Rapid Response Tools and Datasets to support BAER assessment:

Spatial WEPP modeling with QWEPP & the Rapid Response Erosion Database (RRED)

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NASA ARSET Training

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Overview

- Importance of BAER
- WEPP (Water Erosion Prediction Project)
- NASA BAER project and the Rapid Response Erosion Database (RRED)
- QWEPP introduction and DEMO
- NASA BAER in action
- Ravel RAT & Apps for BAER
- Fuels planning with NASA BAER project

Introduction

- Forests provide many products as well as ecosystem services
  - Wood
  - Wildlife and fish habitat
  - Recreation
  - Clean water
- Wildfire impacts on watersheds
  - Increased peak flow rates (up to 100x)
  - Increased sediment delivery to streams (up to 1000x)

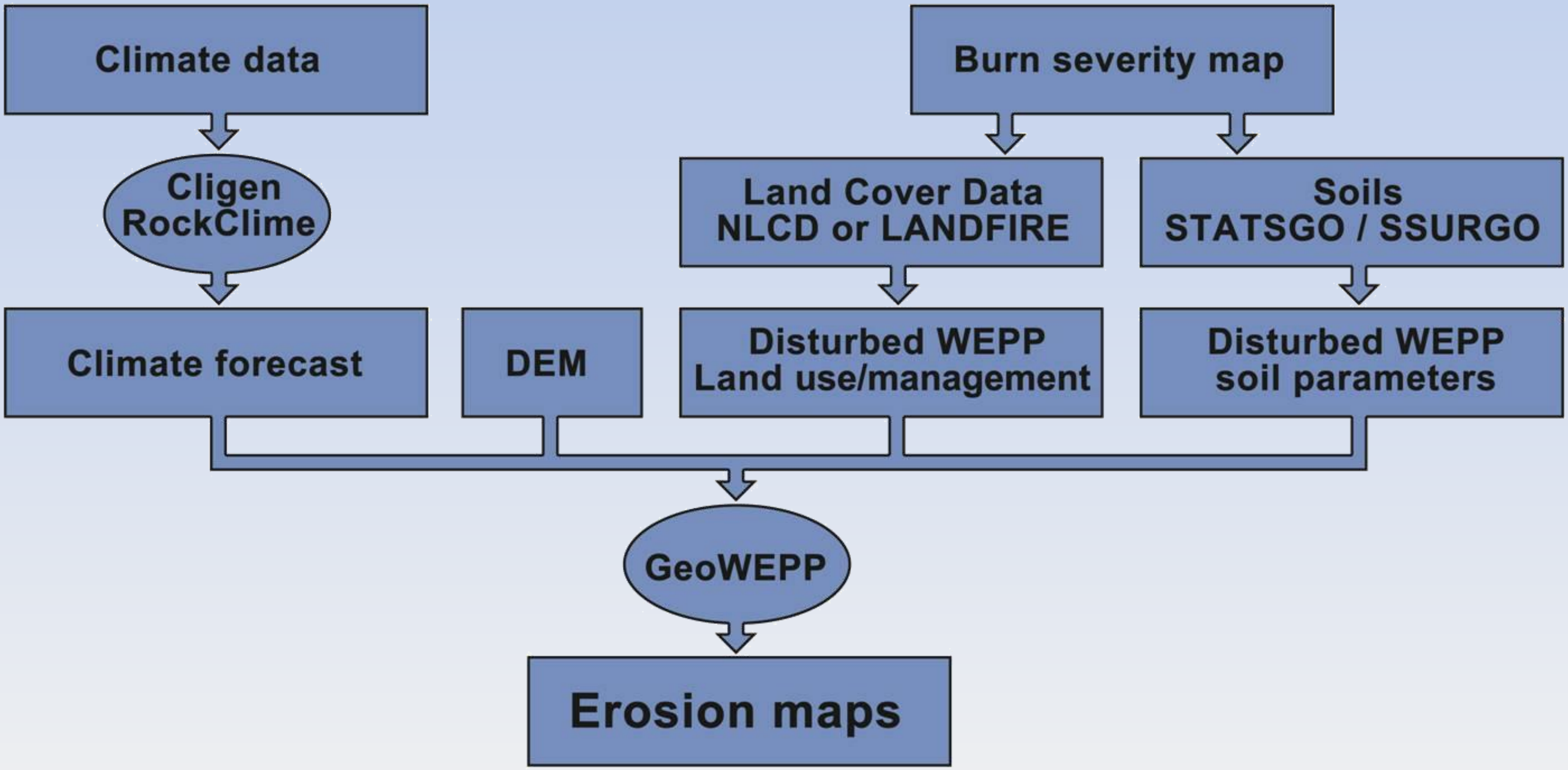
Forest in Northern Idaho

Waiting for the flood after an Arizona fire

BAER Teams
(Burned Area Emergency Response)

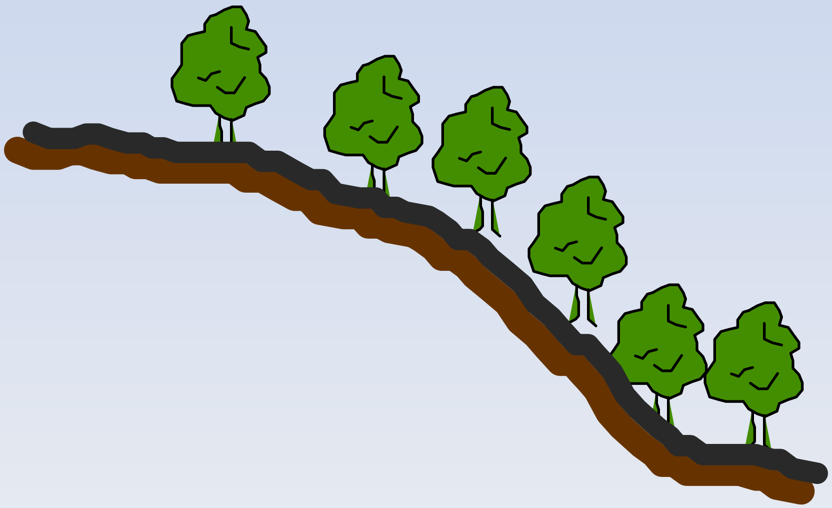
- Mission: Protect lives, property and natural resources threatened by post-fire flooding and erosion.
- BAER Teams go to work before the fire is out.
- Treatments need to be completed before a major storm in order to be effective.

WEPP (**W**ater **E**rosion **P**rediction **P**roject) Watershed Erosion Model



WEPP Versions

- Hillslope
  - Describes a single strip of hillslope



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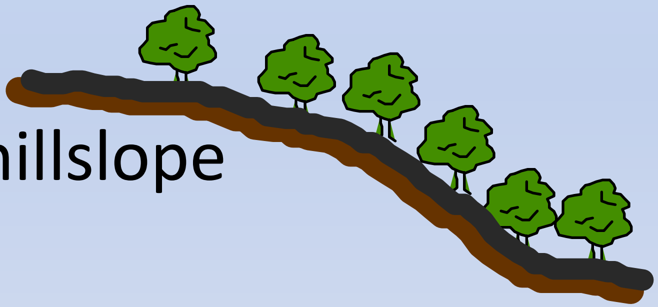

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  - Describes a single strip of hillslope
- Watershed
  - Links hillslopes, channels, and impoundments
  - Suits construction sites

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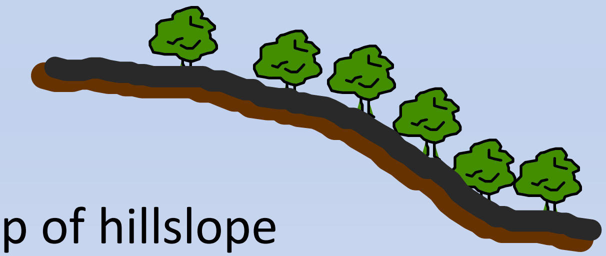
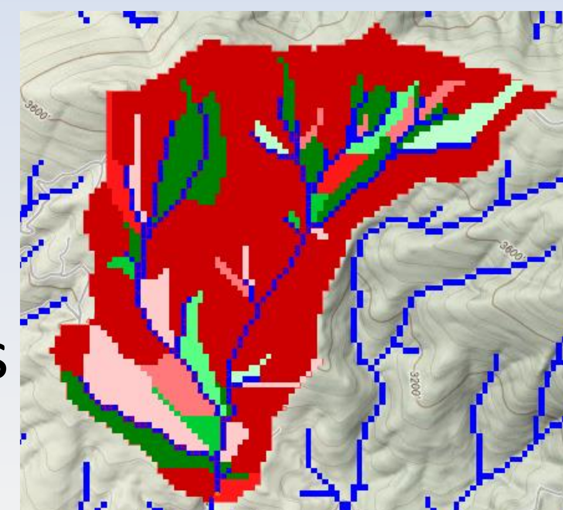
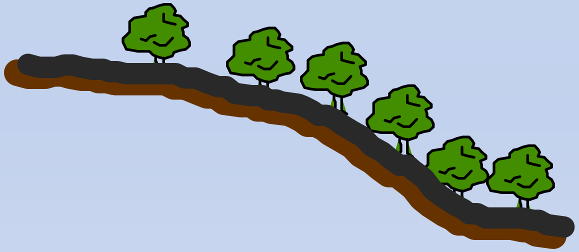


- Hillslope
  - Describes a single strip of hillslope
- Watershed
  - Links hillslopes, channels, and impoundments
  - Suits construction sites

- GIS tools
  - New QWEPP interface in QGIS
  - GeoWEPP ArcGIS Wizard
  - Online interface for U.S. databases

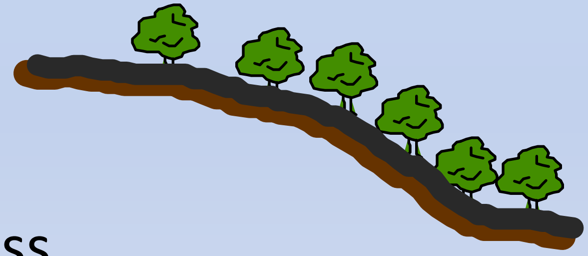


WEPP Inputs



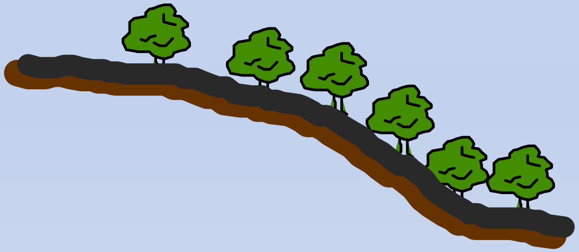
- Slope
  - Distance - Steepness

WEPP Inputs



- Slope
  - Distance - Steepness
- Soil
  - WEPP Erodibility based on texture and vegetation
  - Soil texture and depth base on Soil Survey

WEPP Inputs



- Slope
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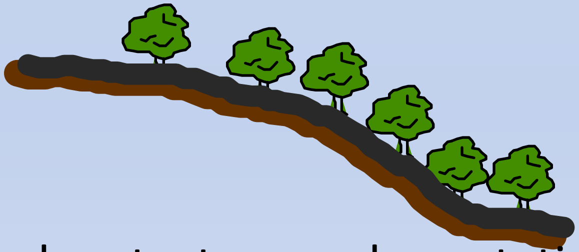
- Vegetation or Management
  - Initial conditions
  - Vegetation growth and residue decomposition properties

WEPP Inputs



- Slope
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  - WEPP Erodibility based on texture and vegetation
  - Soil texture and depth base on Soil Survey
- Vegetation or Management
  - Initial conditions
  - Vegetation growth and residue decomposition properties
- Climate
  - Daily precip, temperatures and wind speed

WEPP Processes 1

- Rainfall, infiltration, runoff, soil water

WEPP Processes 2

- Rainfall, infiltration, runoff, soil water
- Soil detachment, transport, deposition and delivery

WEPP Processes 3

- Rainfall, infiltration, runoff, soil water
- Soil detachment, transport, deposition and delivery
- Plant growth, evapotranspiration, and senescence

WEPP Processes 4

- Rainfall, infiltration, runoff, soil water
- Soil detachment, transport, deposition and delivery
- Plant growth, evapotranspiration, and senescence
- Residue accumulation and decay

Erosion Processes 1

- Interrill Erosion
  - Raindrop splash
  - Shallow Overland Flow

Erosion Processes 2

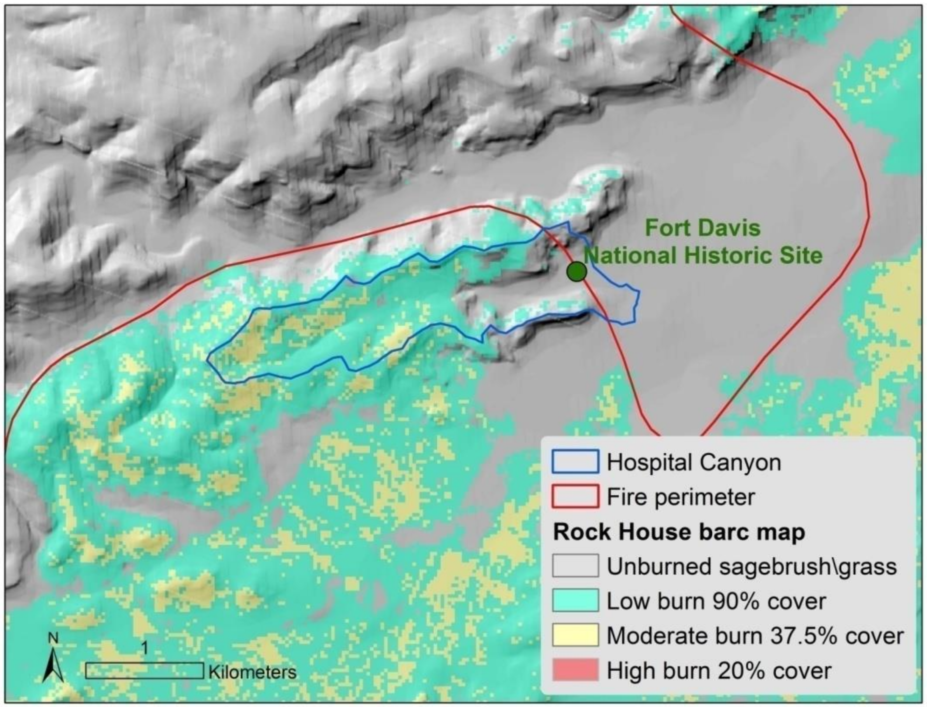
- Interrill Erosion
  - Raindrop splash
  - Shallow Overland Flow
- Rill Erosion
  - Concentrated Channel Flow
  - Assumes about 1 m spacing between rills
    - Varied for roads

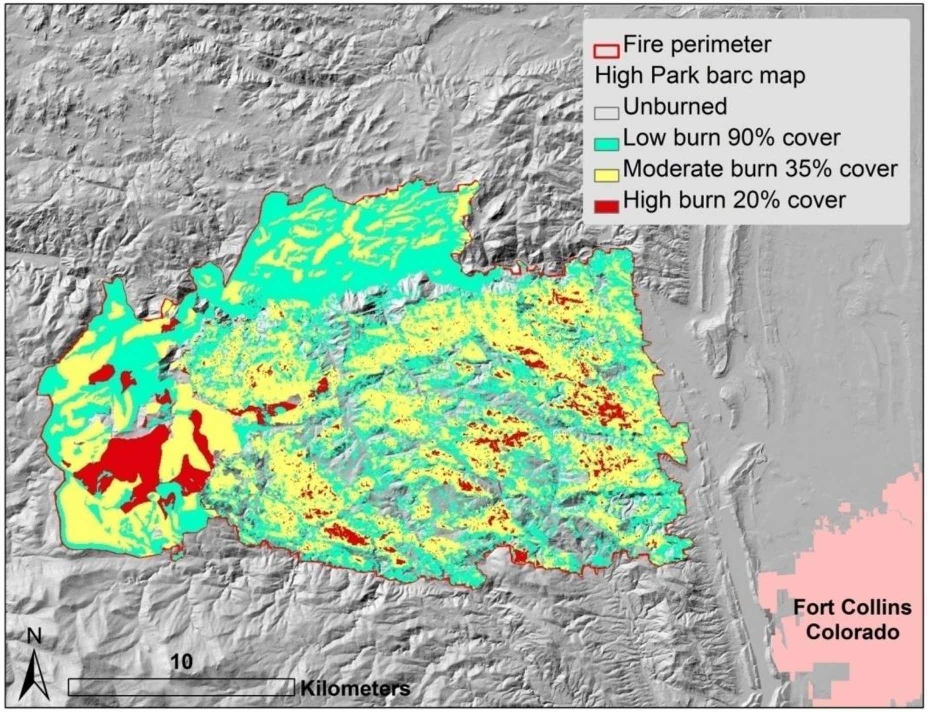
Remote Sensing Data

$$\mathbf{NBR = (R_{NIR} - R_{SWIR}) / (R_{NIR} + R_{SWIR})}$$ **(Key & Benson, 2006)**

Where: R is the reflectance at the satellite in either the near-infrared (NIR) or the shortwave-infrared (SWIR). The change in NBR between the pre- and post-fire conditions is calculated by:

$$\mathbf{dNBR = NBR_{prefire} - NBR_{postfire}}$$

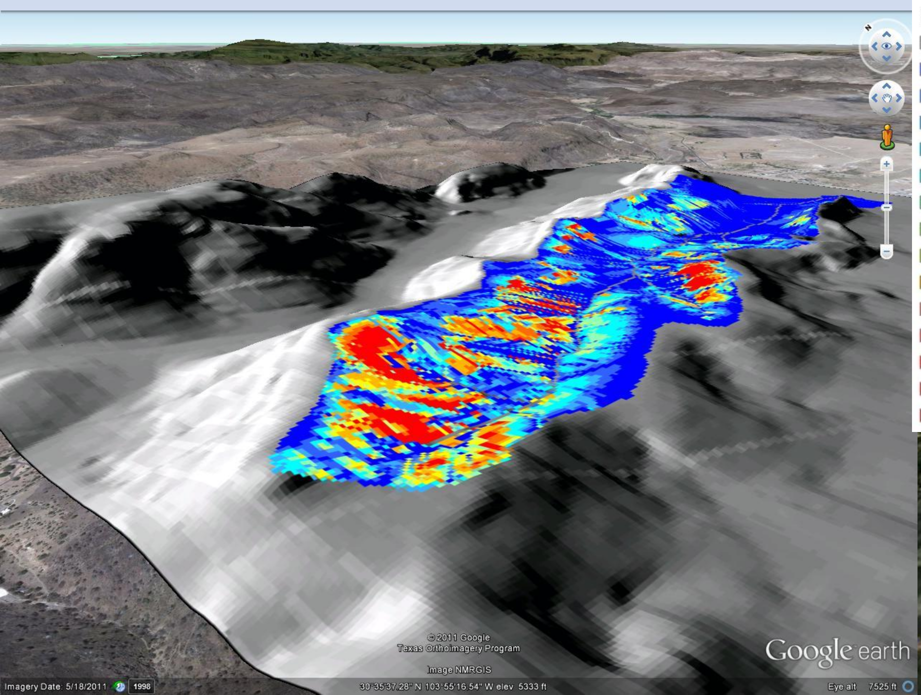


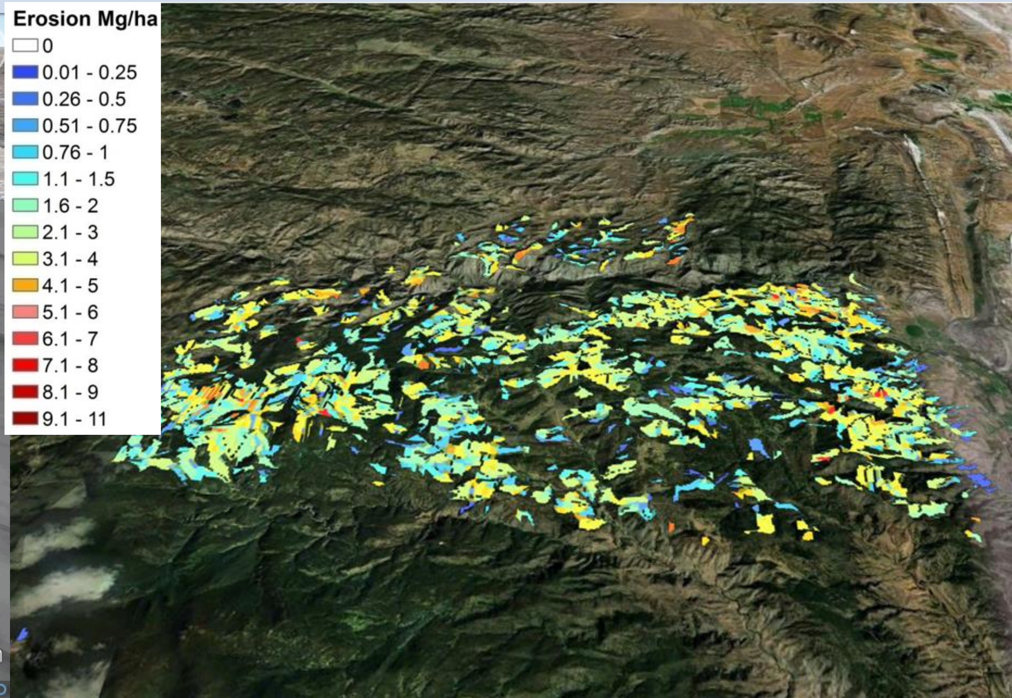


Problem - Spatial process based erosion models are currently under utilized.

Rock House Fire
Date: April 9, 2011
Location: Fort Davis, TX
Size: 314,444 acres ; 127,250 ha
Hospital Canyon: 536 acres; 217 ha
BAER Team: National Park Service

High Park Fire
Date: June 9, 2012
Location: West of Fort Collins, CO
Size: 87,284 acres; 35,322 ha
BAER Team: Forest Service

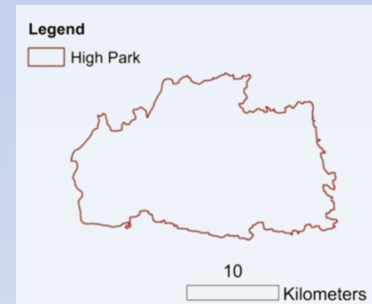




Two Case Studies:

Rock House Fire / High Park Fire

Tip 1: Have the model you want installed and functioning!



Installation of model
ESRI software can be difficult to install

Model already installed and ready to go!

Tip 2: Have inputs ready!

