FIRE-BAT User Manual

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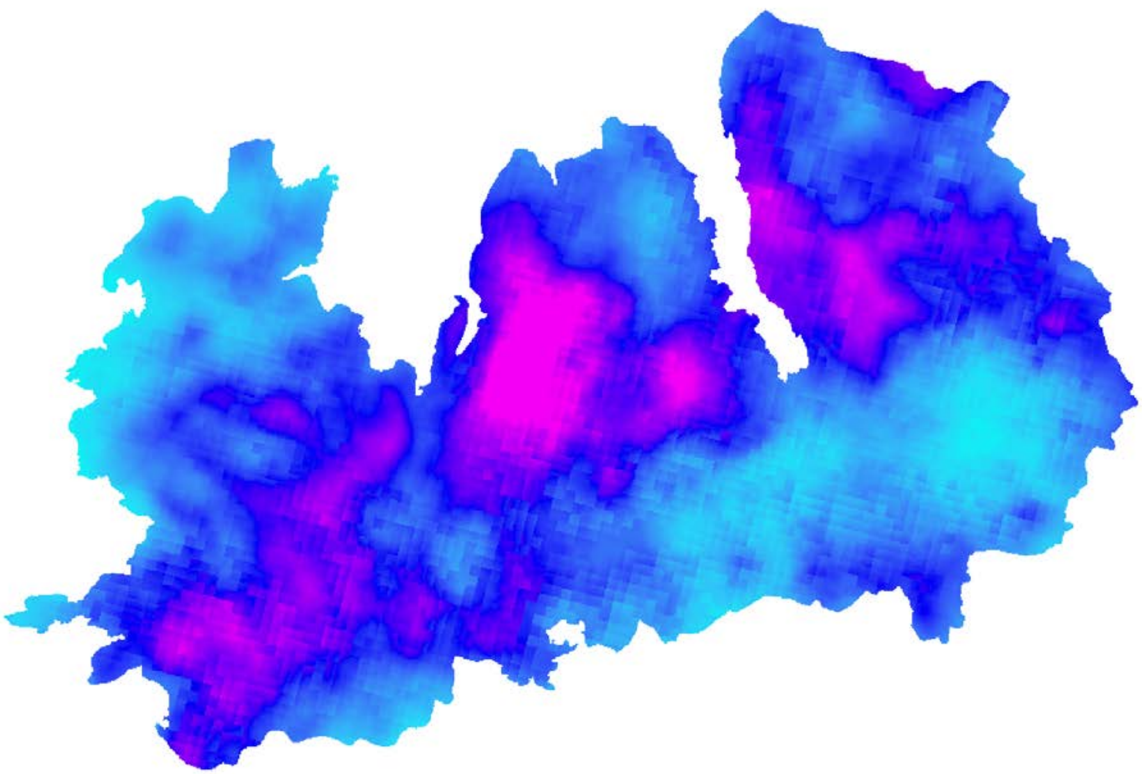

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INTRODUCTION

Land managers are often tasked with competing objectives, and lacking sufficient information to understand the complexity of synergistic effects on ecosystems, leaving them without clear-cut solutions (DeFries & Nagendra 2017). Habitat suitability models (a.k.a. species distribution models) can inform management decisions by describing key habitat requirements and predicting species distributions (e.g. Maiorano et al. 2006, Bellamy et al. 2013). Habitat suitability models quantify statistical relationships between environmental features and known species occurrences. With this information, managers can then restrict potentially detrimental activities (e.g., salvage logging) to areas of lower habitat suitability, or limit those activities where habitat suitability is high, to meet conservation targets. Such information can enhance planning effectiveness. However, despite numerous publications describing new models, few are applied (reviewed by Guisan et al. 2013). Application of species distribution models and resulting maps are computationally intensive, requiring time and resources not available to most natural resource specialists at land management agencies.

We developed an ArcGIS toolbox that is designed to streamline the application of habitat suitability models for bats to inform forest management in burned landscapes in California's Sierra Nevada Mountains. The toolbox and the underlying data target burned habitats, and is intended to facilitate rapid identification of suitable habitat for bat species in previously burned habitats and as new fires occur. In this manual, we summarize the basis and applicability of the underlying occupancy models (a form of habitat suitability model) in the FIRE-BAT ArcGIS application toolbox. We then detail step-by-step instructions for implementing these tools, which currently quantify post-wildfire occupancy for seven bats species.

OCCUPANCY MODELS

Here we detail the methods used to build the occupancy models that are the basis for the spatially explicit occupancy models in FIRE-BAT. A companion report titled *Bat occupancy in Sierra Nevada wildfire areas and implications for post-fire forest management* contains additional information regarding the collection of bat occurrence data as well as additional analyses informing post-fire management in the Sierra Nevada Mountains (Steel et al. 2018).

Bat Acoustics Data

Automated recording units (ARUs; SM3BAT model, Wildlife Acoustics Inc.) and ultrasonic microphones (SMM-U1 model, Wildlife Acoustics Inc.) were deployed in and around three wildfire areas in the northern and central Sierra Nevada Mountains to conduct nightly bat surveys from May–September in 2014–2017. Recorded bat passes were subsequently classified using specialized software (SonoBat version 3.2.1). The three fires include the 2004 Power Fire, the 2012 Chips Fire (sample locations also included areas previously burned by the 2000 Storrie Fire), and the 2013 Rim Fire. In total 328 survey periods (unique location–year combinations) and 2057 survey nights from the 2014–2017 sampling seasons were used to build predictive models. Additional details on sample design, sampling effort and data processing can be found in previous and concurrent reports (Campos & Burnett 2016; Campos et al. 2017; Steel & Safford 2017; Steel et al. 2018).

Environmental Variables

The environmental variables we considered when building landscape-level bat occupancy models are summarized in Table 1. Burn severity, density class, and size class were measured at multiple scales. For distance to water, distance to perennial water and distance to intermittent or perennial water (whichever was closer) served as two alternative scales.

Table 1. Descriptions of environmental variables used to develop occupancy models for bats in burned and green forests. Local, middle, and landscape scales were calculated at 50 m, 500 m, and 2 km radii, respectively.

Variable (abbrev.)	**Description**	**Scale**
Burn severity (severity)	mean Relative differenced Normalized Burn Ratio (RdNBR)[1]	local, middle, landscape
Distance to water (distance)	meters to the nearest perennial or intermittent stream, river, or waterbody	intermittent, perennial
Temperature (max temp)	mean daily maximum temperature (1981-2010)	270-m pixel
Solar radiation (sol rad)	total annual solar energy exposure (watt-hours / m^2)	30-m pixel
Density class (density)	percent area composed of CWHR[2] density class D (dense forest)	local, middle, landscape
Size class (size)	percent area composed of CWHR[2] size classes 5 & 6 (medium or large, and multi-layered trees)	local, middle, landscape
Burned (burned)	boolean indicator of whether a survey location was within a burned area	NA
Old fire (old fire)	boolean indicator of whether the burn is “old” (i.e. 10-13 years post-fire; input value of one) vs. recent (i.e. 1-4 years post-fire; input value of zero)	NA
Salvaged (salvaged)	boolean indicator of whether a location was previously salvage logged	NA
National forest (plas, enf, snf)	three-level categorical variable indicating whether the survey location was within the Plumas/Lassen NFs, Eldorado NF or Stanislaus NF	NA
Survey length (length)	hours of recording during a survey night	NA
Julian Day (day)	julian day of the year	NA
Canopy cover (canopy)	% canopy cover around ARU	15-m radius

[1]RdNBR data were obtained from the US Forest Service Region 5 Remote Sensing Lab and represented the data from the image classified as the “best assessment” of the initial and extended post-fire burn severity assessments.

[2]California Wildlife Habitat Relationships data from US Forest Service Existing Vegetation data

Model Selection

We developed occupancy models for twelve Sierra Nevada bat species (Table 2). Occupancy models could not be fit for five additional species known to occur in the region either due to insufficient presence data (i.e. rare species) or insufficient absence data (i.e. one near-ubiquitous species; Table 2). Models were built using the R statistical environment (R Core Team 2016) and the unmarked package (Fiske & Chandler 2011). To identify the best predictive model for each species we compared candidate models using the area under the curve (AUC) metric. AUC is a measure of model goodness of fit where values close to 1 indicate a model consistently identifies true presences (here true detections) whereas values near 0.5 indicate model predictions are no better than random (Fawcett 2006). Due to imperfect detection occupancy cannot be observed directly. Thus, in order to calculated AUC values we compared model estimates of naïve occupancy (i.e. uncorrected for rates of detection) against observed presence/non-detections.

Table 2. Species recorded during acoustic surveys. Naïve occupancy is the percentage of survey and year combinations that a species was observed at least once.

Species Code	Common Name	Scientific Name	Naïve Occupancy (%)
anpa	pallid bat	*Antrozous pallidus*	37
coto*	Townsend's big-eared bat	*Corynorhinus townsendii*	6
epfu	big brown bat	*Eptesicus fuscus*	61
euma*	spotted bat	*Euderma maculatum*	2
eupe*	western mastiff bat	*Eumops perotis*	8
labl	western red bat	*Lasiurus blossevillii*	19
laci	hoary bat	*Lasiurus cinereus*	58
lano	silver-haired bat	*Lasionycteris noctivagans*	74
myca	California myotis	*Myotis californicus*	91
myci	small-footed myotis	*Myotis ciliolabrum*	21
myev	long-eared myotis	*Myotis evotis*	73
mylu	little brown bat	*Myotis lucifugus*	55
myth	fringed myotis	*Myotis thysanodes*	48
myvo*	long-legged myotis	*Myotis volans*	8
myyu	Yuma myotis	*Myotis yumanensis*	36
pahe	western pipistrelle	*Parastrellus hesperus*	31
tabr*	Mexican free-tailed bat	*Tadarida brasiliensis*	94

* Species for which occupancy models were not fit either due to too few detections or too few non-detections.

We used a two-stage model selection process to identify the predictor variables and spatial scales most relevant to bat occupancy:

1) For each of the twelve species, a near-global model was fit with all single-scale predictors (e.g. temperature max) and one multiple-scale predictor (severity, density, size, distance) at a time. For each varying-scale predictor, a 5-fold cross-validation procedure was conducted to calculate mean AUC values[1]. The scale of each multiple-scale predictor that produced the highest mean AUC of these models was used in the second phase of the model selection process (Table 3).

Table 3. Scales selected during stage one of the model selection process for multiple-scale predictors.

Species	Density	Severity	Size	Distance
anpa	Landscape	Middle	Landscape	Perennial
epfu	Local	Local	Landscape	Perennial
labl	Local	Landscape	Middle	Intermittent
laci	Middle	Landscape	Local	Intermittent
lano	Landscape	Local	Landscape	Intermittent
myca	Landscape	Landscape	Landscape	Intermittent
myci	Middle	Local	Local	Perennial
myev	Middle	Local	Middle	Intermittent
mylu	Local	Local	Middle	Perennial
myth	Middle	Local	Middle	Perennial
myyu	Landscape	Landscape	Local	Perennial
pahe	Landscape	Local	Landscape	Perennial

2) The following global model was considered in the second stage of model selection with a set of fixed and candidate variables:

[1] Cross-validation is a procedure where part of the data (in this case 1/5th) is held out of the model-building processes to be used as testing data in order to generate a fit statistic (e.g. AUC). This is repeated with different subsets of the data (e.g. 5) to generate a mean fit statistic.

$$logit(\psi_i) = \beta_{for} * forest_i +$$

$$(\beta_{burn} + \beta_{old} * OldBurn_i + \beta_{sal} * salvage_i + \beta_{sev} * severity_i) * burn_i +$$

$$\beta_{distw} * DistWater_i + \beta_{mtmp} * MaxTemp_i + \beta_{solrad} * SolRad +$$

$$\beta_{dens} * density_i + \beta_{size} * size_i$$

where β_{for}, β_{burn}, and β_{sev} are parameters estimated for fixed variables, and β_{old}, β_{sal}, β_{distw}, β_{mtmp}, β_{solrad}, β_{dens}, and β_{size} represent parameters for candidate variables. For each species, models were fit using all combinations of candidate variables. Each candidate model included all fixed variables. Parameters for old burn/recent burn (i.e. Power vs. Chips and Rim), salvaged/not salvaged, and severity were estimated using data for burned points only (i.e. only when $burn_i = 1$). Site was indexed by i. Selection between models of different combinations of candidate variables was done using mean AUC calculated from 5-fold cross-validation, resulting in a final best predictive model for each species.

