Fire Analysis: FSim Methods

To simulate FSIM for the Rio Grande study area, we used the model inputs developed from the FPA project for three distinct geographic areas or Fire Planning Units (FPU) including the Northern, Central and Southern New Mexico FPUs. Geospatial land-cover inputs consisted of surface fuel characteristics (i.e. fire behavior fuel model), canopy fuel characteristics (canopy base height, canopy bull density), vegetation (canopy cover and height), and topography (slope, aspect, elevation) – which all originated from the Landfire Refresh project and were resampled from 30-m to a 270-m resolution. Historical wildfire occurrence data needed for model simulations consisted of fire records from the years 1992-2010 (Short 2014); these data in conjunction with weather records were used in the model to determine the probability of large fire starts on any given data.

Weather inputs required by FSim include hourly wind-speed during the burning period, daily precipitation amount and duration, maximum and minimum temperature, maximum and minimum relative humidity, and 1300-hour observations for relative humidity and temperature. With the exception of windspeed, these eight weather variables are integrated to calculate the Energy Release Component (ERC) for fuel model G (Cohen and Deeming 1985) - which is a metric that essentially reflects short and long term changes in fuel moisture content caused by precipitation and changes in temperature and humidity and can represent the influence of fuel moisture on fire behavior (Finney et al. 2011). More specifically, FSim uses ERC to determine, using logistic regression, the probability that a large fire will ignite on a given day, and then ERC and windspeed are both used to determine the behavior of those fires that do ignite (i.e. fire spread and size).

To model future weather, we obtained climate predictions developed using the Multivariate Adaptive Constructed Analogs (MACA) method (Abatzoglou and Brown 2011) which downscales model output from various global climate models (GCMs) of the Coupled Model Inter-Comparison Project 5 (CMIP5). Due to time constraints, we only simulated future conditions based on one GCM and chose the GFDL-ESM-2m because of its demonstrated success in historical climate simulation (Dunne et al. 2012, Sheffield et al. 2013). We also chose to model future conditions predicted by the CMIP5 8.5 Representative Concentration Pathway (RCP) – a scenario with the highest estimated temperature increases (4.0 to 6.1°C by 2100; Rogelj et al. 2012) but the one that appears increasingly most likely to occur (Peters et al. 2013). We modeled three projected time periods to capture potential climate conditions over the near-term (2020-2040), mid-century (2050-2070) and end-of-century (2080-2100).

Downscaled weather variables available for the RCP85 scenario from GFDL-ESM-2m GCM included daily minimum and maximum temperature, precipitation amount, and relative humidity; however data for wind-speed and precipitation duration were not readily available. To appropriately model weather in FSim, we needed to maintain the correlations among precipitation (both amount and duration), temperature and relative humidity. We decided to preserve these relationships by starting with recent weather observations (1992-2010) from RAWS weather stations for each FPU (Jemez for Northern New Mexico; Grants for Central New Mexico; Dripping Springs for Southern New Mexico) and calculated monthly differences.
between observed records and future predictions for each weather variable and then assumed these proportional changes on a daily basis to develop future weather data streams. To estimate future precipitation duration (currently unavailable from downscaled climate projections), we simply applied the same relative changes calculated from precipitation amount to determine the precipitation duration variable. For wind-speed, a variable also absent from downscaled projections, we could only use historic wind data and therefore model results assume that winds do not change in the future. We used the program Fire Family Plus 4.1 to calculate daily ERCs from these variable estimates for each FPU.

To obtain stable estimates of fire behavior across each landscape, fire ignition and growth was simulated by FSim for 10,000 potential annual weather scenarios (i.e. ‘years’) for each FPU. We ran simulations for this extended length because FSim needs sizeable samples of potential scenarios to estimate the probability for the rare events of large fires. That is, FSim was not projecting 10,000 years into the future but generating a large sample of possible fire seasons based on projected future climate conditions. We assumed that current levels of fire suppression would continue into the future, which for the FSIm model was determined in the FPA effort to be equivalent to a suppression factor of 2 for Northern New Mexico, 5 for Central New Mexico, and 3 for Southern Mexico. To simulate large fires, FSIm requires estimates of live fuel moisture values for the upper percentiles (80\textsuperscript{th}, 90\textsuperscript{th} and 97\textsuperscript{th}) of ERC, and we used the same values used in the FPA project based on estimates by Finney (et al. 2011). In addition, FSim uses spatial estimates of the distribution of ignitions based on fire size from the 1992-2010 period, and we used fire ignition layers from the FPA project which for the Northern and Central New Mexico FPUs, was based on ignition distributions for fires larger than 50 acres, and for Southern New Mexico, for fires larger than 300 acres.

References