Post-Inferno Erosion:
An Analysis of Erosion Rates after the Tea Fire in Santa Barbara, California

Introduction

The Santa Barbara Tea Fire had devastating effects on the local community by destroying over 200 homes in the blaze and burning over 1940 acres (BART). However, the dangers of the fire are not over. The recently scorched chaparral and soil now poses a new threat to the community: erosion. The damaged region is now extremely vulnerable to erosion processes from even the slightest amount of precipitation. Chaparral and healthy soils prevent erosion by slowing surface water flow, increasing infiltration into the subsurface and dampen precipitation impact on the soil surface. The community of Santa Barbara now faces the threats of increased erosion issues such as mudslides, topsoil erosion, washouts and additional property damage. The study takes place over the most severely burned Sycamore Canyon Basin, where 88% of the fire damage occurred (BART).

Area of Interest Map: Santa Barbara

The modeling of erosion for the watershed basin was performed using the Water Erosion Prediction Program (GeoWEPP) developed by the Landscape-based Environmental System Analysis & Modeling Institute. This project attempts to locate the regions where erosion will be most severe in order to provide valuable information for the community, where to focus mitigation efforts to dampen the effects of erosion on the landscape avoid further damage to the ecology and community.

Methods

Initial maps were created to provide background information regarding the region, watershed, fire damage and land-use characteristics. These maps provide valued information used to extrapolate specific parameters to reflect the consequences of the fire on the watershed. The watershed map was developed using the automatic watershed delineation tool in the open-source MapWindowGIS program from a digital elevation model (MapWindowGIS). Fire burn class severity was produced by reclassifying fire threat data provided by the California Department of Forestry and Fire Protection (FRAP). This fire burn class data was classified into four categories to correspond to the Soil Burn Severity Classes that are embedded in the GeoWEPP software: none, low, moderate and high soil burn class severities. Additionally, this reclassified data was used in conjunction with the GeoWEPP software to create corresponding percentages for the burned vegetation on the land-use layer; the none, low, medium and high burn class severity was translated into percentages of remaining land cover in the post-fire basin. The soil map was clipped to the dimensions of the watershed to effectively extrapolate soil data for use in the Water Erosion Prediction Program model (SSURGO). Lastly, land-use maps were obtained from the USGS Seamless Data server (USGS) the GeoWEPP software used this data to create the initial ground cover and vegetation parameters for running the pre-fire erosion model on the watershed. These maps provided the information necessary to produce the maps for the GeoWEPP software and provide information to extrapolate fire damage severity for the burned portion of the watershed.

Post-fire erosion amount is calculated using the analytical solution programs of Water Erosion Prediction Program (GeoWEPP). The input parameters for the WEPP include a Digital Elevation Model (NOAA), Soil Data (SSURGO), and Land-use data (USGS). The land-use data provided both the vegetation and human impact sites for the GeoWEPP model. The GeoWEPP program provides information regarding climate history, fire damaged soil statistics and fire damage vegetation models.

The climate data utilized for this project was recorded from a local Santa Barbara, California weather station located at 120 feet elevation and reflect annual data averages from 66 years of measurements (GeoWEPP). GeoWEPP utilizes the digital elevation model to calculate the hillslope and aspect of the erosion surfaces The pre-fire analysis relied on these parameters to produce an erosion map indicative of the healthy Sycamore Canyon basin.

