Willow Fire, Caribou-Targhee NF, Idaho, 2008 (USDA Forest Service)

Detecting Large-Scale Spatial Hot Spots of Forest Fire Occurrence Using MODIS Satellite Data

Kevin M. Potter

Department of Forestry and Environmental Resources, North Carolina State University, Research Triangle Park, NC 27709; kevinpotter@fs.fed.us

Blackhall Fire, Wyoming, 2000 (USDA Forest Service)

Introduction

Wildland forest fire outside the historic range of frequency and intensity can result in extensive economic and ecological impacts. The detection of geographic clusters of fire occurrence can assist in both **1)** the identification of areas at greatest risk from such impacts and **2)** the selection of locations for more intensive analyses focusing on the causes and effects of wildland fire.

Data

❖ The Moderate Resolution Imaging Spectroradiometer (MODIS) Active Fire Detections database (USDA Forest Service 2009) collects data from two satellites at 1-km^2 resolution, with a pixel center point recorded when the satellites' MODIS sensors identify a fire on a given day (Figure 1).

❖ The MODIS sensors do not differentiate between a high-intensity 0.01-km^2 fire and a low intensity 1-km^2 fire.

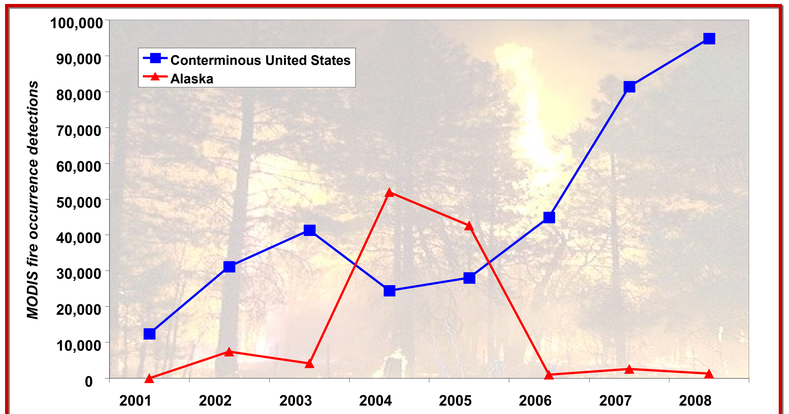

Figure 1: ***Forest fire occurrences detected by MODIS peaked in 2004 in Alaska, but have increased in the conterminous United States. Each occurrence is the presence of a fire for one day on a 1 km^2 pixel.***

Methods

❖ A forest cover layer screened out fires on non-forested land. A lattice of ~2,500 km^2 hexagons was superimposed over the conterminous 48 states, and the number of fires occurring per 100 km^2 of forest was calculated for each hexagon.

❖ Clusters of hexagons with higher fire occurrence values than expected by chance were identified using a Getis-Ord geographic hot spot analysis (for all fire occurrences from 2001 to 2008, and for each of the years 2005-08 individually).

❖ The number of fire occurrences per 100 km^2 of forested area, from 2001 to 2008, was determined for each ecoregion section in the conterminous 48 states and Alaska.

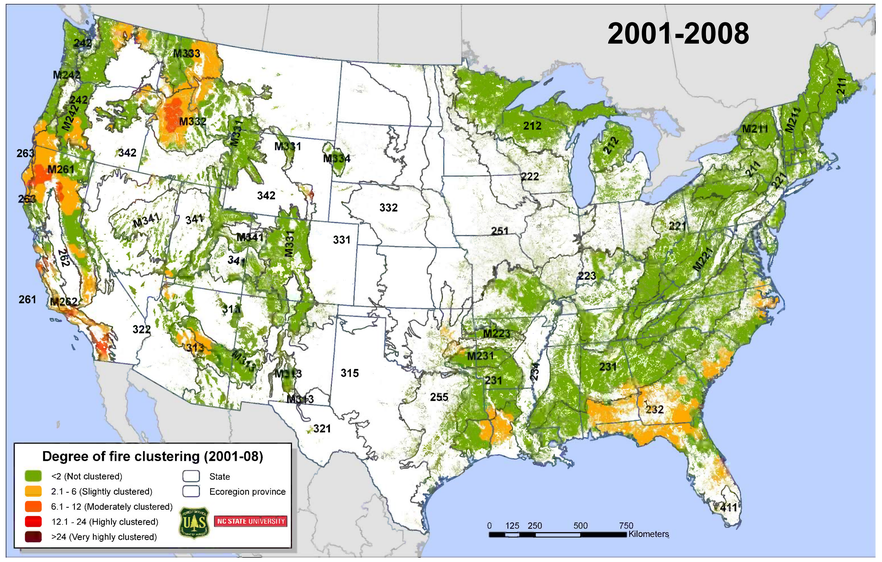

Figure 2: ***The analysis of fire occurrences across 2001 to 2008 detected the strongest geographic hot spots in the West, with less clustered hotspots in the Southeast.***