All occupancy models were fit with the following detection model to estimate rates of false absences:

$$logit(p_{ij}) = \alpha_0 + \alpha_{length} * length_{ij} + \alpha_{jday} * jday_{ij} + \alpha_{cc} * cancov_i$$

Length and jday are the survey length in hours and julian day for each site i and survey night j, and cancov is the percent canopy cover within 15m of the bat detector at each site i.

Mean parameter estimates used in the GIS tools are listed in Table 4. Additional discussion of model estimates including parameter uncertainty measures can be found in the accompanying report (Steel et al. 2018).

Table 4. Mean parameter estimates for all final models. NA values indicate a variable was not included in the final model for that species. Detection (Det) variables were used to fit the full hierarchical model, but only the variables include in the occupancy submodel (Occ) are used to make spatial prediction.

Predictor	**Type**	**anpa**	**epfu**	**labl**	**laci**	**lano**	**myca**	**myci**	**myev**	**mylu**	**myth**	**myyu**	**pahe**
ENF	Occ	-0.50	-0.19	-2.38	0.60	1.26	1.75	-0.64	0.93	-0.69	-0.57	0.00	-0.34
PLAS	Occ	-2.08	0.30	0.42	-0.27	1.38	0.29	-1.86	1.75	1.80	-1.23	-0.78	-2.68
SNF	Occ	-0.31	0.14	-3.60	0.08	-0.44	11.19	-1.17	0.05	-1.21	0.33	-0.58	1.30
Density	Occ	-1.21	0.19	NA	-0.41	-0.43	-0.38	NA	NA	-0.23	NA	-0.16	-1.05
Size	Occ	0.48	NA	NA	NA	0.97	NA	0.21	0.47	0.66	0.29	NA	-0.29
Distance	Occ	0.19	NA	NA	NA	0.20	0.53	NA	-0.16	-0.16	NA	0.10	0.33
MaxTemp	Occ	0.53	-0.66	NA	0.25	NA	0.00	NA	-0.26	NA	NA	0.18	0.79
SolRad	Occ	NA	NA	0.24	-0.44	-0.40	NA	0.04	NA	0.32	0.31	0.05	NA
Burned	Occ	0.77	0.64	0.13	0.38	1.14	2.20	0.39	0.88	0.54	0.46	0.68	0.51
Severity	Occ	0.39	-0.26	0.80	-0.02	0.73	0.37	-0.72	-0.45	0.18	-0.29	0.49	-0.47
Old Fire	Occ	NA	1.00	NA	0.54	NA	-1.93	-0.43	NA	NA	1.43	-0.95	NA
Salvaged	Occ	NA	NA	NA	0.73	NA	1.23	0.80	NA	0.32	NA	NA	NA
Intercept	Det	-0.82	-0.37	-1.40	-0.60	0.24	0.99	-1.26	-0.19	-0.18	-0.61	-1.31	-1.29
Day	Det	0.18	0.41	0.38	-0.07	-0.08	0.36	0.45	0.20	0.02	-0.01	0.02	0.29
Length	Det	0.13	-0.01	-0.07	0.14	-0.13	0.15	0.18	0.05	-0.15	0.20	0.16	0.12
Canopy	Det	-0.05	-0.26	-0.46	-0.30	-0.61	0.06	0.00	0.03	-0.14	-0.08	-0.05	-0.20

Model Validation

In addition to calculating AUC as a measure of predictive ability, we ran the Mackenzie and Bailey goodness of fit test (MacKenzie & Bailey 2004) for each of the final models. A significant result from this test ($P < 0.05$) indicates model lack of fit, and c-hat values > 1 indicate overdispersion, with c-hat values > 4 indicating high levels of lack of fit. The Mackenzie Bailey test identified final models for three species (Pahe, Myth, and Myev) were poorly fit, indicating model estimates of uncertainty may be low. For the other nine species, final models had reliable uncertainty estimates. Of these, Labl, Myca, Lano, and Mylu exhibited the best predictive performance (AUC > 0.8; Table 5).

Table 5. Model validation metrics. AUC mean and standard deviations values were calculated using 5-fold cross-validation. Models identified as showing significant lack of fit (p > 0.05 and c-hat > 4) are in italics.

	Cross-validation AUC		Mackenzie & Bailey Test	
Species	**Mean**	**Std. Dev.**	**p-val**	**c-hat**
labl	0.8431	0.0559	0.76	0.03
myca	0.8213	0.1097	0.37	0.94
lano	0.8137	0.0114	0.43	0.48
mylu	0.8048	0.0480	0.43	1.11
pahe	*0.8012*	*0.0361*	*0.00*	*815.52*
myth	*0.7279*	*0.0398*	*0.00*	*20.14*
myev	*0.7198*	*0.0106*	*0.01*	*8.14*
anpa	0.7184	0.0634	0.24	0.91
laci	0.6962	0.0408	0.57	0.90
epfu	0.6649	0.0423	0.69	0.10
myci	0.6527	0.0271	0.09	2.76
myyu	0.6321	0.0839	0.21	0.24

MODEL APPLICABILITY

Models are restricted in applicability by the range of conditions within which they were developed. Applicability should ideally be tested with independent data before managers use model predictions to inform their decisions and planning (Wenger & Olden 2012; Bahn & McGill 2013). Such testing is particularly critical when applying models beyond the environmental range where originally developed. In light of these principles and where models have been tested, we offer guidelines for model applicability here.

The bat occupancy models within the FIRE-BAT toolset should only be applied within the regions, habitats, and timing relative to wildfire ignition in our study. Bat occupancy models were developed and are applicable to burned forests in three regions: Lassen/Plumas, Eldorado, and Stanislaus National Forests. We recommend the models only be applied to fires within or very near these forests (e.g. Tahoe National Forest). These burned areas are primarily within the Sierra mixed conifer and yellow pine forest zone, but also included significant pre-fire areas of white fir, montane chaparral, and red fir habitat types, as designated by California Wildlife Habitat Relationship System (Mayer & Laudenslayer 1988). Lastly, our models are applicable to bat occupancy from May-September within 13 years following wildfire.

Sampled landscapes were affected by selective harvest salvage logging on USFS lands and often more intensive salvage logging on private lands, though sample locations were entirely on USFS land. Our models quantified relationships with salvage logging at a single, local scale on USFS land; we did not include larger scale effects of salvage logging, including those on private lands. Predictive performance may decline in extensively logged post-fire areas, especially for recent burns where much of the snag basal area on unsalvaged lands still stands.

INSTRUCTIONS FOR TOOL IMPLEMENTATION

Application tools described in this manual are operated within an ArcGIS environment. Users must have access to ArcGIS 10, a basic understanding of how to operate this software, and spatial data layers for clearly defined study areas. Steps provided here detail how to retrieve and compile environmental data into GIS layers required as model inputs, and how to access and implement the model application tools.

Users can obtain the FIRE-BAT toolset by emailing Brent Campos (bcampos@pointblue.org) or Zachary Steel (zsteel@ucdavis.edu). Two versions of the FIRE-BAT toolset are available: one with many of the input data layers included, the other without these layers. The version of the toolset with the data layers is quite large (~0.9 GB), but can save time by skipping some of the data download steps detailed below.

Once the user has extracted the toolset to a personal workstation, they can follow the steps below. Hereafter, the location “TOOLBOX” refers to the folder extracted from the FIRE-

BAT.zip file to a personal workstation. We provide one model application tool for each of seven bat species for four Sierra Nevada forests. Outputs generated by these tools are 30 m raster layers with occupancy values ranging from 0 to 1. We recommend using ".tif" or ".img" extensions for output layers for flexibility in filename length. The study area must have been burned by sufficiently large wildfires (>1000 acres) for the necessary data to be retrievable.

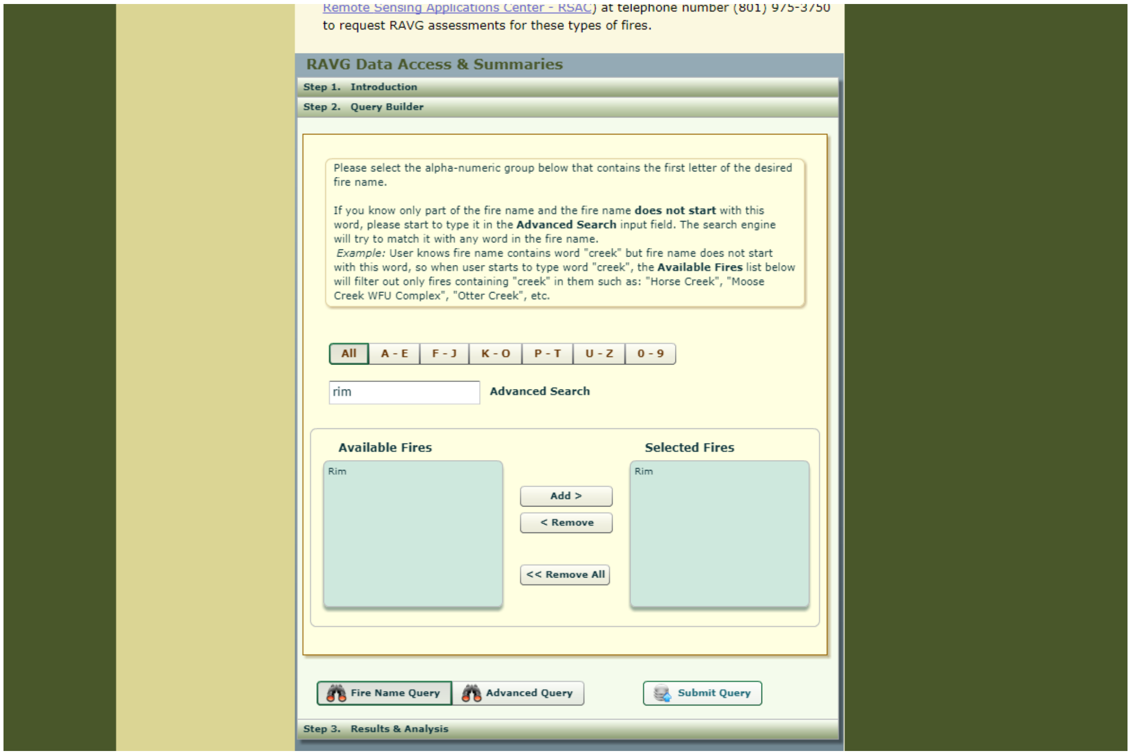
Steps to Implement Tool

I. Retrieve and compile environmental data layers. In this step you will retrieve remotely sensed data from USFS and, optionally, other websites, and input them into the Input Generation tool to compile many of the variables listed in Table 1. None of the files you download will need to be altered from their downloaded form. The pathnames for data files used in these tools cannot have spaces, so when saving the environmental data layers to your workstation, ensure that no parent folders in the file path names have spaces. For example, "C:\GIS\Data\Sierra Bats\rdnbr_cc.tif" is an invalid path name; the folder named "Sierra Bats" needs to renamed to "SierraBats" or "Sierra_Bats".

   A. Retrieve burn severity data. The version of FIRE-BAT that includes some input data layers in the ZIP file does not include burn severity data. For fires ignited in 2008 or after, the user may download the data via the following steps. For fires ignited prior to 2008, you may contact the Region 5 Remote Sensing Lab for burn severity data for your fire of interest.