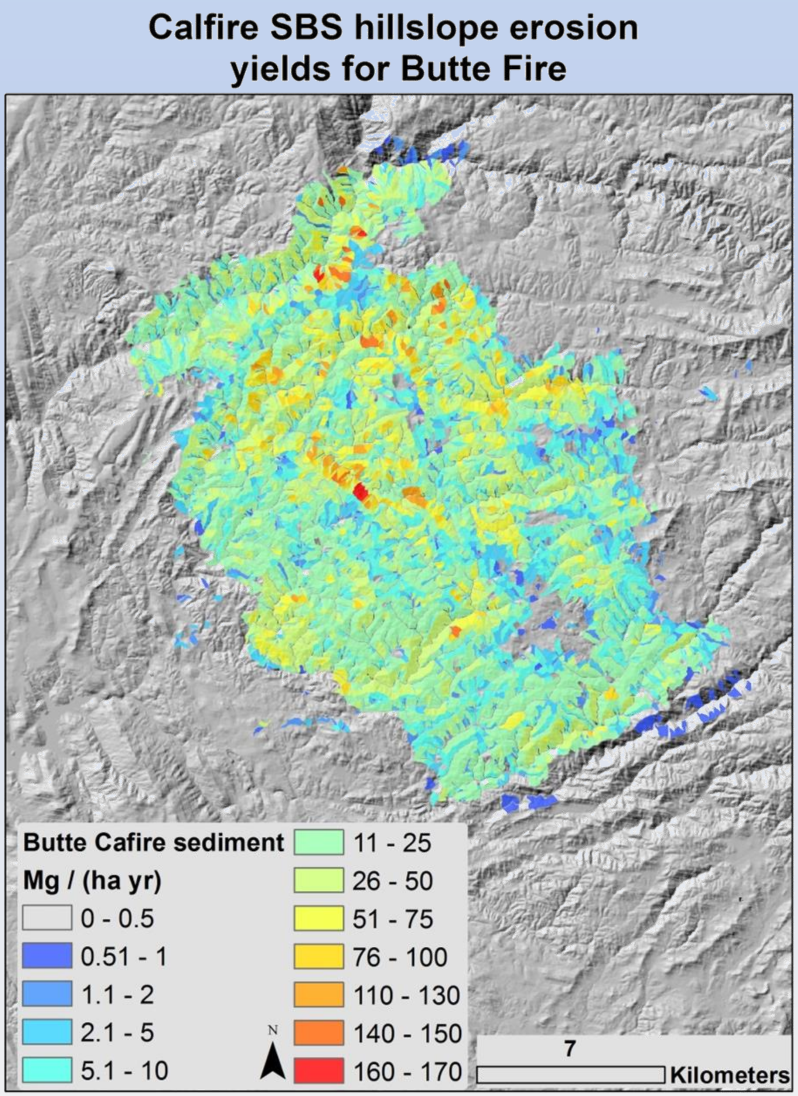
All inputs had to be gathered after the fire:
Soils and land cover take time to build;
Soils data need processing to get key values;
Land cover and soil files need to be modified by burn severity!

Most inputs prepared ahead of time
Land cover and DEM prepared;
Soils were mapped and data organized;
Still have to modify land cover and soils by burn severity!

Solution

Spatial process-based erosion models are underutilized due to time constraints;

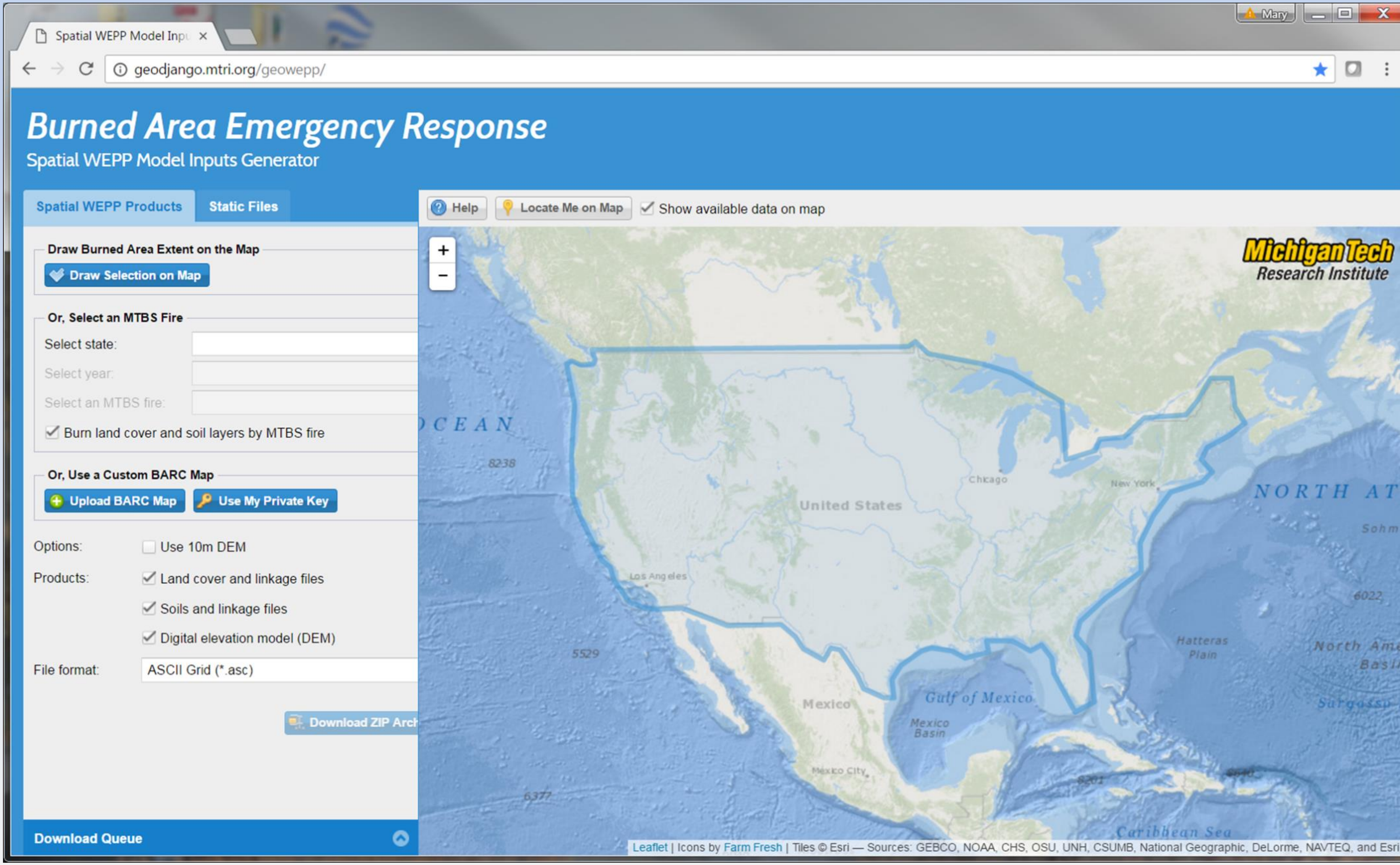
- Prepare datasets and tools before the fire occurs!
- Modelers also need to prepare the model and practice before hand!



Modeling Datasets

- Burn Severity: User Supplied & Monitoring Trends in Burn Severity project
- Soils: USDA SSURGO and STATSGO datasets
- Land cover: Existing Vegetation Type (EVT) data from the LANDFIRE
- 30m & 10m DEM data from the United States Geological Survey (USGS) Seamless Data Warehouse.

http://geodjango.mtri.org/geowepp/



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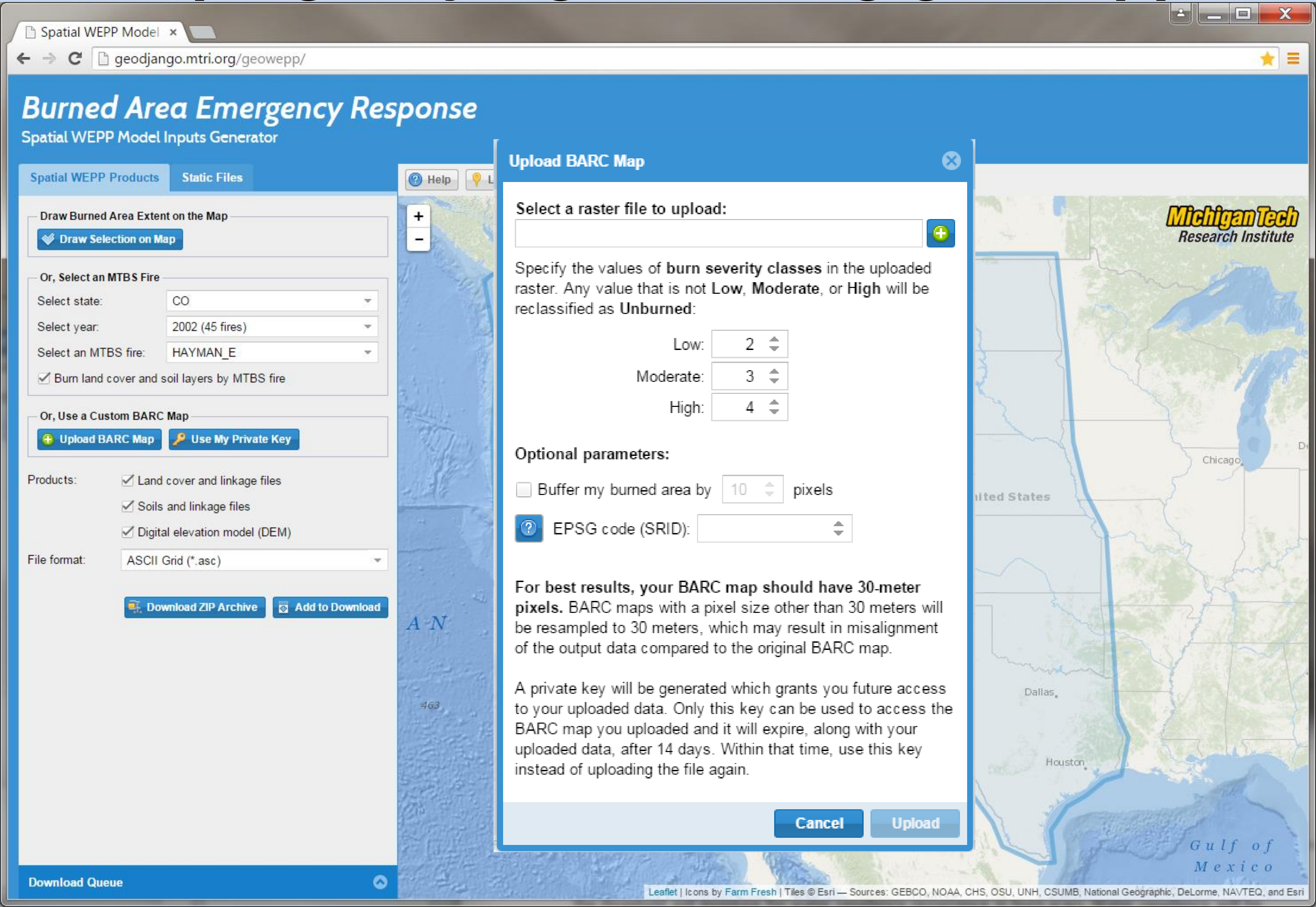
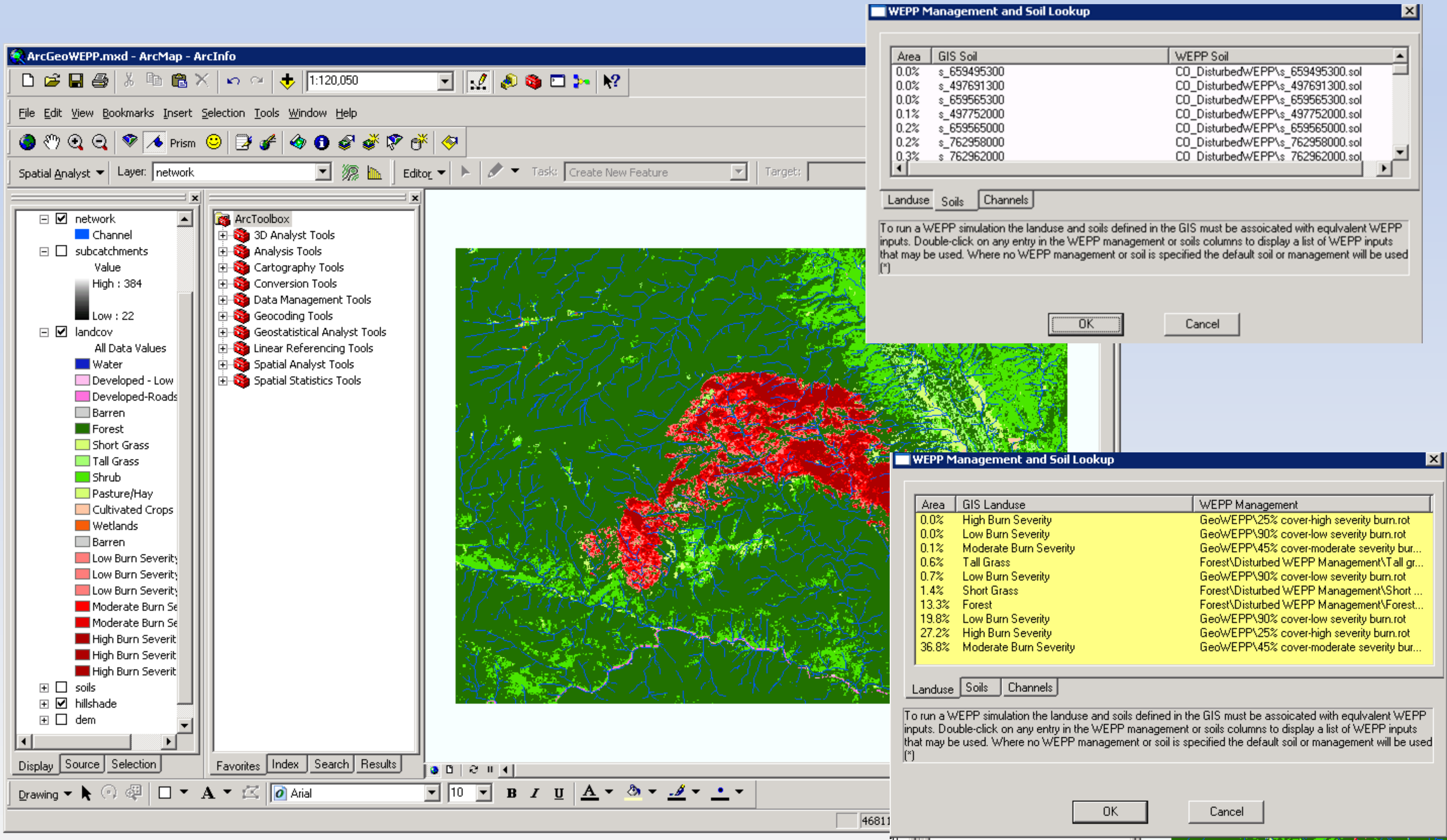


Soil Burn Severity (SBS) Map

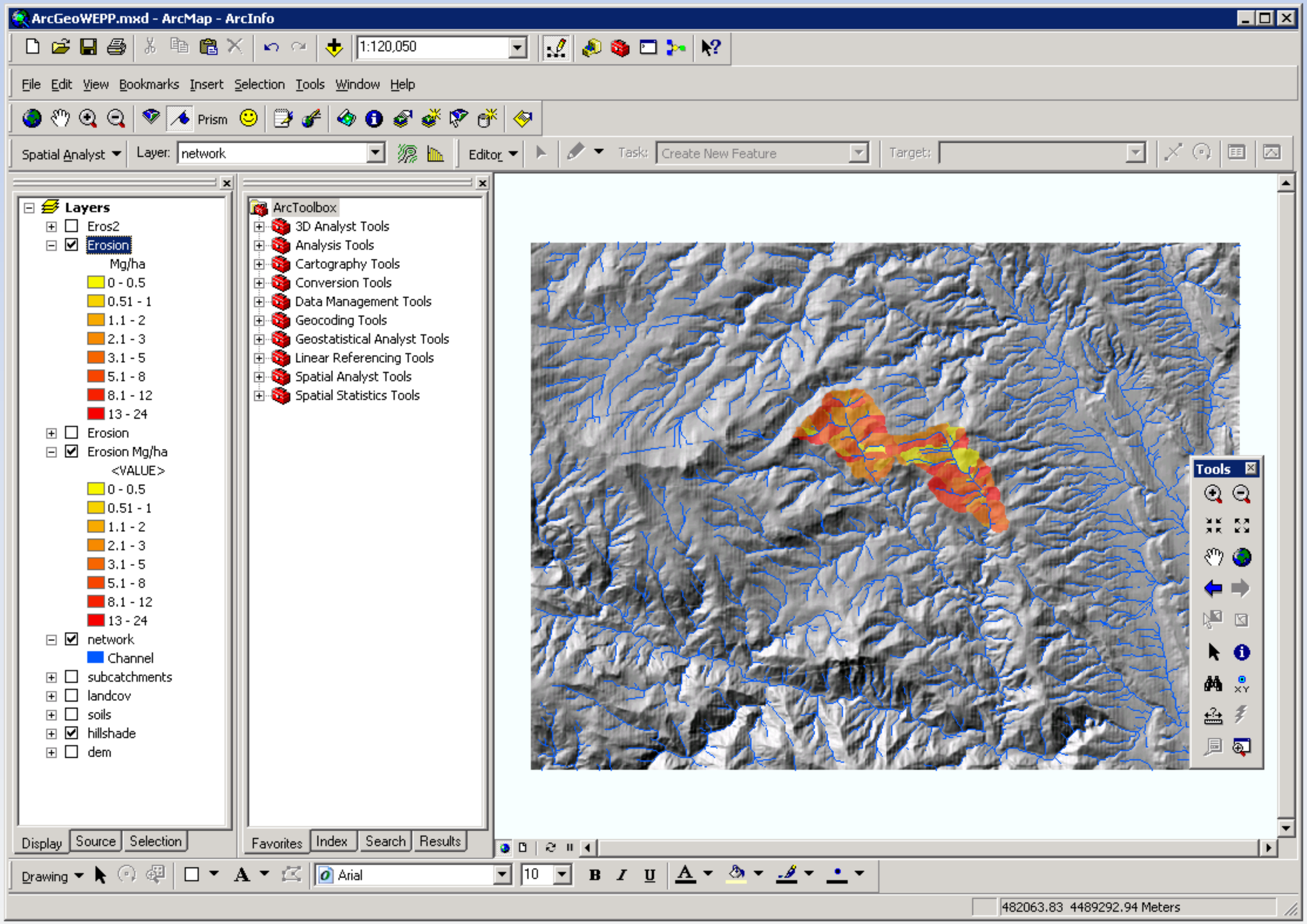
Most soil burn severity (SBS) maps are derived from Landsat data – so if you are creating the SBS map leaving it in the native projection and raster format is best!

- Data needs to be in a classified raster format with three classes represented numerically – low, moderate and high
- Best if raster has a resolution of ~ 30 m
- Projection needs to be standard – UTM nad83 or UTM wgs 84 work best

RRED creates WEPP linkage files!

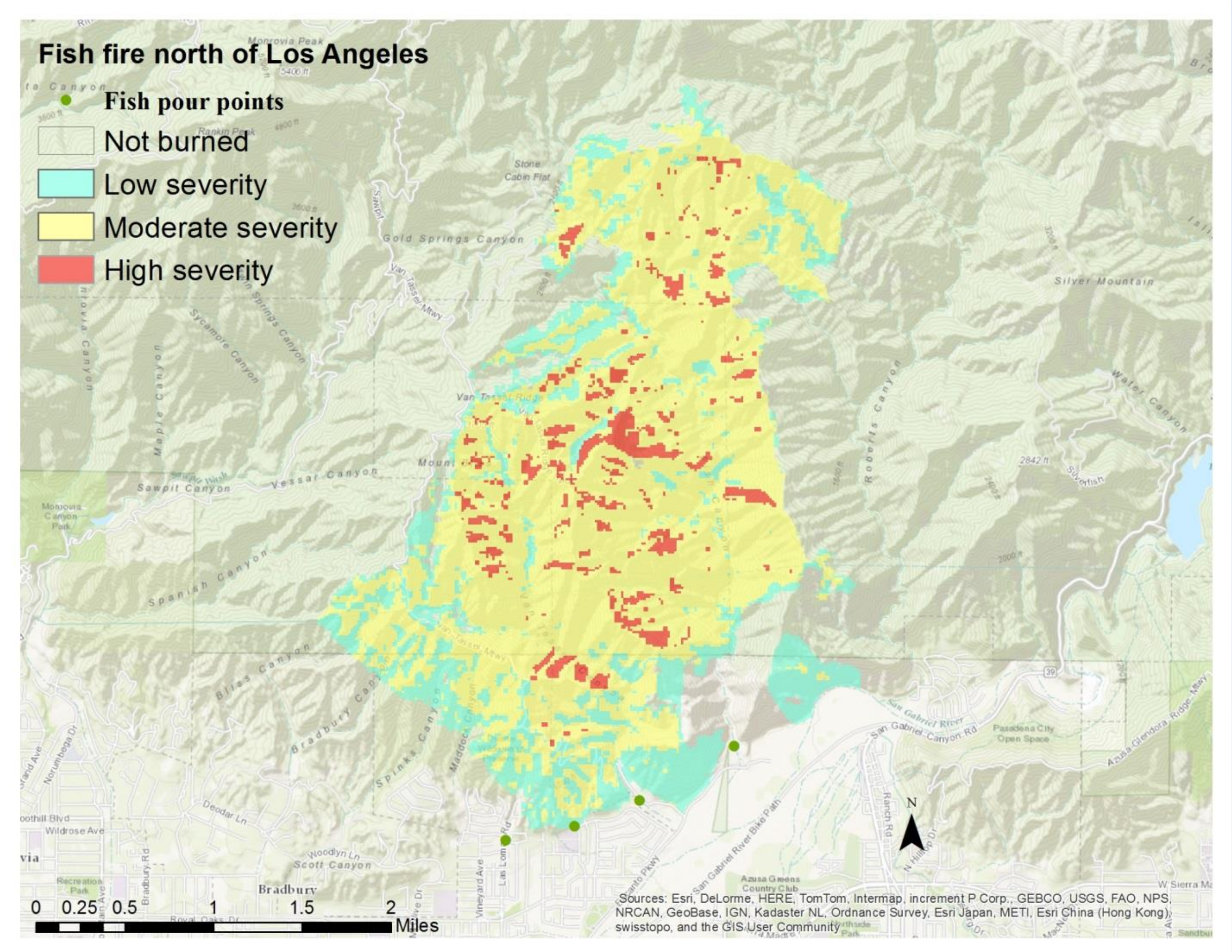


BAER Teams can focus on modeling!