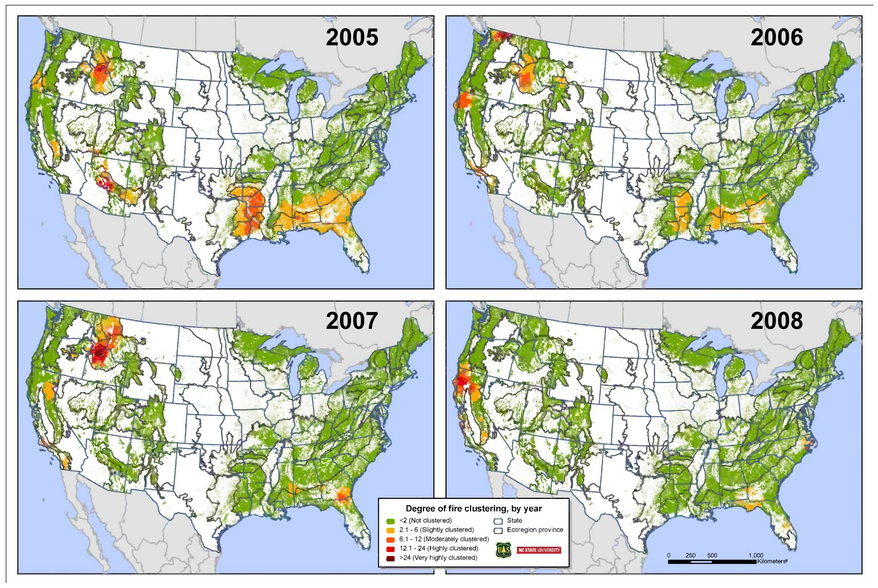

Figure 3: ***The location of geographic hot spots varied when MODIS fire occurrence data were analyzed individually by year from 2005 to 2008.***

Hot Spot Analysis

❖ The Getis-Ord G_i* statistic (Getis and Ord 1992) sums the differences between the mean values in a local sample (here a moving window of each hexagon and its adjacent hexagons) and the global mean. It is then standardized as a *z* score with a mean of 0 and a standard deviation of 1.

❖ Larger G_i* values indicate increasingly greater spatial clustering for a hexagon, with values > 2 representing significant clustering ($p < 0.05$).

Hotspot Results

❖ The analysis of cumulative fire occurrences from 2001 to 2008 detected the strongest geographic hot spots in western ecoregion provinces (Figure 2): Middle Rocky Mountain Forest (M332), Sierran Forest (M261), California Coastal Range (M262), and California Coastal Chaparral (261).

❖ The analyses of fire hot spots on an annual basis (Figure 3) detected considerable geographic variation across years, with hot spots occurring in California and in the Southeast every year, and in central Idaho for three years.

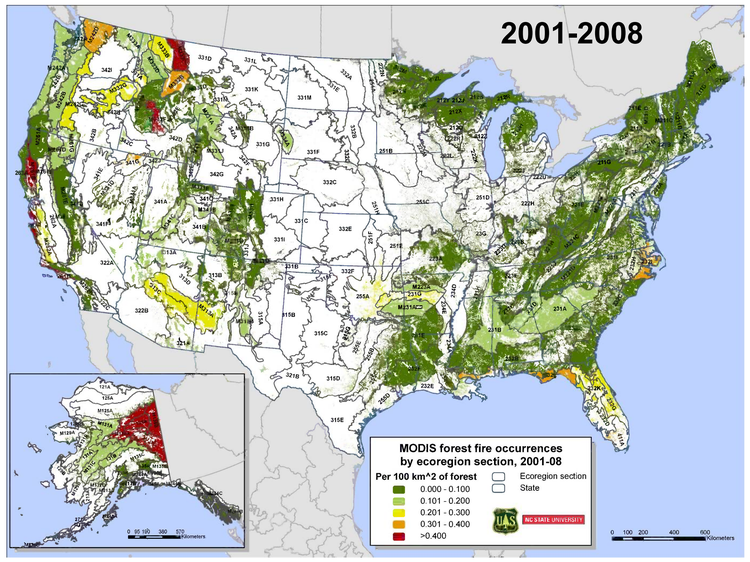

Figure 4: ***The ecoregion sections with the greatest number of fire occurrences per 100 km^2 of forest, from 2001-08, were located in California, Idaho, Montana, and the interior of Alaska.***

Ecoregion Results

❖ The ecoregion sections with the greatest number of fire occurrences relative to forest area (Figure 4) were the Northern Rockies (M333C), the Challis Volcanics (M332F), the Northern California Coast Ranges (M261B), the Central California Coast (261A), and the Southern California Coast (261E). Four interior Alaskan sections also had similarly high fire occurrence.

References

Getis, A.; Ord, J.K. 1992. The analysis of spatial association by use of distance statistics. *Geographical Analysis*. 24(3):189-206.

U.S. Department of Agriculture Forest Service. 2009. MODIS Active Fire Mapping Program: Continental United States and Alaskan Fire Detection GIS Data. *http://activefiremaps.fs.fed.us/gisdata.php*. [Accessed Feb. 3, 2009.]

This research was supported in part through Research Joint Venture Agreement 08-JV-11330146-078 between the USDA Forest Service and North Carolina State University.

NC STATE UNIVERSITY