The post-fire analysis utilized the soil data embedded within the GeoWEPP software to reclassified the soils and vegetation based on the burn class severity. Through visual interpretation from the Burn Severity maps, soils and vegetation were reclassified using the data embedded within the GeoWEPP software. Areas that were severely burned were thus reclassified as experiencing high soil-burn severity and decreased vegetation cover, and areas with low burn severity were reclassified as low soil-burn severity and low vegetation loss. Thus the burn severity map was visually translated to the soil and vegetation parameters provided by GeoWEPP. Finally the simulation was run using the same climatic data from the initial scenario to determine the areas and volume of increased erosion.
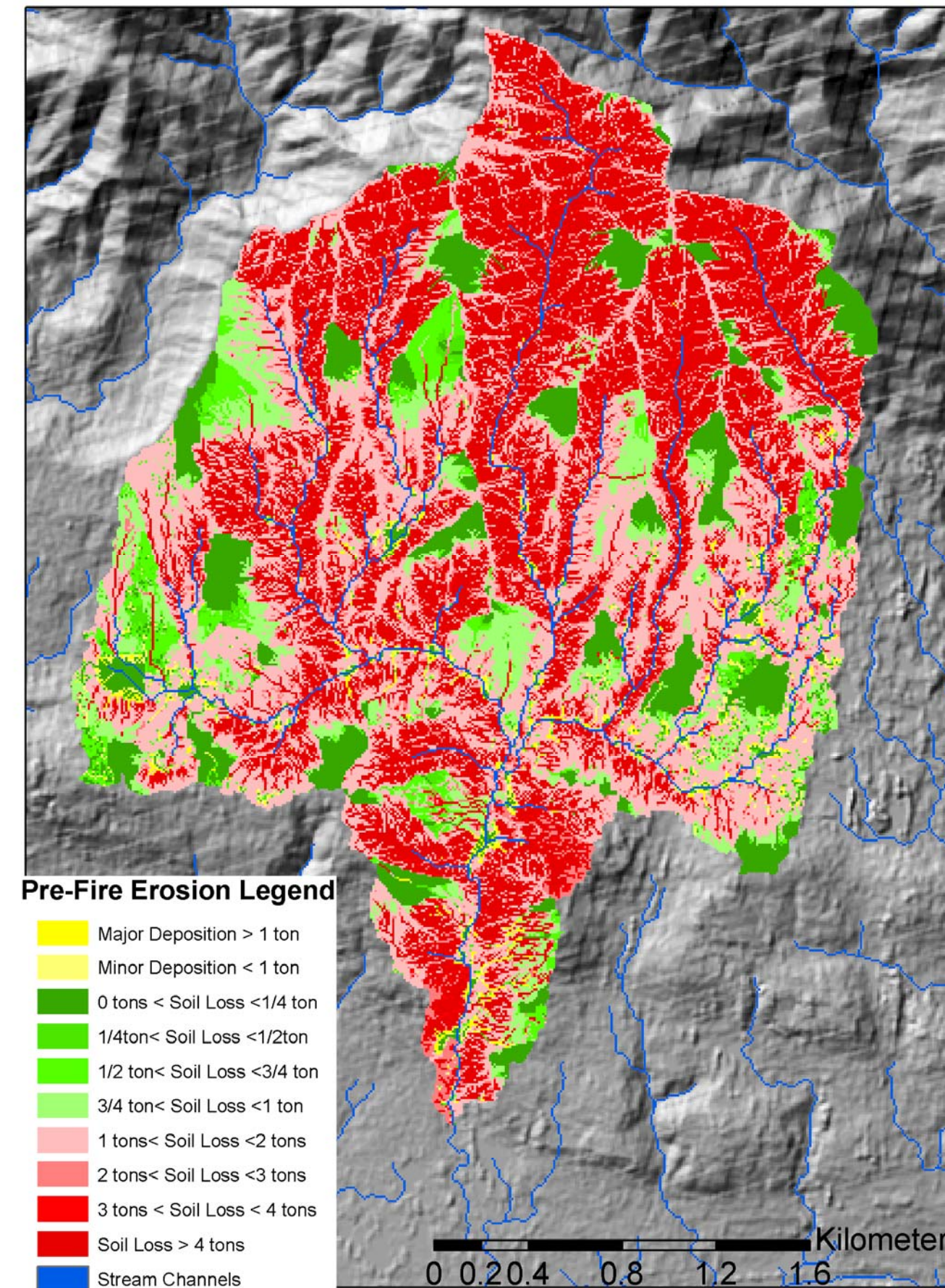
Analysis Base Maps

