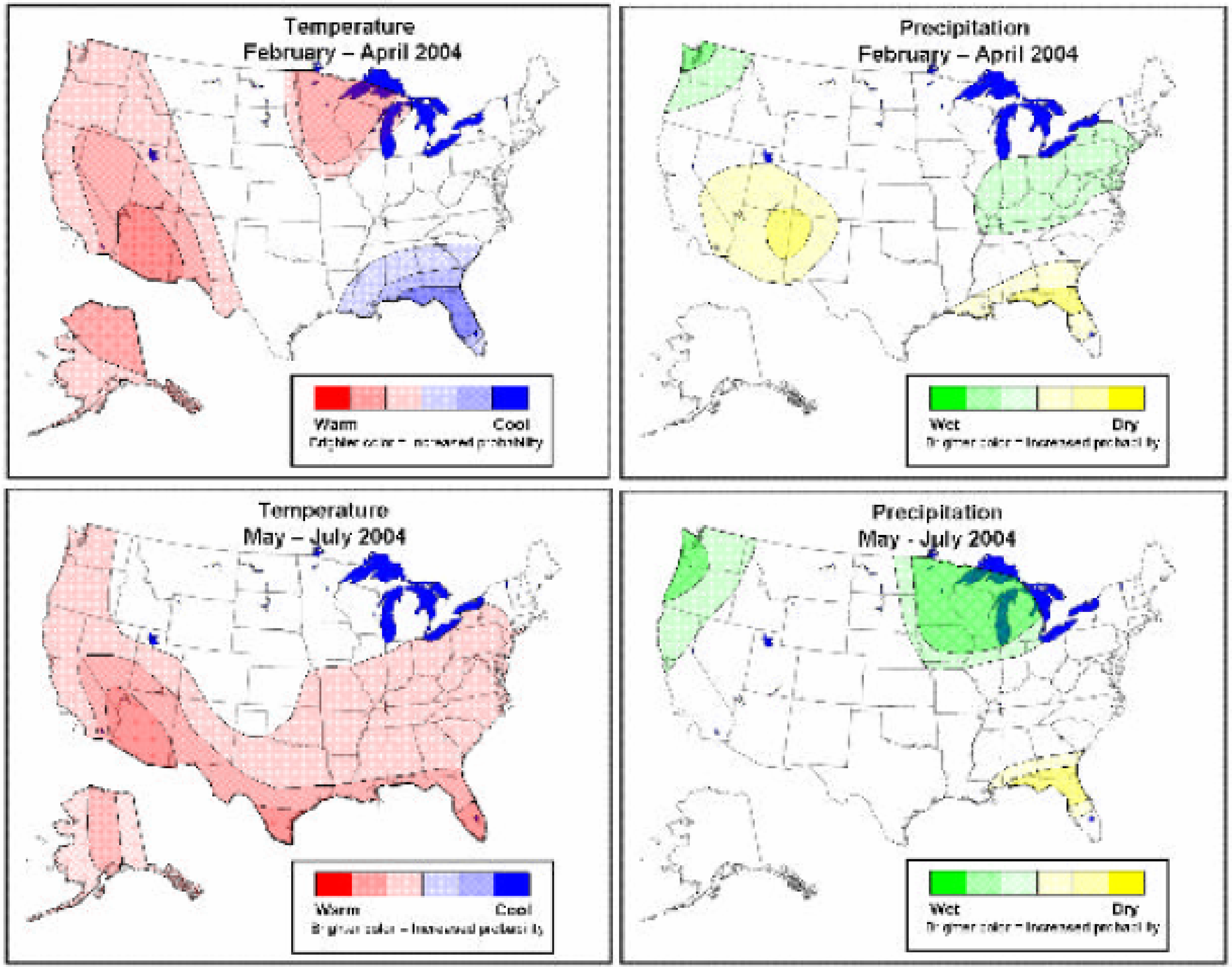


http://www.nifc.gov/news/2003_statssumm/intro_summary.pdf

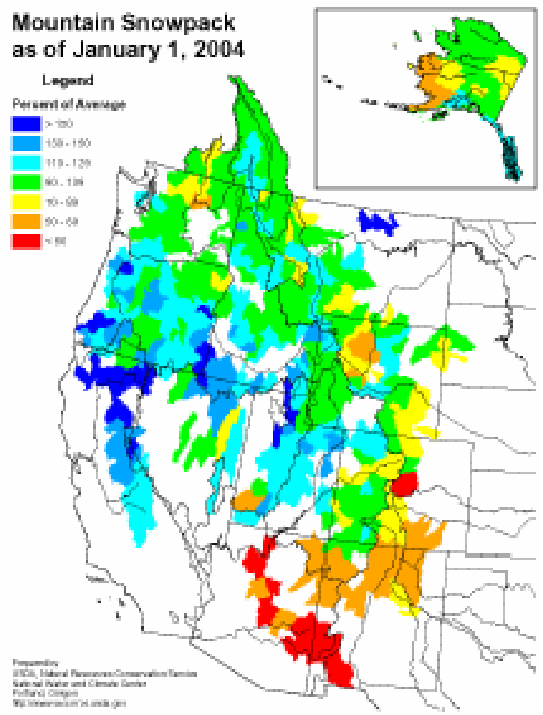
National Interagency Coordination Center (NICC) – Predictive Services Unit

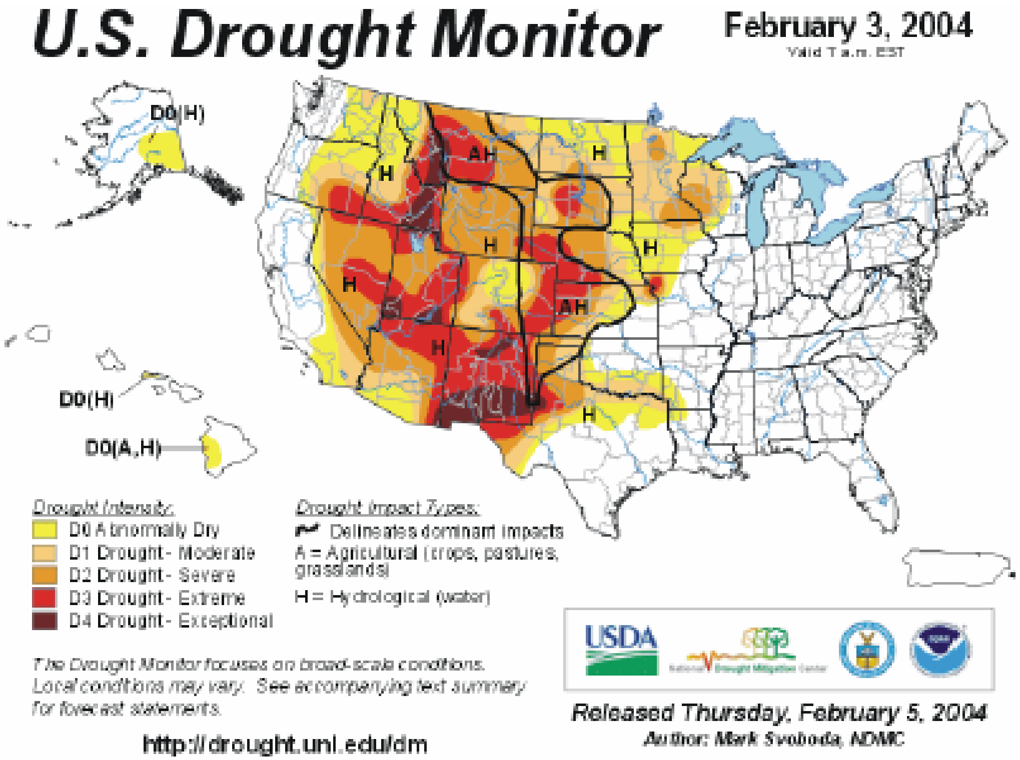
Climate and Meteorological Services
for Fire Management

