Main themes:

- Fire is a natural and essential ecosystem process in many forest systems
- Vegetation and climate largely govern fire regimes
- Human land uses have altered fire regimes in the region, with cascading effects
How do we understand fire as an ecosystem process?

• Observe contemporary events (fire behavior and fire effects)
• Reconstruct historical ecosystem dynamics (fire and climate history)
• Model fire-climate-vegetation interactions (ecological modeling)

What we observe: large, high-intensity fires
Hi Meadow, CO
4,422 ha

Viveash, NM
11,017 ha

Bobcat Gulch, CO
3,059 ha

Area Burned on National Forests in
Pacific Northwest (Regions 1 & 6) & American Southwest (Region 3)
1945 to 1990

Region 1 Northern Rockies
Region 6 Washington & Oregon
Region 3 Arizona & New Mexico

Year
0 10000 20000 30000 40000 50000 60000 70000 80000

Low/Unburned
High burn

Courtesy N. Kotliar, USGS
Central question: Are these large and impressive fires within or outside the range of natural variation?

Forest and fire history provide insight into such questions.

Lightning strike frequency in Saguaro National Park, Rincon Mountains, Arizona

Lightning Density From 1989 to 1999

~3 strikes /km²/year

Courtesy of Calvin Farris
Some salient attributes of the tree-ring record

- Wide spatial distribution (> 130° global latitudinal range)
- Record wide array of ecological variables
- Long temporal extent (≥10⁴ yr) and preservation
- High temporal resolution (10⁻¹ yr) and accuracy (exact, if crossdated)
- Direct, affirmative evidence of ecological events
“Sky Island” Mountain Ranges with Fire Scar Fire Histories:

- Santa Catalina
- Rincon
- Santa Rita
- Huachuca
- Pinaleños
- Chiricahua
- Sierra de los Ajos
- Animas
- Mogollon
- White

Southwestern US Fire-Scar Network
Extensive Fire-Scar Networks in the western U.S


3. West Slope Sierra Nevada, 4 elevational transects, 49 sites, 446 trees, Swetnam & Baisan, In Press.


90 fire scarred trees sampled in 2 stands
Composite fire record for Monument Canyon RNA, Jemez Mountains, New Mexico

Fire scar chronology from pine/mixed conifer on Mount Graham
Fire-scar chronology from Gila Wilderness, in Southwestern New Mexico.

Swetnam and Baisan 2003

Fire-Scar Chronology from Rustler Park, Chiricahua Mountains, AZ

Large aspen stands in the Southern Rockies are typically a “footprint” of past crown fires. Margolis, Swetnam & Allen, in prep.
Synchronous crown fire years in northern NM and southern CO are coincident with regional surface fire years in the Southwest.

Margolis et al., in prep.
The role of climate as a governing factor for fire regimes:

- Decadal climate governs the distribution of vegetation
- Inter-annual climate variation regulates biomass (fuel) production
- Intra-annual (seasonal) climate variation generates “fire weather” that regulates fuel moisture, provides most ignitions, and triggers extreme events

The Southwestern US network of fire scar sites shows a high degree of regional fire synchrony— the largest and smallest fire years are well correlated with dry and wet years, respectively.
Synchronous stand replacing fire years correspond with major drought years.

Margolis et al., in prep.
Drought, fire...what about insect outbreaks?

Western spruce budworm extends from British Columbia to the Southwest. Outbreaks encompassing millions of hectares have occurred several times in the 20th century, far exceeding area burned in major fires. Current outbreak in BC > 10 million ha.
The mid-1990s to present drought follows the extraordinary decadal wet period of the mid-1970s to early 1990s.

Turn-of-the-century drought

![Diagram of precipitation data for Arizona Climate Division 7](image)

1910-20s wet period  1930s to 1960s droughts  1970s-1990s wet period  Current drought

Insect infestations have killed many of the trees surrounding MBO over the last two years.

Courtesy of Kurt Kipfmueller, Univ. Arizona Laboratory of Tree-Ring Research. From Ni et al., 2002
Multiproxy temperature reconstructions (from tree rings, ice cores, etc.) and simulations global circulation models agree that Northern Hemisphere temperatures in recent decades are at the highest levels in at least 1,000 years.

**WESTERN USA DROUGHT TREND: 1900 - 2003**

\[ y = -329.72 + 0.185x \]

\[ R = 0.232^* \quad p<0.05 \quad 2\text{-tailed} \]

Cook et al. 2004
Observed change in surface temperature for the Southwest US (black line) compared to a global climate model simulation of SW US temperature driven by increasing GHG.

Multi-model projection of winter temperature and precipitation changes for the Southwest United States. Curves show the temporal evolution as departure from the 1971–2003 averages.
Dense overgrown forests are a common element in severe fires and insect outbreaks.

Land use: People, forests, and fire on a collision course.
Private Inholdings on the Payson District, Tonto NF

Graphic courtesy Tonto NF

- 75 locations within District subdivided into more than 3,000 parcels
- Occupy only 4.7% of acreage but influence management decisions across entire District
How can we make our forests more resilient to the effects of climate change?

We know:

- Fire was ubiquitous in grasslands, woodlands and forests of western North America before *ca.* 1900, and drastically reduced in frequency and extent thereafter.
- Fires were ignited by both lightning and people before and after 1900. The initial disruption of frequent, widespread fire was caused by the introduction of large numbers of livestock.
- Increasing forest density and connectivity sets up large high-severity events.
- Fire suppression feeds the cycle of large fires.
- Inter-annual and decadal climate variability influence fire occurrence now as in the past.
We need to know more about:

- Fire frequency estimates from more locations and how they varied in space and time.
- The role of Native Americans in altering/influencing pre-1900 fire regimes.
- Effects on fire behavior of the combination of forest structure changes and climate.
- The effect of greenhouse gas-caused warming on Southwestern climate and wildfire occurrence, including changes in seasonality.
- Effects of changing land use in the West, and social acceptance of fire as a landscape presence.