Research Problem:

From the time of colonization and subsequent to the onset of the U.S. land use policy (circa the 1880’s) fire suppression, grazing and large scale logging operations have transformed forested landscapes across geographic frontiers (Fulé et al. 2012). In southwestern forest, both macro and micro-studies have been conducted utilizing dendrochronological methods to reconstruct fire regimes across extended temporal scales (Swetnam, Allen, and Betancourt 1999; Swetnam & Baisan 2003; Fulé et al. 2012; Larson et al. 2013). These reconstructions have demonstrated a deviation from pre-settlement fire return intervals, an increase in cataclysmic fire events and a departure from analog vegetative communities (Savage & Joy, 2005; Peros, Gajewski, and Viau 2008). In Southwestern sky-island forests, classified as Mandrean-oak woodlands (Pearson 1931; Brown 1982) vegetative forest communities that co-evolved with cyclical fire regimes have been shifted by infrequent, more extreme and widespread fire disturbance events (Swetnam & Baisan 1996; Swetnam, Allen, and Betancourt 1999; Fulé et al. 2012; Larson et al. 2013). Within the Chiricahua Mountains and Chiricahua National Monument, landscape scale fire events such as the Horseshoe II fire, characterize the common fire pattern emergent in the southwestern forests (USDA Forest Service 2011; Fulé et al. 2012). Occurring in June of 2011, the Horseshoe II fire burned more than 225 thousand acres, several homes, and took the lives of several fire fighters (USDA Forest Service 2011; Arizona Daily Star 2011 (citation needed)).
Land-use policy, climate and vegetative modifications are all complexly interrelated as drivers of fire across landscapes. In the case of the Horseshoe II fire, opportunities exist to connect and quantify spatial and temporal fire patterns at a larger landscape scale. Similarly, vegetation inventory methods can be utilized to construct a chronosequence of vegetative conditions and will likely reveal both changes in analog communities, future forest trajectories, and alternative stable states (Biesner, Haydon, and Cuddington 2003; Fulé et al. 2012). The objective research aims to describe the temporal spatial interactions under current fire regimes and guide forest management and restoration activities following catastrophic fire disturbance. Combined with vegetative comparisons, the research purposes to produce resiliency benchmarks, ground truth severity and correlate vegetative outcomes post fire occurrence.

Similar investigations have been conducted across larger temporospatial scales (Baker 2013). The accumulative research has recognized a shift in both spatial occurrence and forest composition (Barton 1991, 1993a, 1993b, 1995, 2002; Swetnam & Baisan 1996; Savage & Joy 2005; Fulé et al. 2012). Much of the research will attempt to supplement and compare findings over larger spatial and landscape scale events. The correlation between fire severity, forest trajectories and shifting stable states is emphasized as the main investigative component. This study hopes to test the conclusions of Barton, 1999-2005, and to draw further correlations from temporal and spatial patterns and severity as components of species distribution and diversity following ecophysiological disturbances (Barton 1991, 1993a, 1993b, 1995, 1999, 2005).

**Hypothesis:**

Although catastrophic in extent (Horseshoe II fire extent, Figure 1.), the occurrence of fires subsequent to 1953 fall within the historic fire return intervals illustrated by Fulé et al. 2012 in dendrochronological comparisons in Mexico (Fulé et al. 2012). Corollary, where extant fires
overlap, depending on return interval, micro-climatic conditions, severity, and vegetation type, equivalent communities prior to land-use change should be present. It is hypothesized then that depending on the number of fire events, spatial association and severity, communities can be presented as analog, non-analog or alternative stable states through a comparative chronosequence.