http://www.nifc.gov/news/intell_predserv_forms/feb_2004.pdf

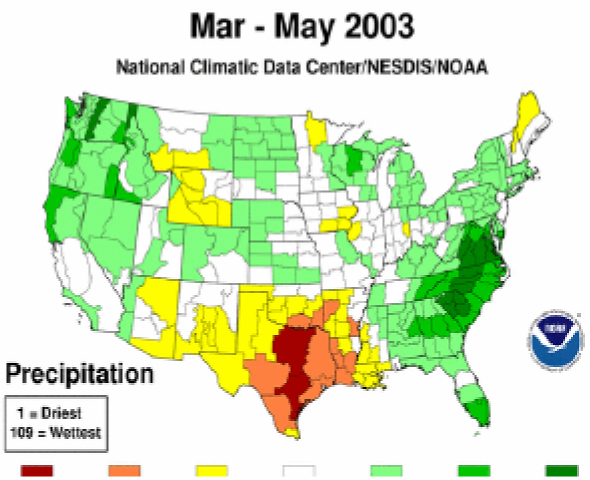


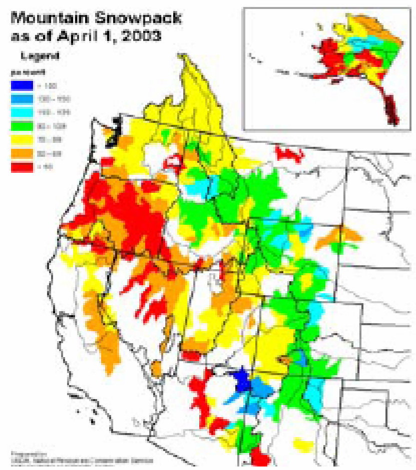
http://www.nifc.gov/news/intell_predserv_forms/feb_2004.pdf

