7.5 ASSESSING LONG-TERM FIRE DANGER VARIABILITY AND CHANGE FROM CLIMATE MODEL OUTPUT

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1. INTRODUCTION

The condition of forests and rangeland are primarily a function of two factors – climate and land use management. Climate determines natural conditions of ecosystems, such as species composition and density. In a simple scenario wet periods encourage vegetation growth and development, and hence increases the fuel loading for fire, while dry periods stress vegetation via soil and fuel moisture deficits and increase the overall risk of fire. The relationship between fire and precipitation is closely linked and large spatial regions exhibit synchronized wet and dry patterns with fire occurrence under the influences of El Niño Southern Oscillation (ENSO) and drought (Swetnam and Betancourt 1998). Of course the affects of climate on ecosystems are more complex than simple precipitation relationships. For example, the impacts of disease and pests on tree mortality, CO_2 exchange, and atmosphere-land feedback processes are all closely related to climate (e.g., Ryan 2000).

Anthropogenic effects on landscape scales are also impacting ecosystems in significant ways. For example, it is now generally accepted that 100 years of wildfire suppression has substantially increased the risk of catastrophic fire in many areas. As the population of the West increases, numerous people are living in a rural and urban zone known as the wildland/urban interface. This lifestyle increases the demand for suppression and treatment practices to reduce the risk of fire. It is estimated that 25% of California residents reside in the interface. In addition to the risk of fire, land use also impacts characteristics of the ecosystem itself, such as the introduction of exotic species, vegetation density change and species composition changes.

The goal of this project is to assess changes and variability in fire danger over North America based on climate factors alone. It is assumed that no substantial change in vegetation type or density either naturally or by humans has occurred regionally during the past 50 years, or will occur during the next century. We make this assumption for three reasons, 1) the coarse 2.5 – 2.8 degree spatial resolution grids from the climate models represent huge ecosystem areas to begin with; 2) a single fuel model is used for the fire danger component; and 3) we wanted to begin with a simplified approach before incorporating more complex vegetation dynamical models (e.g., Neilson 1995). This may be considered a steady-state approach for understanding the first-order effects of climate change and variability on fire danger.

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2. ACCELERATED CLIMATE PREDICTION INITIATIVE

This project is an applications component of the Department of Energy (DOE) Office of Biological and Environmental Research (OBER) Accelerated Climate Prediction Initiative (ACPI). ACPI was established in response to a need for projections of climate variability and climate change to support U.S. participation in international assessments of climate change, as well as to understand the regional and national effects of global change (DOE 1998). The three main goals of ACPI are 1) to accelerate progress in climate simulation model development and application; 2) to substantially reduce the uncertainties in decade-to-century model-based projections of climate change; and 3) to increase the availability and usability of climate change projections to the broader climate change research and assessment communities. Details regarding ACPI may be found at http://www.csm.ornl.gov/ACPI.

3. FIRE DANGER

The National Fire Danger Rating System (NFDRS; Bradshaw et al. 1983) was established in the late-1970s to address the need of assessing fire danger at local to regional scales. Fire danger describes the state of vegetation conditions as related to weather and climate, and provides an indicator for the potential of fire activity. Temperature, relative humidity and precipitation are key elements for several fire danger indices, such as the energy release component (ERC) and the burning index (BI). The ERC indicates the potential available energy per square foot of flaming fire at the head of the fire expressed in units of BTUs per square foot. The BI is a value relating fire behavior to suppression effort using flame length at the head of the fire. This index is used by many fire management agencies to determine the staffing level – an index of suppression resources required on a daily basis that includes personnel and equipment such as fire engines and air tankers. The staffing level can then be subsequently tied to dollars, or the economics of fire business.

We use climate model output to acquire daily precipitation duration and surface maximum/minimum temperature and relative humidity. These data are used as input in fire danger computer code provided by the Fire Behavior Research Unit, USDA Forest Service, Fire Sciences Laboratory, Missoula, Montana, allowing us to calculate fire danger for past known climate conditions and future scenarios.

4. DATA

We are employing two datasets in this project. The first is the NCEP/NCAR reanalysis (Kalnay et al. 1996) for the period 1948-2000. This dataset provides directly daily surface maximum/minimum temperature and relative humidity. Precipitation duration is estimated based upon four times daily precipitation totals. For each output time that precipitation is reported, six hours of duration is assumed. The grid cell size from reanalysis is approximately 2.5 degrees spatial resolution. As part of the analysis, we are examining sensitivity of fire danger values to climate model output using reanalysis. Also, more recent years from the reanalysis dataset can be validated using in situ observations.