RRED DEMO

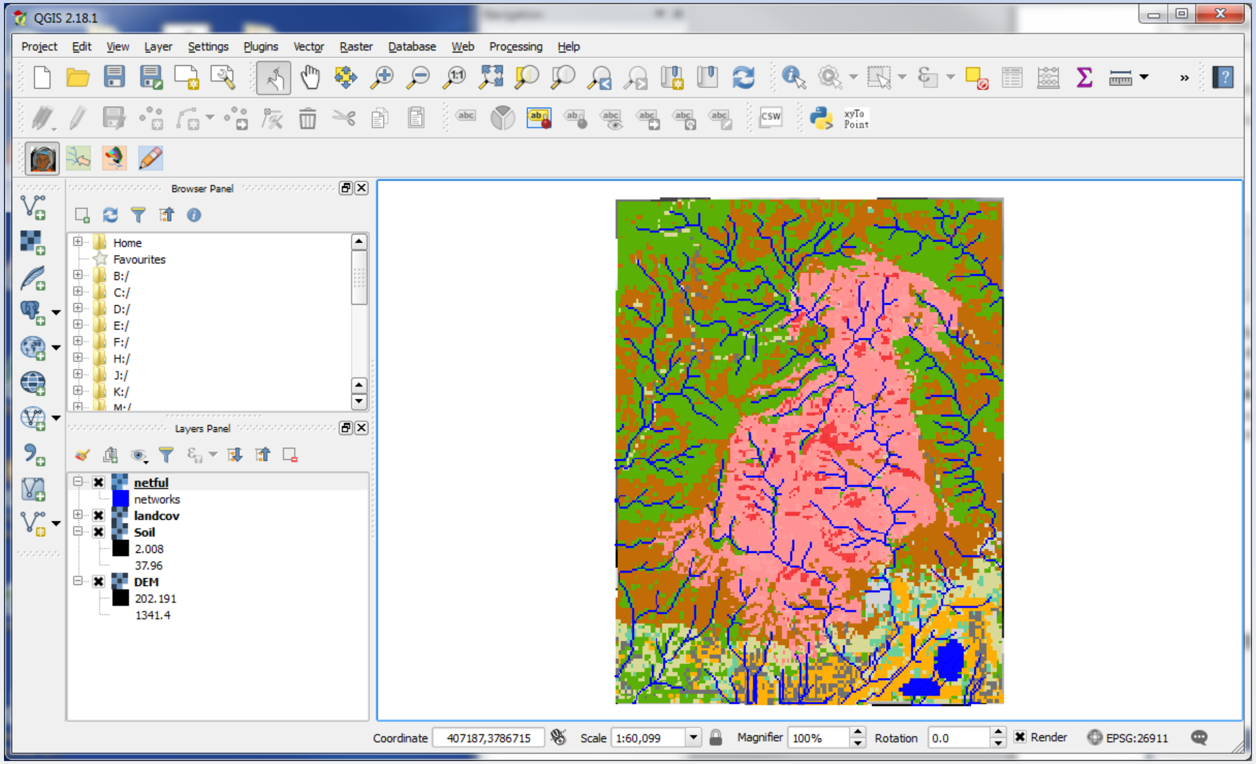
- Rapid Response Erosion Database Example



QGIS Spatial interface for WEPP

QWEPP

- Easy to use geographical interface for the **W**ater **E**rosion **P**rediction **P**roject!



QWEPP

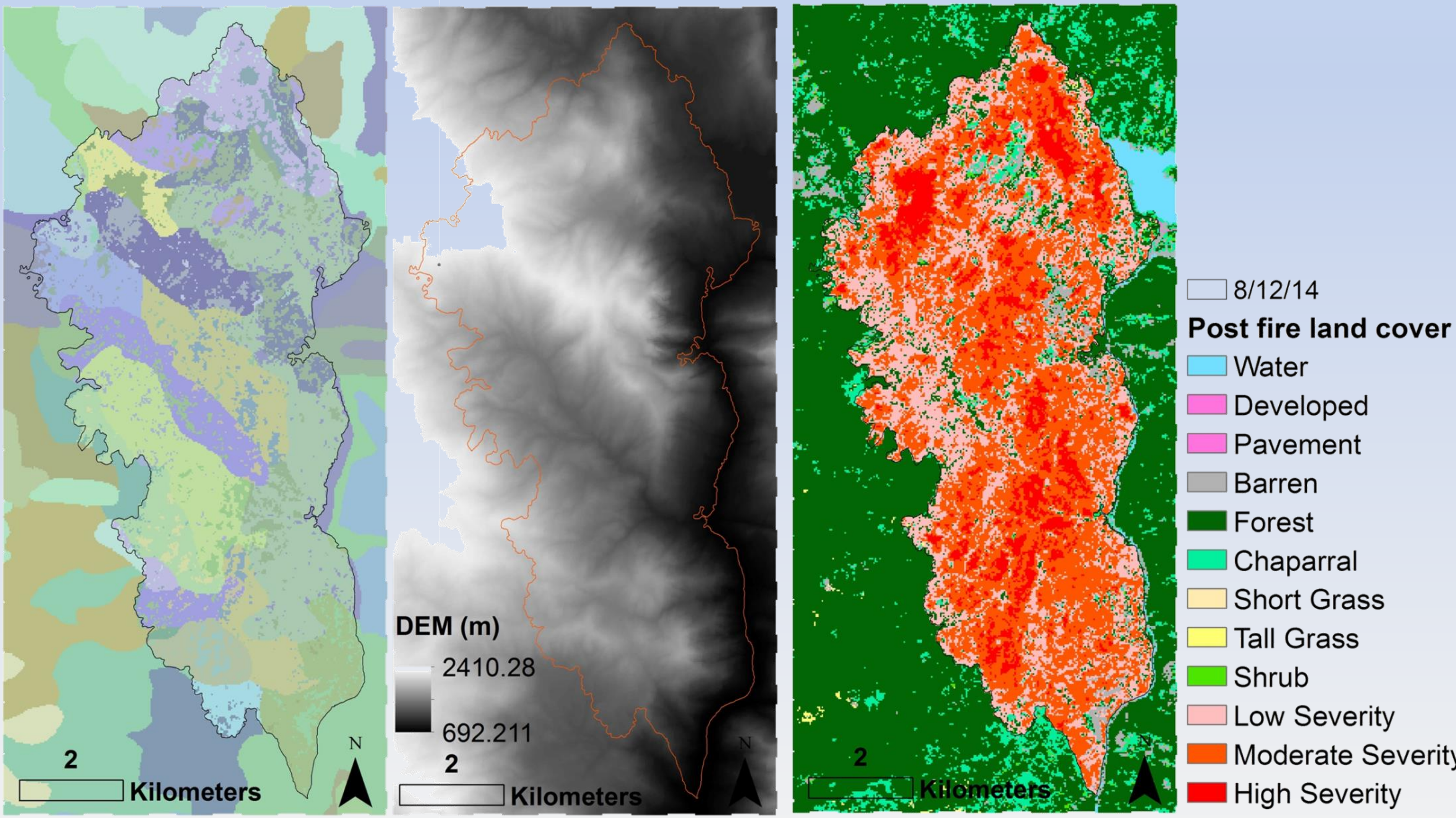
- In order to utilize QWEPP users will need **QGIS software** installed and the **QWEPP plugin**.
- You need the .NET Framework and at least 250 MB of hard drive space.
- For QGIS installation software and instructions go to: http://www.qgis.org/en/site/forusers/download.html.

QWEPP Software Components

- QGIS– provides the GIS framework for display, tools for assembling and manipulating spatial data.
- QWEPP – plugin to collect user inputs, run model and assemble results.
- USDA-ARS TOPAZ - uses DEM to delineate channels, delineate watershed from outlet, create the topographic slope files needed to run WEPP.
- Topwepp2 – create WEPP inputs from gridded data and translate between TOPAZ watershed files to WEPP model inputs.
- WEPP – Process based erosion model!

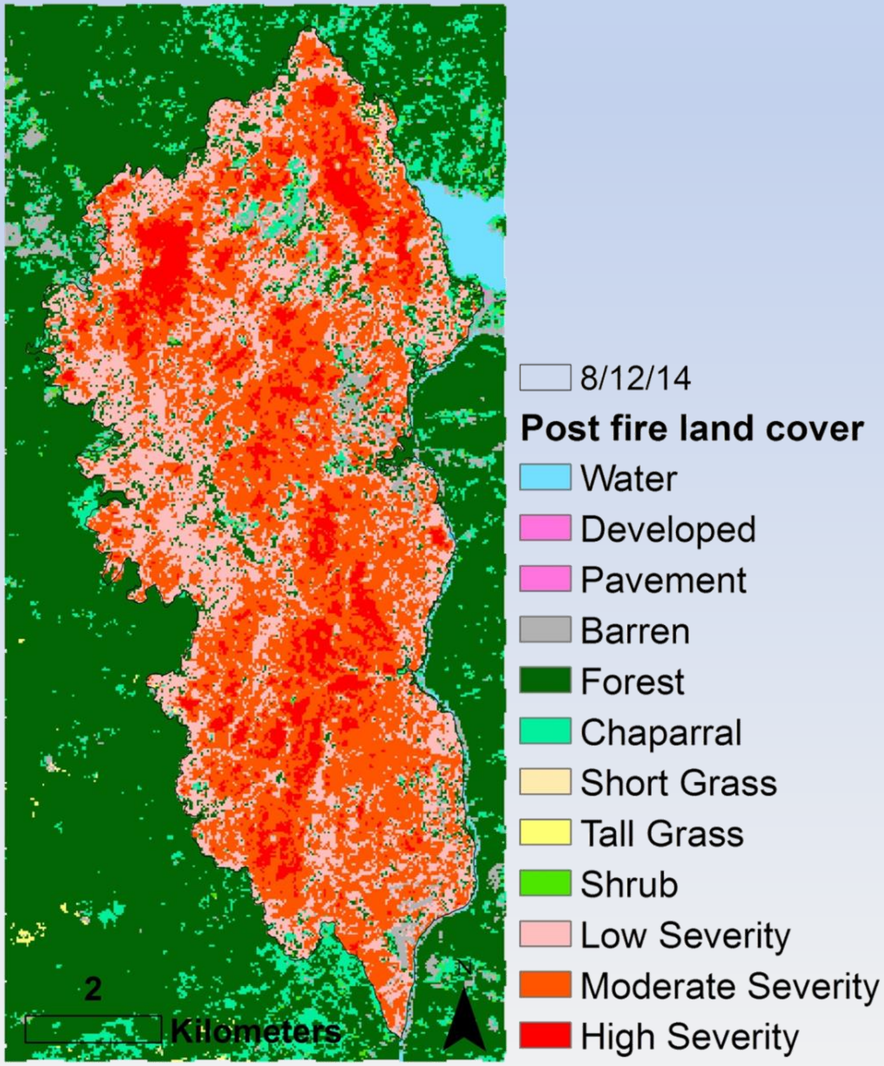
Spatial Inputs from the French Fire (CA, 2014)

Soils DEM Land cover



WEPP Linkage files

- Simple text files
- Four files
  - landcov.txt
  - landusedb.txt
  - soilsmap.txt
  - soilsdb.txt



Land Cover linkage files

landcov.txt - Notepad

File Edit Format View Help

```
11 Open Water
12 snow/ice
22 Developed - Low Intensity
23 Developed-Roads
31 Barren
40 Young Forest
41 Forest
52 Chaparral
70 Short Grass
71 Tall Grass
73 Shrub
81 Pasture/Hay
82 Cultivated Crops
91 Wetlands
100 Low Burn Severity
111 Open Water
112 snow/ice
122 Low Burn Severity
123 Developed-Roads
131 Barren
140 Low Burn Severity
141 Low Burn Severity
152 Low Burn Severity
170 Low Burn Severity
171 Low Burn Severity
173 Low Burn Severity
181 Low Burn Severity
182 Low Burn Severity
191 Low Burn Severity
200 Moderate Burn Severity
211 Open Water
222 Moderate Burn Severity
223 Developed-Roads
231 Barren
240 Moderate Burn Severity
241 Moderate Burn Severity
252 Moderate Burn Severity
```

landusedb.txt - Notepad

File Edit Format View Help

```
Low Burn Severity|FC_85%.rot
High Burn Severity|FC_25%.rot
Moderate Burn Severity|FC_60%.rot
Chaparral|Mokelumne\Chaparral.rot
Open Water|GeoWepp\grass.rot
Forest|Mokelumne\Forest Perennial.rot
Young Forest|Mokelumne\Young Forest.rot
Short Grass|Mokelumne\Short grass.rot
Tall Grass|Mokelumne\Tall grass.rot
Shrub|Mokelumne\Shrub.rot
Developed - Low Intensity|Mokelumne\Short grass.rot
Developed-Roads|Pavement.rot
Barren|Mokelumne\Barren.rot
Pasture/Hay|Mokelumne\alfalfa with cuttings.rot
Cultivated Crops|Mokelumne\winter wheat, mulch till CA.rot
Wetlands|GeoWepp\grass.rot
snow/ice|GeoWepp\grass.rot
```

Soil linkage files

soilsmap.txt - Notepad

File Edit Format View Help

```
1,100,s_1014342011
2,100,s_1014342041
3,100,s_1014342070
4,100,s_1014342071
5,100,s_1014342073
6,100,s_1014343011
7,100,s_1014343040
8,100,s_1014343041
9,100,s_1014343070
10,100,s_1014343071
11,100,s_1014343073
12,100,s_1014343100
13,100,s_1014343300
14,100,s_1014344011
15,100,s_1014344041
16,100,s_1014344070
17,100,s_1014344071
18,100,s_1014344073
19,100,s_1014347011
20,100,s_1014347041
21,100,s_1014347070
22,100,s_1014347071
23,100,s_1014347073
24,100,s_1014347100
25,100,s_1014353041
26,100,s_1014353070
27,100,s_1014353071
28,100,s_1014353073
29,100,s_1014354011
30,100,s_1014354041
31,100,s_1014354070
32,100,s_1014354071
33,100,s_1014354073
34,100,s_1014355041
35,100,s_1014355070
36,100,s_1014355071
37,100,s_1014355073
```

soilsdb.txt - Notepad

File Edit Format View Help

```
s_1014342011|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014342011.sol
s_1014342041|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014342041.sol
s_1014342070|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014342070.sol
s_1014342071|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014342071.sol
s_1014342073|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014342073.sol
s_1014343011|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343011.sol
s_1014343040|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343040.sol
s_1014343041|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343041.sol
s_1014343070|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343070.sol
s_1014343071|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343071.sol
s_1014343073|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343073.sol
s_1014343100|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343100.sol
s_1014343300|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014343300.sol
s_1014344011|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014344011.sol
s_1014344041|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014344041.sol
s_1014344070|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014344070.sol
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s_1014344073|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014344073.sol
s_1014347011|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014347011.sol
s_1014347041|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014347041.sol
s_1014347070|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014347070.sol
s_1014347071|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014347071.sol
s_1014347073|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014347073.sol
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s_1014353070|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014353070.sol
s_1014353071|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014353071.sol
s_1014353073|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014353073.sol
s_1014354011|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014354011.sol
s_1014354041|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014354041.sol
s_1014354070|DisturbedWepp_KEY-4ae0f3982b6b935a9031dea3f1b3c3f4/s_1014354070.sol
```
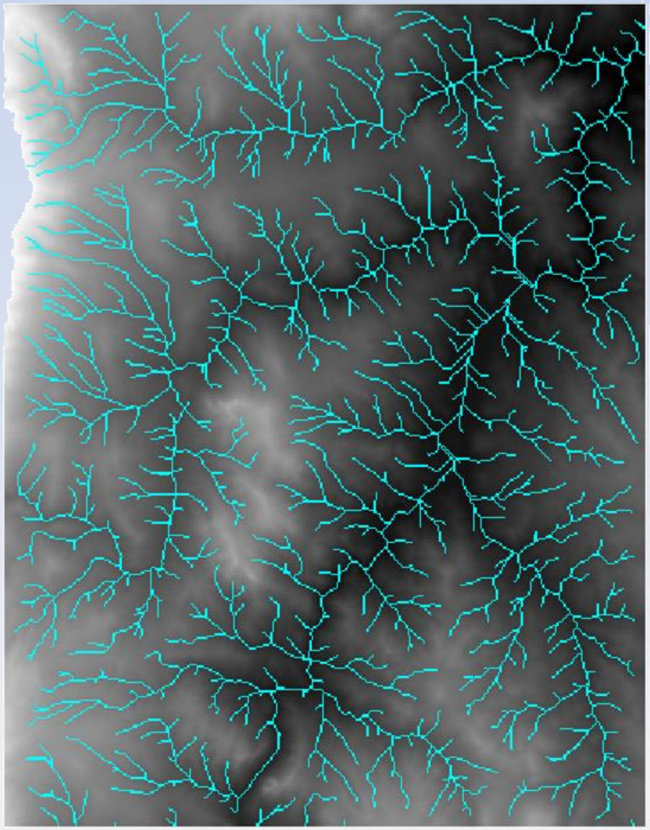
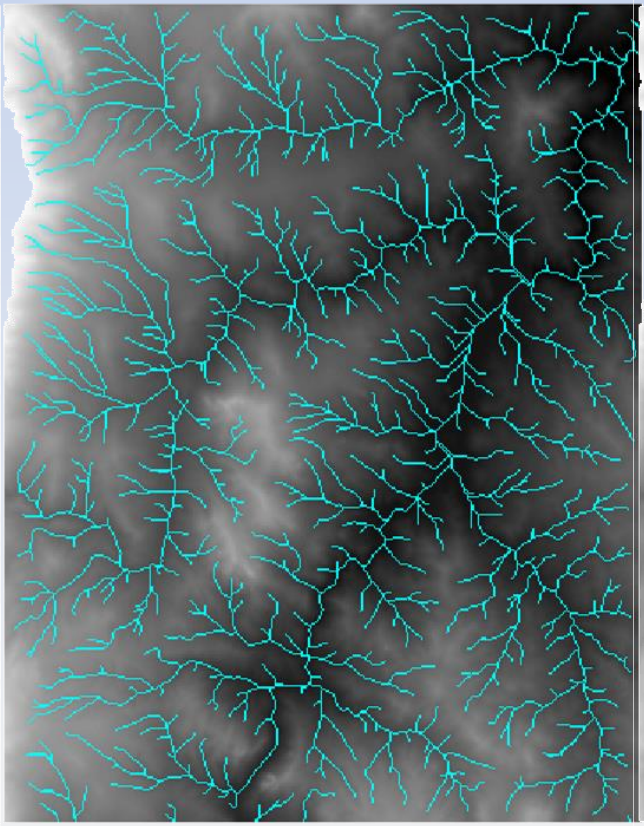

TOPAZ inputs: CSA, MSCL

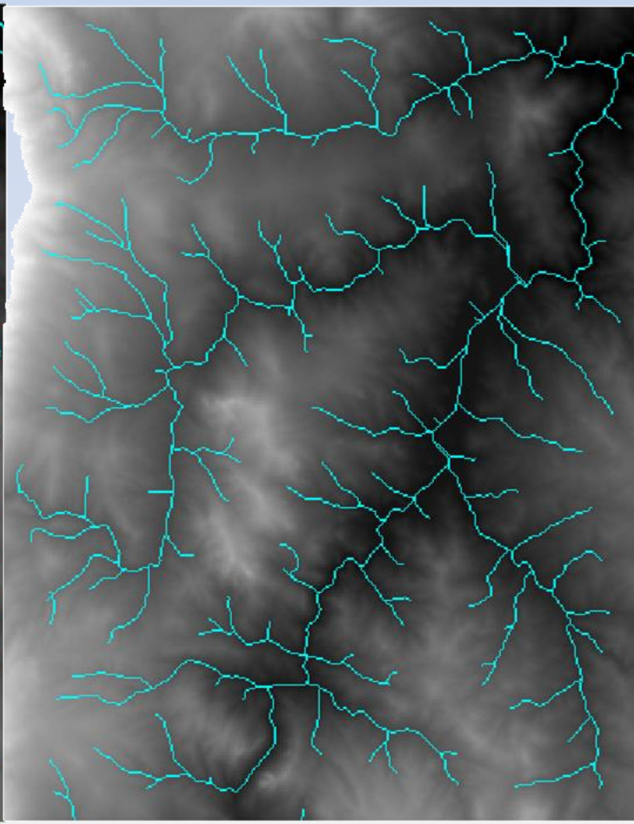
- CSA : Critical Source Area
  - Determines when a channel forms
  - Current default setting is 30 ha
- MSCL – Minimum Source Channel Length
  - Minimum channel length needed to initiate a channel
  - Current default is 100 m

TOPAZ inputs: CSA, MSCL

CSA 5 ha	CSA 5 ha	CSA 30 ha
MSCL 60 m	MSCL 100 m	MSCL 100 m







Watershed vs. Flowpath

Watershed Method

- Each hillslope has one:
  - Slope profile
  - Dominant land cover
  - Dominant soil type
- Offsite assessment as the spatial results represent the sediment yield that leaves each hillslope

Flowpath Method

- Each flowpath has its own slope profile
- Each pixel keeps it land cover and soil type
- Flowpath converge so they are aggregated
- Onsite assessment as the spatial results represent erosion or deposition occurring in each raster cell of the subcatchment