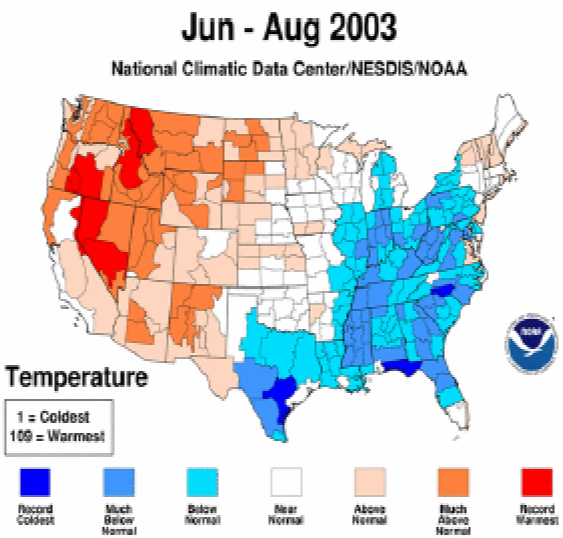


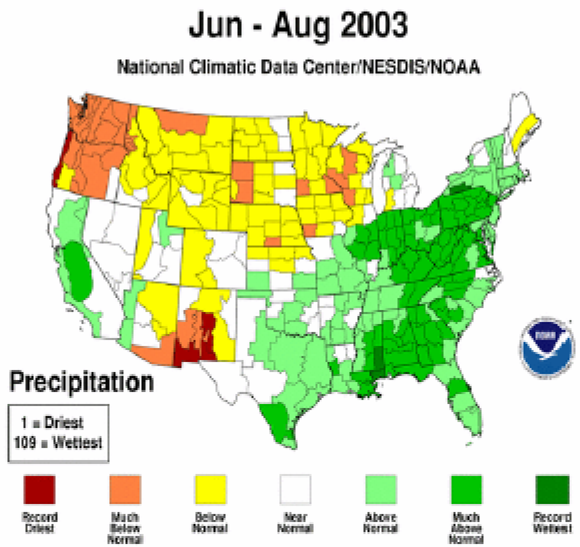


http://www.nifc.gov/news/intell_predserv_forms/feb_2004.pdf

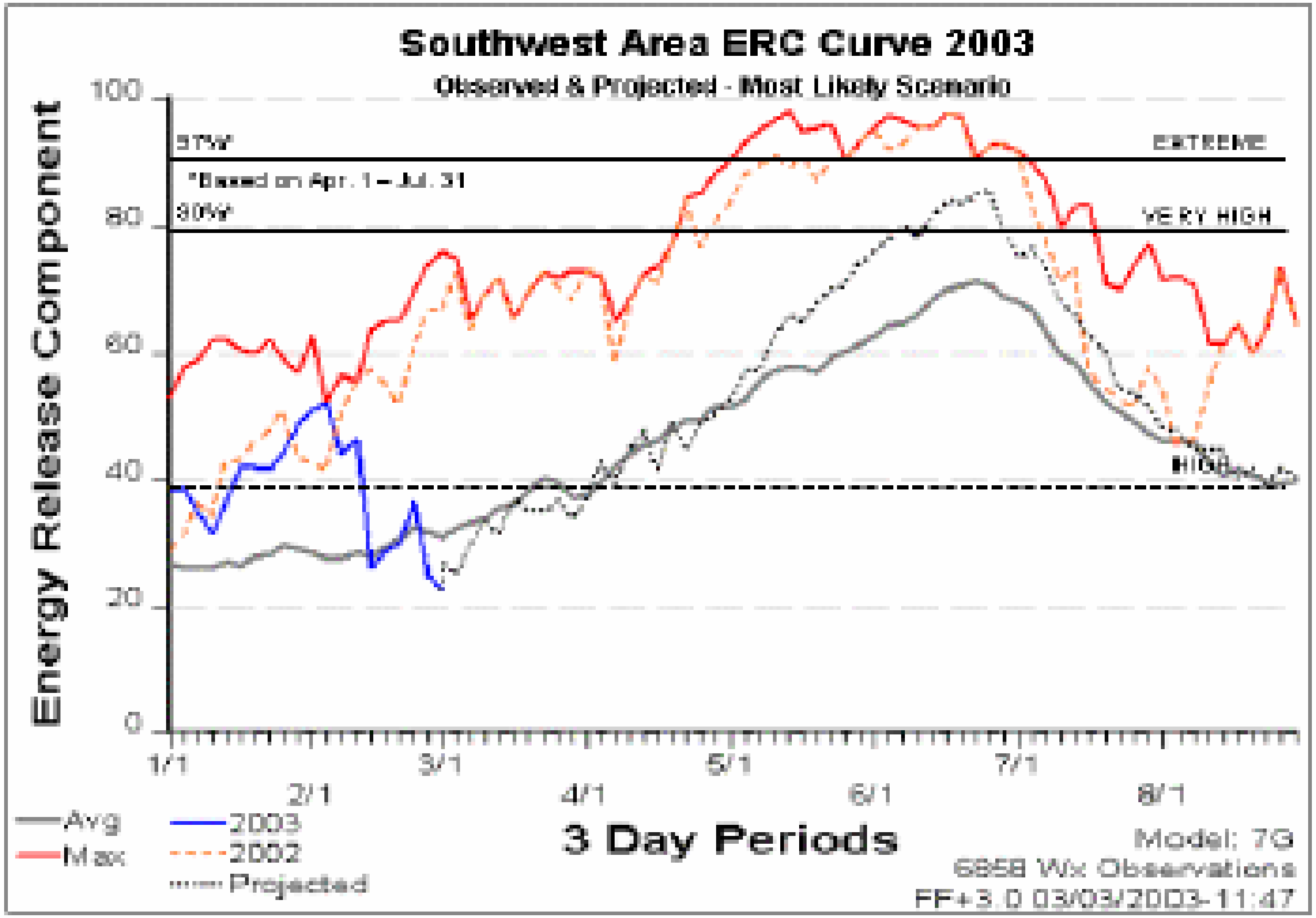




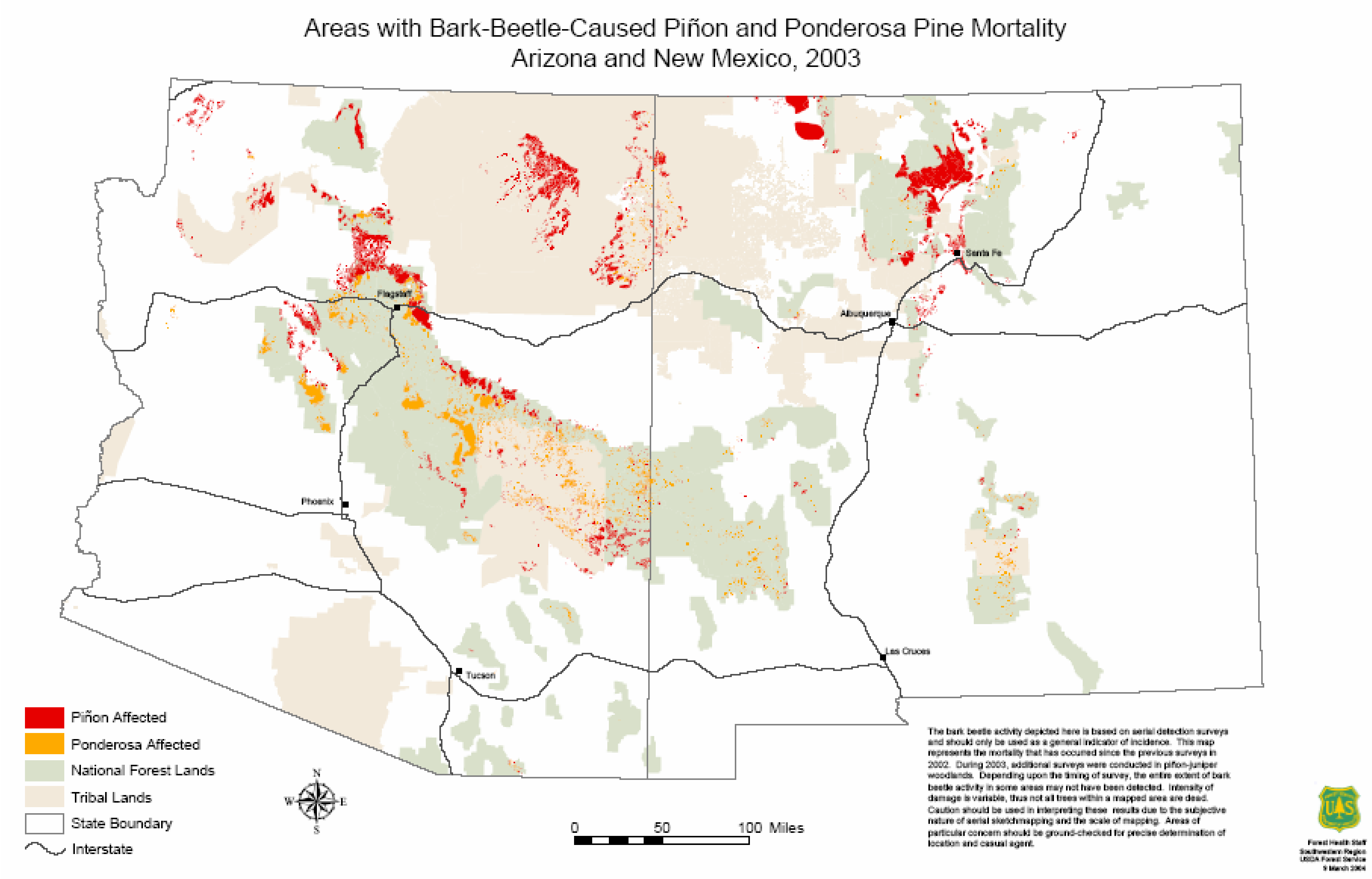




http://www.nifc.gov/news/2003_statssumm/intro_summary.pdf



http://www.nifc.gov/news/2003_statssumm/intro_summary.pdf



http://www.fs.fed.us/r3/resources/health/documents/r3_2003_bb.pdf

Fire in the US

Cumulative and for 2003

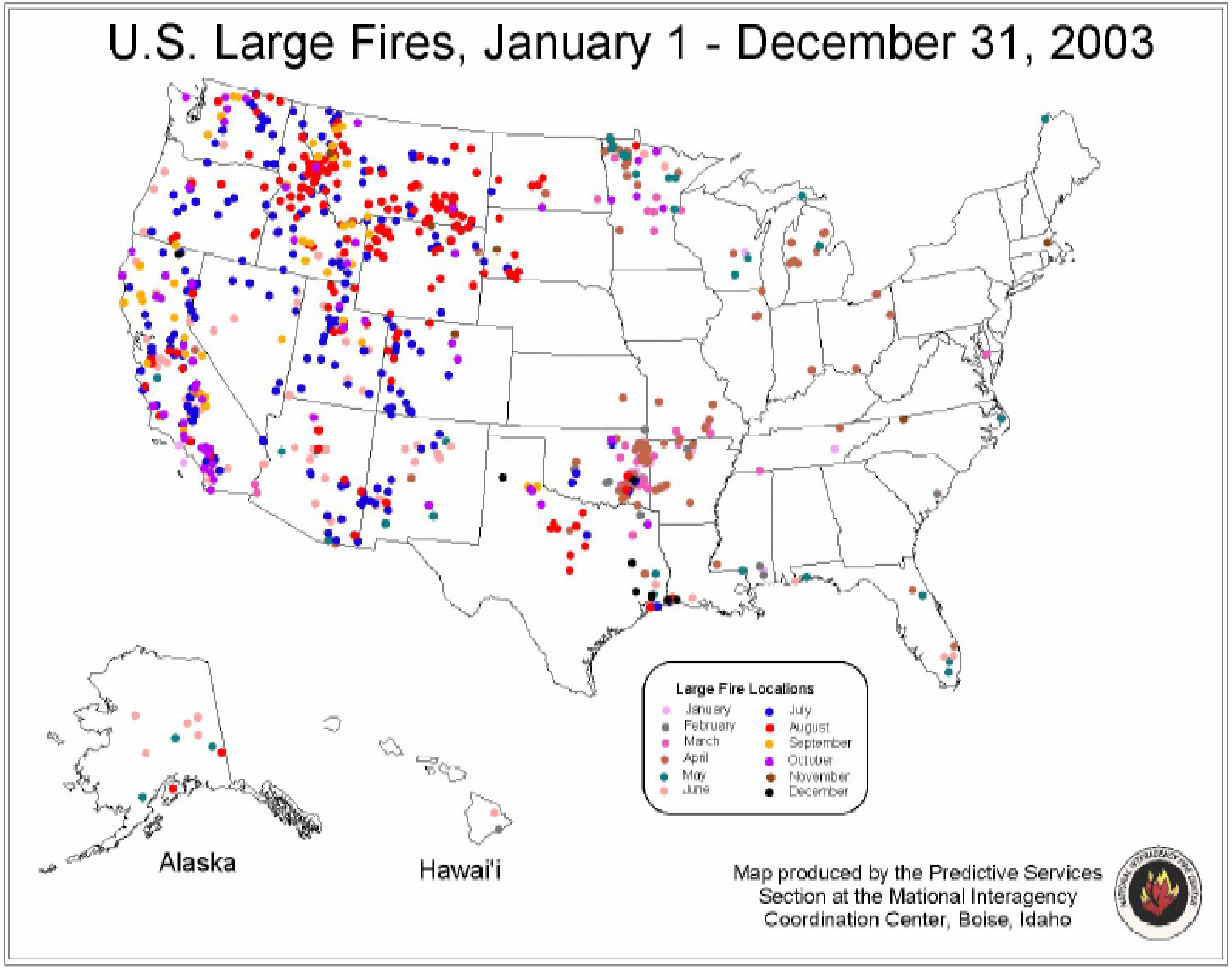
NICC Book of Records

CATEGORY	YEAR	AMOUNT	2003 STATS
WILDLAND FIRES	1996	96,363	63,269
WILDLAND ACRES BURNED	2000	7,383,493	3,959,223
WILDLAND FIRE USE FIRES	2002	1,611	342
WILDLAND FIRE USE ACRES BURNED	**2003**	**330,933**	