Watershed
### Fire Burn Severity

Soil Data for Watershed
Land-use
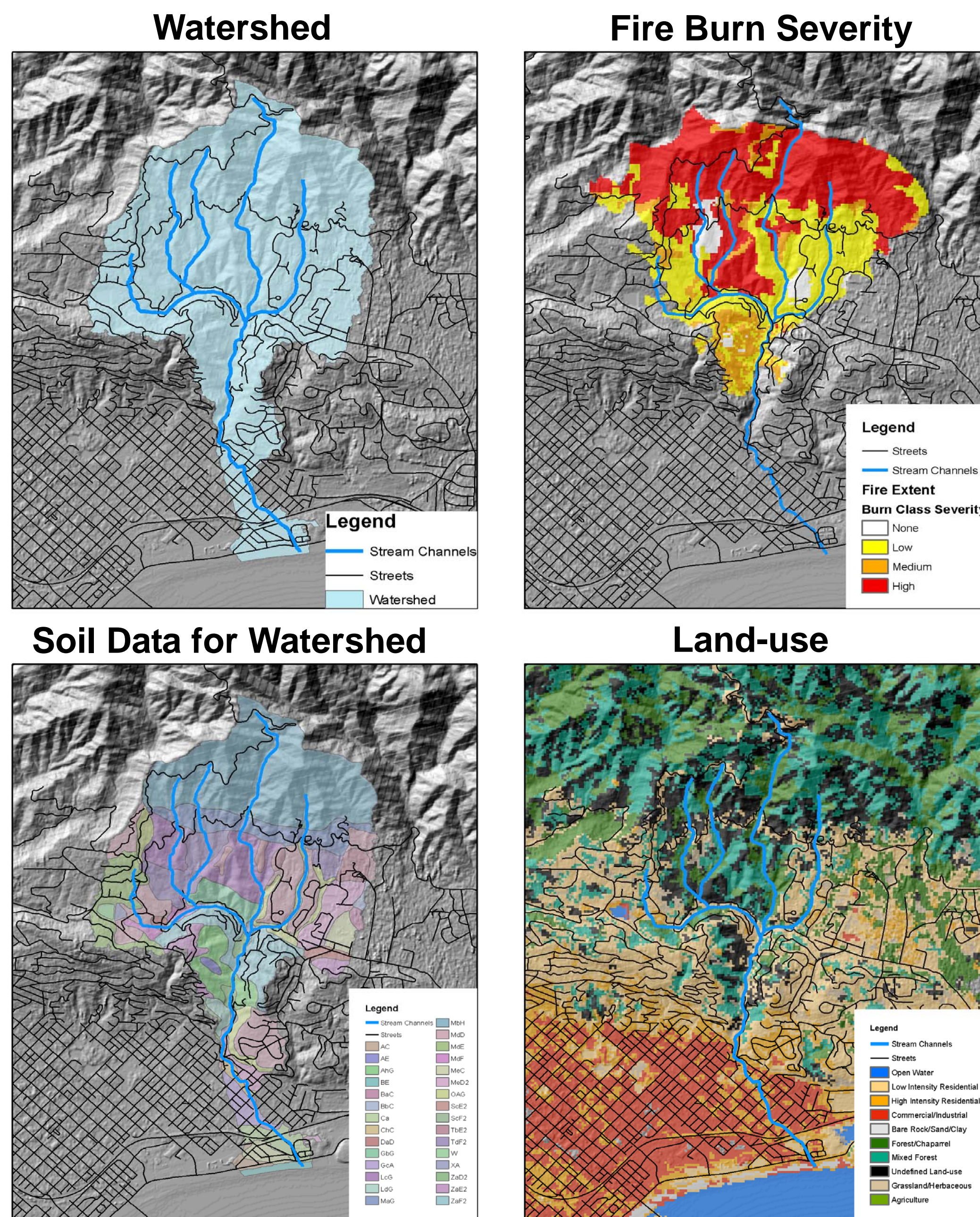
Analysis Base Maps: (clockwise from top left) Watershed delineation using MapWindowGIS, Fire Burn Severity through reclassification of Fire Data from FRAP, Land-use data map from USGS, Soil Data for Watershed from SSURGO
Note: All of maps were used to extrapolate the parameters allocated when running the GeoWEPP software for pre– and post-fire analysis.