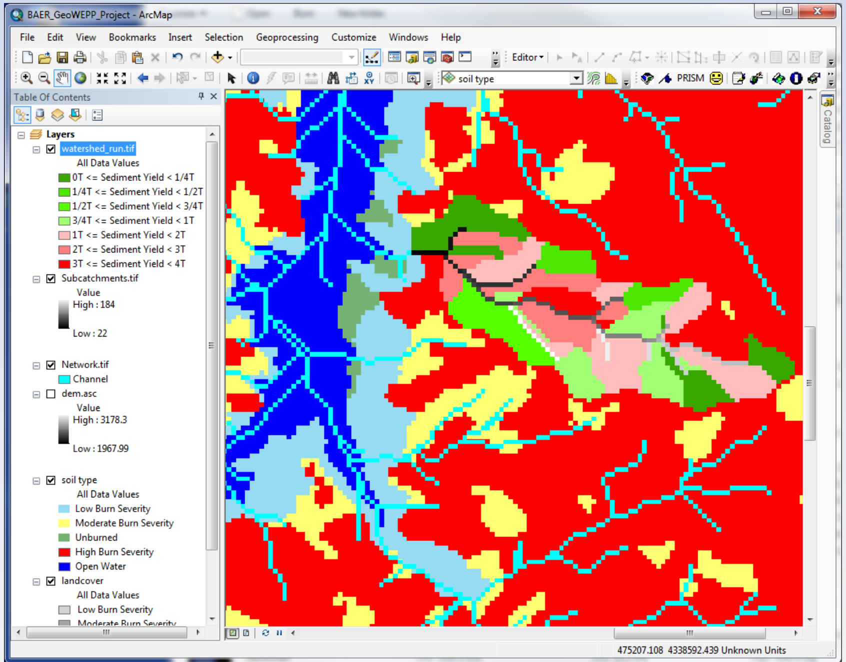
Watershed vs. Flowpath

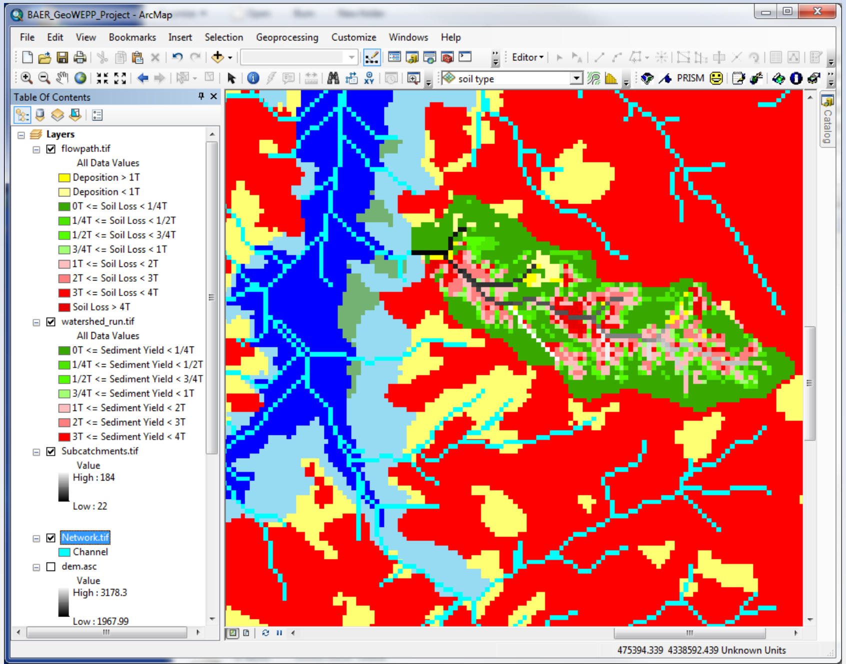
Watershed Method

- Less spatial resolution
- Faster, example 2 year run in 0:17 seconds

Flowpath Method

- More detail
- Longer to run, example 2 year run in 3:24 minutes





QWEPP DEMO

- Rapid Response Erosion Database
- QWEPP Example

ftp://ftp.mtri.org/pub/NASA_BAER/Workshop/

NASA BAER in Action!

for **Fuels Planning**

- Mokelumne
- Flagstaff

for **BAER Teams**

- Canyon Creek, OR
- Clearwater, ID
- Butte, CA
- Valley, CA
- French, CA
- Happy Camp, CA
- Silverado, CA
- King, CA
- Soberanes, CA
- Fish, CA
- Cedar, CA

for **Validation study**

- High Park, CO

Canyon Creek Fire

Cover Settings provided by BAER Team:

Low burn severity - 75% cover

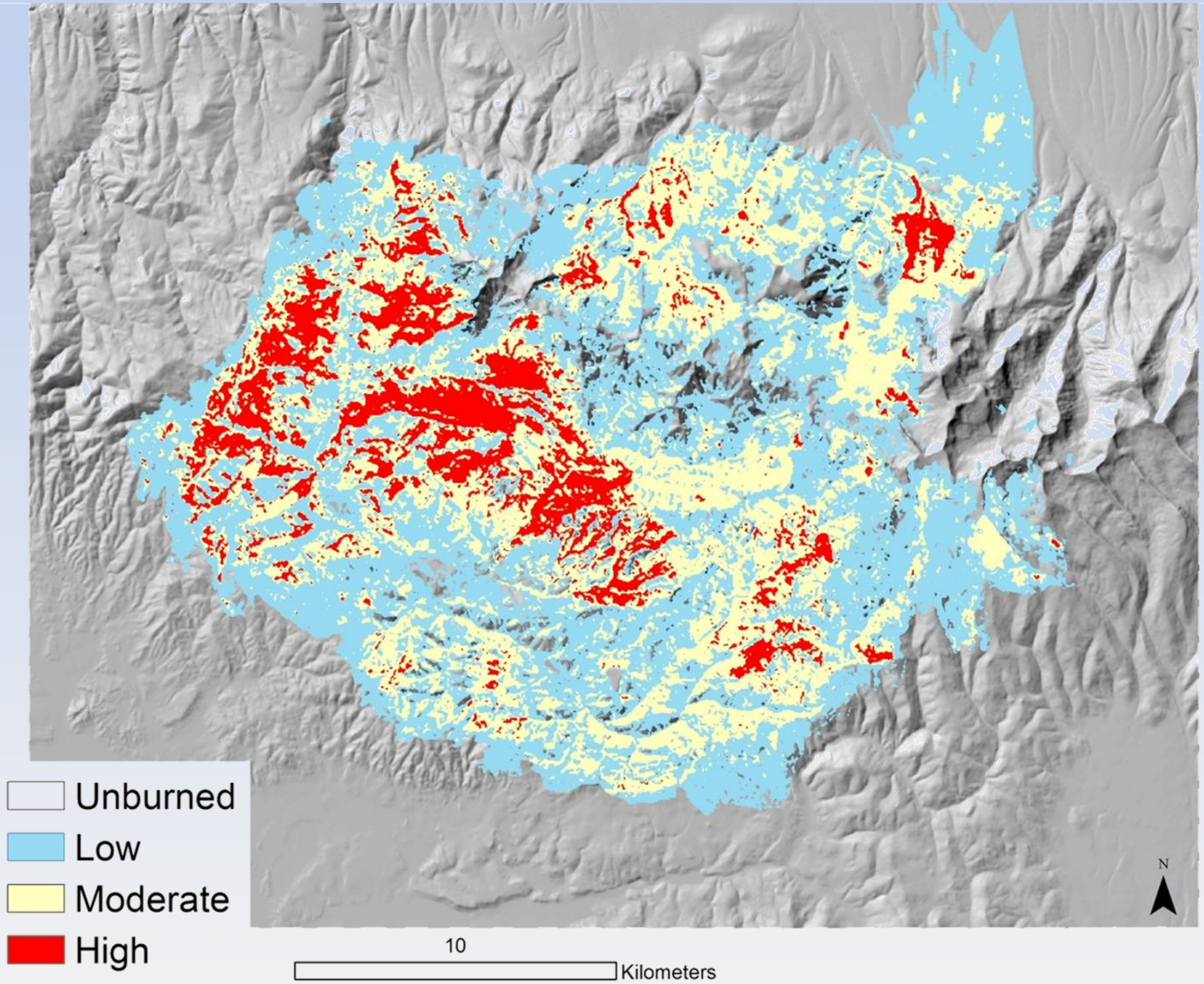
Moderate burn severity - 55% cover

High burn severity - 20% cover

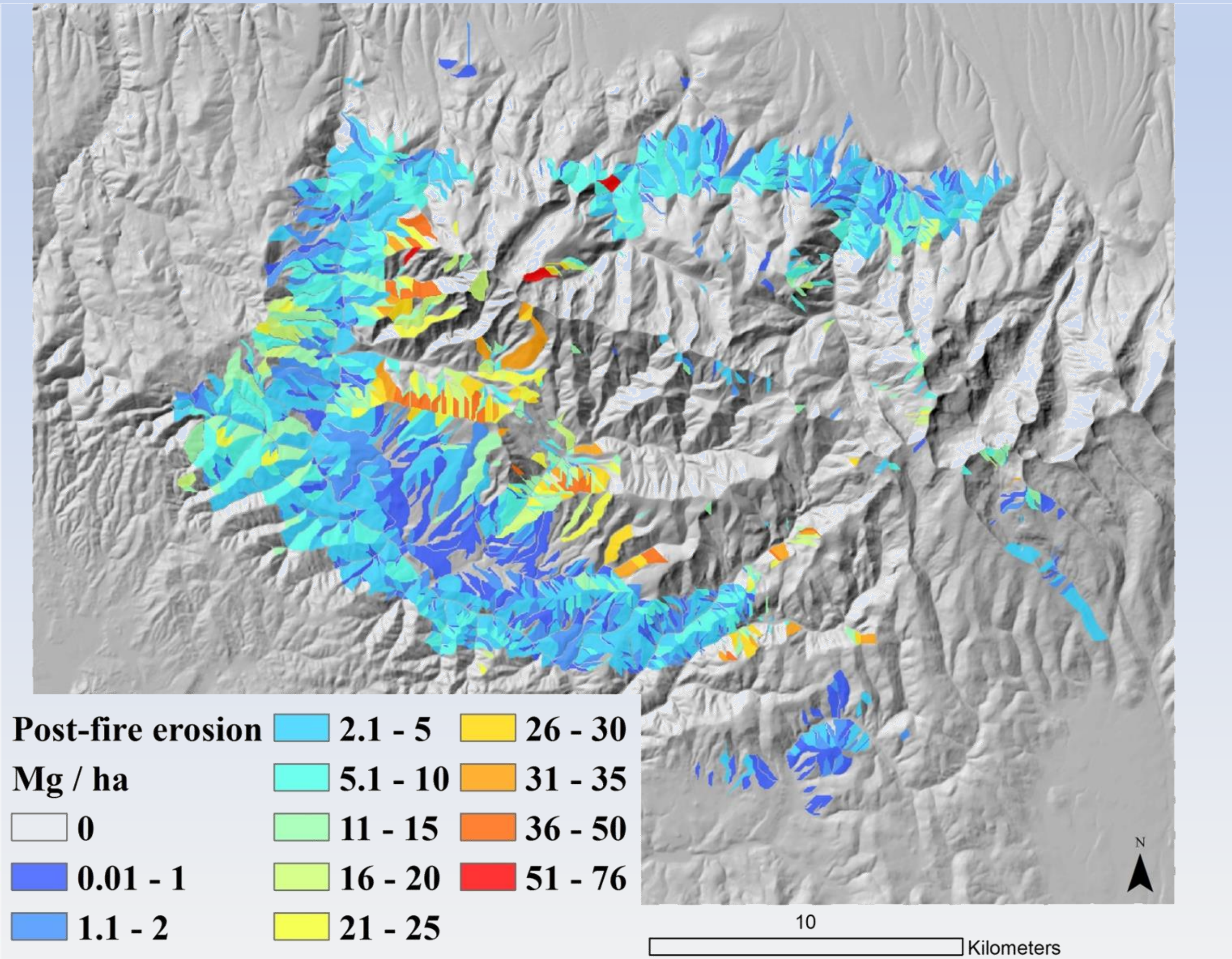
Mulch – 80% cover

Precipitation: 2.5 inches in 6 hrs with a peak intensity 1.25 in/hr, and a time to peak of 0.3 of the duration

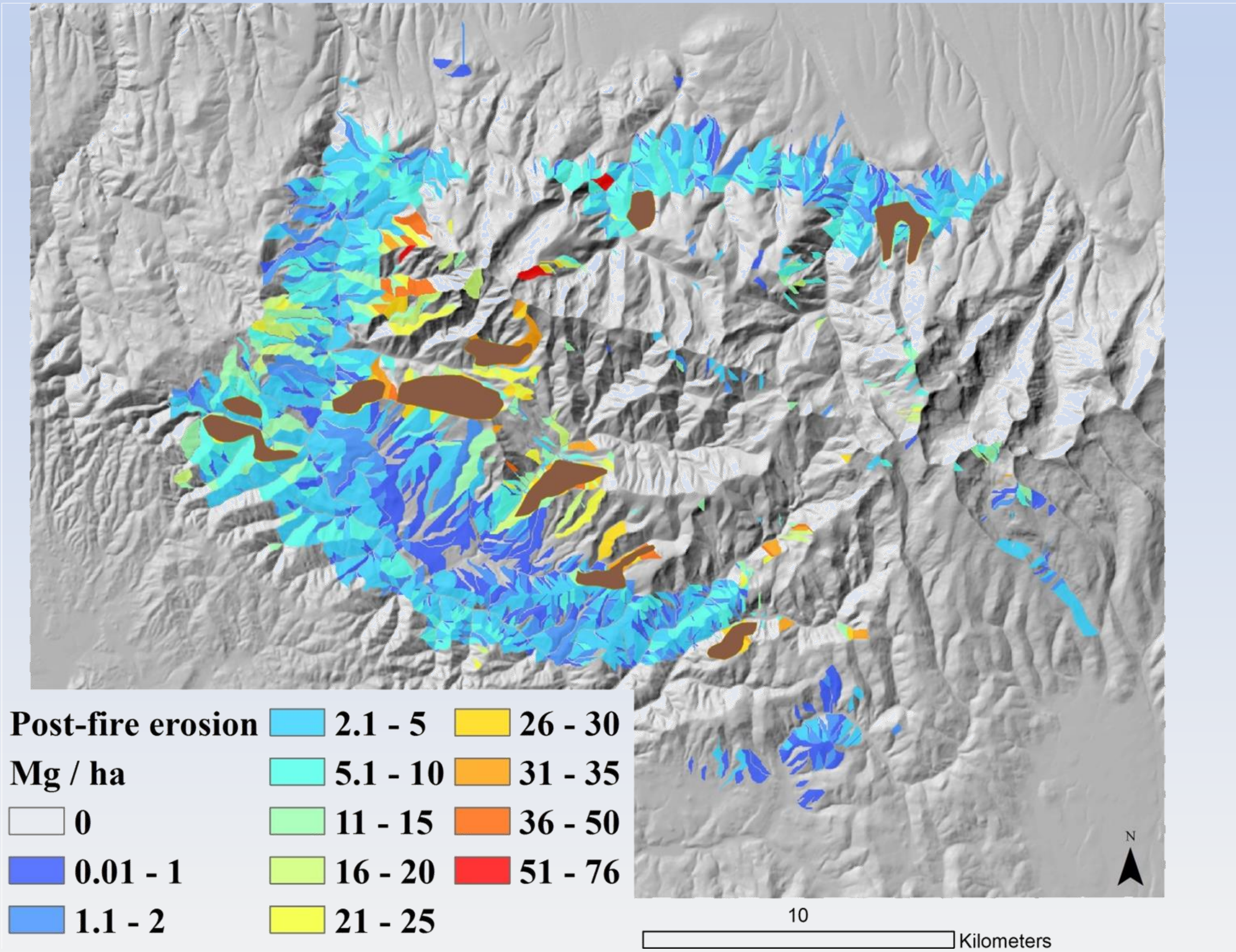
Canyon Creek Soil Burn Severity Map



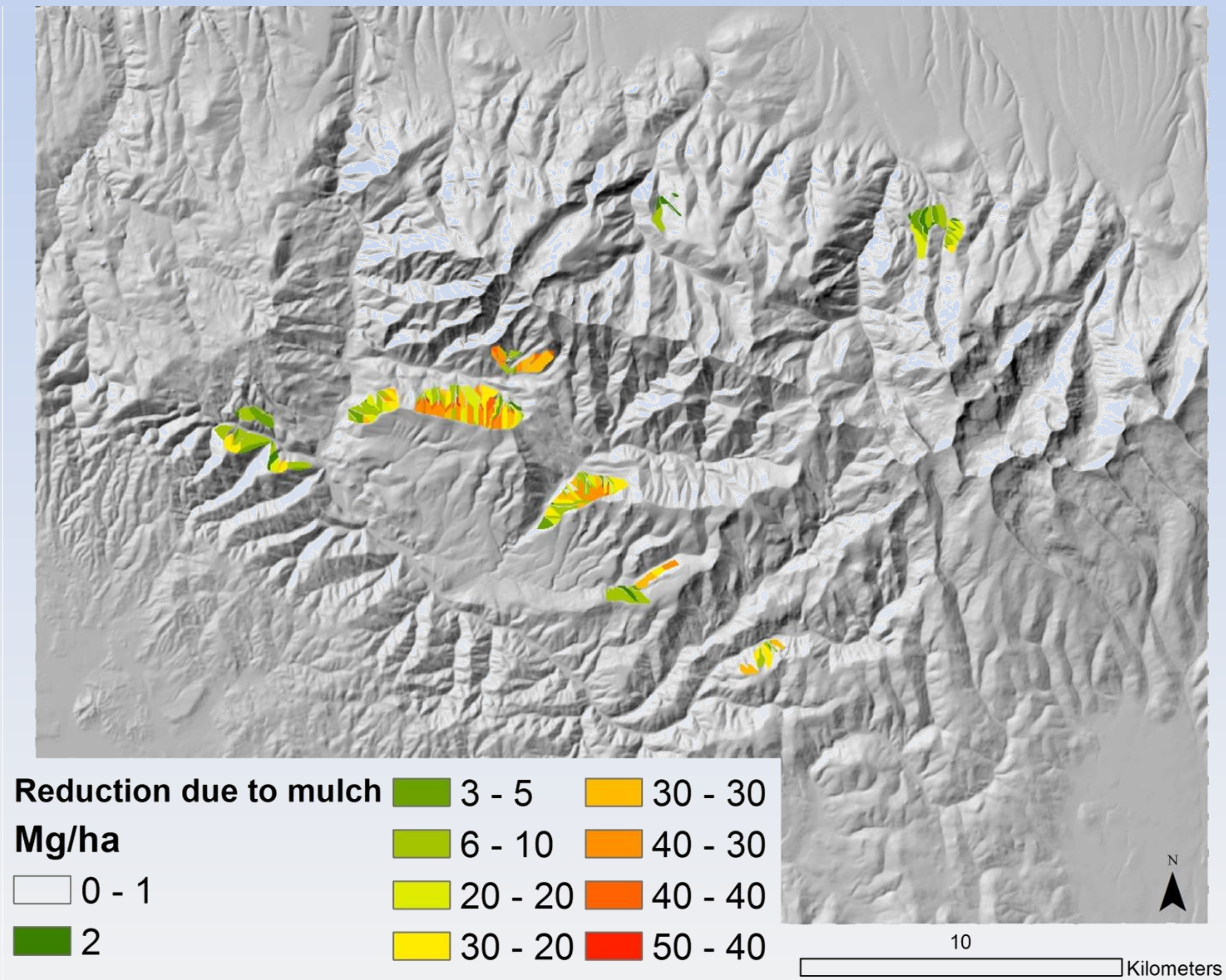
Canyon Creek – single storm event



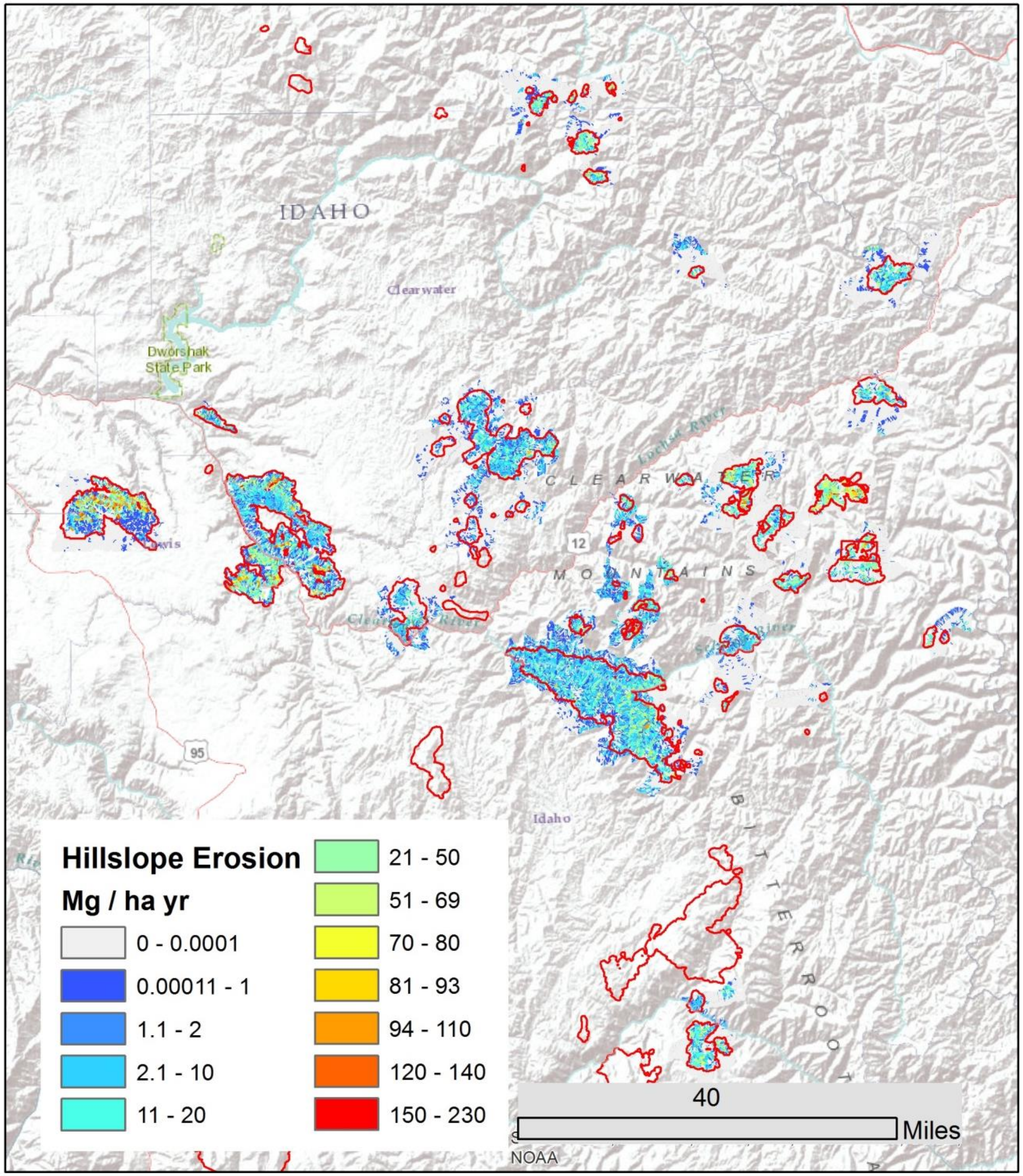
Canyon Creek – mulch treatments



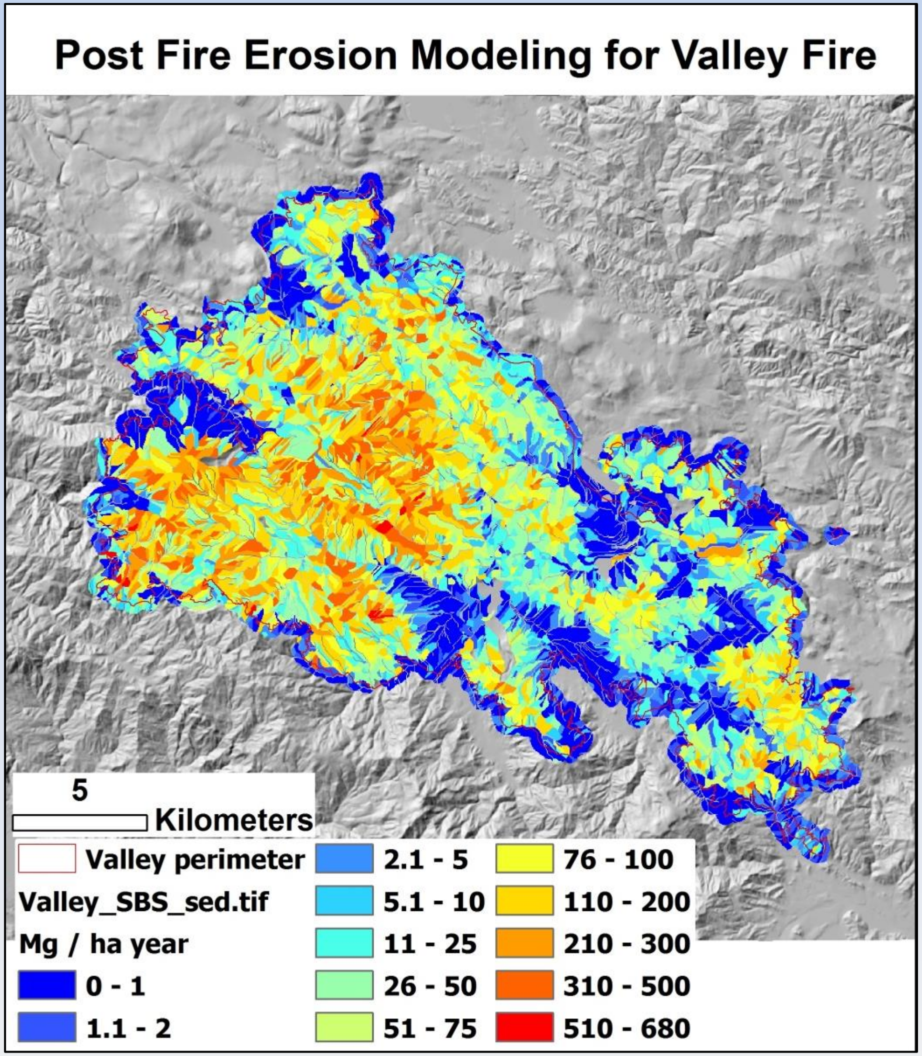
Canyon Creek – predicted reduction in erosion due to proposed mulching