Average Worst Summary

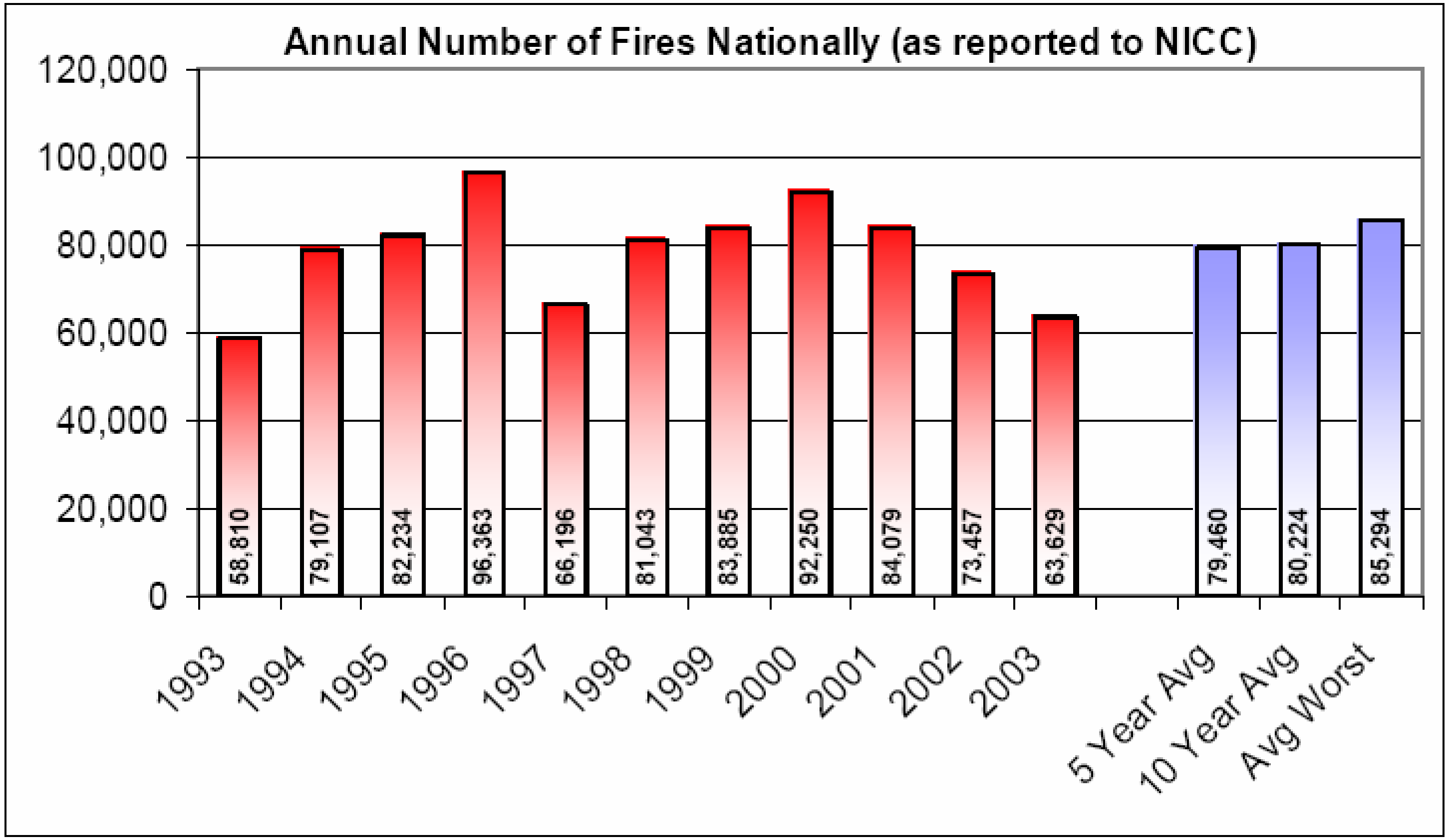
Quick analysis of the past ten years of data and averaging the data from extremely active years, an average worst was developed. Using data from the years 1994, 1996, 2000 and 2002 the National Interagency Coordination Center could expect as an average:

- 85,000 - Fires to be reported.
- 6,177,000 - Acres burned.



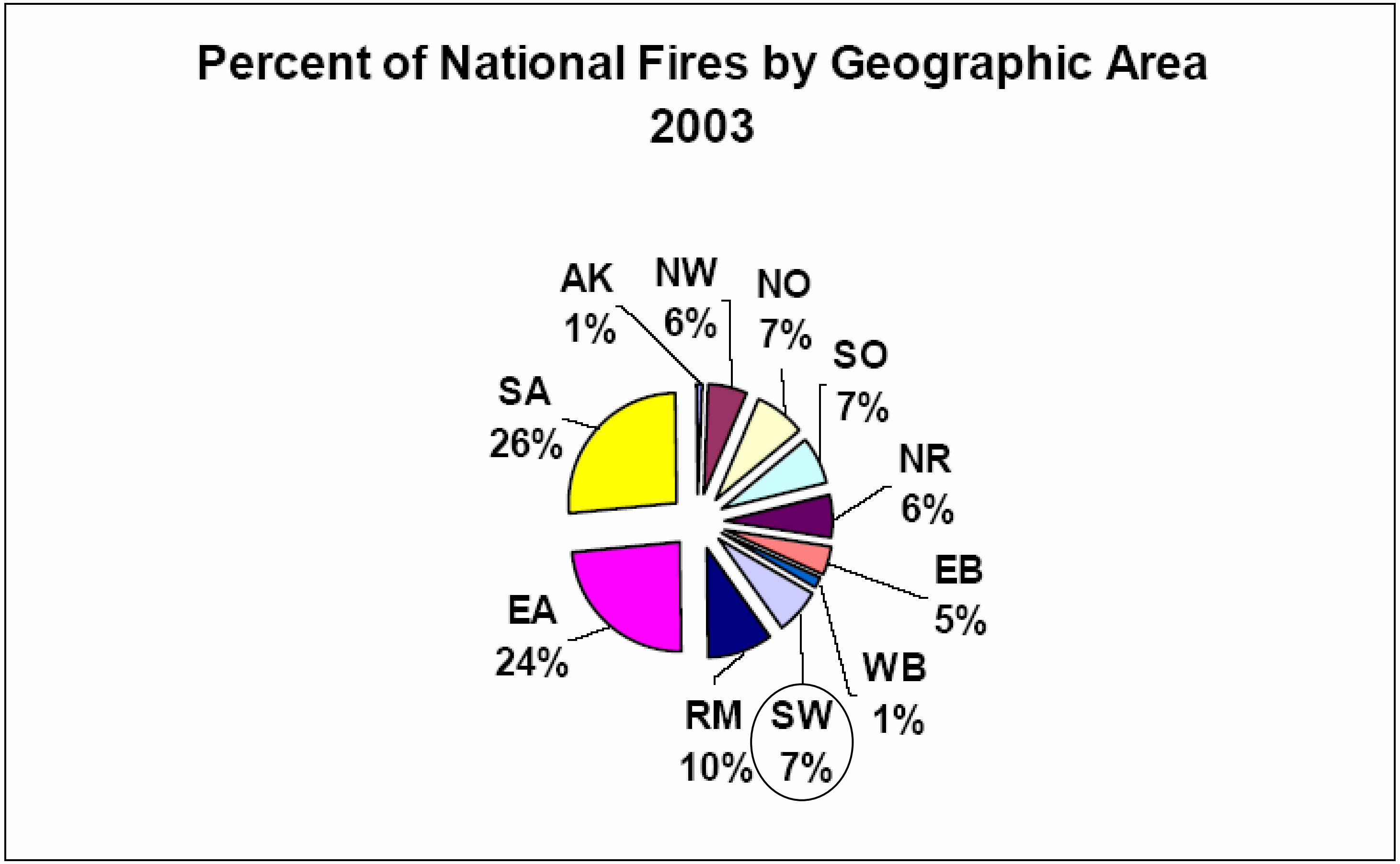
http://www.nifc.gov/news/2003_statssumm/intro_summary.pdf