      1. Go to the USFS Post-Fire Vegetation Conditions website https://www.fs.fed.us/postfirevegcondition/index.shtml and enter the necessary information for your fire in the query builder. In this example, we are looking for the 2013 Rim Fire in California. If a window like the one below is not visible in your web

browser at the webpage linked to above, ensure that Adobe Flash Player is enabled in your web browser then refresh the webpage.



2. Click on the compressed file icon under the Download Data column to download the GIS data packet for your fire, then unzip the contents into your GIS workspace.

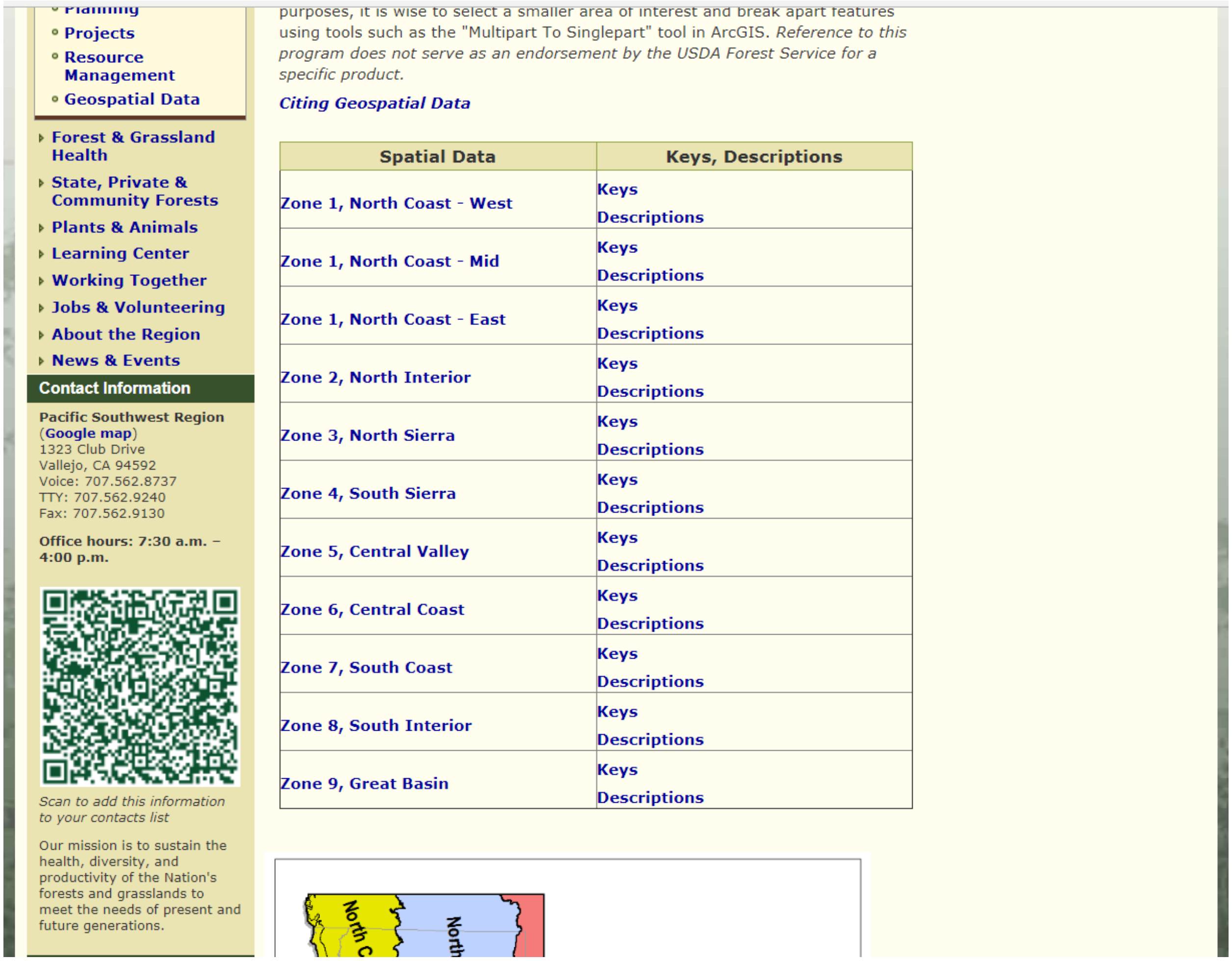
3. See the metadata document in the extracted file folder for explanation of the files associated with your download. In general, the fire perimeter polygon shapefile will end in "…burn_bndy…" and the burn severity raster will end in "_rdnbr.tif" or "_rdnbr_alb.tif" (hereafter "fire perimeter" and "burn severity" layers, respectively).

B. Retrieve pre-fire forest structure data. The version of FIRE-BAT that includes some input data layers in the ZIP file does not include pre-fire forest structure data. This must be supplied by the user by downloading via the following steps. (NOTE: If the data available from sources in the following steps do not contain pre-fire data, such as when applying this tool to an old fire rather than a new fire, you may contact the Region 5 Remote Sensing Lab for the appropriate Existing Vegetation [Eveg] tiles that provide complete coverage of the fire perimeter and a 2-km buffer area outside the perimeter. To ensure the data reflects pre-fire conditions, request tiles that have all image source dates prior to the ignition date for your fire of interest).

1. Navigate to the Region 5 Vegetation Classification and Mapping webpage https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192. Identify the Zone containing your fire of interest using the CALVEG Mapping Zones map on the webpage. If your fire of interest is near the border of a

Zone, you may also need vegetation data from an adjacent Zone to get complete coverage of the fire perimeter and a 2-km buffer area outside the perimeter. Once you have identified your Zone(s), click on "Download Existing Vegetation Zones, Keys and Descriptions."

2. A table of available spatial data will appear. Click on the Zone containing your fire of interest under the Spatial Data column of the table. Doing this will take you to the National FSGeodata Clearinghouse at https://data.fs.usda.gov/geodata/edw/datasets.php.



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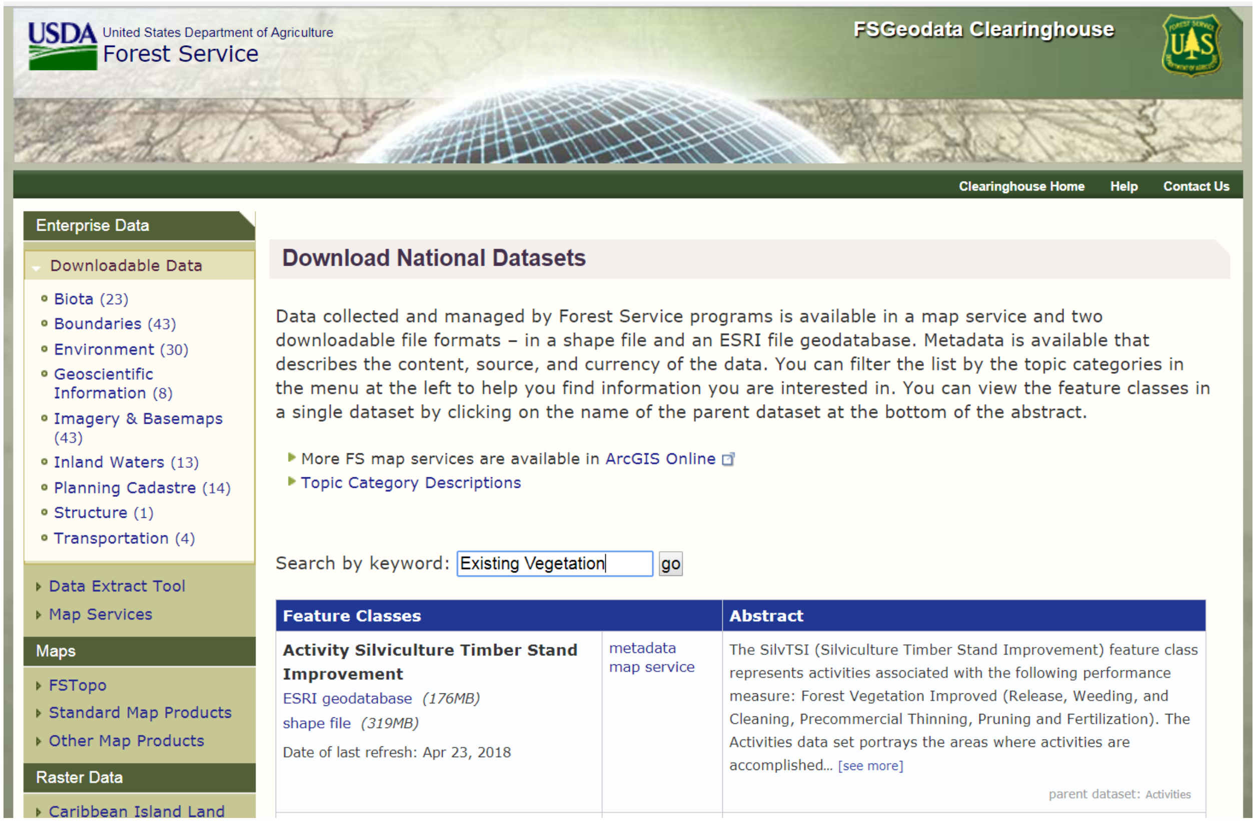
purposes, it is wise to select a smaller area of interest and break apart features using tools such as the "Multipart To Singlepart" tool in ArcGIS. *Reference to this program does not serve as an endorsement by the USDA Forest Service for a specific product.*

Citing Geospatial Data

Spatial Data	Keys, Descriptions
Zone 1, North Coast - West	Keys Descriptions
Zone 1, North Coast - Mid	Keys Descriptions
Zone 1, North Coast - East	Keys Descriptions
Zone 2, North Interior	Keys Descriptions
Zone 3, North Sierra	Keys Descriptions
Zone 4, South Sierra	Keys Descriptions
Zone 5, Central Valley	Keys Descriptions
Zone 6, Central Coast	Keys Descriptions
Zone 7, South Coast	Keys Descriptions
Zone 8, South Interior	Keys Descriptions
Zone 9, Great Basin	Keys Descriptions

3. On the FSGeodata Clearinghouse webpage, there is a “Search by keyword” option above the table of feature classes. Type “Existing Vegetation” into the “Search by keyword” text box and click the “go” button.



4. Scroll down to your Zone of interest. In the example below, we are looking for the "South Sierra" Zone in Region 5. Once you have found your Zone, click the "ESRI geodatabase" hyperlink below the Zone name to download the Zone data. Unzip the file and place the geodatabase into your GIS workspace.

Existing Vegetation: Region 5 - South Interior ESRI geodatabase *(14MB)* Themes: vegetation, cover, tree, shrub, usnvc, existing vegetation, nvcs Date of last refresh: Jan 18, 2018	metadata map service	This Existing Vegetation (Eveg) polygon feature class is a CALVEG (Classification and Assessment with LANDSAT of Visible Ecological Groupings) map product from a scale of 1:24,000 to 1:100,000 for CALVEG Zone 8, the South Interior. Source imagery for this layer ranges from the year 2000 to 2008. The CALVEG classification system was used for vegetation typing and crosswalked to other classification systems in this database including the California Wildlife Habitat Relationship System (CWHR). **Purpose:** Existing vegetation is a foundational layer applicable to many business needs of the Forest Service. Mid-level products are intended to support regional and multi-unit information needs. Products at this level are typically developed programmatically from remotely sensed data but should integrate standard base level maps where they exist.
Existing Vegetation: Region 5 - South Sierra ESRI geodatabase *(539MB)* Themes: vegetation, cover, tree, shrub, usnvc, existing vegetation, nvcs Date of last refresh: Jan 18, 2018	metadata map service	This Existing Vegetation (Eveg) polygon feature class is a CALVEG (Classification and Assessment with LANDSAT of Visible Ecological Groupings) map product from a scale of 1:24,000 to 1:100,000 for CALVEG Zone 4, the South Sierra. Source imagery for this layer ranges from the year 1995 - 2016. The CALVEG classification system was used for vegetation typing and crosswalked to other classification systems in this database including the California Wildlife Habitat Relationship System (CWHR). **Purpose:** Existing vegetation is a foundational layer applicable to many business needs of the Forest Service. Mid-level products are intended to support regional and multi-unit information needs. Products at this level are typically developed programmatically from remotely sensed data but should integrate standard base level maps where they exist.