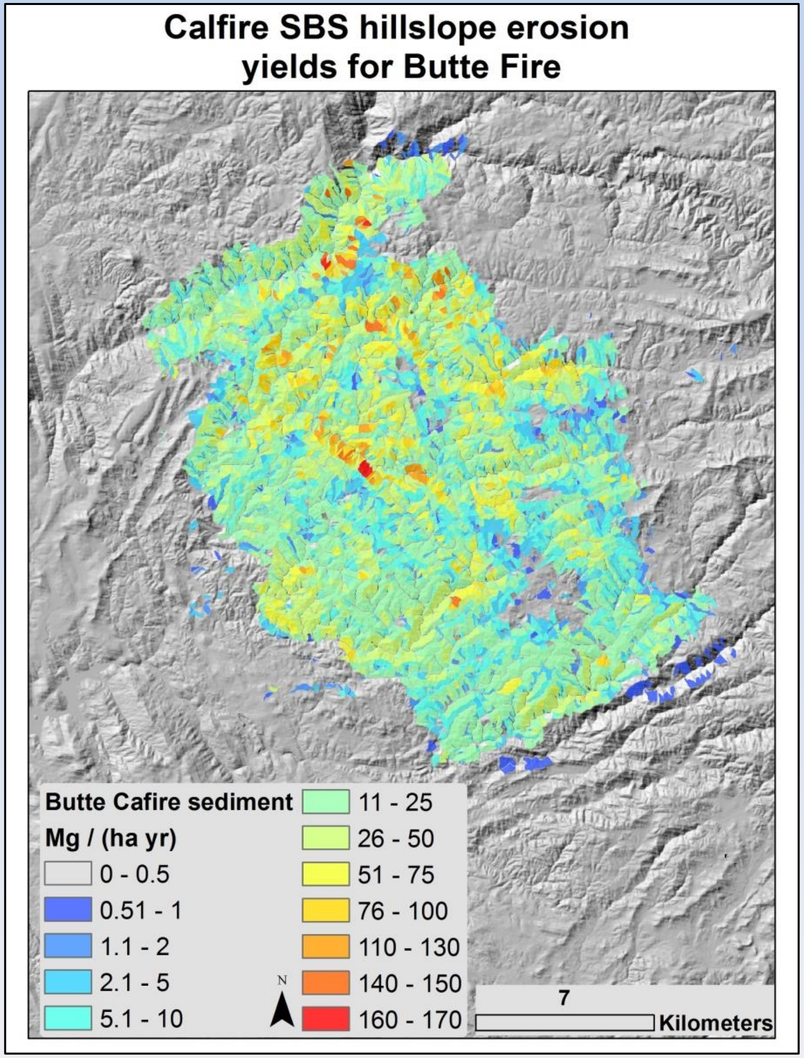


Clearwater ID Fires



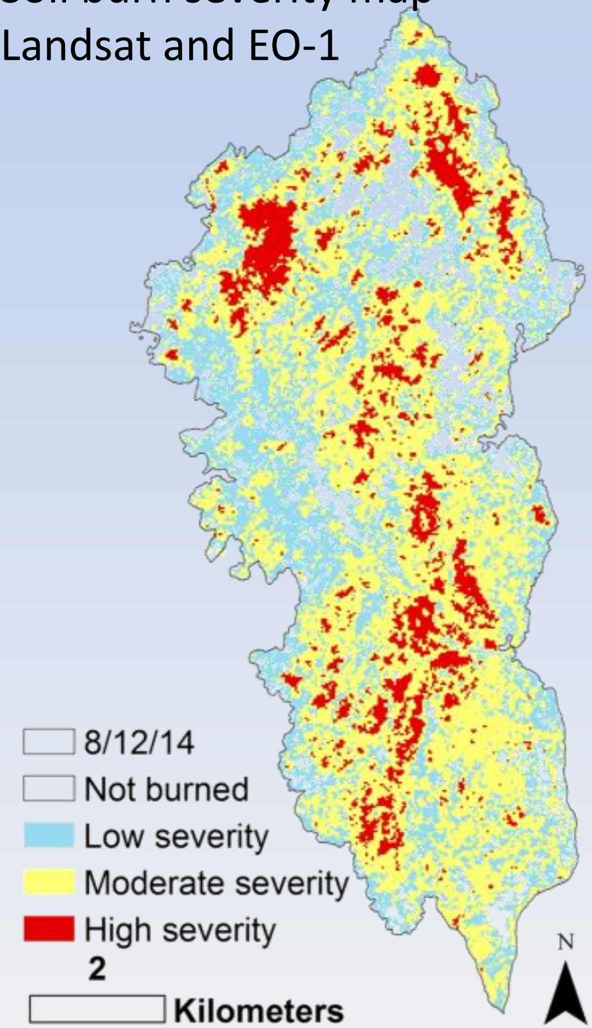
Valley & Butte Fires in California

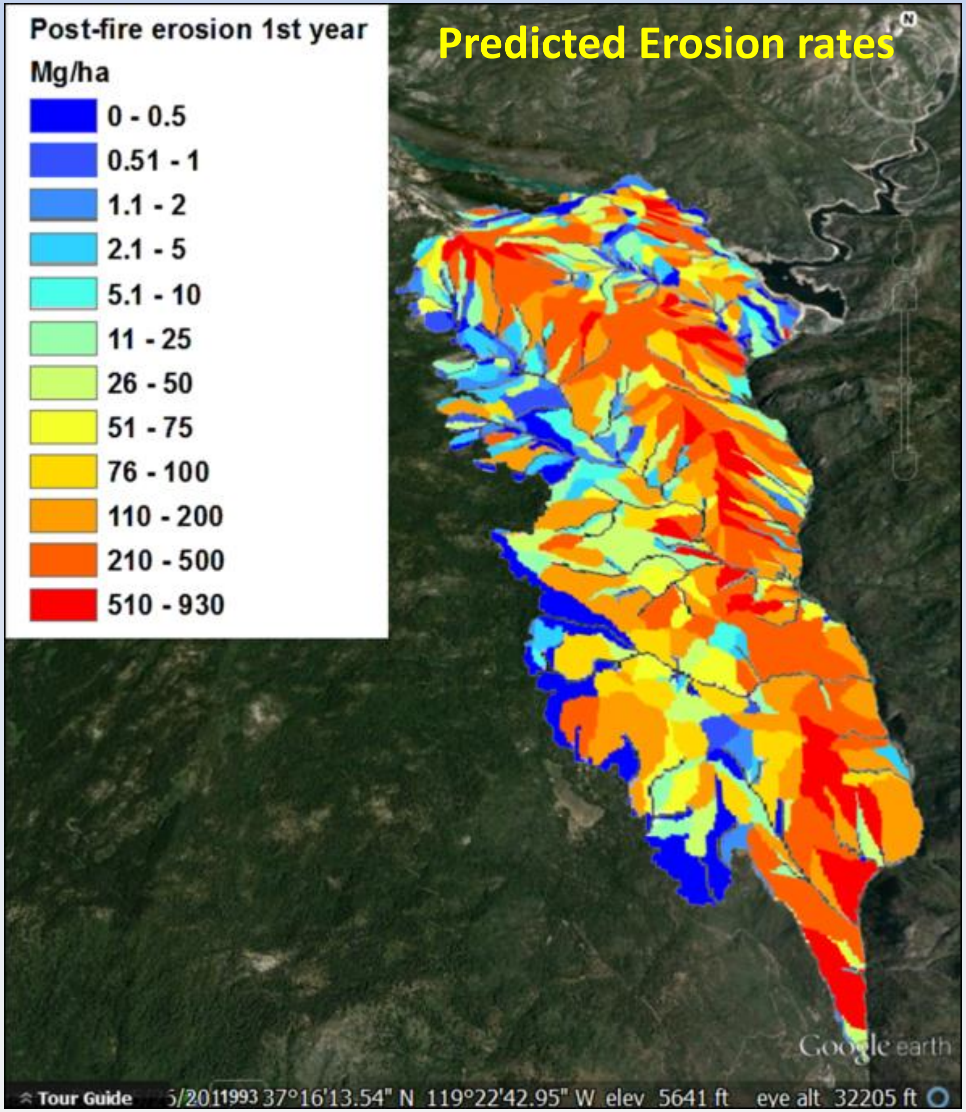




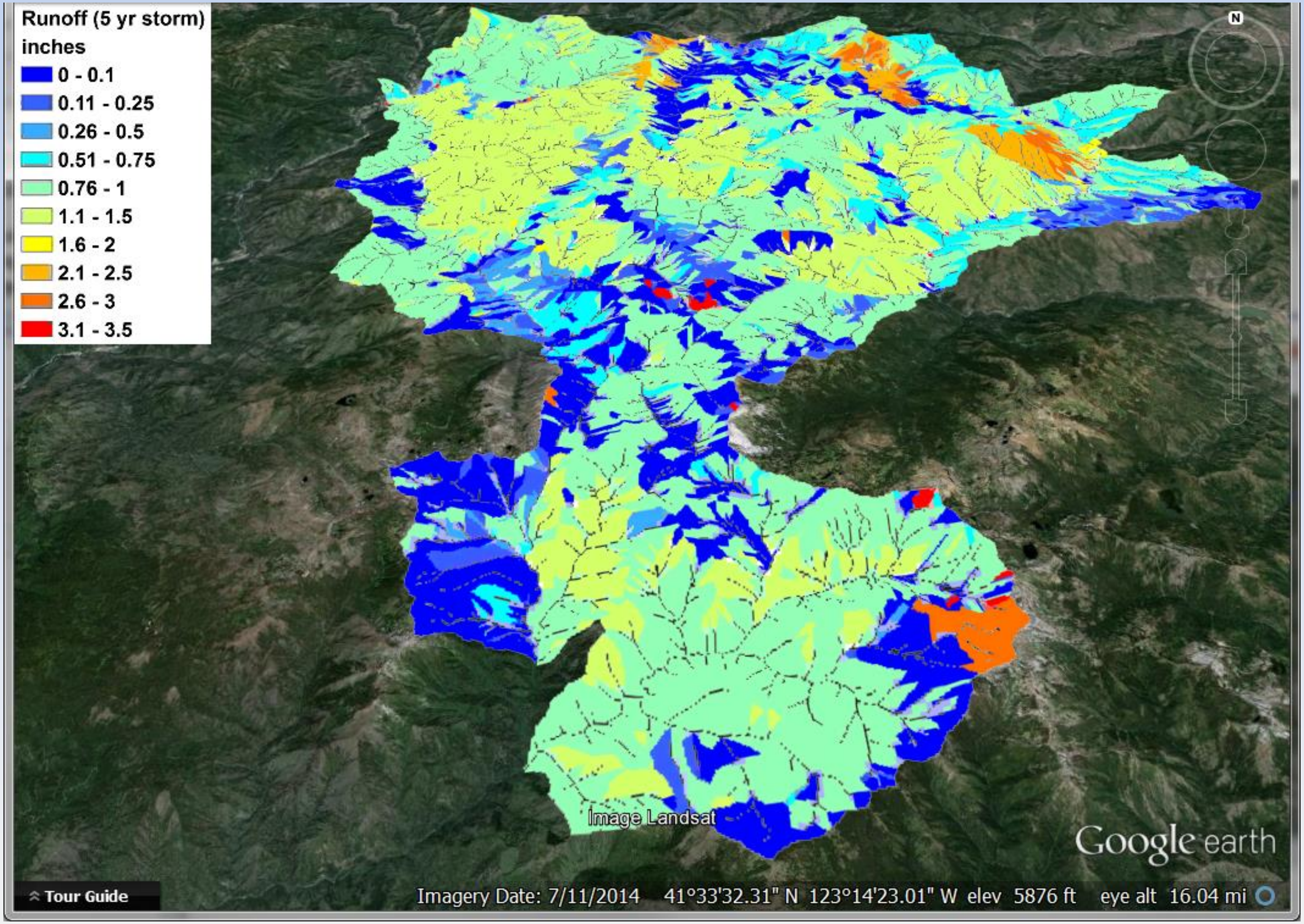
French Fire (5,600 ha)

Soil burn severity map
Landsat and EO-1



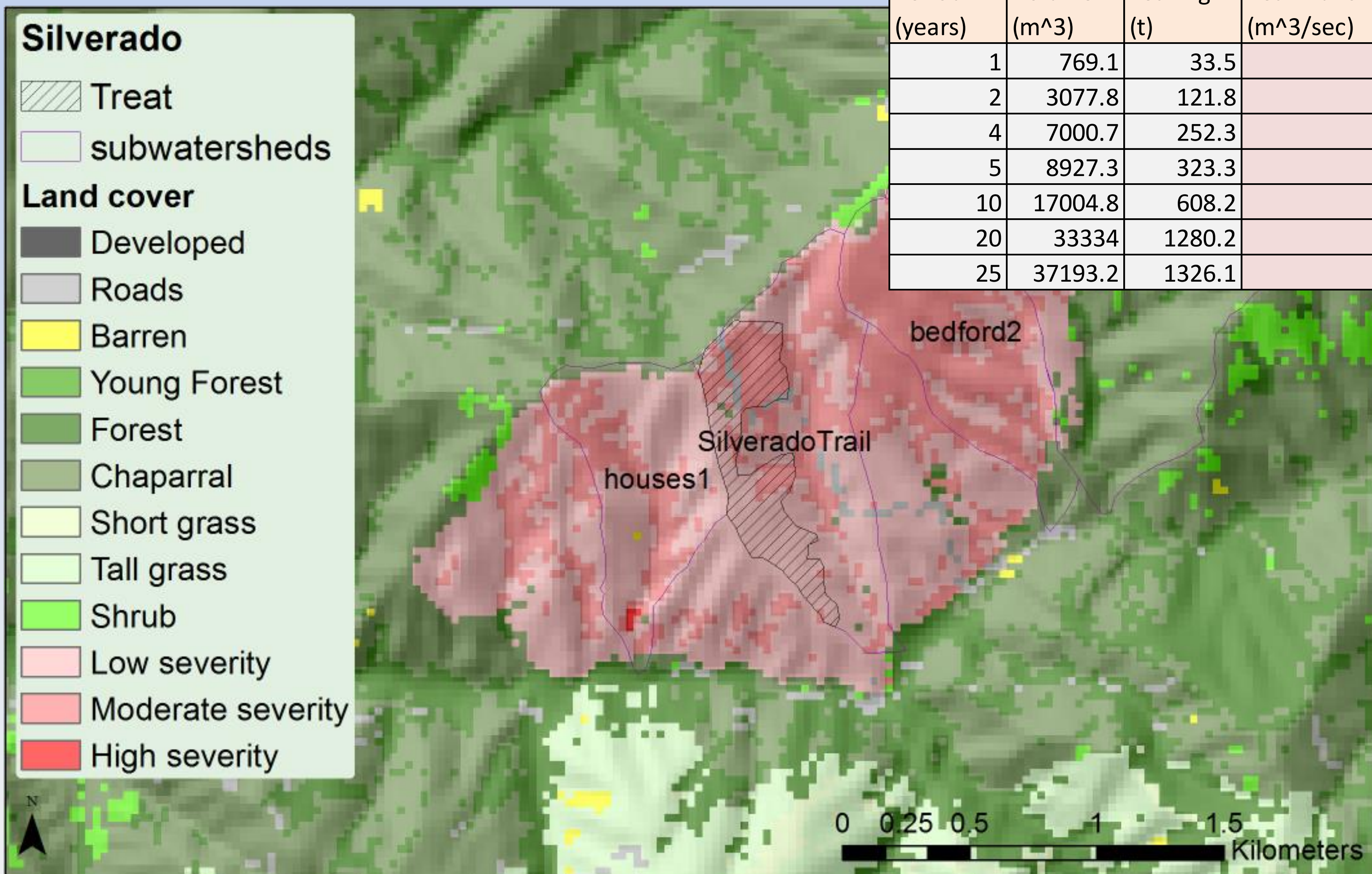


Happy Camp (54,200 ha)

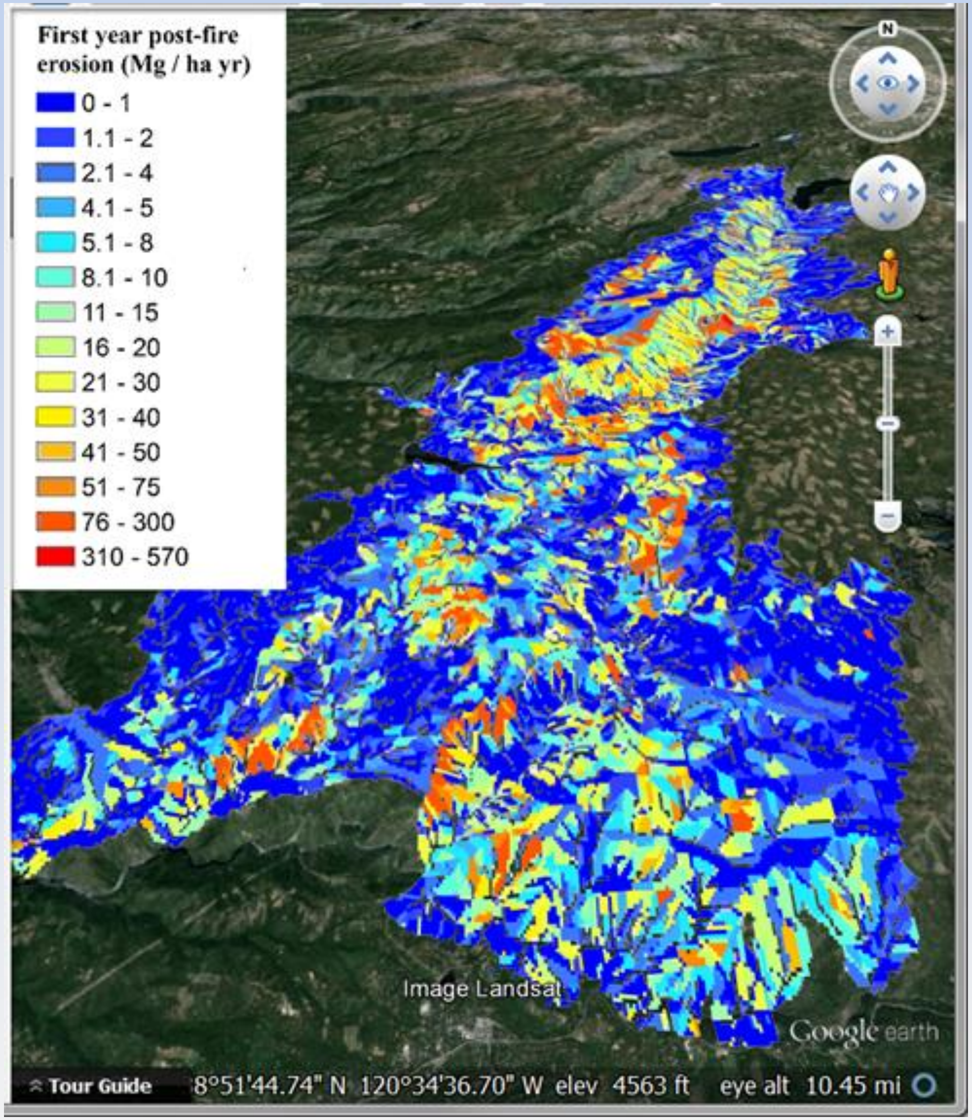


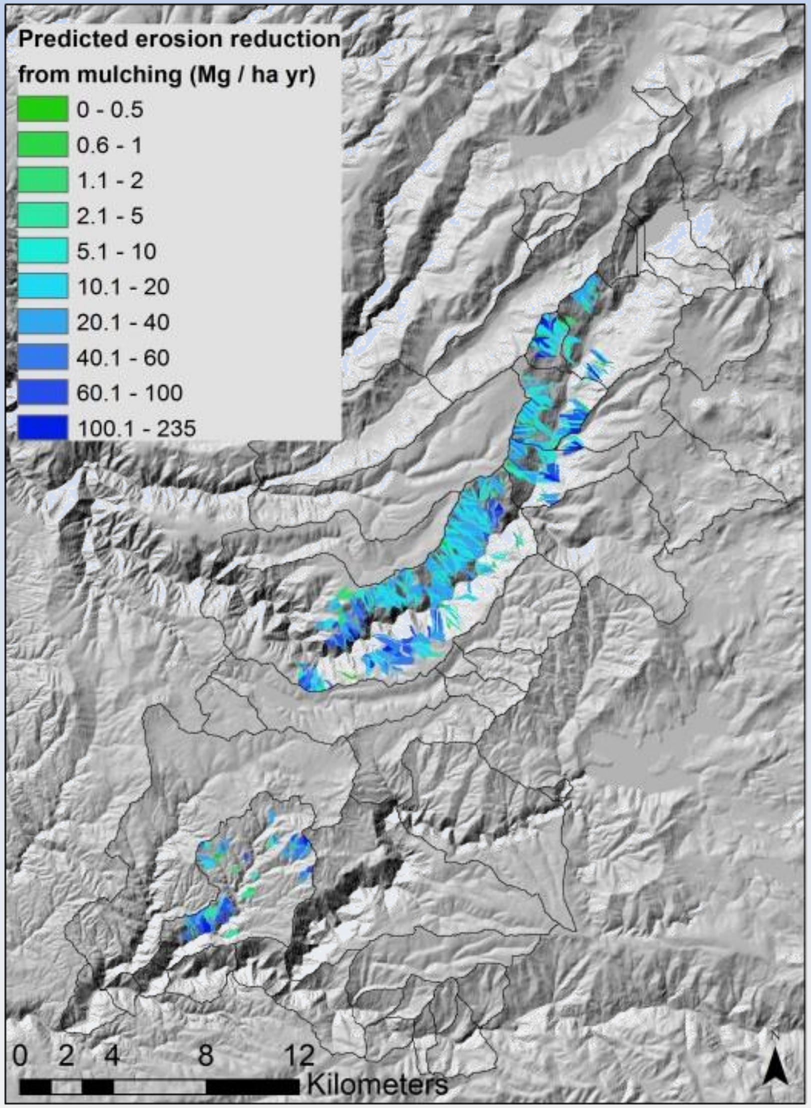
Silverado Fire (390 ha)