Future climate (e.g., 2002-2098) is obtained based on output from the Parallel Climate Model (PCM), which is the coupled NCAR Community Climate Model version 3, the Los Alamos National Laboratory Parallel Ocean Program, and a sea ice model from the Naval Postgraduate School. The PCM spatial resolution is approximately 2.8 degrees. Output includes four times daily temperature and specific humidity. Specific humidity is converted to relative humidity and 00 and 12 UTC are used as proxy maximum and minimum daily values, respectively. Several scenarios are being run for a number of PCM related projects, but of interest for fire danger analyses are “business-as-usual” (i.e., Dai et al. 2001) and climate change (e.g., doubled CO_2) runs. Details of the PCM can be found at http://www.cgd.ucar.edu/pcm.

5. PRELIMINARY RESULTS

The work is still very much in progress as of this writing, but here we briefly discuss some example output of fire danger using reanalysis data.

Figure 1 shows an example plot of the annual number of days with staffing level 5 for a region in north-central Nevada using the BI computed from reanalysis output for the period 1948-99. This staffing level represents the highest fire activity conditions – that is, the highest potential demand for suppression resources. For example, in 1999 the number of days with staffing level 5 is approximately 25, which historically is in the upper fourth of the distribution. This number corresponds well to the large number of fires and acres burned in Nevada during this particular year. However, since this index represents the potential of fire activity rather than actual fire activity, it will not always correlate with fire occurrence.

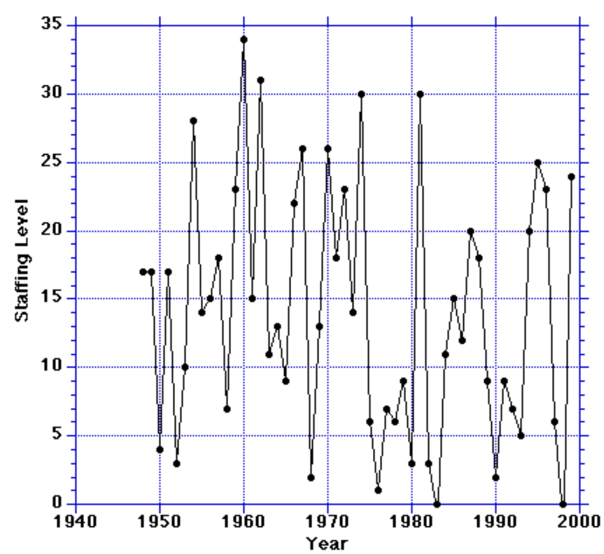

Figure 1. Annual number of days with BI staffing level of 5 for north-central Nevada.

Figure 2 is similar to Figure 1 except showing the annual number of days for staffing level 1, or the lowest amount of suppression resources required for the same Nevada region. Note that there is some negative correlation with staffing level 5. For example, this is readily seen in the two most recent years of 1998 and 1999.

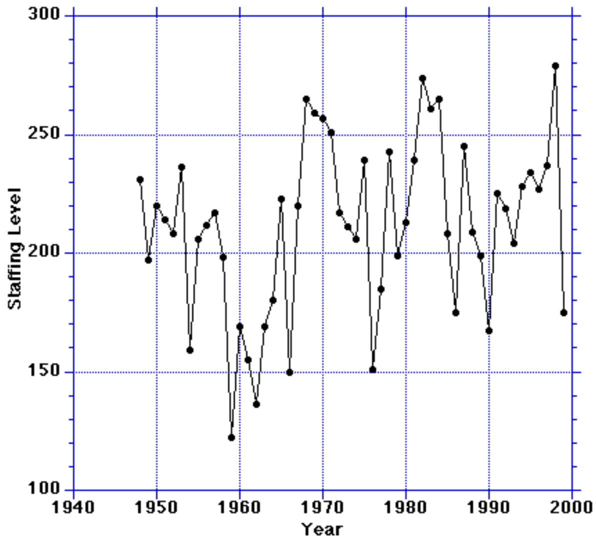

Figure 2. Same as Figure 1 except for BI staffing level 1.

These plots cannot be considered final until further sensitivity studies and validation is complete. However, they do at this time provide an indication that fire danger indices exhibit large interannual variability, which can be expected given historical regional annual temperature and precipitation observations. Some of the more fundamental questions to be answered by the end of this project are 1) does this interannual variability exhibit similar patterns across regions of North America; and 2) are trends present in future climate scenario runs such as "business-as-usual" and doubled CO_2? We believe that the final results of the project can benefit long-term policy for wildfire suppression and land use management, especially rehabilitation efforts. Additional work anticipated for this project will include an economic analysis based upon the staffing level and resource requirements for suppression activities.

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