C. Retrieve water source data

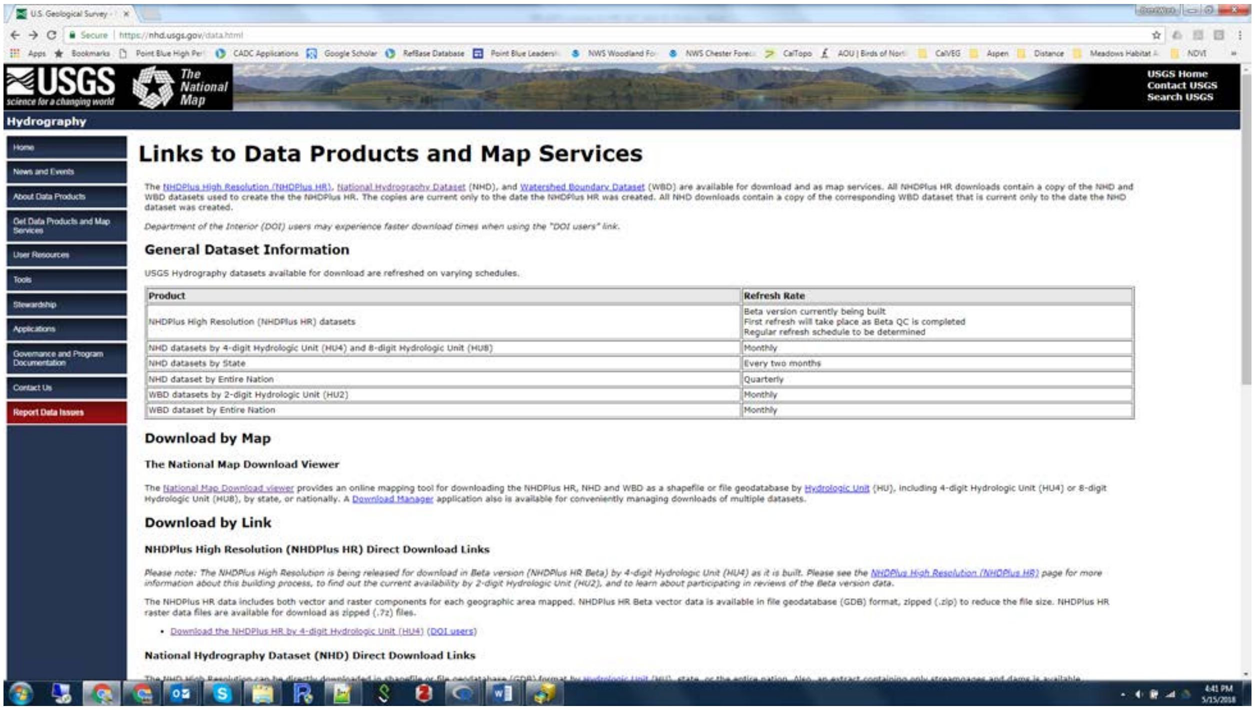
1. Option 1 for water source data: Use the water source data layer supplied in the FIRE-BAT Toolbox.

   a. Navigate to “TOOLBOX → Input_Layers → NHDFlowline” and locate the “NHDFlowline.shp” file (hereafter referred to as the “water source” layer). You can leave the file here, or copy it to your workspace.

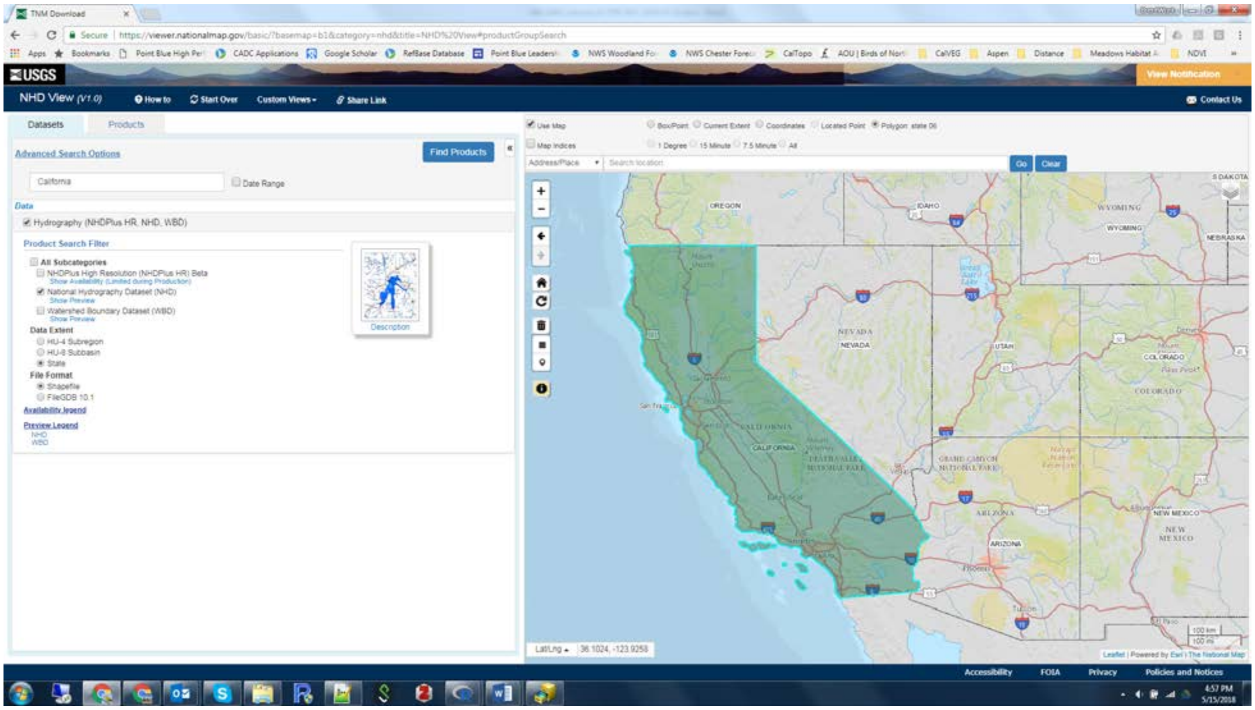
2. Option 2 for water source data: Download the water source data layer from a USGS website.

   a. Go to https://nhd.usgs.gov/data.html. Under the section titled “Download by Map Viewer” click on the hyperlink for “National Map Download Viewer,” or visit the link directly here:

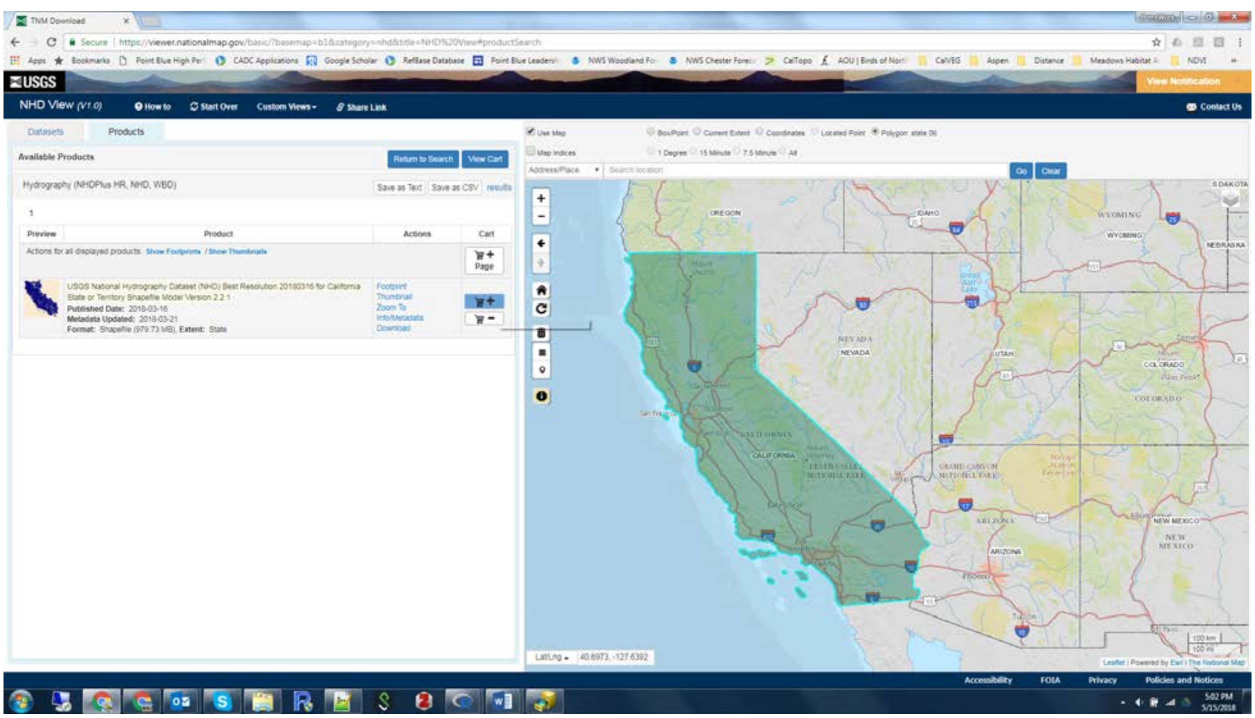
https://viewer.nationalmap.gov/basic/?basemap=b1&category=nhd&title=NHD%20View



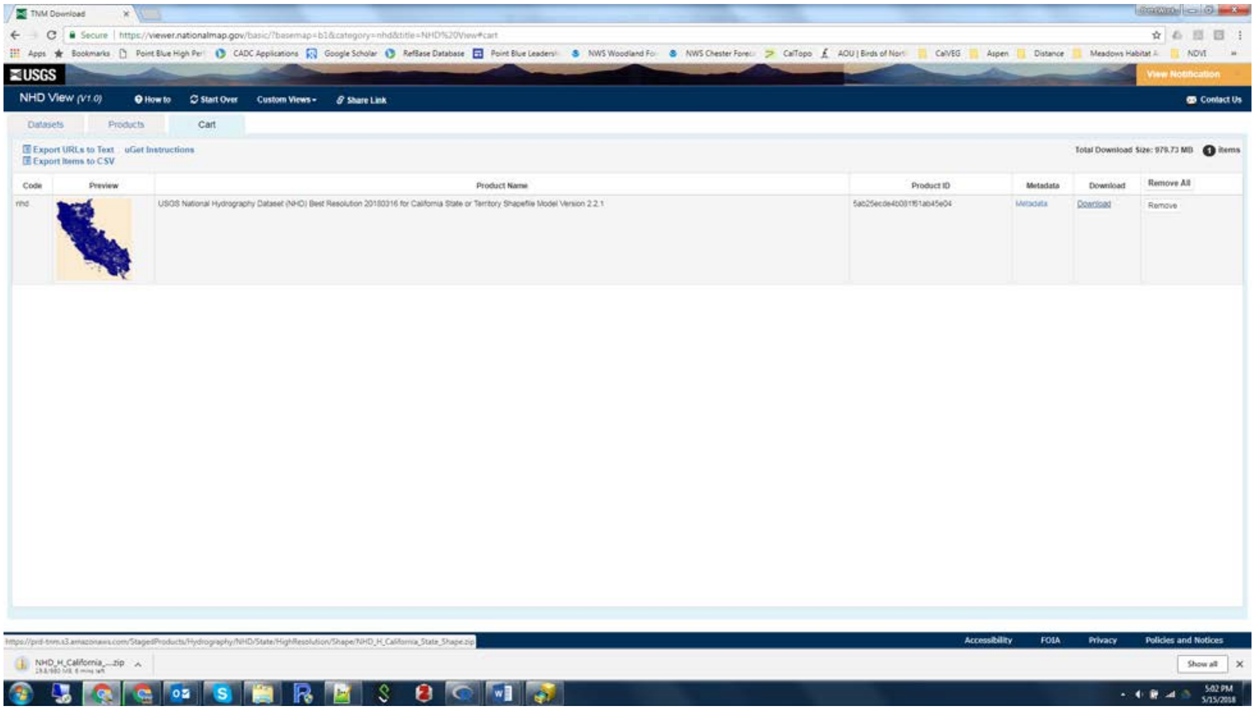
b. On the left side of the website will be series of options under the Product Search Filter. Select the boxes for “National Hydrography Dataset”, “State” data extent, and a “Shapefile” file format, then click on California on the map.



c. Click the blue “Find Products” button and the Products pane will appear on the left side of the webpage. Click on the “cart +” button to add this dataset to your cart, then click the blue “View Cart” button.



d. The Cart pane will appear with the data you selected. Click the “Download” hyperlink to download the data.



e. Place the downloaded ZIP file into your GIS workspace and extract the file. You will now have a folder called “NHD_H_California_Shape” in your workspace, with a subfolder called “Shape,” within which is the water source shapefile called “NHDFlowline.shp” (hereafter referred to as the “water source” layer).