Wildland Fires – Number of Fires



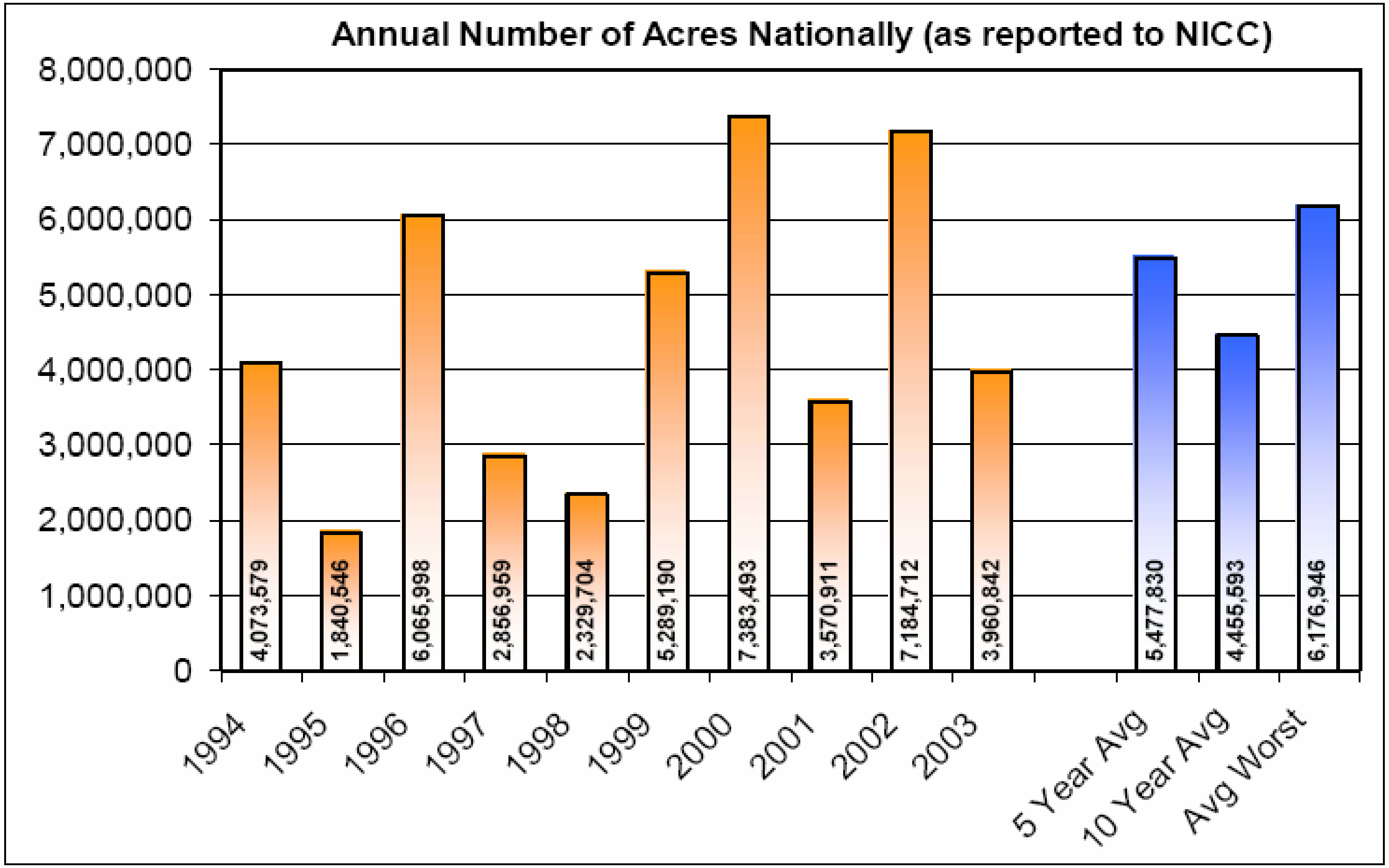
Average worst determined by averaging data from 1994, 1996, 2000 and 2001

http://www.nifc.gov/news/2003_statssumm/incident_support.pdf



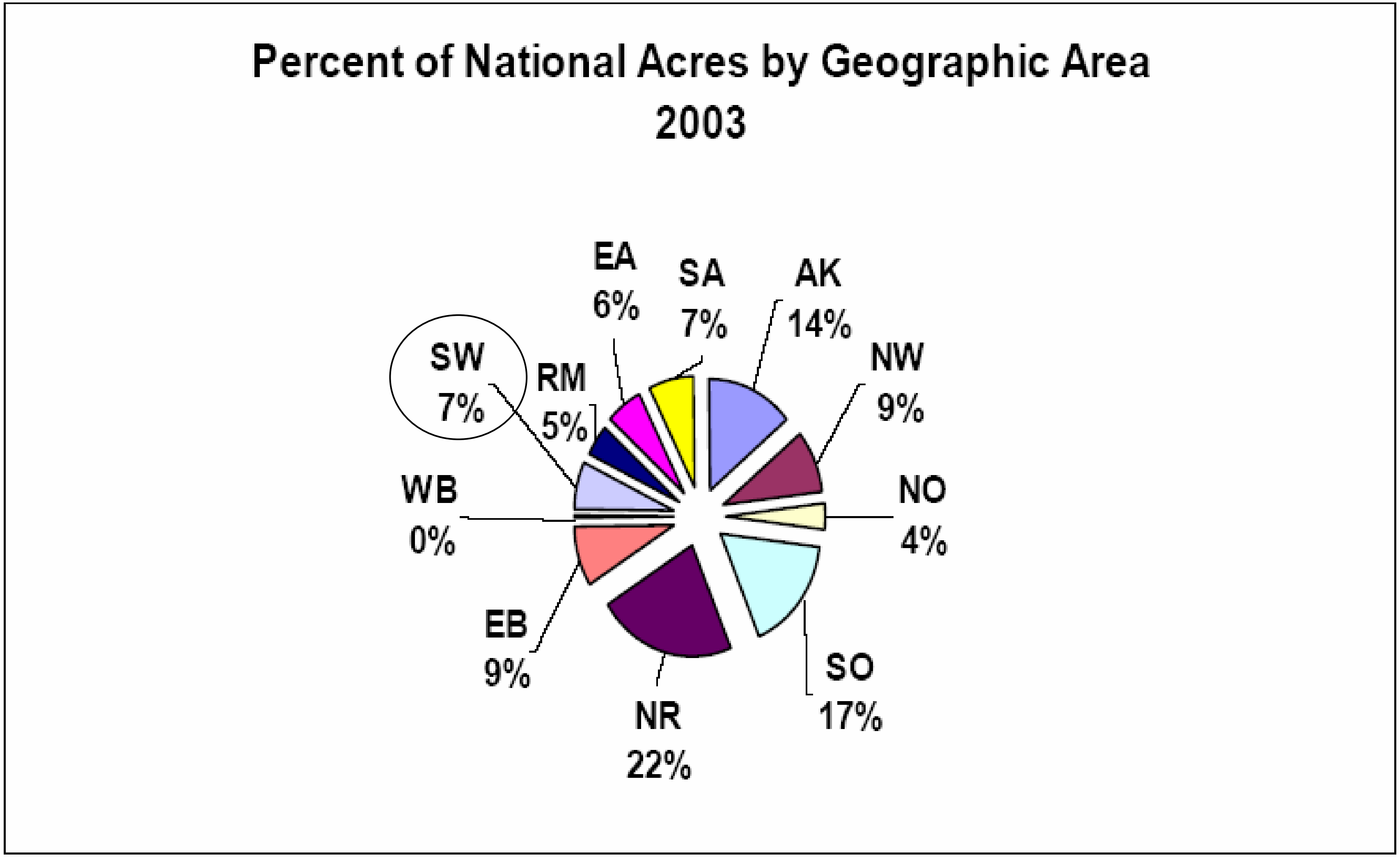
http://www.nifc.gov/news/2003_statssumm/incident_support.pdf

