Fire and monsoon 8/27/14 meeting notes, research ideas, and task list

Meeting attendees: C.Woodhouse, K. Miller, T.W. Swetnam, D. Falk, E. Margolis

Tasks:

1. Write up a document (research prospectus or outline) defining the research goals, research questions and the tasks necessary to achieve these goals. This should be reviewed internally by at least Tom and Connie and then passed on to Russ. This is the first step toward that document.

2. Review the funded Macrosystems proposal (webpage) – monsoon, vegetation focus on lower elevation vegetation types (grasslands?) Fire component was general.

**3. Literature review** of instrumental period summer (monsoon and pre-monsoon) fire-climate relationships (e.g., (Crimmins and Comrie, 2004; Crimmins, 2006, 2011). A primary topic to address in the review is when and where is summer precipitation, including prior years, important for fire occurrence in the Southwest? This should be used to drive hypotheses about historical fire-climate relationships, with some caveats including: (1) changed fuel structure in current ecosystems due to over a century of anthropogenic fire exclusion and (2) invasive species (grasses).

**4. Literature review** of fire scar seasonality. Original data came from (Baisan and Swetnam, 1990), but other data exists from contemporary fires (e.g., (Farris et al., 2010)maybe (Stephens et al., 2010) or recent W.L. Baker papers.

**5. Fire scar data**: acquire the regional fire scar data set used for the preliminary analysis from E.Bigio.. Add newly collected fire history: (1) Margolis Jemez mixed conifer sites, (2) Margolis Rowe Mesa sites, (3) Guiterman and Margolis Jemez shrub fire history sites, (4) Swetnam and Farrela Jemez fire history, (5) Arizpe & Falk AZ/Mexico border sites, (6) others??? Identify sites without fire seasonality data, which could be completed and added to the network. We’ll ultimately need to decide if we composite the data at some scale (plot or study area). One reason to do this is to “normalize” the different number of trees sampled between areas or sites. Then we discussed whether the collectors curves (and tools developed for FHAES – D.Falk) could be used to test (and correct) for differences in sample size between areas.

6. **Climate reconstructions:** map the existing earlywood (cool season) and latewood (monsoon) precipitation reconstruction regions in the SW and indicate the strength of the reconstructions. This would be useful to help select the region(s) with the best summer precipitation reconstructions and extensive fire history data.

6. Explore the **potential for pre-monsoon reconstructions** (May June). Run seascorr analyses to identify chronologies with sensitivity to april, may and/or june precip (and temp).

Extra (semi-)related tasks that could be justified and presented to Russ as part of the project:

1. Dating seasonality of fire scars in our existing collections that don’t already have these data – (e.g., Guadalupe Mtn collection on loan from NPS - A. Taylor’s project; Rincon Mtns C.Farris gridded network; Margolis M.S. samples?).
2. Timing and variability of tree phenology questions – (as they relate to fire scar seasonality dating and other questions) – this one is BIG, but important. Malcolm will have the equipment for processing micro cores soon. Kiyomi is collecting on Mt. Bigelow now. D. Griffin has existing collections from the Catalinas that are not (processed?) or analyzed.
3. Herbaceous (grass) growth and biomass data from repeatedly measured, long term sampled plots to assess the prior year lag questions (see below for details)
4. Test whether ENSO oscillatory behavior is possibly driving significant prior year wet lags in SEA fire-climate analyses that are not related to antecedent fuel production (see below for details)

**Research ideas (and thoughts):**

Elevation (vegetation type) gradient: from high elevation spruce or mesic mixed conifer aspen sites down to the grassland ecotone forests (pj or pine-oak). There is the potential for variability in the monsoon (and pre-monsoon) fire-climate response among vegetation types along the gradient. **H1**: lowest elevation, less productive (fuel limited), relatively warm and dry sites might benefit from above average prior summer moisture to produce greater herbaceous material (fuel) to increase the probability of spreading fire. **H2**: highest elevation, productive (non-fuel limited), relatively cool and wet sites likely would not respond (directly) to prior wet summer moisture in terms of fire, but could potentially be inhibited to burn, even during very dry years, following multiple seasons of above average precipitation (including prior summers and winters). Multiple elevation and vegetation gradient “transects” could be composited or analyzed in parallel to address these hypotheses. Potential areas with existing fire history encompassing these gradients include: (1) Santa Fe watershed, NM (potentially including nearby Rowe Mesa at the lowest elevations), (2) Jemez Mountains, NM, (3) Santa Catalinas, (4) Pinalenos?, (5) Gila?