Return Period (years)	Runoff Volume (m^3)	Sediment Leaving (t)	Peak Runoff Rate (m^3/sec)	Daily Precipitation (mm)
1	769.1	33.5	0.4	46.1
2	3077.8	121.8	1.5	57.9
4	7000.7	252.3	3.1	68.9
5	8927.3	323.3	3.8	72
10	17004.8	608.2	6.8	92.5
20	33334	1280.2	12.5	104.7
25	37193.2	1326.1	13.8	110.8



King Fire (39,500 ha)





Field data sheet

Appendix B—Soil Burn Severity Field Data Sheet and Key

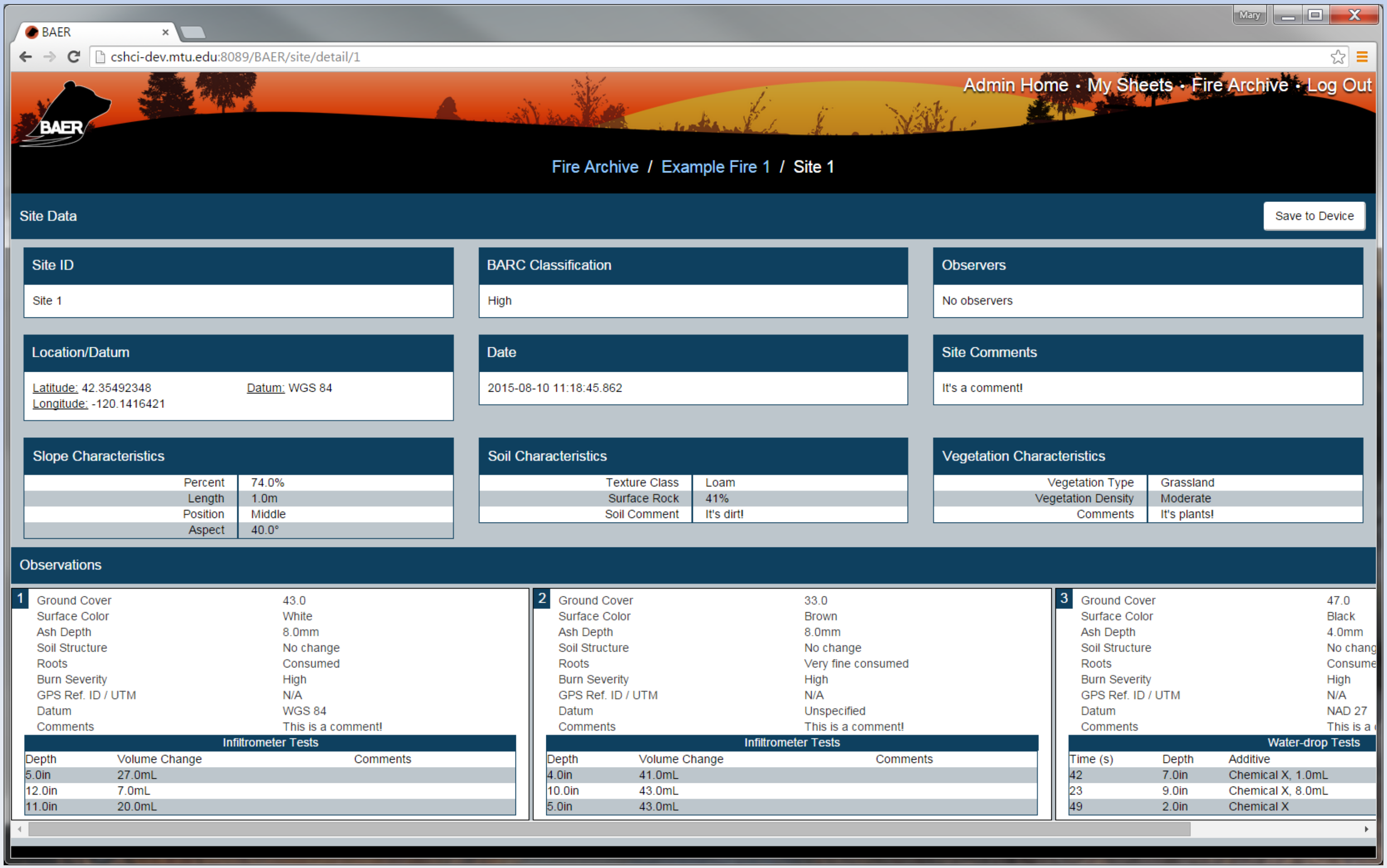
Soil Burn Severity Assessment Field Data Sheet		**Fire name:**	**Observers:**
Date:	**Site ID:**	**GPS coordinates:**	**BARC classification:**

Observation point	Ground cover (1)	Surface color and ash depth (2)	Soil structure (3)	Roots (4)	Soil water repellency (5)			Observed soil burn severity class (6)	Photo #	Other comments
EXAMPLE	*20 to 50%*	*white, 1 mm*	*no change*	*intact*	*I*	*3 mL*	*surf*	*Mod*	*23*	*homogenous*
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
Average/majority for site (7)										

Site characteristics:	Aspect (deg):		Slope %:				
Slope length (ft or m):	Slope position:	Lower	Middle	Upper	Ridge	Other	

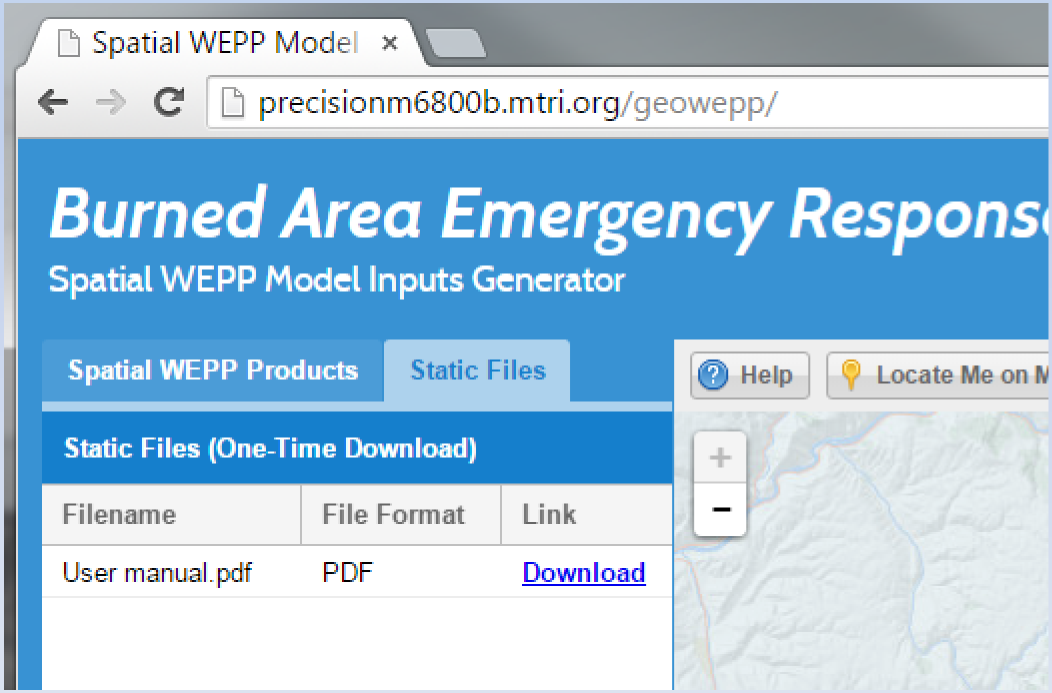
Soil texture class: clay loam, silt loam, loam	**Dominant pre-fire vegetation type**	**Pre-fire vegetation density**	**Vegetation comments:**	**Other notes:**
Surface rock %:	Chaparral	Low		
Soil comments:	Forest	High		
	Sagebrush/grassland	Other		
	Other			

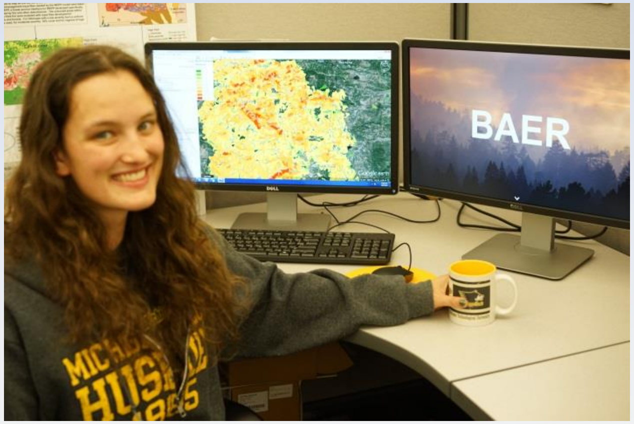
Field App for BAER Teams



Enable Modelers

- **Training Manual available!**
- Training webinar this winter
- MTRI's NASA BAER team is ready to help with modeling

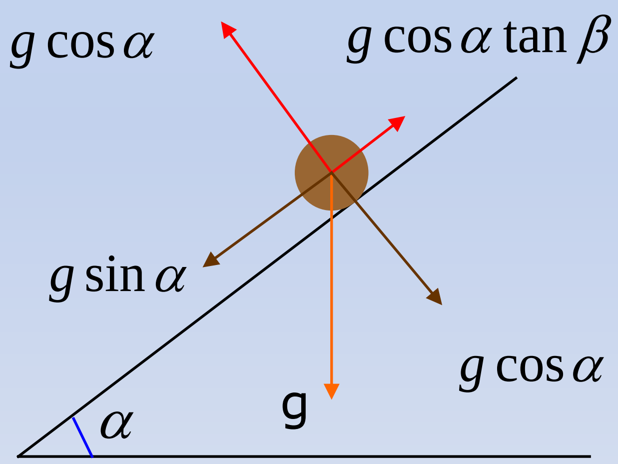


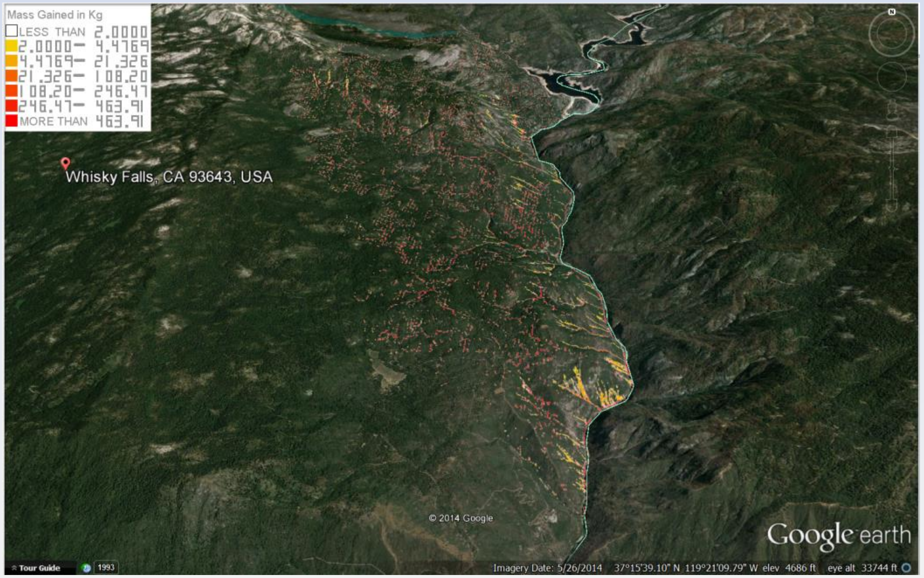


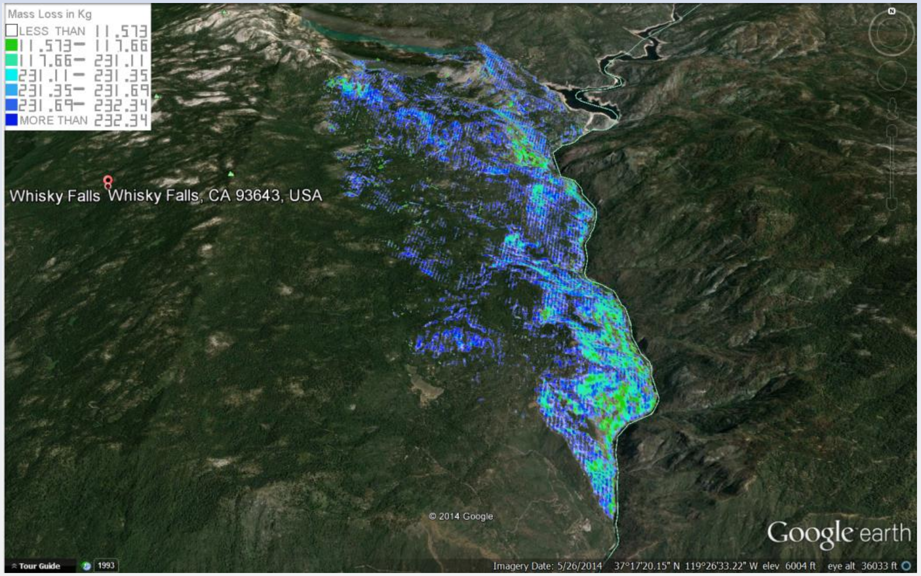
Ravel RAT
Ravel Risk Assessment Tool

Dry Ravel Inputs:

- DEM - 10 Meter Digital Elevation Map.
- Burn Severity Map
- Parameter file
  - Mean stem diameter of vegetation (0.05 m)
  - Vegetation density (1 plant/m^2)
  - Burn Depths
  - Bulk density of soil (1300 kg/m^3)
  - Static friction angle \ angle od repose (34°)
  - Kinetic friction angle (31.1°)

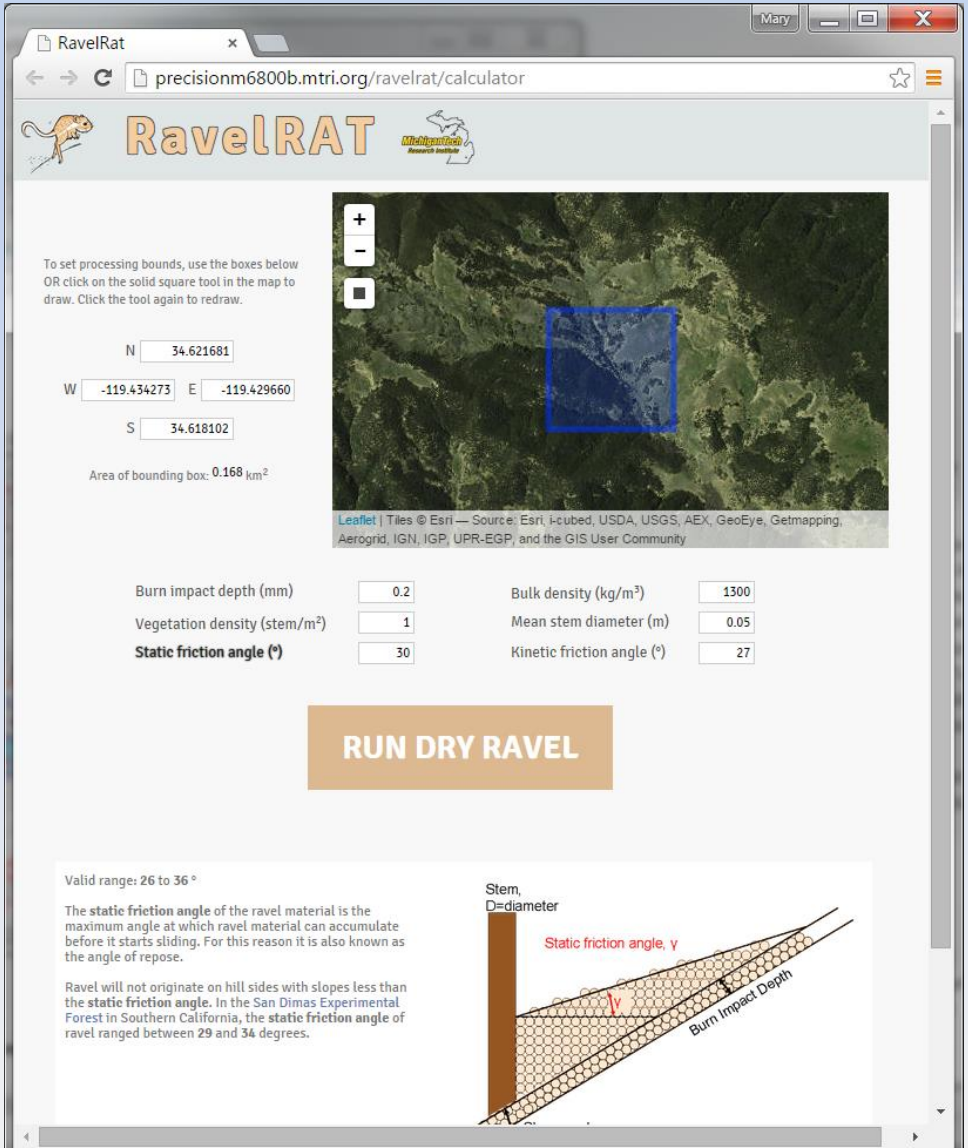






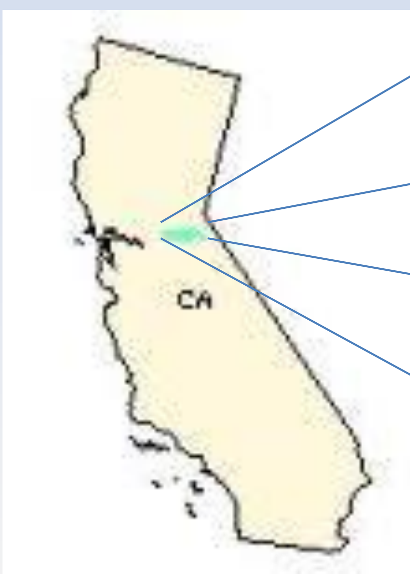
Ravel RAT

Ravel Risk Assessment Tool



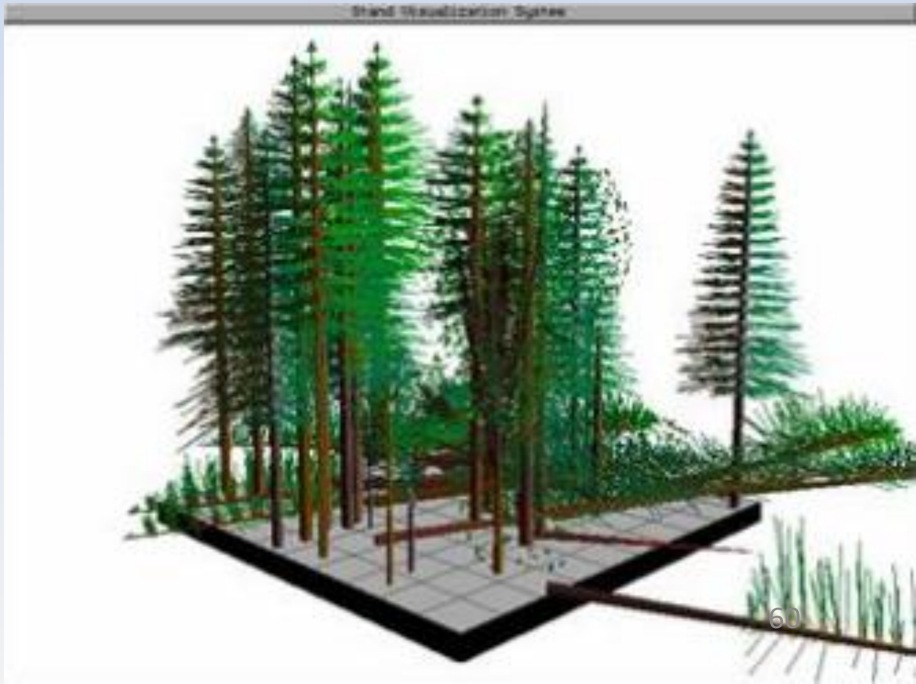
RRED for fuel planning

- Mokelumne Watershed in the Sierra Mountains in central California
  - 5500 km^2
  - Vegetation: oak savannah to evergreen forest
  - 800-1430 m elev.



Key Question

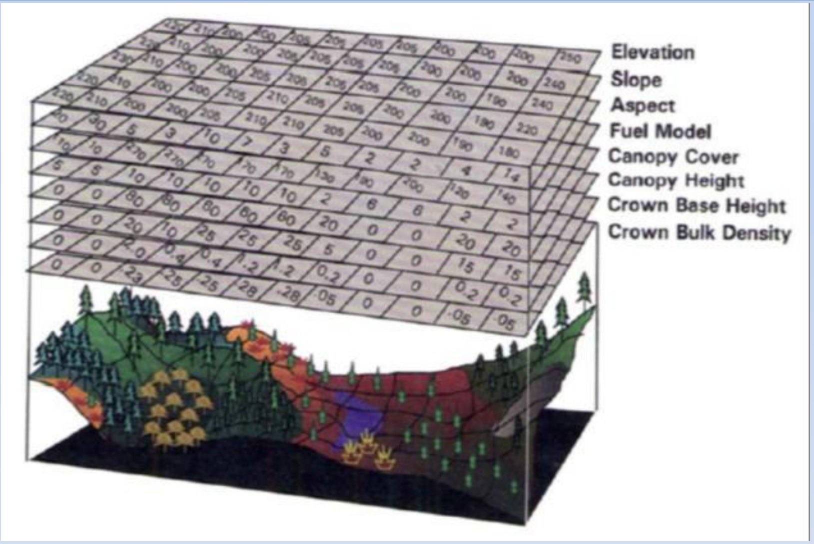
- How can we
  – quantify the benefits of fuels treatments, and
  – use those benefits to pay for fuels treatments;
  – thereby reducing the risk of wildfires and associated loss of environmental services?