**Data Collection:**

Spatial and temporal data have been compiled from GIS three-dimensional data from the Monitoring Trends in Burn Severity (MTBS), Landfire program, and the Coronado National Forest, Benson Arizona (USDA, 2013). Overlays were conducted using ESRI ArcGIS 10.1 software package. Study sites were recognized according to a spatial intersection of fire incidence over the Horseshoe II boundary extent. Stratified random samples were extracted utilizing the Geospatial Modeling Environment (GME) developed by spatialecology© (Spatialecology 2013) at a 5% sampling intensity across the MTBS fire severity matrix (Figure 1.). Stratified random samples were further extracted, utilizing raster sample techniques (ArcGIS), to define burn severity and were compiled accordingly (Figure 1.) Universal Transverse Mercator, and decimal degree coordinates were queried to be used in locating plots during field inventory and are given in Table 1.

![UTM_Site_Points](image)

Table 1. Stratified Random Sample points with corresponding decimal degree and Universal Transverse Mercator (UTM) coordinates utilized in vegetation samples scheduled for summer 2014.
Vegetative inventory will commence in May 2014, with some preliminary data being compiled from Coal Pit Canyon, Turkey Creek, AZ in 2012, 2013. Methods utilized will parallel those of Barton, 1999 utilizing a transect sampling method. Initial site inventory of 300 sample points will be conducted across low, moderate, and severe burn severity types, where the Horseshoe II (2011), Rattlesnake (1994) and Horseshoe I (1996) fires. Several other inventory sites are available and have yet to be identified and spatially correlated to severity masks; however similar methodology would be utilized in establishing survey intensity in these areas.

**Data Analysis:**

Data analysis will be facilitated using the R statistical package with much of the script being compiled or personally authored (R Core Team 2013). Several measures will be produced to examine the changes in vegetative community; basic statistics, dissimilarity measures, and figurative outputs will be derived using RStudio statistical package (RStudio 2013).

This code and scripting project has several objectives. The authored script provides an appraisal of prior conditions and illustrates data accumulated from Barton (2002) as a baseline study of comparison. Figures 2-4 illustrate similar associated outputs utilizing the vegetative data from Barton (2002). A second component of the R analysis involves the comparison of transected vegetative data compiled from Coal Pit Canyon, Turkey Creek, AZ in 2012, 2013. Figure 5. shows the vegetative frequency in transects established in baseline investigations in Coal Pit Canyon. This script will provide an analytic platform to accommodate subsequent data resulting from field studies 2014. Although not completely derived, diversity and vegetative changes (intra and inter site comparisons) will be compared utilizing Jaccard’s similarity coefficient to quantify landscape scale changes in species composition (Jaccard 1901; Oksanen et
al. 2013). However, other methods may be explored as appropriate. Other successive yields of the R script will accommodate a survey design with integration of the Geospatial Modeling Environment (GME), further integration of shapefiles will be utilized in R along with the more common ArcGIS platform (ESRI 2011; Spatial Ecology 2013).

![Graphs showing species composition](image)

Figure 2. Species composition from prefire and postfire compositions prior to the Rattlesnake fire 1994, and Methodist Fire 1983, Chiricahua Mountains, Arizona. Species are designated by binomial species code. Notice the dominance of *Quercus hypoleucoides* (QUHY), silverleaf oak, in both pre and post disturbance. Extrapolated data from Barton (2002).
Figure 1. Fire severity for fire disturbance occurring in the Chiricahua Mountains, AZ 1994-2011. Inset map identifies stratified random samples to be utilized in vegetation sampling summer 2014.
Figure 3. Forest compositions prior and subsequent to the Rattlesnake fire 1994, and Methodist fire 1983, Chiricahua Mountains, AZ. Species are designated by binomial species code. *Quercus hypoleuroides* (QUHY), silverleaf oak continues to dominate (due to sprouting ability) other species decline accordingly. Correlation from severity is warranted. Data from Barton (2002).

Figure 4. A three dimensional view of Chiricahua Fires occurring between 1994 and 2012. Burn Severity (x), logAcres(y), and landcover type (z). Landcover types most affected are mixed forest (42) and evergreen forest (43) types. Synthesized data from MTBS shape files 2013.
Figure 5. Vegetative locations across transects for initial surveys conducted in 2012, 2013 Coal Pit Canyon, AZ.

Literature Cited


**Literature Cited: continued**