Fuel-related mechanisms explaining lagged climate relationships with fire occurrence:

a. TWS - **2 year prior wet lag** evident in many SEA analyses could be a function of pine needle retention (and subsequent dropping of the needles during dry years that ultimately provide sufficient fuel loads or fuel continuity).

b. **Role of pine litter versus grass** or herbaceous material fueling fire spread – we could test for spatial variability in seasonal response of grasses to climate (e.g., summer vs winter annuals) that could drive patterns in wet lags in the fire scar record. Mapping the variability in cool vs summer grasses and dominance of grass vs needle litter within the SW could help detect spatial variability in fire-climate relationships. It’s important to note that there has been a reduction in grass cover in many contemporary forest types due to shading and lack of fire, so contemporary conditions don’t necessarily reflect historical conditions.

Side paper to put to rest some long-standing questions regarding prior lagging relationships in fire-climate analyses: (1) Using long-term records of grass (and needle litter) production, test the hypothesis of climate driven variability in surface fuel production as an important variable for fire spread, which we see as antecedent wet (cool season moisture) lags in SEA analysis. Ft. Valley or other experimental forests or research stations could have these records (2) Is the prior year wet lag commonly observed in tree-ring fire climate relationships in the SW just a function of ENSO oscillatory behavior that is embedded in the SW climate data (i.e., do wet years consistently precede dry years)? This should be easily testable with a simulation that includes many random draws of *n* dry years (i.e., a surrogate for fire years, since fires consistently occur on dry years) and then quantify the antecedent conditions associated with these random dry (fire) years. This could be done using SEA. There are some substantial arguments against the wet lags just being a function of climate variability (e.g., ENSO oscillations) including: (1) wet lags are present mostly in pipo and other drier forest types and NOT generally present in wet, less fuel limited, MC forests, (2) fine fuels drive most surface fire spread and therefore variability in fine fuel sources should affect fire occurrence. Some arguments supporting a spurious (climate related) cause of significant wet lags preceding fire years include: (1) significant lags that sometimes occur AFTER a fire (i.e. positive lags; fires predict wet climate!!!), (2) significantly wet conditions (lags) that are 2 or 3 years prior to the fire year, but not 1 year prior.

**Additional thoughts and research questions:**

Special case of back-to-back fire years (Falk): There are certain years in the fire-scar record (e.g., 1715 and 1716 – Santa Fe Watershed, #### and ####, Valles Caldera) and the instrumental record (e.g., 2002 and 2003 Santa Catalinas) where fires burn in consecutive years in one study area. The fires rarely re-burn the same exact area, but burn adjacent areas. **Research question:**  Is there a unique climate signal for consecutive fire years, which could include antecedent summer (and winter) precipitation? The Ho would be that back to back fire years occur during consecutive years with dry winters.

Alex Arizpe’s (and Don’s) **Northern Mexico fire history data** could show a stronger monsoon relationship because of the increasing important of monsoon moisture in Mexico. Alex had some fires that occurred during years with wet reconstructed winter precipitation (i.e., opposite of the general pattern). Preliminary investigations into to the summer precipitation (from the Griffin et al. reconstructions) during these years seemed to suggest they had low summer precip.

Accounting for the effects of the pre-monsoon (MJ) period, since it has an effect on instrumental fire occurrence. D. Falk brought up VPD – could we develop a new reconstruction of AMJ VPD, temp or precip? Some trees (e.g., San Juan bristlecone) have a June temp signal. Sangres P. aristata (Round Mtn) might have a similar signal and would be located geographically closer to the study area of interest. C.Baisan indicated that some Sandias white pine (or psme?) were very sensitive to pre-monsoon moisture. Maybe a subset of these trees could be used for a reconstruction that would be beneficial for better explaining variability in SW fire-climate relationships.