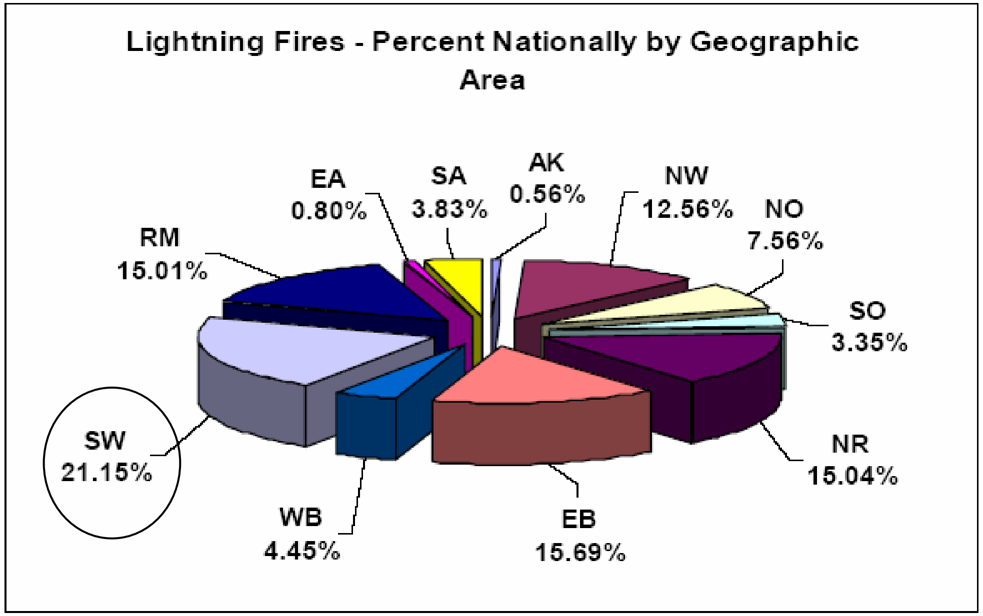
Wildland Fires - Acres

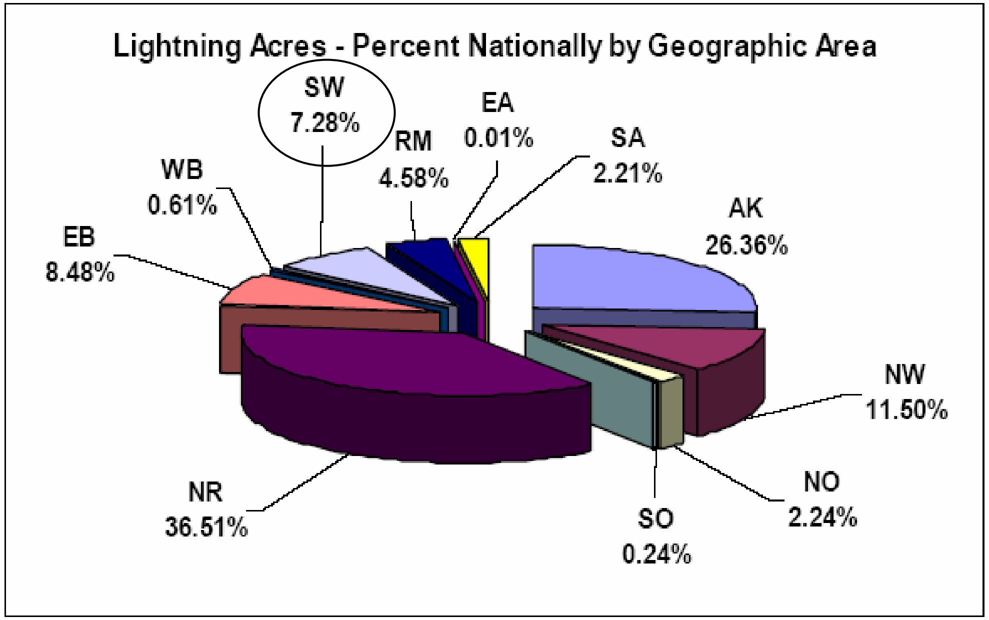


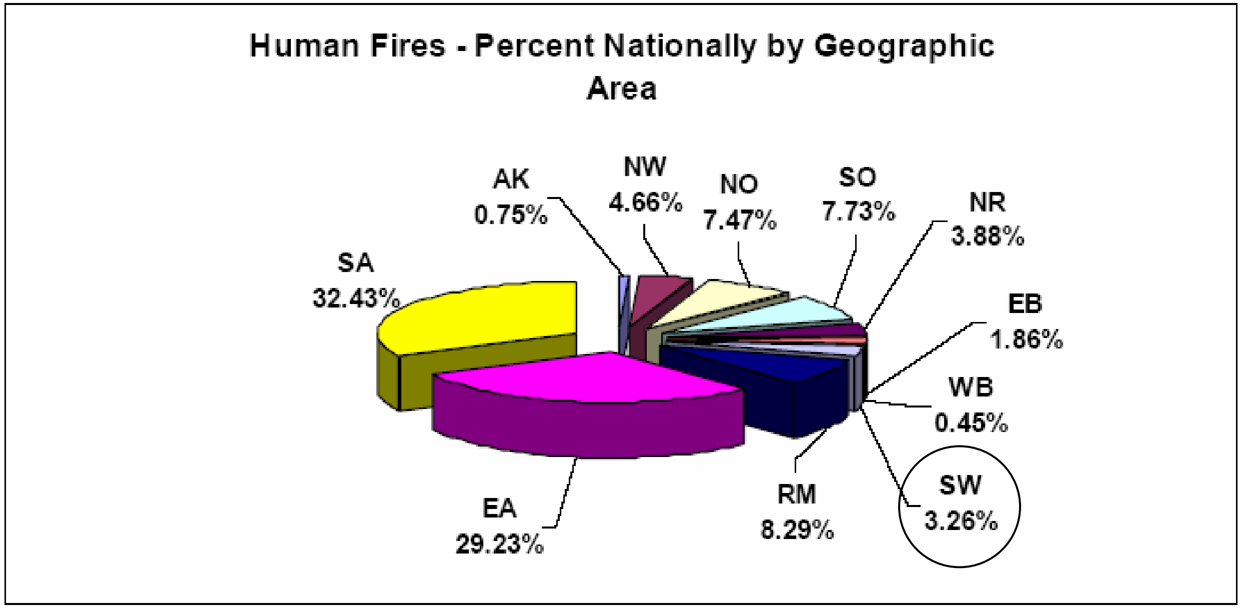
Average worst determined by averaging data from 1994, 1996, 2000 and 2001