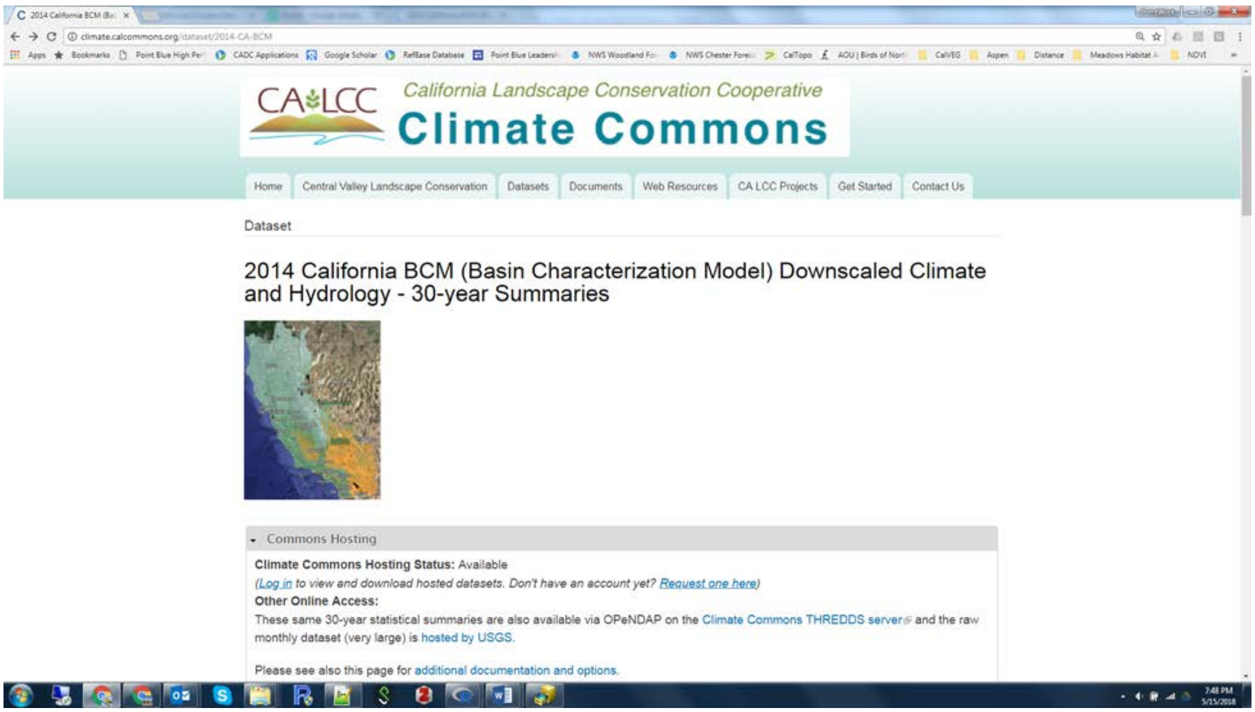
D. Retrieve temperature data

1. Option 1: Use the temperature data layer supplied in the FIRE-BAT Toolbox.

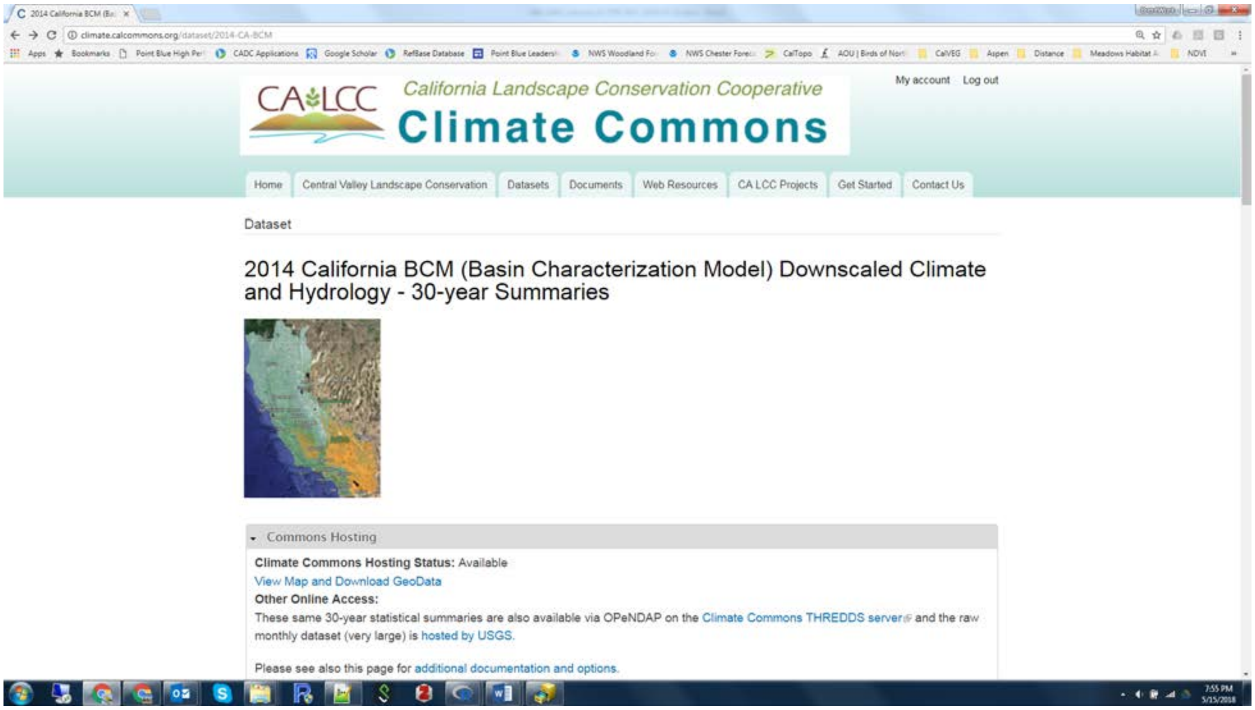
   a. Navigate to “TOOLBOX → Input_Layers → temperature” and locate the “tmx1981_2010jja_ave_HST_1507159793.tif” file (hereafter referred to as the “temperature” layer). You can leave the file here, or copy it to your workspace.

2. Option 2: Download the temperature data layer from a Point Blue website.

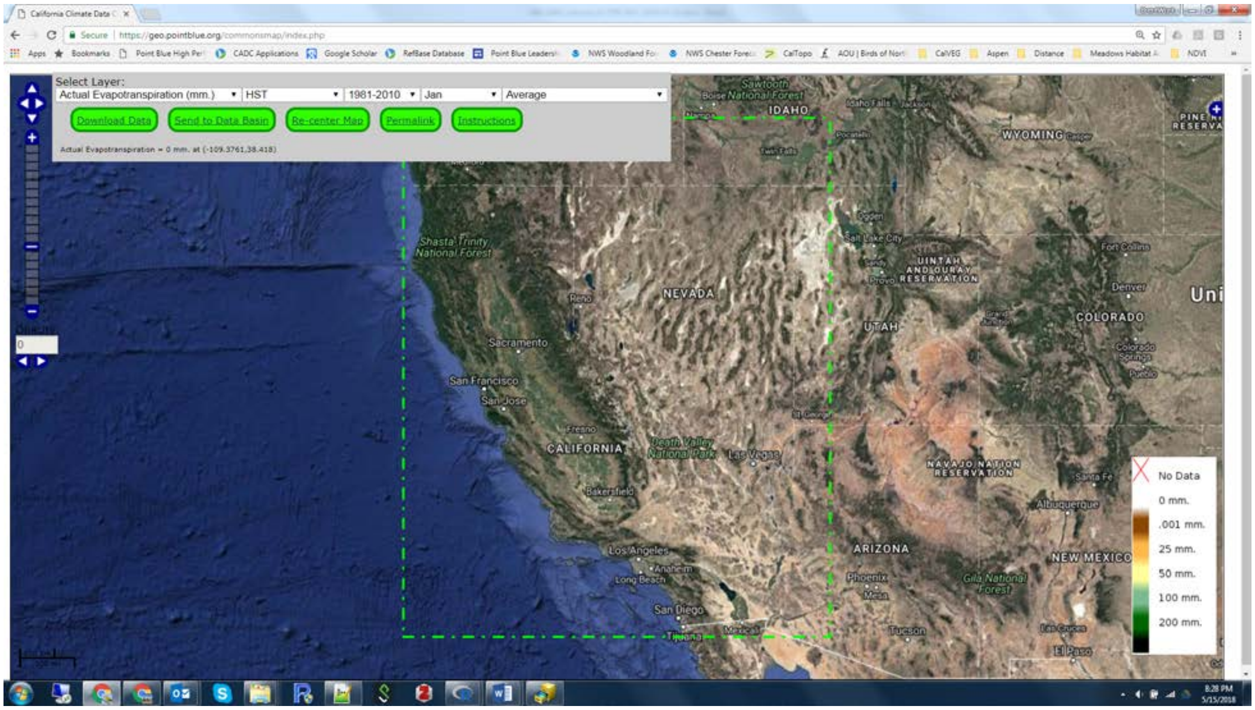
a. Navigate to http://climate.calcommons.org/dataset/2014-CA-BCM. If you do not already have a CA Climate Commons account, click the "Request one now" hyperlink, or click the "Log in" hyperlink if you have an account.