Analytical notes: thinking of the monsoon fire-climate relationships as residuals, because a high proportion of the variability in historical fire occurrence in the SW is explained by cool season moisture (O – A) prior to the fire season (MJJ). A regression approach may be appropriate, although the relationships with summer moisture may not be linear. On years when winter moisture doesn’t explain the fire occurrence, or absence, then maybe the monsoon played a role (e.g., monsoon shutdown, delayed monsoon, total monsoon failure). Could regression be used to model inter-annual variability in fire occurrence as a function of current and lagged cool season precipitation, summer season precipitation, and pre-monsoon season precipitation (MJ)? The predictand could be number or proportion of sites (or trees) recording fire from the SW network (+ mexican sites) in a given year. Geography would be important so that the precipitation reconstructions were paired spatially with the fire history reconstructions.

Upper elevation (high severity) fire: **Research question**: Is fire in upper elevation, wet, cool mixed conifer, aspen and spruce forests associated with consecutive dry summer and winter seasons, or inhibited by consecutive antecedent wet (or even average) summer and winter conditions? For example, 1748 was the most widespread fire year in the SW in the ponderosa pine zone, but doesn’t seem to have been a particularly widespread fire in the upper elevation wetter forests. 1748 was preceded by multiple wet winters (what about the preceding summers), which potentially built up fuel in the more fuel-limited drier forests, but this antecedent moisture could have inhibited the fires from spreading to the upper elevation forests.

Preliminary analyses using fire scar seasonality by C.Woodhouse, E.Bigio, D.Griffin, H.Falstich, T.W. Swetnam:

Data:

a. 3 sets of fire scar data for multiple sampling sites combined (Holly and Erica):

* SE AZ (Arizona: Pinalenos, Huachucas, Rincons, Catalinas, Santa Ritas)
* Two areas in NM:
  + Jemez/Bandelier
  + Sandias
* Percent of recording trees scarred, averaged across the sites within the two regions, for D, E, M, L, A, (no Us). Percentages calculated with zeros
* 1650-1900

b. 2 pairs of seasonal climate reconstructions:

* NAM2 region in AZ (standard precipitation index)
* Rio Grande box from Cochiti Dan to Elephant Butte dam (CEB), total precip
* Cool season (Oct-April) and monsoon (JJA)
* 1650-1900

Research questions:

1. How closely linked is seasonal climate to fire occurrence in these two regions?
2. How widespread are the largest fires (across the three regions)?
3. What are the corresponding cool season, and prior monsoon and cool season anomalies that accompany these big fire years?
4. Are there any patterns in DEM fires and seasonal precipitation that correspond to these relatively rare summer (L and/or A) events?
5. Is there any association between wet prior monsoon and the DEM fire season?

References

Baisan, C.H., Swetnam, T.W., 1990. Fire history on a desert mountain range: Rincon Mountain Wilderness, Arizona, U.S.A. Canadian Journal of Forest Research 20, 1559-1569.

Crimmins, M.A., 2006. Synoptic climatology of extreme fire-weather conditions across the southwest United States. International Journal of Climatology 26, 1001-1016.

Crimmins, M.A., Comrie, A.C., 2004. Interactions between antecedent climate and wildfire variability across south-eastern Arizona. International Journal of Wildland Fire 13, 455-466.

Farris, C.A., Baisan, C.H., Falk, D.A., Yool, S.R., Swetnam, T.W., 2010. Spatial and temporal corroboration of a fire-scar-based fire history in a frequently burned ponderosa pine forest. Ecological Applications 20, 1598-1614.

Stephens, S.L., Fry, D.L., Collins, B.M., Skinner, C.N., Franco-Vizcaino, E., Freed, T.J., 2010. Fire-scar formation in Jeffrey pine-mixed conifer forests in the Sierra San Pedro Martir, Mexico. Canadian Journal of Forest Research-Revue Canadienne de Recherche Forestiere 40, 1497-1505.