http://www.nifc.gov/news/2003_statssumm/incident_support.pdf

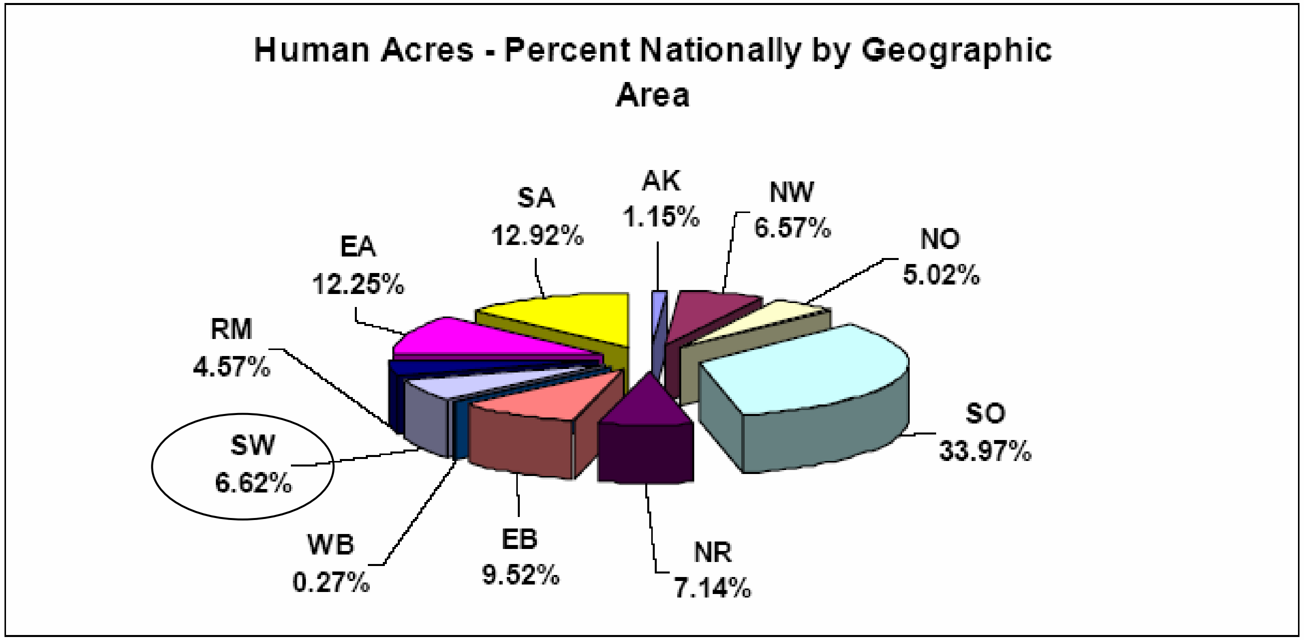

Percent of National Acres by Geographic Area
2003
EA
6%
SA
7%
AK
14%
SW
7%
RM
5%
NW
9%
WB
0%
NO
4%
EB
9%
SO
17%
NR
22%


Lightning Fires - Percent Nationally by Geographic Area
EA 0.80%
SA 3.83%
AK 0.56%
NW 12.56%
NO 7.56%
RM 15.01%
SO 3.35%
SW 21.15%
NR 15.04%
WB 4.45%
EB 15.69%

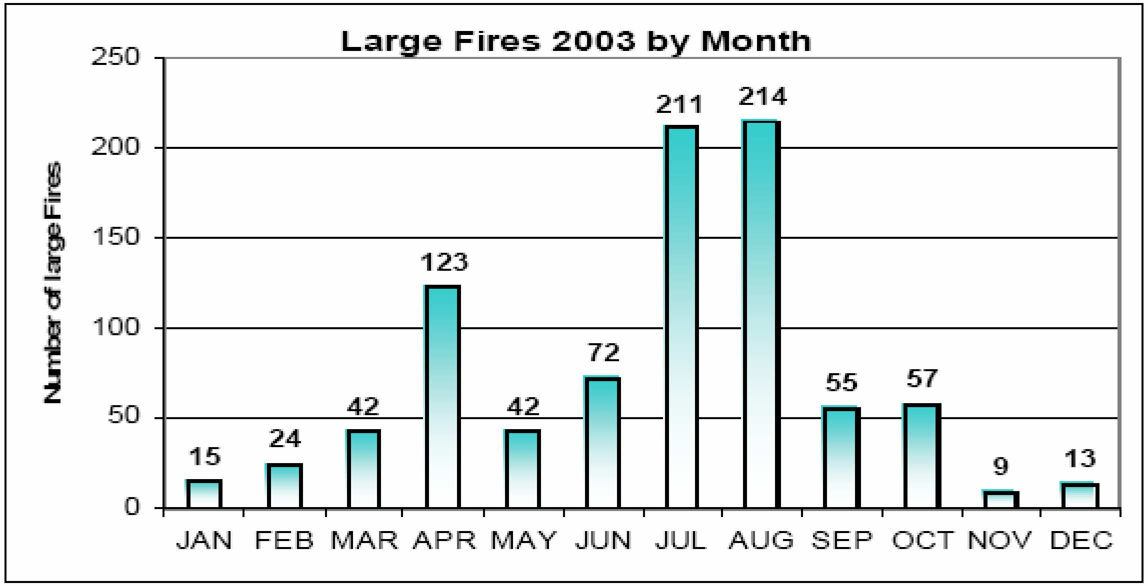

Lightning Acres - Percent Nationally by Geographic Area
SW 7.28%
EA 0.01%
RM 4.58%
SA 2.21%
WB 0.61%
AK 26.36%
EB 8.48%
NW 11.50%
NR 36.51%
NO 2.24%
SO 0.24%



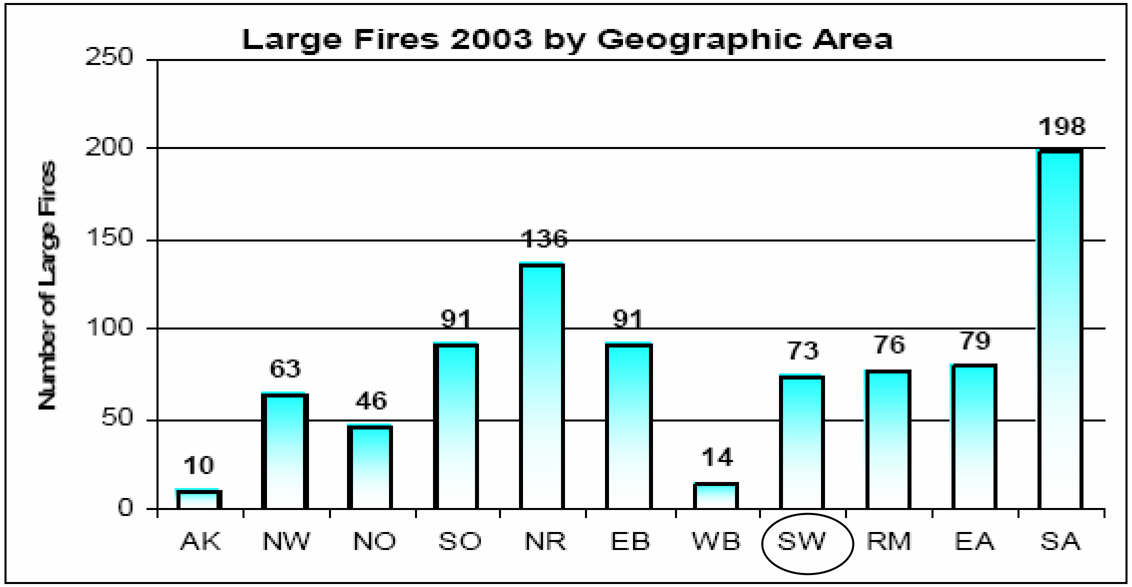
Human Fires - Percent Nationally by Geographic Area
AK 0.75%
NW 4.66%
NO 7.47%
SO 7.73%
NR 3.88%
EB 1.86%
WB 0.45%
SW 3.26%
RM 8.29%
EA 29.23%
SA 32.43%