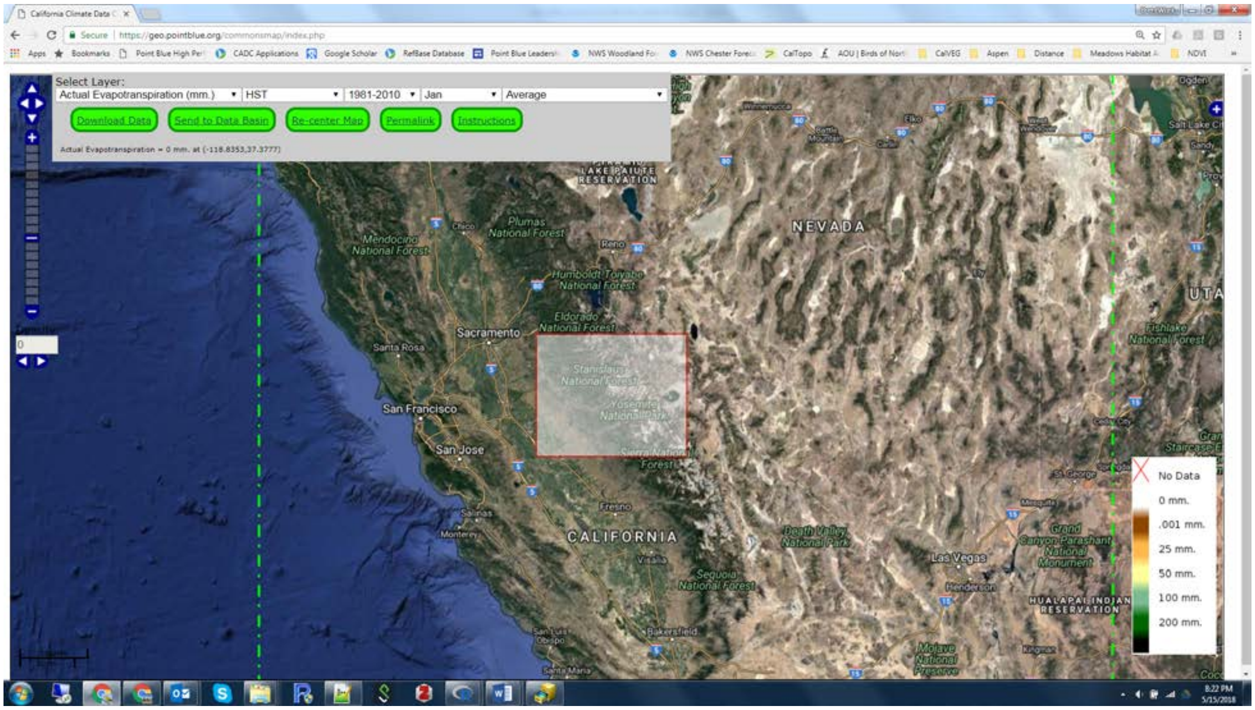
b. After logging in, navigate back to http://climate.calcommons.org/dataset/2014-CA-BCM and click "View Map and Download GeoData" hyperlink (you may need to refresh the webpage to see this hyperlink).



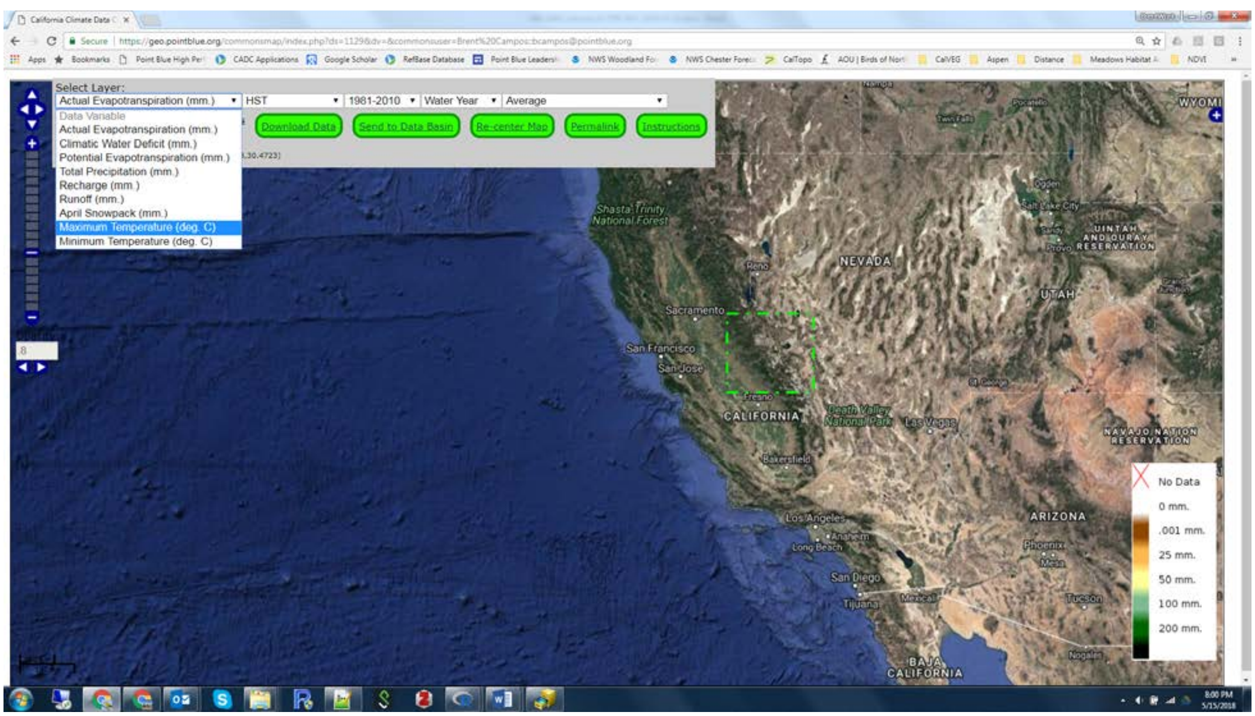
c. You will now be at a map interface where you will download the temperature data. On the top left of the webpage will be a gray dialogue box with a number of drop-down boxes for different options of data to view and download. Feel free to review the instructions by clicking the green "Instructions" button.



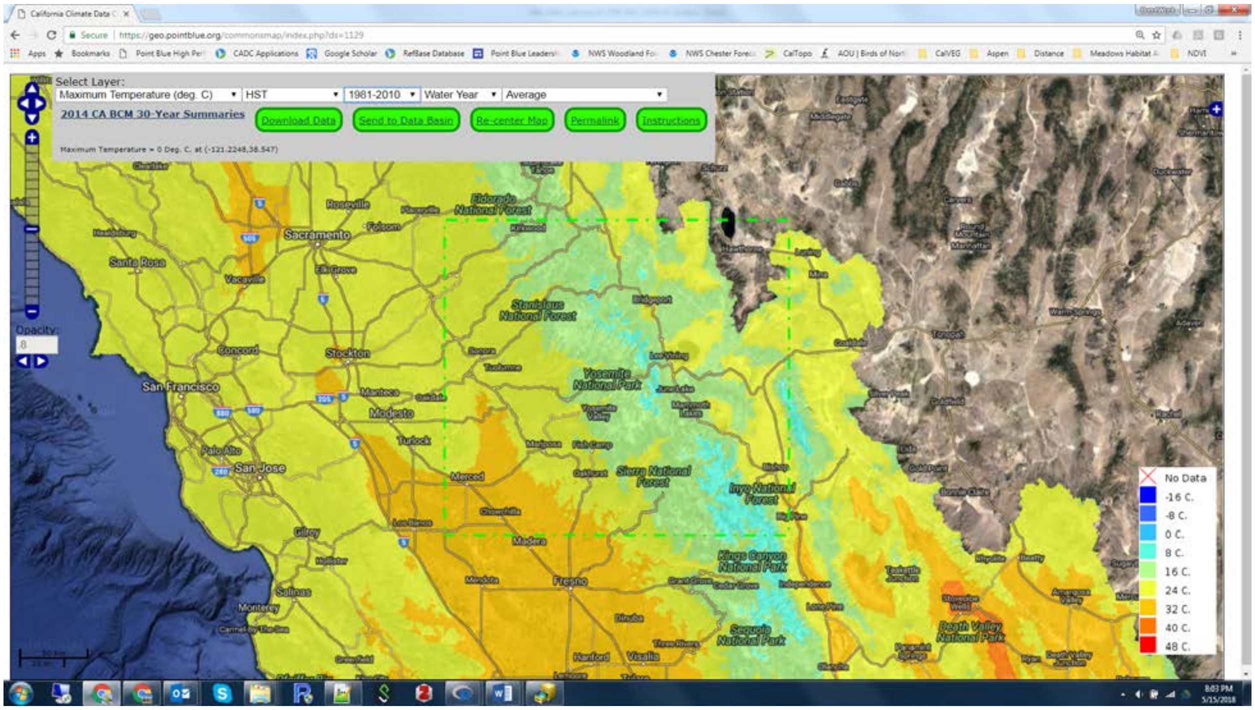
d. First you will need to select a region of interest that encompasses your fire of interest plus a 3-km buffer. Hold down the shift button and left-click with your mouse the select your region of interest, erring on the side of being too large. In the example below, we are selecting an area around the Rim Fire.



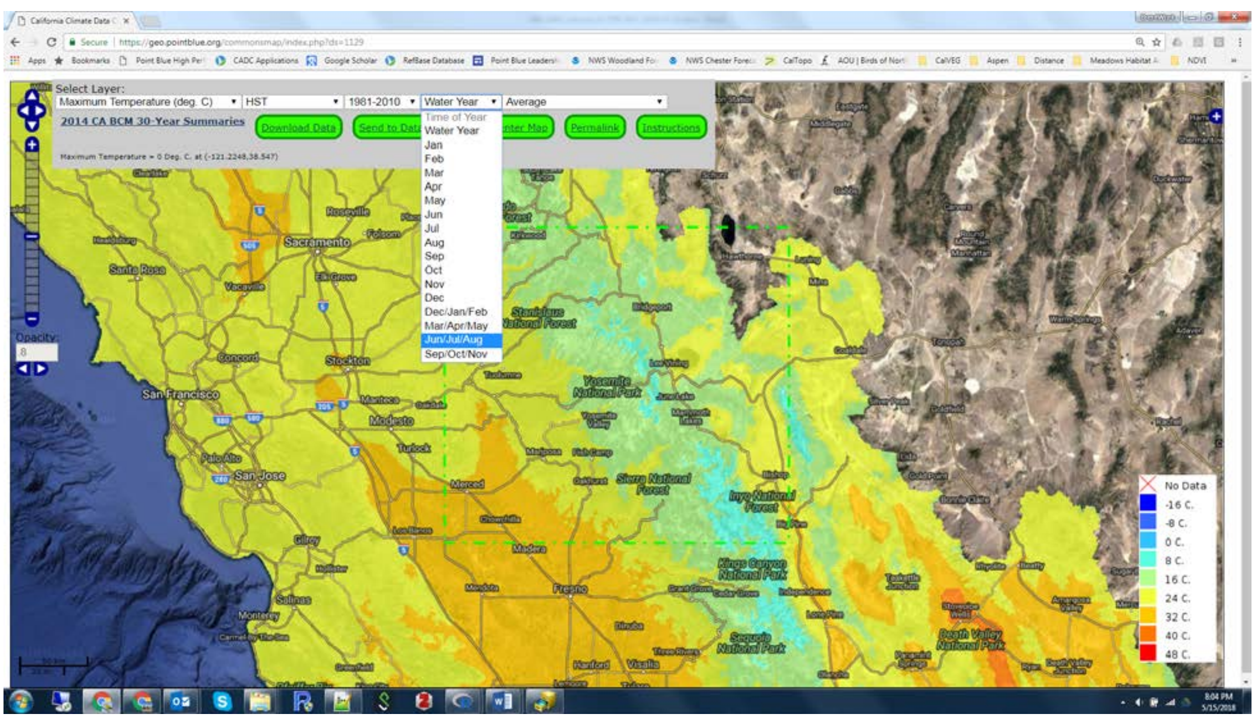
e. For the first drop-down menu, select “Maximum Temperature (deg. C).” The map will display the data after the selection is made.