Approach

- Determine hillslope-scale sediment production for:
  - Current conditions in the absence of fire;
  - After a fire assuming current fuel conditions;
  - After fuel treatments;
  - After a fire following treatments;
- Need to use three models:
  - **FLAMMAP** to predict fire severity
  - **FSIM** to predict fire probability
  - **WEPP Watershed** to predict erosion

FLAMMAP Fire Spread Model



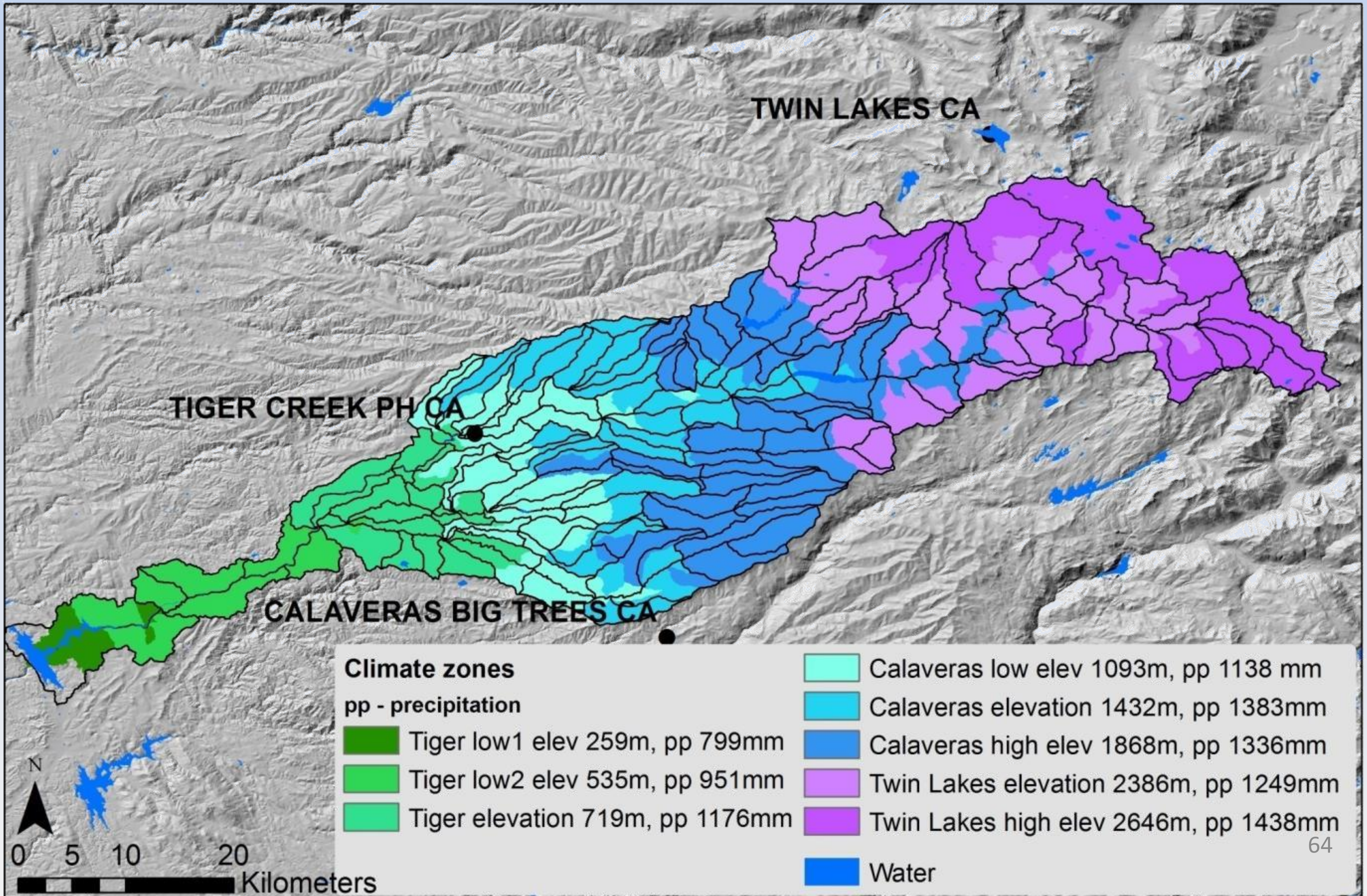
- Main inputs:
  - Forest structure/fuels
  - Fuel moisture
  - Slope aspect and steepness
  - Average wind direction
- Key outputs for each grid cell (typically 90-m):
  - Flamelength (ft)
  - Mean fire line intensity (W m^{-2} or W per unit length)

WEPP (**W**ater **E**rosion **P**rediction **P**roject) Watershed Erosion Model

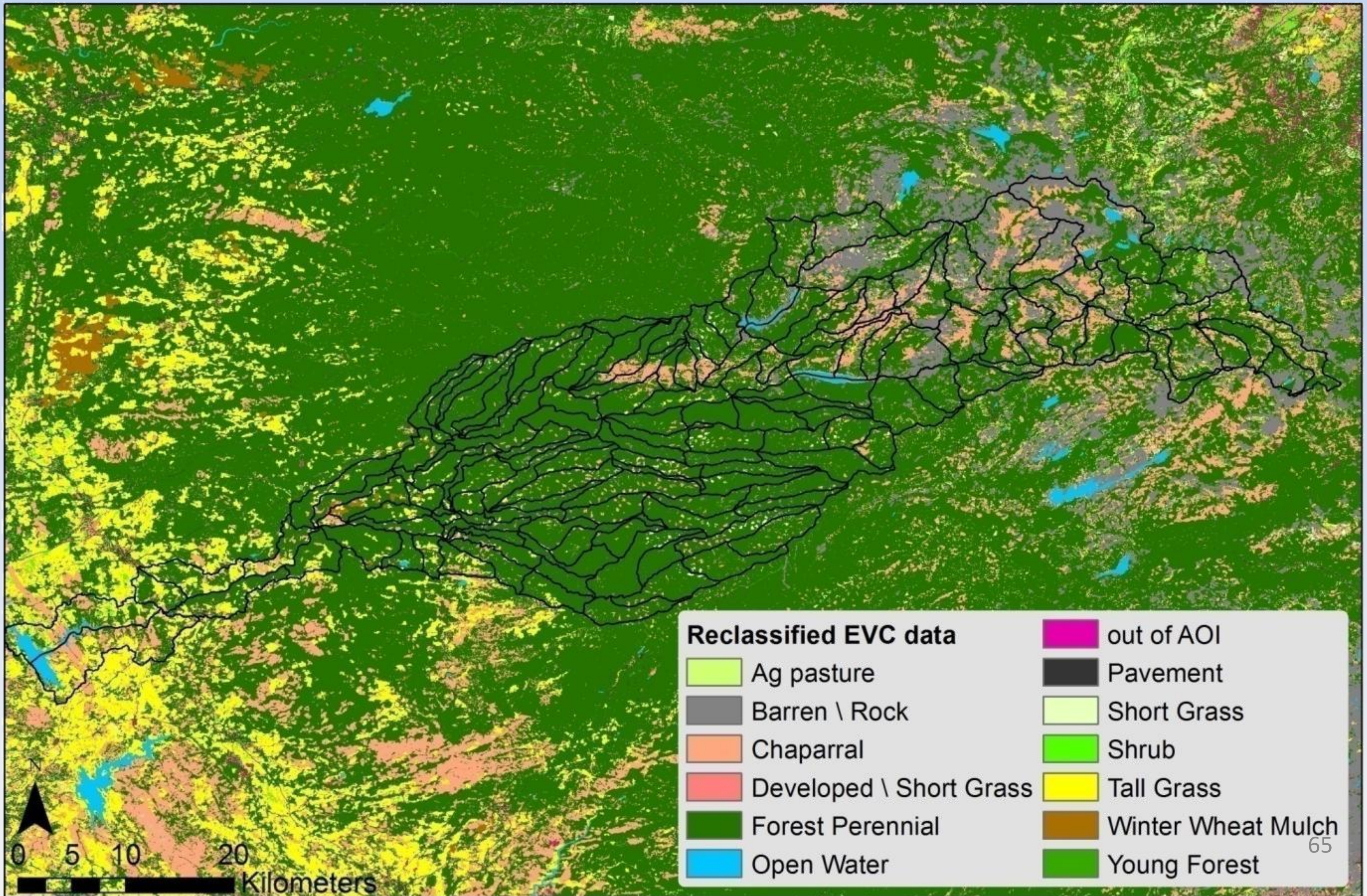
- Main inputs:
  - Stochastic climate (50 years)
  - Topography (typically from 30-m DEM)
  - Soil properties (texture, % rock, and burn severity)
  - Ground cover (linked to land cover & fire severity)
- Main output:
  - Sediment production by hillslope polygon (~6 ha for this study)

Klamath Complex Fire, California

Weather stations used to generate climate statistics, and spatially distributed using PRISM



Land cover: Existing vegetation cover map was simplified to the categories in WEPP



Output and Input: Flame length predictions reclassified to burn severity

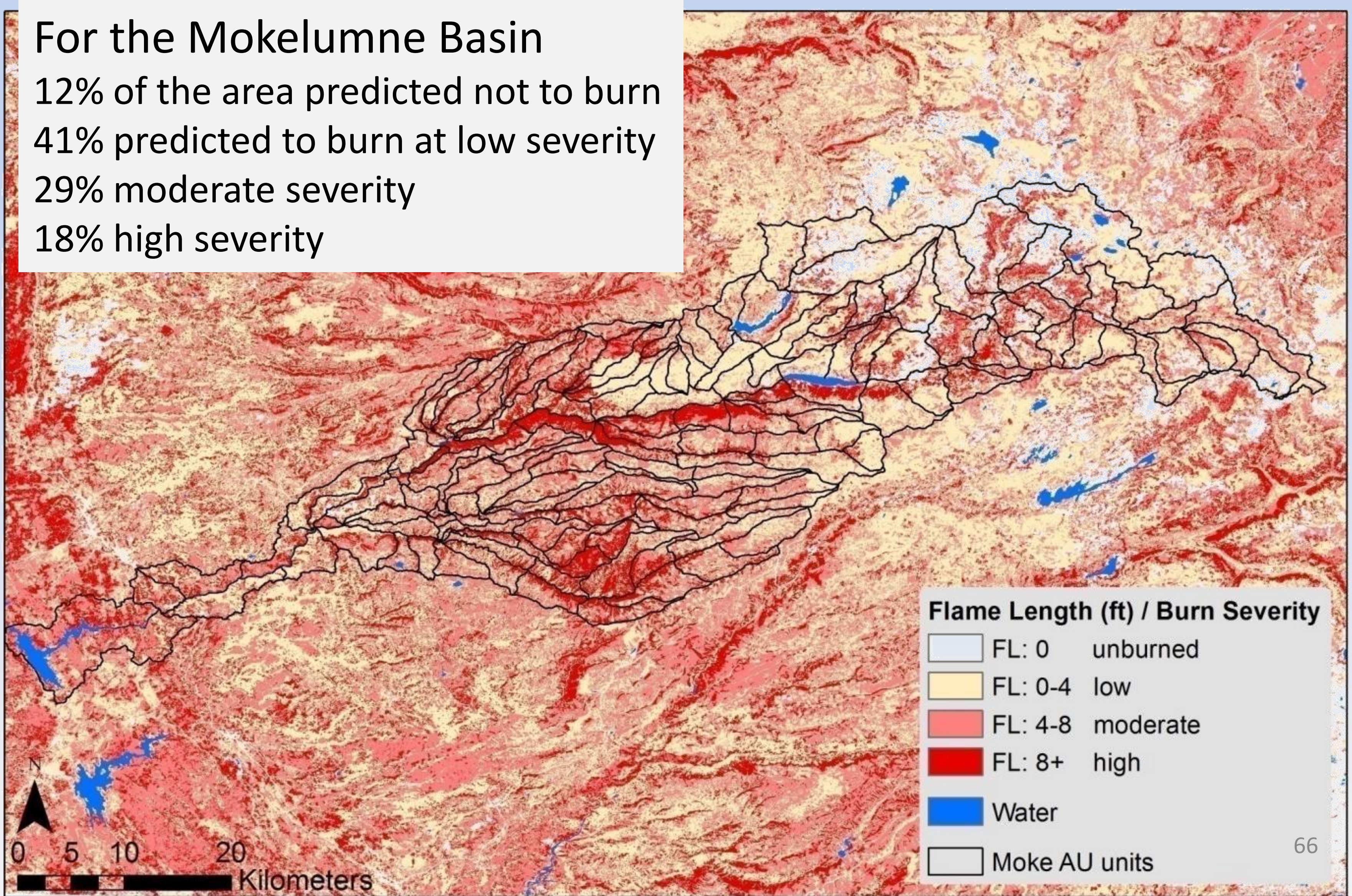
For the Mokelumne Basin

12% of the area predicted not to burn

41% predicted to burn at low severity

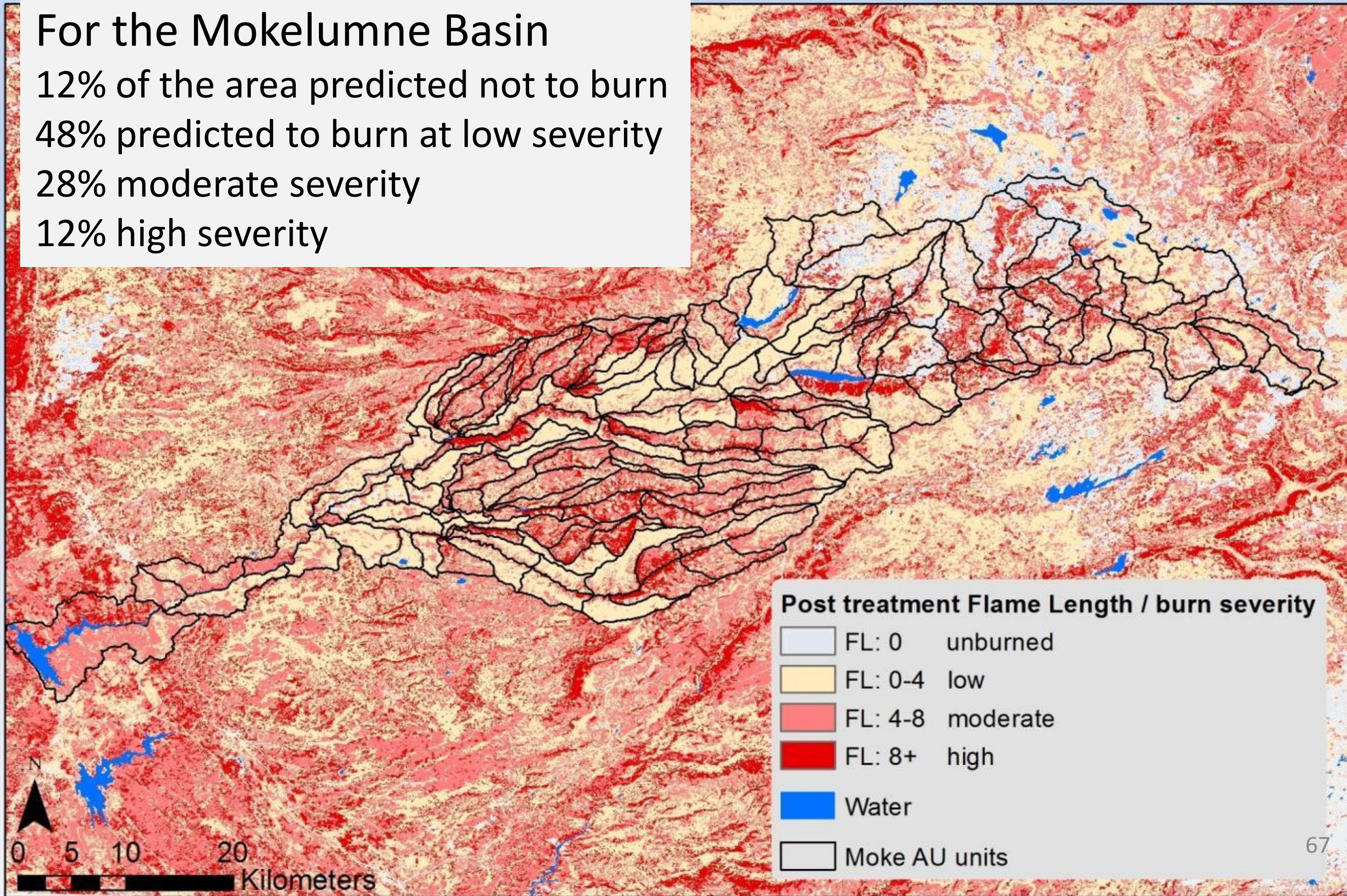
29% moderate severity

18% high severity

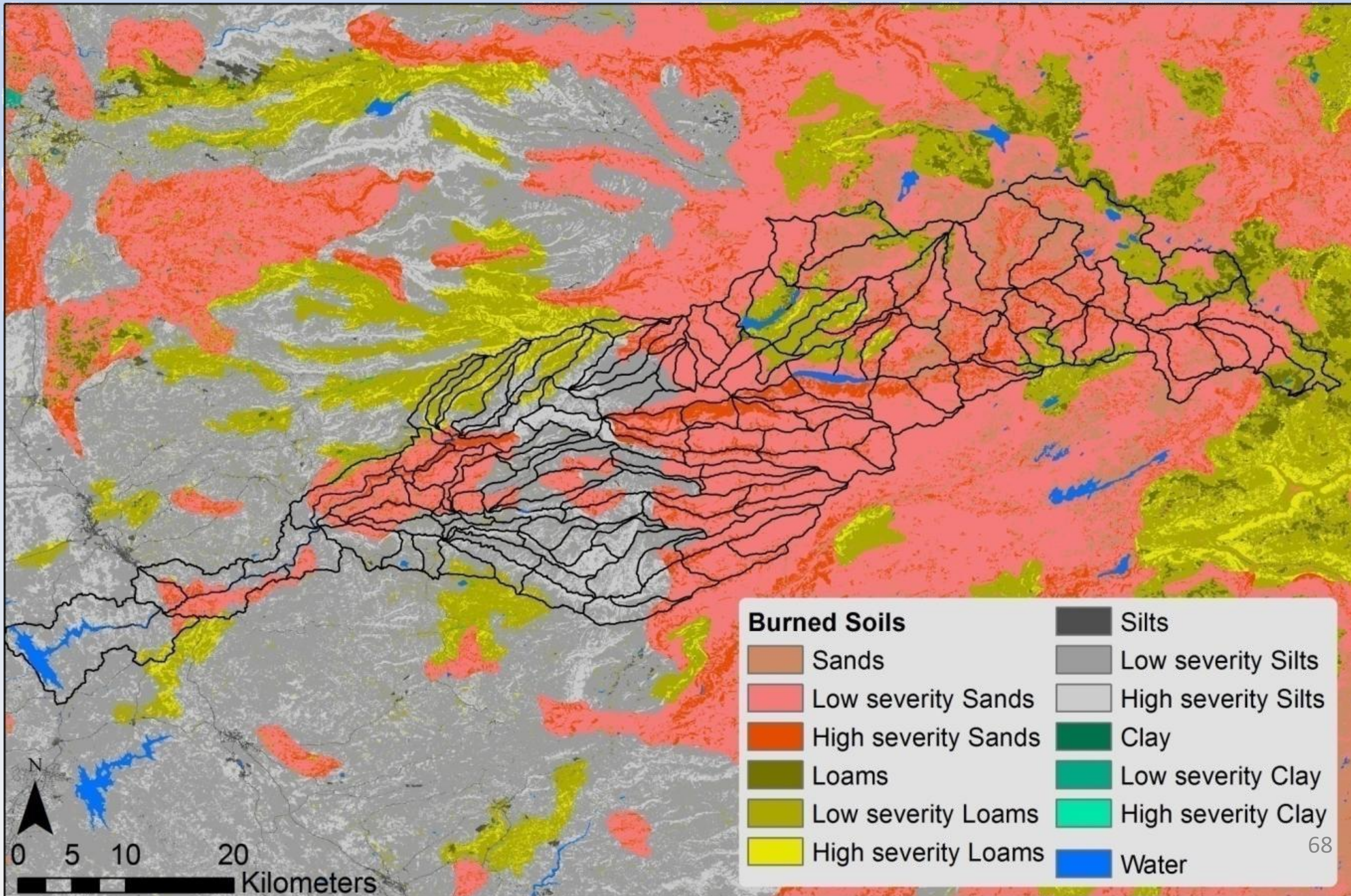


Burn Severity Map post treatment

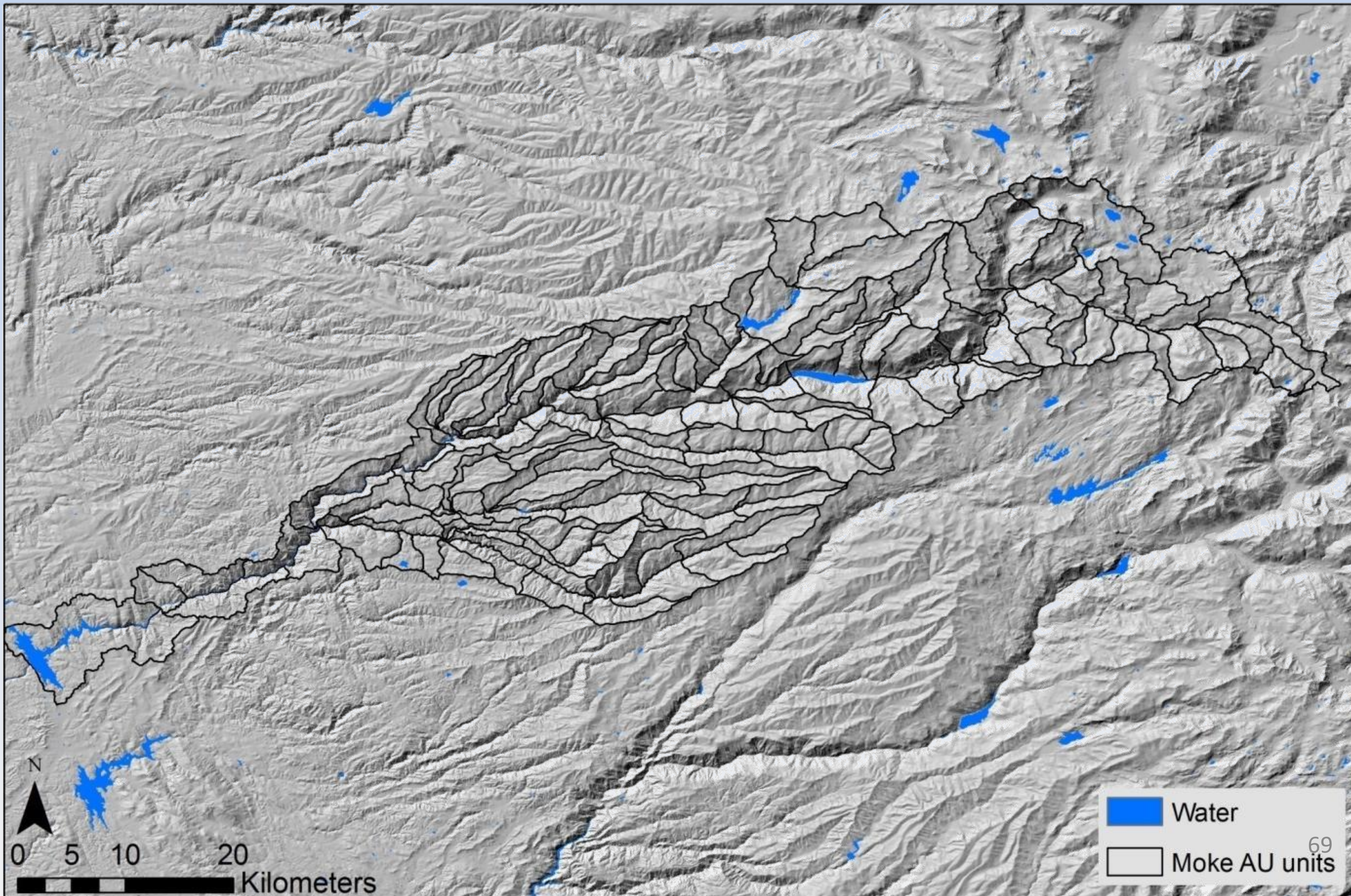
For the Mokelumne Basin
12% of the area predicted not to burn
48% predicted to burn at low severity
28% moderate severity
12% high severity