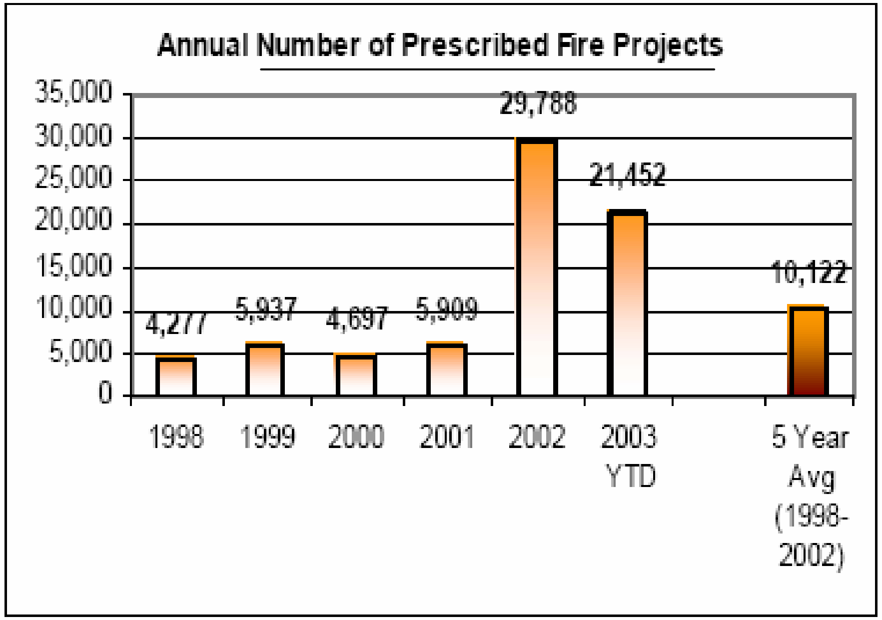
Human Acres - Percent Nationally by Geographic Area
SA 12.92%
AK 1.15%
NW 6.57%
NO 5.02%
SO 33.97%
NR 7.14%
EB 9.52%
WB 0.27%
SW 6.62%
RM 4.57%
EA 12.25%

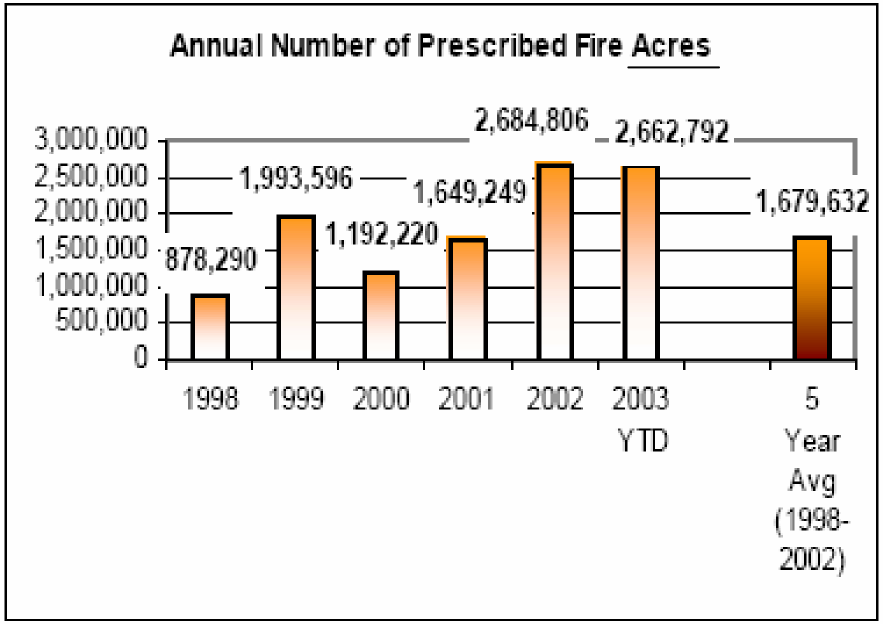


Large Fires 2003 by Month
Number of large Fires
250
200
150
100
50
0
15
24
42
123
42
72
211
214
55
57
9
13
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

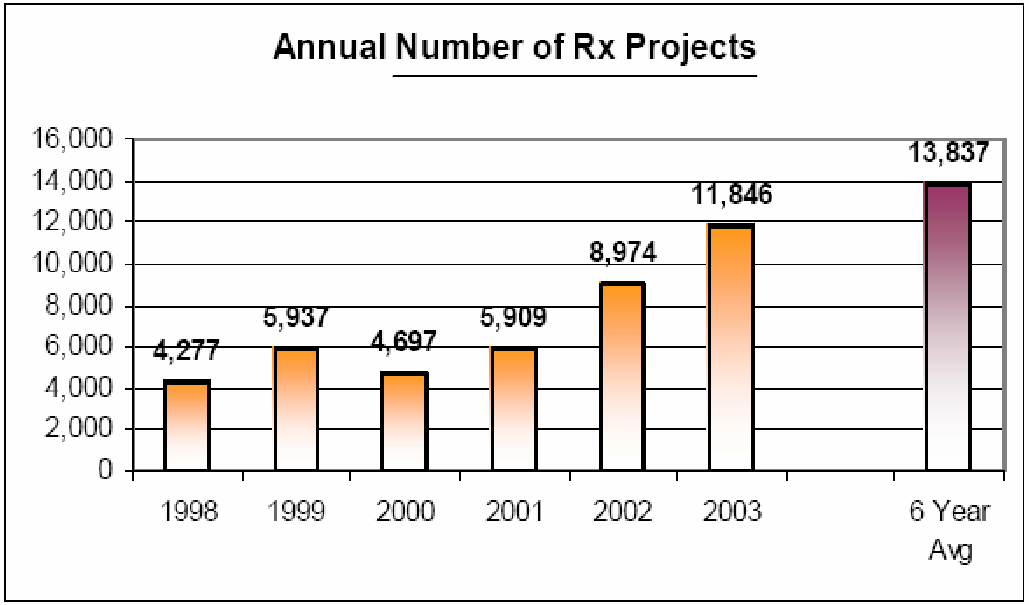


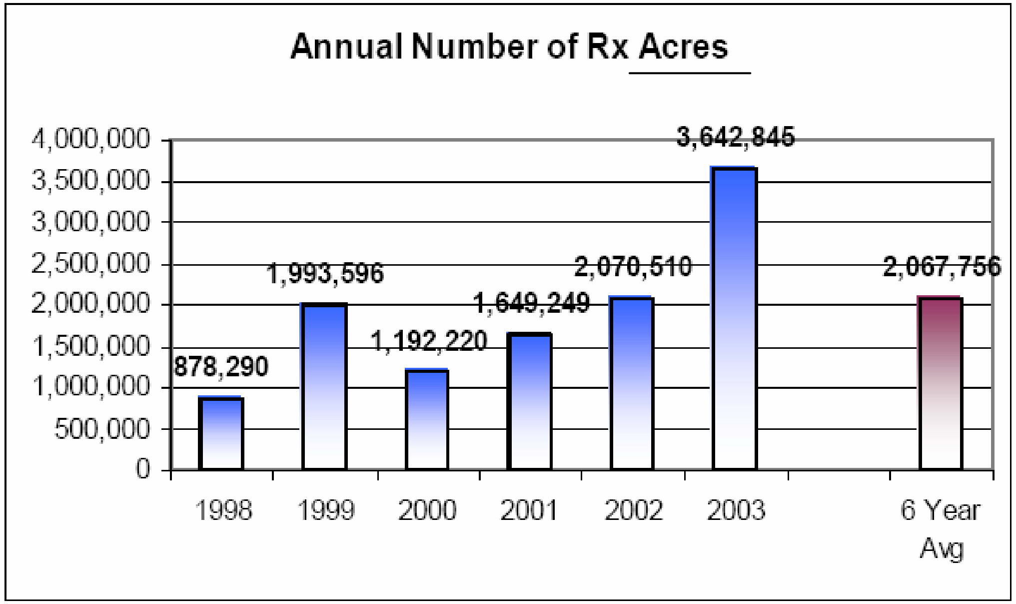
Large Fires 2003 by Geographic Area
Number of Large Fires
250
200
150
100
50
0
10
63
46
91
136
91
14
73
76
79
198
AK
NW
NO
SO
NR
EB
WB
SW
RM
EA
SA





http://www.nifc.gov/news/2003_statssumm/intro_summary.pdf


Annual Number of Rx Projects
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
4,277
5,937
4,697
5,909
8,974
11,846
13,837
1998
1999
2000
2001
2002
2003
6 Year Avg


Annual Number of Rx Acres
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
878,290
1,993,596
1,192,220
1,649,249
2,070,510
3,642,845
2,067,756
1998
1999
2000
2001
2002
2003
6 Year Avg

National reporting of Wildland Fire Use fires and acres began in 1998.