WEPP Erosion Models for Sycamore Canyon

Pre-Fire WEPP Erosion Model
Post-Fire WEPP Erosion Model
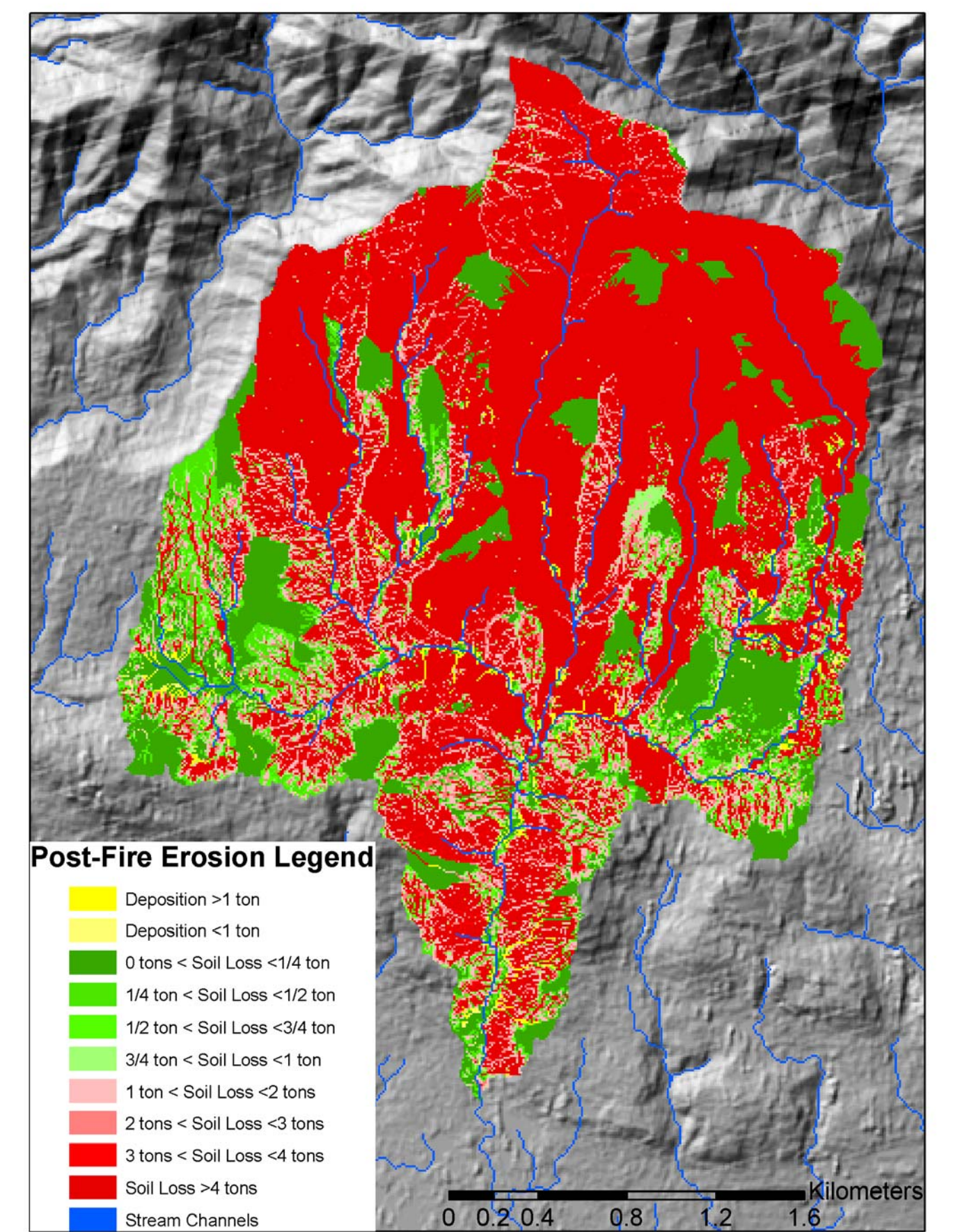
WEPP Output Data for the Sycamore Canyon Watershed

	Total Runoff Volume (m³/yr)	Soil Loss (tons/yr)	Total Area (ha)	Mapped Soil Loss (ton/ha/yr)
Pre-Fire Model	554686.1	4520.4	888.4	929.5
Post-Fire Model	621487.8	25978.3	888.4	3683.4

Note: Values reflect 2-year average annual data for the Sycamore Canyon watershed

Conclusions

The maps demonstrate that all the areas that had previously experienced moderate erosion (pink map regions) are now much more vulnerable to sediment loss. These at risk regions have all almost doubled their sediment load being carried from the basin. However, the low sediment loss areas (green map regions) remained relatively stable in terms of their total soil lost. This is likely due to those regions having very slight slope aspect or underlying bedrock outcroppings protecting the areas from major increases in erosion rates.

The data reports demonstrate that the soil loss in the post-fire Sycamore Canyon watershed is over 5 times the pre-fire watershed. This sediment transport has potential to washout roads, remove valuable topsoil, undercut roads and remaining structures, and deliver excess sediment loads to the stream channels and ocean. Additionally, roughly 10,000 m³/yr of watershed runoff will exit the watershed increasing the threat to the more densely populated urban areas. Immediate mitigation efforts must be implemented in order to dampen the effects of erosion across the watershed in order to protect Santa Barbara city from additional damage caused by post-fire erosion.

References
California Fire and Resource Assessment Program: http://frap.cdf.ca.gov/   April 19th, 2009
Map Window GIS: http://www.mapwindow.com/   April 21st, 2009
National Oceanic and Atmospheric Administration: http://www.noaanews.noaa.gov/stories2009/20090204_santabarbara.html   April 19th, 2009
Santa Barbara Burned Area Response Team: http://hazardmitigation.calema.ca.gov/docs/Tea_Fire_final_draft_1-22-09.part1.1.pdf   April 28th, 2009
Soil Survey Geographic Database: http://soils.usda.gov/survey/geography/ssurgo/   April 21st, 2009
USGS Seamless Data Server: http://seamless.usgs.gov/index.php   April 21st, 2009
Water Erosion Prediction Project (GeoWEPP): http://www.geog.buffalo.edu/~rensch/geowepp/   April 19th, 2009

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