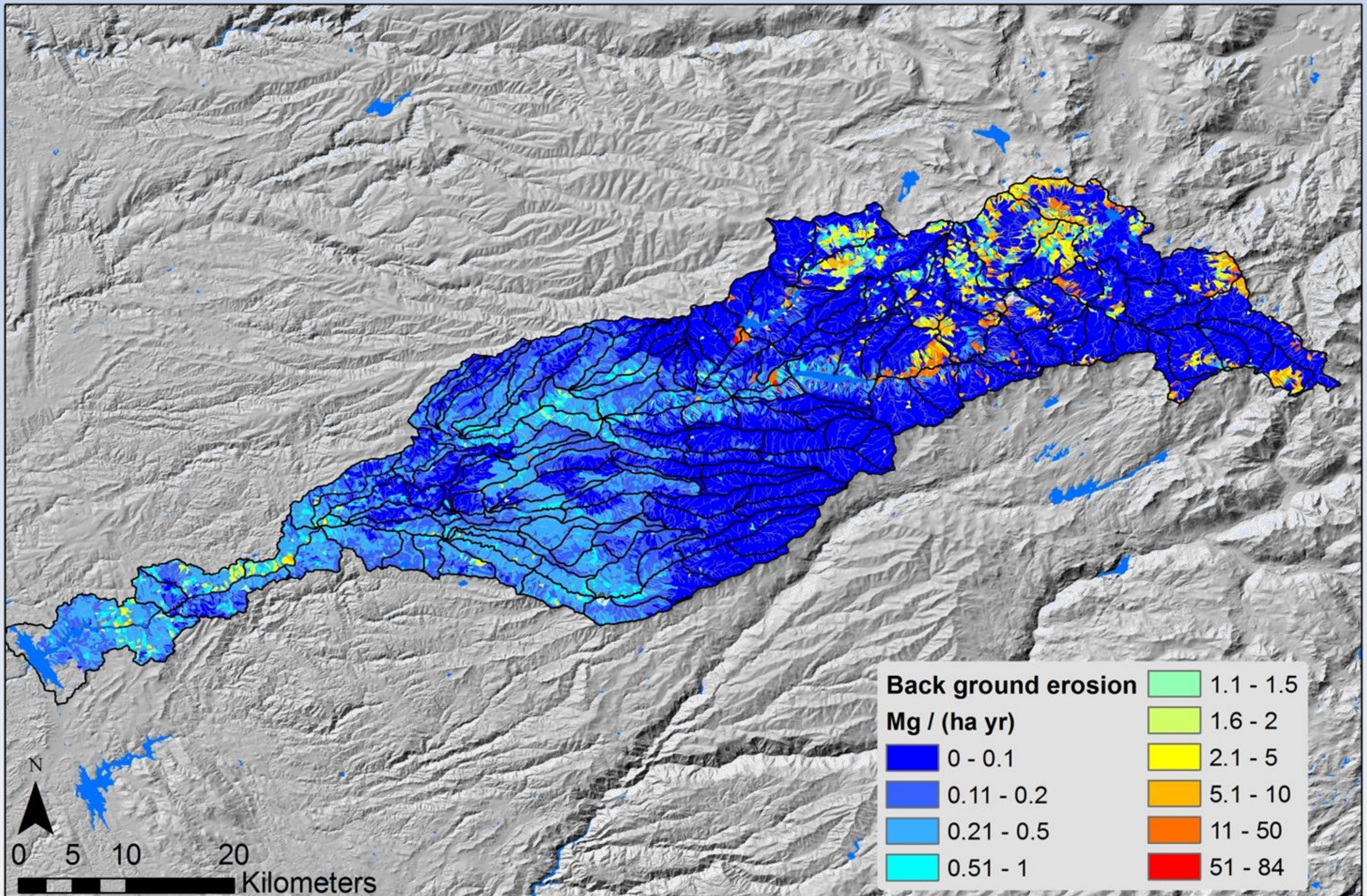
Inputs: Soils modified by burn severity and land cover



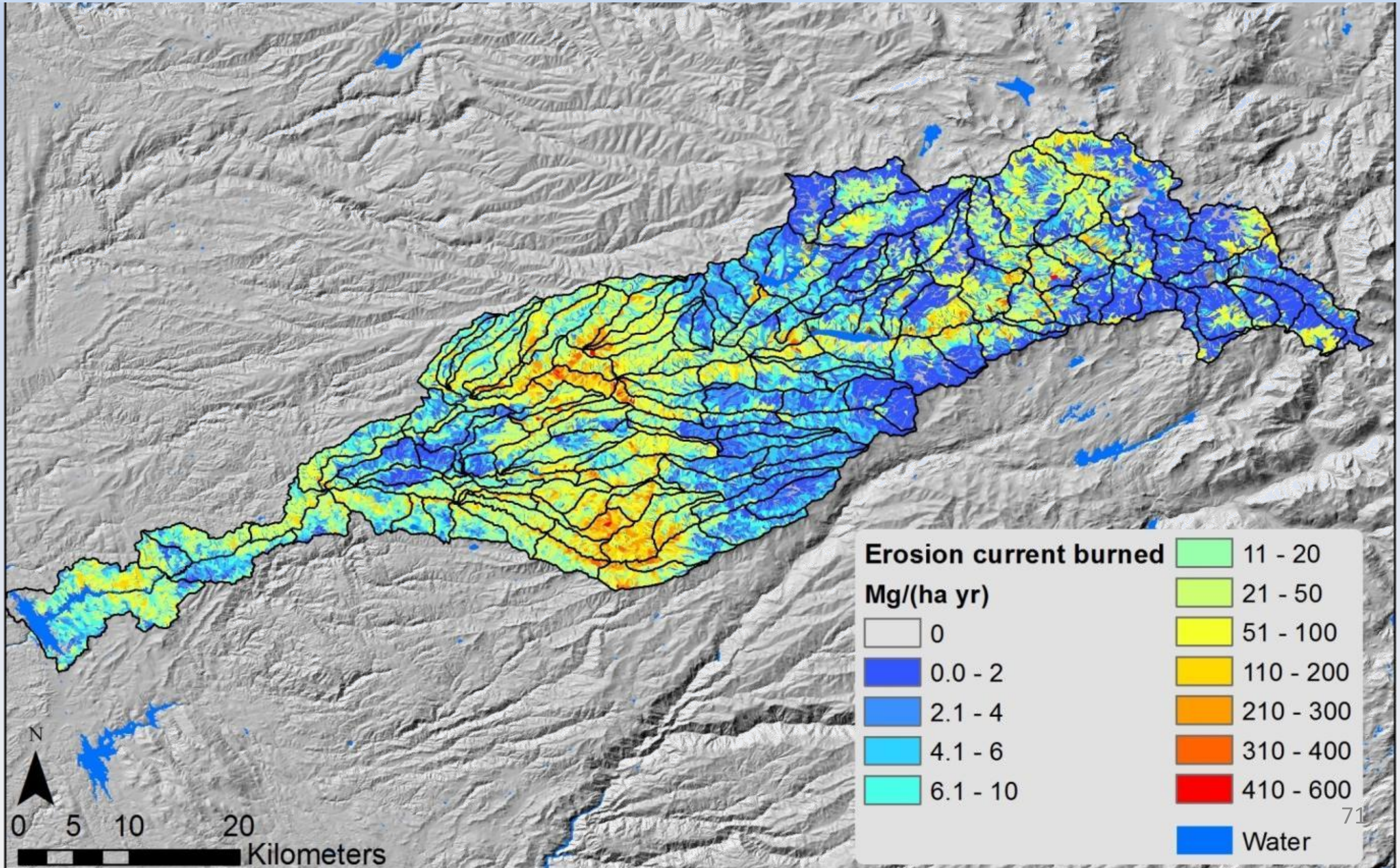
Inputs: 30-m National Elevation Dataset



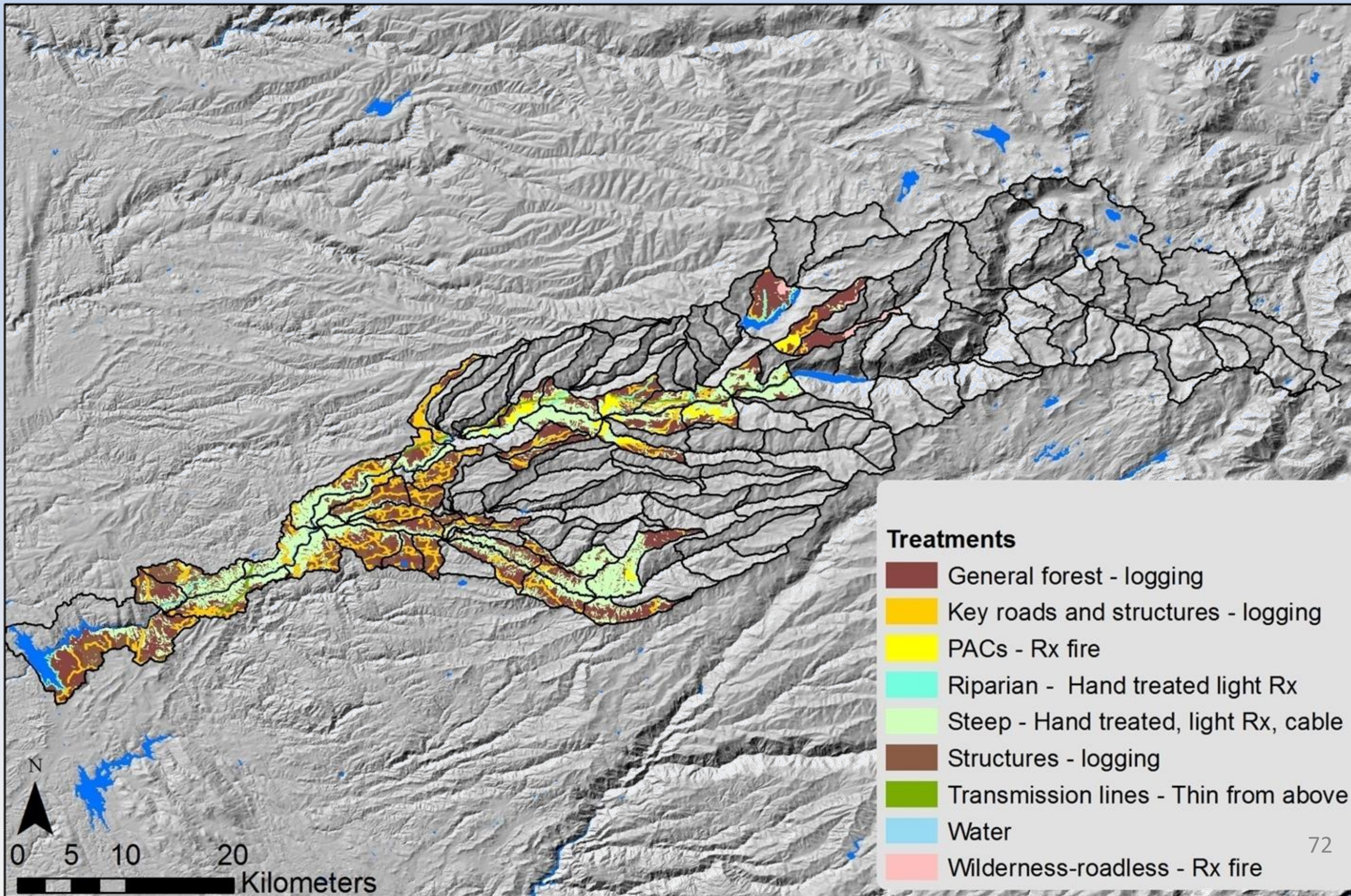
Results: Predicted annual hillslope-scale erosion for current land cover (NO Fire)



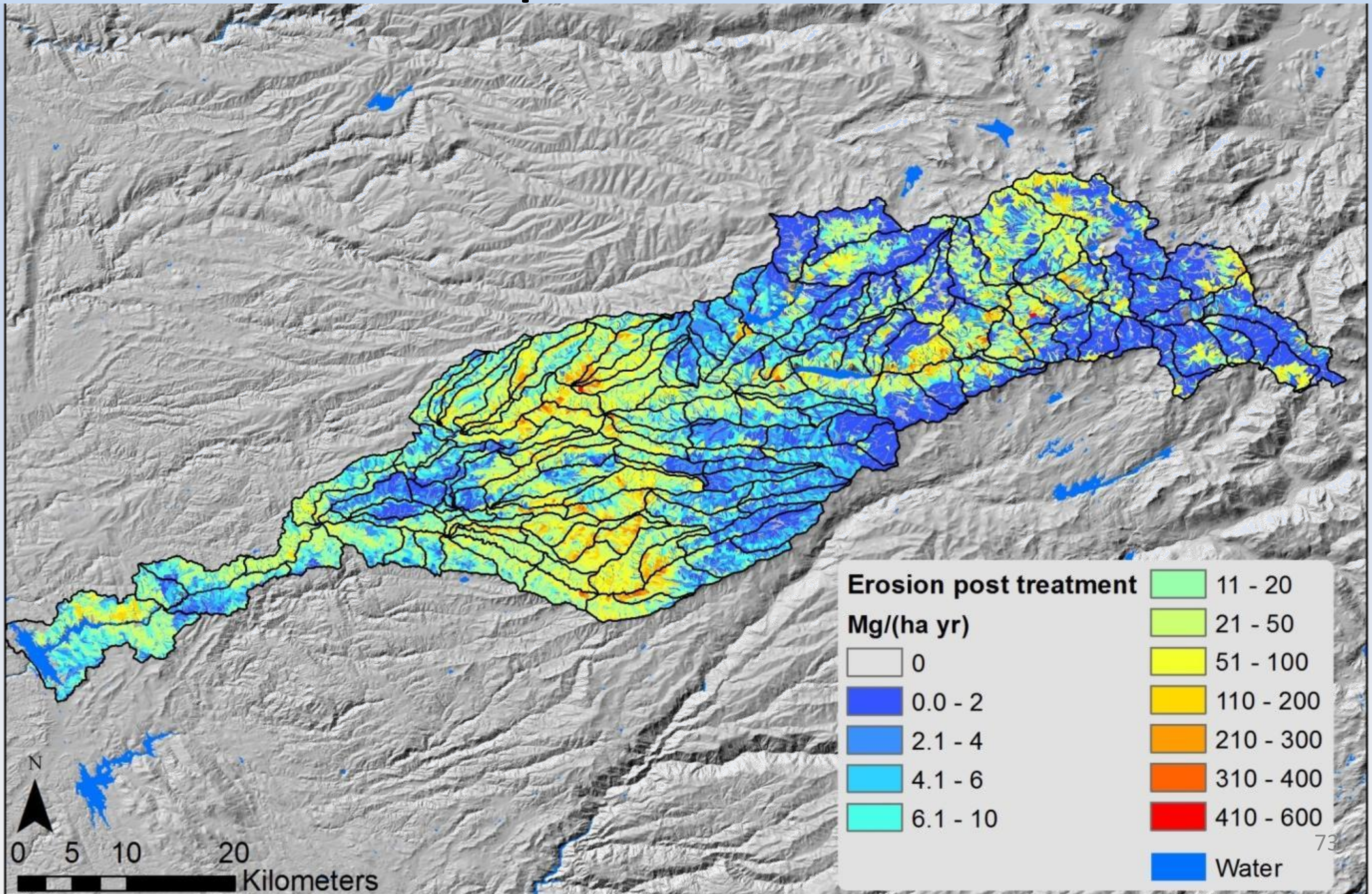
Results: Predicted first-year hillslope erosion AFTER burning, no treatment



Treatment Maps



Predicted first year erosion if selected hillslopes are treated



Summary of Results

	Current Condition	Fire Following Current Condition	Treatment Effects	Fire Following Treatment
Average Erosion in Basin	0.67 Mg/ha	32 Mg/ha in year 1	0.69 Mg/ha	26 Mg/ha in year 1
Range	0 – 84 Mg/ha	0 – 566 Mg/ha	0 – 84 Mg/ha	0 – 535 Mg/ha
Standard Dev	3.0 Mg/ha	55 mg/ha	2.5 Mg/ha	44 Mg/ha

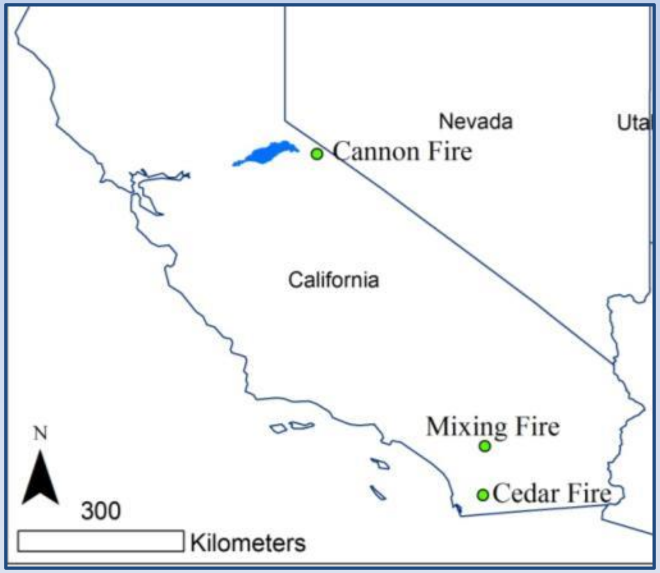
- Steep, relatively bare areas are predicted to have high erosion rates regardless of burning.

Summary of Results for Treatment Area

	Current Condition	Fire Following Current Condition	Treatment Effects	Fire Following Treatment
Average Erosion in Basin	0.40 Mg/ha	46 Mg/ha in year 1	0.69 Mg/ha	26 Mg/ha in year 1
Range	0 – 84 Mg/ha	0 – 566 Mg/ha	0 – 84 Mg/ha	0 – 535 Mg/ha
Standard Dev	2.5 Mg/ha	69 mg/ha	2.5 Mg/ha	36 Mg/ha

Are the results reasonable?
(average value of 32 Mg ha^{-1} yr^{-1})

- Average annual first year post-fire erosion values observed recently in California:
  - Mixing Fire were 6-13 Mg/(ha yr^{-1})
  - **Cannon Fire were 2.5-15 Mg/(ha yr^{-1}) - closest site**
  - Cedar Fire 19-46 Mg/(ha yr^{-1})



Avg. Prediction for Mokelumne Fire 32 Mg/(ha yr^{-1})

- In all cases, the observed climates were drier (604 mm, 658 mm, and 398 mm respectively) than the Mokelumne Basin which ranged from 799 mm to 1438 mm.

How do we put wildfire erosion in context?

- Wildfire is part of disturbance driven forest ecosystem
- An “average annual” erosion from fire can be estimated by:
  Avg Erosion = Wildfire Erosion x Probability

“Average Annual” Erosion

$$Average\ Erosion_{cc} = E_{cc\_fire} * bp_{cc\_fire} + (1 - bp_{cc\_fire}) * E_{nf} \qquad \text{(Eq 1)}$$

$$Average\ Erosion_{tr} = E_{tr\_fire} * bp_{tr\_fire} + (1 - bp_{tr\_fire}) * (24 * E_{nf} + E_{tr})/25 \qquad \text{(Eq 2)}$$

where:

E_{cc_fire} is the mapped post-fire erosion rates for current conditions.
E_{tr_fire} is the mapped post-fire erosion rates following fuel treatments.
E_{tr} is the mapped erosion rates due to the effects of the fuel treatments.
E_{nf} is mapped erosion rates for current conditions in the absence of fire.
bp_{cc_fire} is the mapped probability of fire under current conditions.
bp_{tr_fire} is the mapped probability of fire following fuel treatments.

For treated portion of the watershed

***Average Erosion$_{cc}$* = 0.64 Mg yr^{-1} ha^{-1}**

***Average Erosion$_{tr}$* = 0.52 Mg yr^{-1} ha^{-1}**

Fuel Planning Conclusions

1. FLAMMAP and WEPP can be used to quantify the changes in fire severity and erosion associated with fuel reduction treatments;
2. Knowing the distribution of potential erosion is useful to forest and watershed managers;
3. Managers can expect a significant reduction (19%) in sediment delivery with fuel treatment;

Thank you

Be Prepared!

- ✓ Have the data ready
- ✓ Have plan to incorporate Earth Observations
- ✓ Have your model installed and ready!

Questions?

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http://geodjango.mtri.org/geowepp