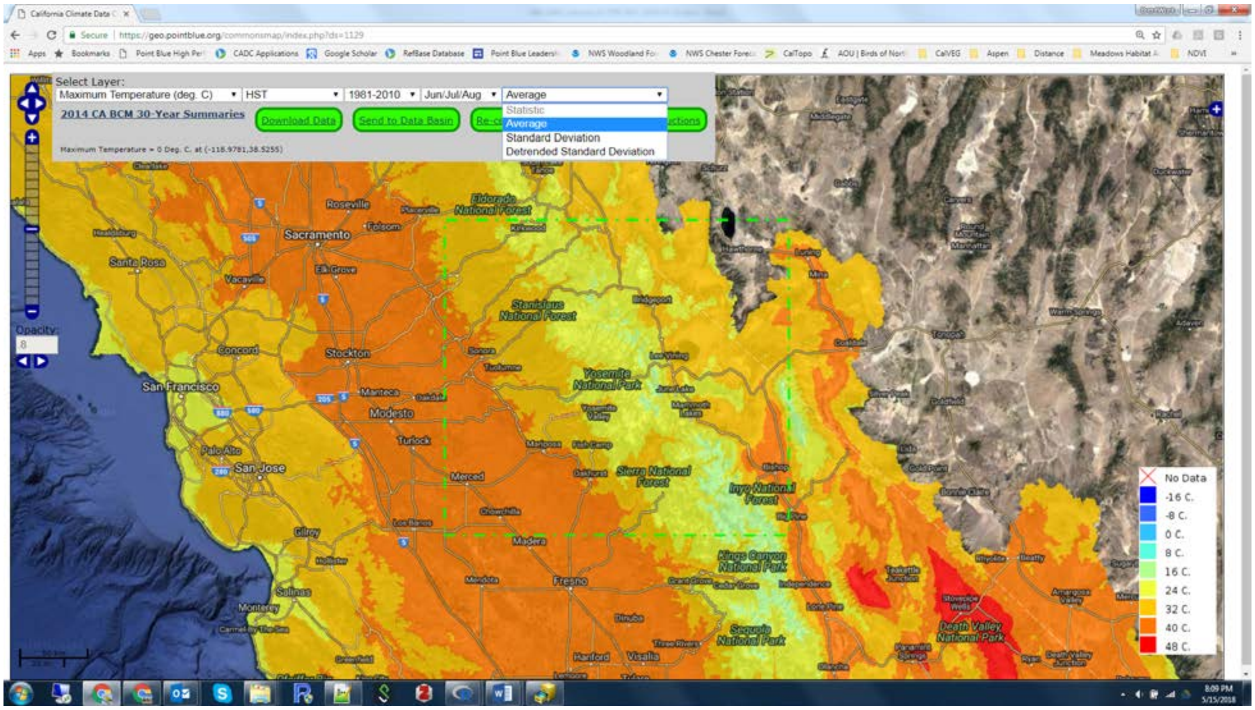
f. For the second and third drop-down menus, “HST” and “1981-2010” should be selected as default. If not, select them.



g. For the fourth drop-down menu, select “Jun/Jul/Aug.”



h. For the fifth drop-down menu, “Average” should be selected as default. If not, select it. Click the green Download Data button.



i. Place the downloaded ZIP file into your GIS workspace and extract the file. You will now have a folder called “tmx1981_2010jja_ave_HST_…” in your workspace (there is a timestamp at the end of the folder name). Within this folder is file called “tmx1981_2010jja_ave_HST_ … .tif” (hereafter referred to as the “temperature” layer).

E. Retrieve elevation data

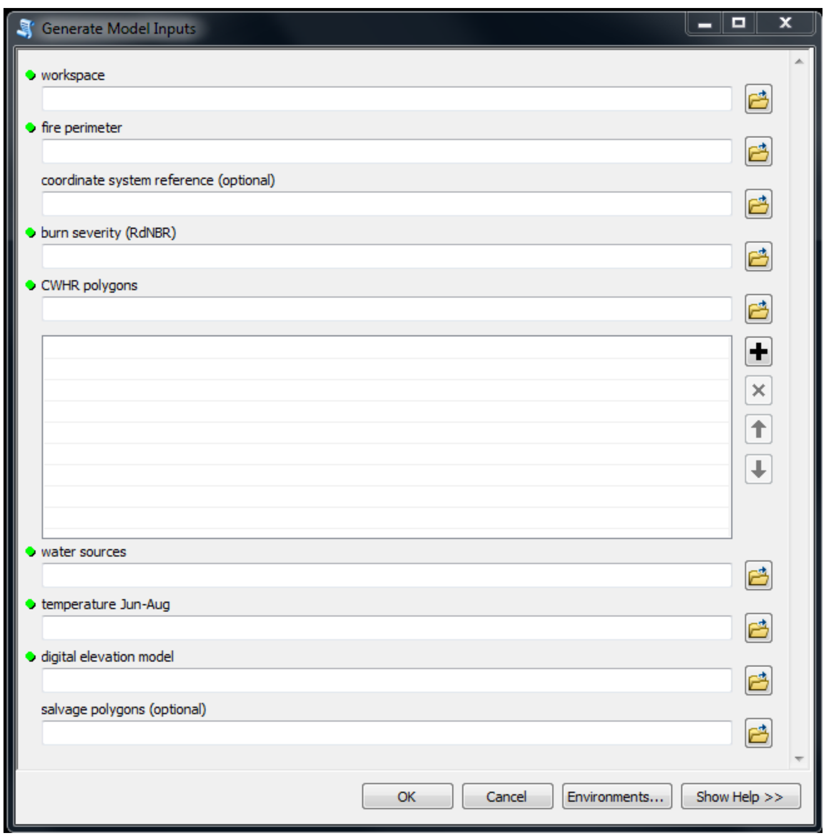
1. Option 1: Use the digital elevation model (DEM) data layer supplied in the FIRE-BAT Toolbox.

a. Navigate to “TOOLBOX → Input_Layers → dem → US_DEM2010” and locate the “us_dem2010” ArcGrid file (hereafter referred to as the “elevation” layer). You can leave the file here, or copy it to your workspace.

2. Option 2: Provide your own DEM. We highly recommend a DEM resolution of 30m — higher resolutions will result in prohibitively long computation times when the Generate Model Inputs tool calculates solar radiation (see following steps). The DEM layer's extent must cover the entire footprint of the fire of interest.

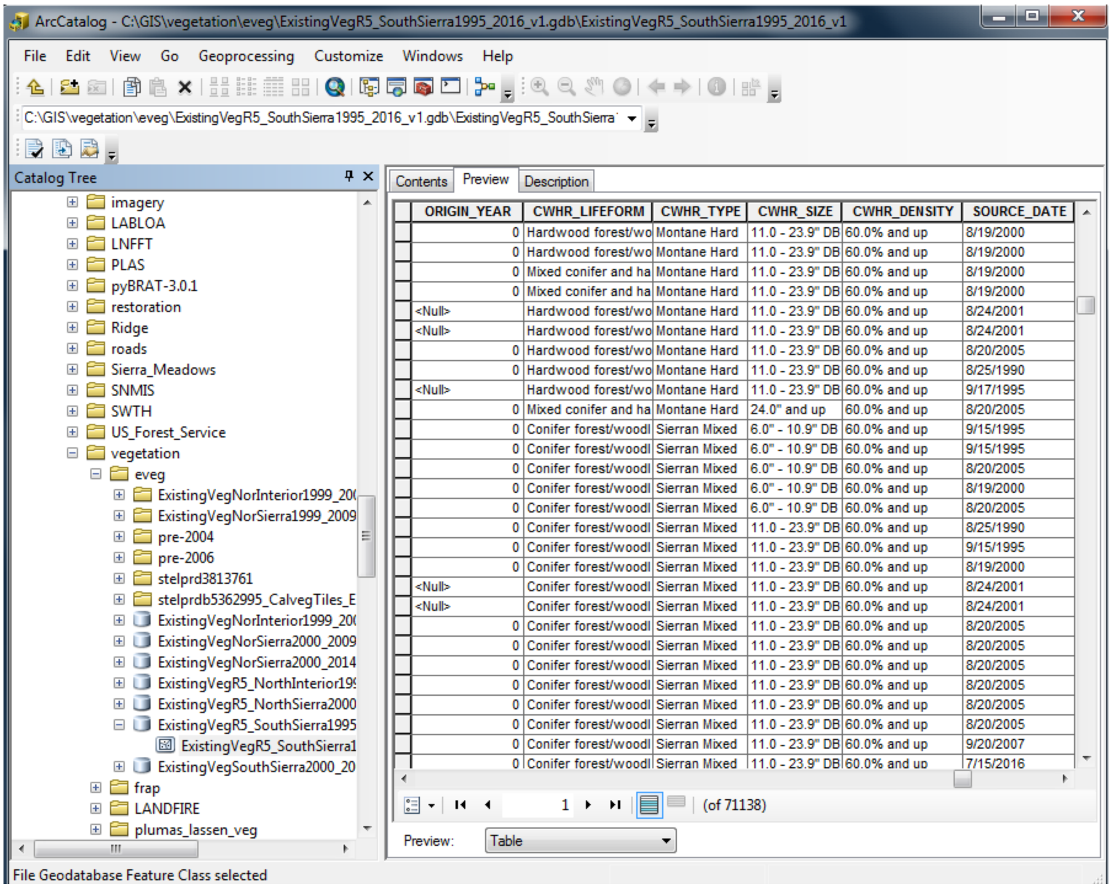
F. Now you will compile many of the input variables needed to apply any of the habitat models for bats (Table 1) using the associated Generate Model Inputs tool. The following subtasks are best preformed entirely from ArcCatalog.

1. From ArcCatalog, navigate to the "TOOLBOX → Habitat Suitability Modeling.tbx → Generate Model Inputs" and open the "Generate Model Inputs" tool by double-clicking it.



2. Identify or create a folder where you want the layers generated from this tool to be stored. Under “workspace”, navigate to this folder. Then click “Add”. Alternatively, you can drag and drop the desired folder to this window from ArcCatalog.
3. For “fire perimeter”, navigate to the fire perimeter shapefile downloaded along with RAVG data (Step I.A). You can either navigate from outside the tool interface and drag and drop the perimeter shapefile into the “Fire Perimeter” box from ArcCatalog, or navigate from within the tool and click “Add”.
4. If the user desires the output file to be in a different coordinate system from RAVG data (i.e., the fire perimeter shapefile), provide a spatial layer (shapefile or raster) that represents the desired coordinate system (drag and drop or navigate from within the tool). Otherwise, leave blank.
5. For “burn severity”, use the relativized delta-normalized burn ratio (RdNBR) layer downloaded with RAVG data (Step I.A; drag and drop or navigate from within the tool). The filename for this layer may vary but should end in “rdnbr.tif” and not, for example, “rdnbr_ba.tif” or “rdnbr_cbi.tif”. The user may need to review metadata for downloaded layers (click on the “Description” tab when previewing in ArcCatalog) to identify the right layer. If no such layer exists, the user may contact the Region 5 Remote Sensing Laboratory for an appropriate file.
6. For “CWHR polygons”, provide the Existing Vegetation polygon file(s) retrieved in Step I.B (drag and drop or navigate from within the tool). The attribute table for each polygon file should contain “CWHR_DENSITY” and “CWHR_SIZE” fields, from which the input layers are derived. Users can verify existence of these fields by previewing the attribute table for each polygon file in ArcCatalog (go to “Preview”

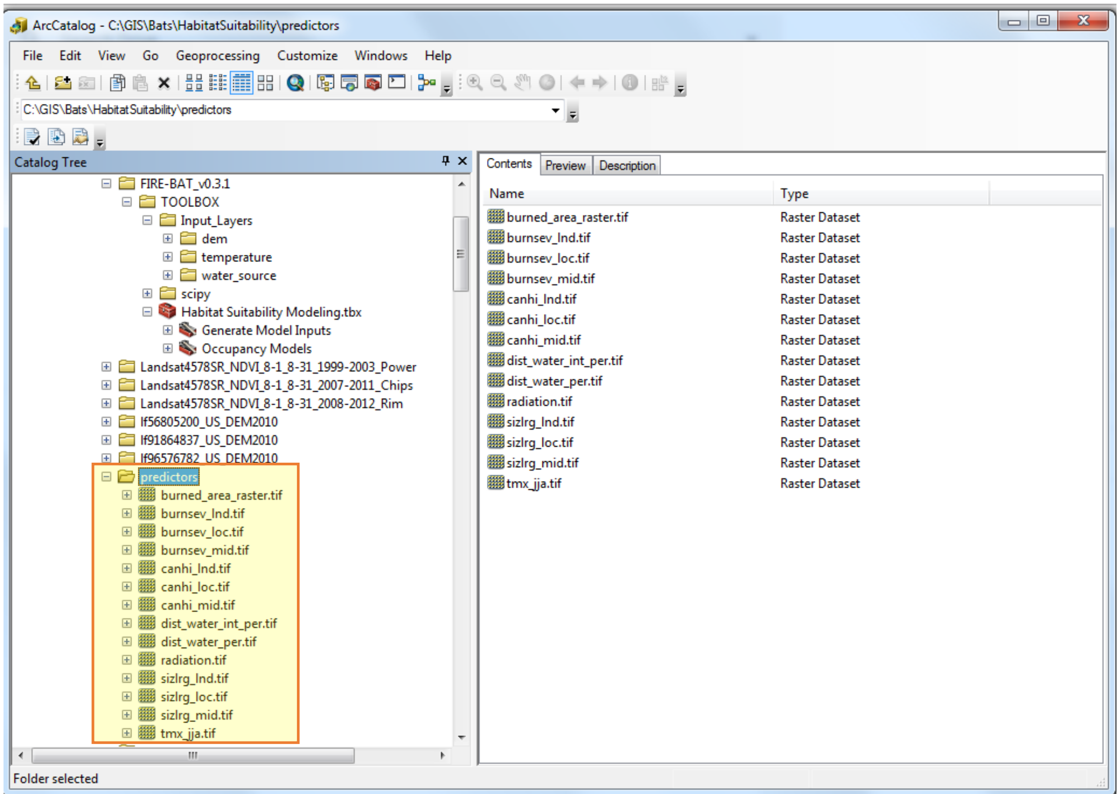
tab at the top and select “Table” in the drop down menu at the bottom and scroll to the right, e.g., see screen shot below). If the attribute table(s) contains “WHRDENSITY” and “WHRSIZE” fields, see the next step.



7. If you provided older USFS Existing Vegetation data in the previous step, your attribute table will contain “WHRDENSITY” and “WHRSIZE” fields. In this case, click the box next to the “Click here if providing Eveg data (CWHR polygons) in the old format"

8. For “water sources”, provide the water source layer located in the Input_Layers folder under Step I.C.1 or download under Step 1.C.2 (drag and drop or navigate from within the tool).

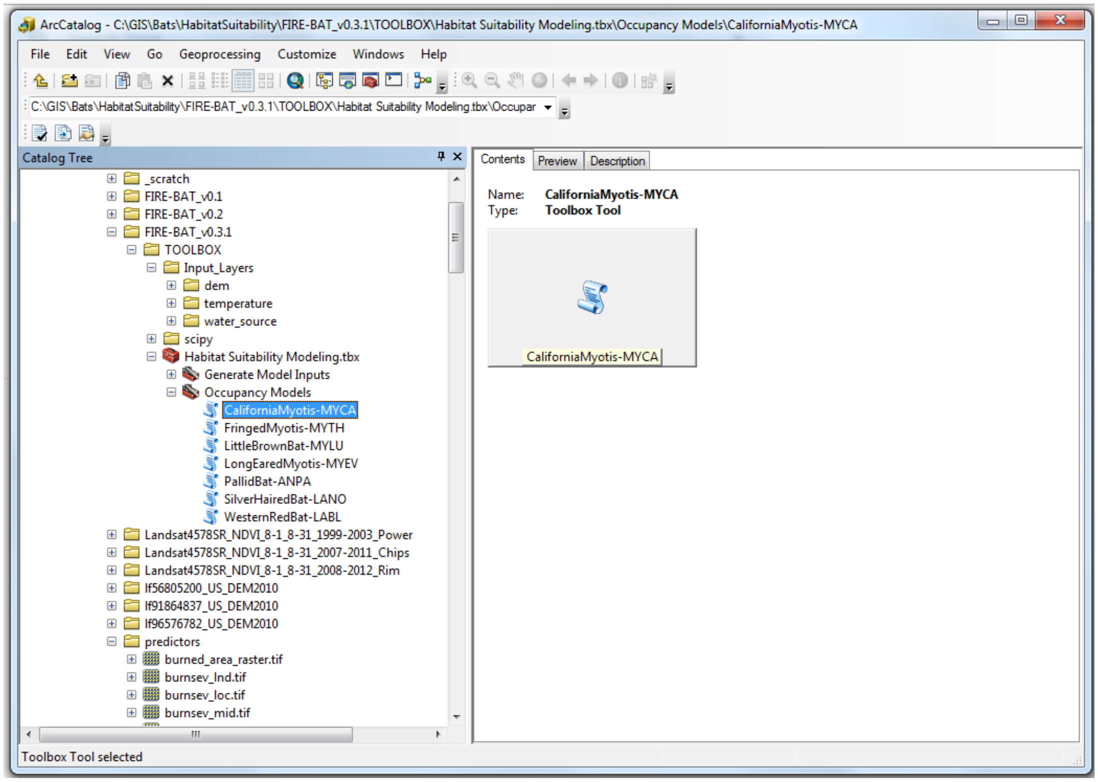
9. For “temperature Jun-Aug”, provide the temperature layer located in the Input_Layers folder under Step I.D.1 or download under Step 1.D.2 (drag and drop or navigate from within the tool).
10. For “salvage polygons”, you have the option of providing salvage units within the fire perimeter. The salvage data must be vector data in a single feature class.
11. Click OK. The tool will take 2-10 minutes to complete depending on the size of the burned area of interest. All outputs will be stored under “predictors” in your designated workspace. Open this folder and verify presence of the following layers (see the transparent yellow polygon in the screen shot below): “burnsev_lnd.tif”, “burnsev_loc.tif”, “burnsev_mid.tif”, “burned_area_raster.tif”, “canhi_lnd.tif”, “canhi_loc.tif”, “canhi_mid.tif”, “dist_water_per.tif”, “dist_water_int_per.tif”, “fire_perim.tif”, “radiation.tif”, “salvage_raster.tif” (in predictors folder only if salvage polygons were supplied), “sizelrg_lnd.tif”, “sizelrg_loc.tif”, “sizelrg_mid.tif”, “tmx_jja.tif”.



12. Optional: The "_scratch" directory generated in the designated workspace when implementing this tool can be deleted upon successful completion.

II. Run any or all model application tools as desired. Now you will use the layers in the predictors file above as inputs for the species-specific occupancy suitability models for Sierra bats. The following tasks are best preformed entirely from ArcCatalog.

A. From ArcCatalog, navigate to "TOOLBOX →Habitat Suitability Modeling.tbx", open the "Occupancy Models" toolbox, and then open the tool for your species of interest by double-clicking it.

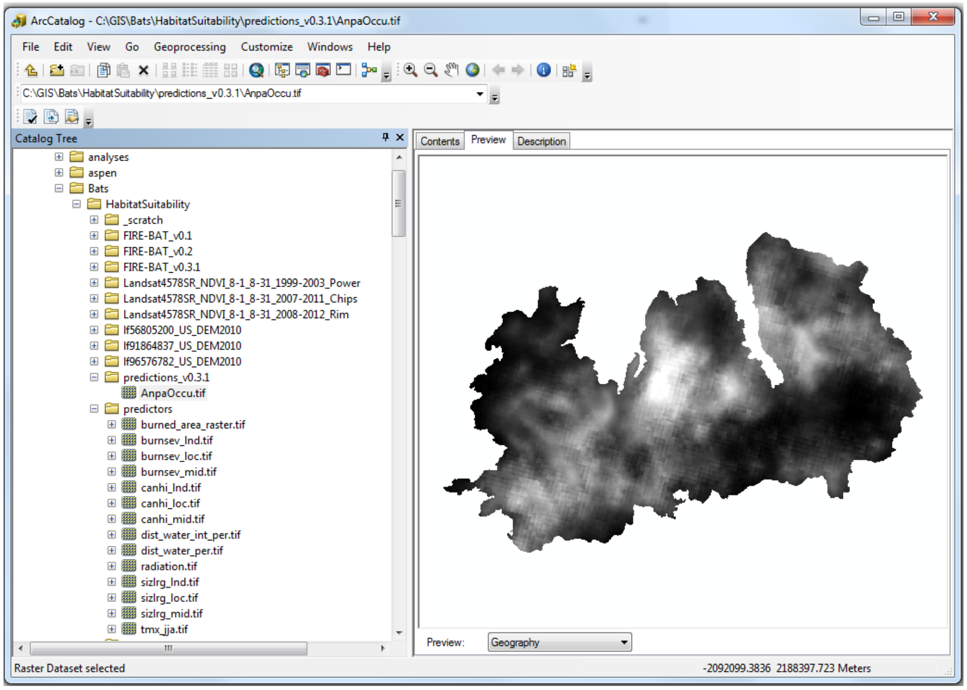


B. For the variables listed in Table 4 use the associated layers generated in Step I.E. Either navigate to the "predictors" folder in ArcCatalog and drag and drop each input layer, or navigate from within the dialog box and click "Add" to designate each layer. A subset of 2-7 of these input layers will be required for any one tool. The "Salvaged area" parameter is only applicable to users who supplied a salvage polygon layer in Step I.E.9.

C. Select the region your fire of interest is located in: Lassen/Plumas NF, Eldorado NF, or Stanislaus NF. (**IMPORTANT**: *If no region is selected, the tool will run and output will be generated, but the output will be wrong*!)

D. For the "Output" parameter, designate an appropriate location and filename for the output occupancy raster. Click the button with the folder icon to the right, locate your workspace or any other desired location, and create a meaningful name, e.g., "AnpaOccu.tif". Again, we recommend ".img" or ".tif" file extensions to allow longer filenames.

E. Click on OK to run the model. A series of progress bars will flash. If necessary, close the results window once “succeeded” is displayed. To view the model output, navigate to the file named in step II.D (e.g., “AnpaOccu.tif”), and then select preview pane to preview the HSI map.



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APPENDICES

Appendix A – Troubleshooting guide

Problem 1. – When attempting to retrieve RAVG burn severity data for my project area, the data retrieval window is not visible on the website as shown in the instructions (Section 4.4).

Solution 1. – You may not have Adobe Flash Player installed or enabled. Search for "install or enable Adobe Flash Player" on the internet to find instructions to install, enable, and check the status of Adobe Flash Player. If Adobe Flash Player is enabled but the online data retrieval tool remains unavailable, you can contact the RAVG program directly via email or their website.

Problem 2. – When attempting to operate the Generate Model Inputs tool, I receive errors that resemble the following:

```
Error: "000732: <value>: Dataset <value> does not exist or is not
supported."
ExecuteError: Failed to execute. Parameters are not valid.
ERROR 000732: Input Features: Dataset '…' does not exist or is not
supported
Failed to execute (PolygonToRaster).
```

Solution 2. – Check the folder names and pathways for input files. Filenames and pathways should contain no spaces. In particular, the most likely reason for this error is an invalid path name for Existing Vegetation polygons downloaded from the Region 5 website. If the file geodatabase containing the polygons is embedded within a file of the same name, you will receive this error. For example, these paths result in an error:

C:\GIS\vegetation\eveg\ExistingVegR5_SouthSierra1995_2016_v1.gdb\ExistingVegR5_SouthSierra1995_2016_v1.gdb\ExistingVegR5_SouthSierra1995_2016_v1

C:\GIS\vegetation\Existing Veg\ExistingVegR5_SouthSierra1995_2016_v1.gdb\ExistingVegR5_SouthSierra1995_2016_v1

But this path is acceptable:

C:\GIS\vegetation\eveg\ExistingVegR5_SouthSierra1995_2016_v1.gdb\ExistingVegR5_SouthSierra1995_2016_v1