



Potential Recreation Displacement By Wildfire



# Potential Recreation Displacement By Wildfire

Cleveland National Forest

Pacific Southwest Research Station

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**Cleveland National Forest**

**Cleveland National Forest Landscape**

The Cleveland National Forest spans approximately 460,000 acres across San Diego, Riverside, and Orange Counties in southern California (USFS). The close proximity to large urban centers coupled with diverse landscapes provide unique recreation opportunities for urban dwellers (USFS). Forest visitors can experience wilderness areas (Agua Tibia Wilderness, Hauser Wilderness, Pine Creek Wilderness, San Mateo Canyon Wilderness) that cover a range of ecosystems from grasslands to conifer forests. Wildlife is abundant throughout the forest which provides recreationists the opportunity to view 500+ wildlife species and thousands of plant species, many of which are endangered (USFS, The Center for Biological Diversity).



Sunset Trail to Big Laguna  
Cleveland National Forest

## Cleveland National Forest Recreation

Popular recreation destinations with the Cleveland include campsites, trails, and picnic areas such as the Sunset Trail, a 4.6-mile loop through pine forests and meadows offering views of the Pacific Ocean (USFS) and the Big Laguna Trail, a 10-mile loop that connects to Sunset and Noble Canyon trails and features the Big Laguna Lake (USFS). Popular destinations include Lake Cuyamaca and the Mount Laguna Observatory

(Lake Cuyamaca, SDSU). Each map below provides location of select campsites, trails, and other areas of interest.

## Potential for Recreation Displacement by Wildfire Project Goals

This project was initiated to provide land managers with spatial information on the potential for recreation destinations to be closed or disrupted due to wildfire. Wildfires are a common occurrence in fire prone landscapes including much of southern California. Wildfires of any size can close national forests to the public for short durations due to safety concerns for forest visitors while the fire is active. However, larger, more destructive wildfires can lead to long term recreation displacement by removing trail and campsite infrastructure, killing surrounding vegetation leading to safety concerns from falling trees, and increase the time to restore recreation opportunities. In this project, we create spatial data to show where the greatest risk of long term recreation displacement due to wildfire is likely. In the following sections we discuss the data and processes we used to create our potential for recreation displacement by wildfire spatial datasets.

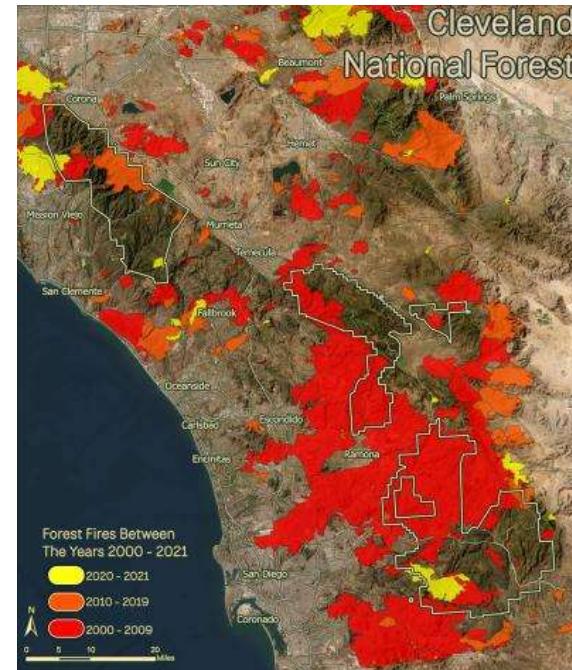
## Cleveland National Forest Fire History

**Background:** Between the years 2000 - 2021, approximately 43% of Cleveland National Forest was burned by wildfires, which impacted large parts of the landscape and visitor

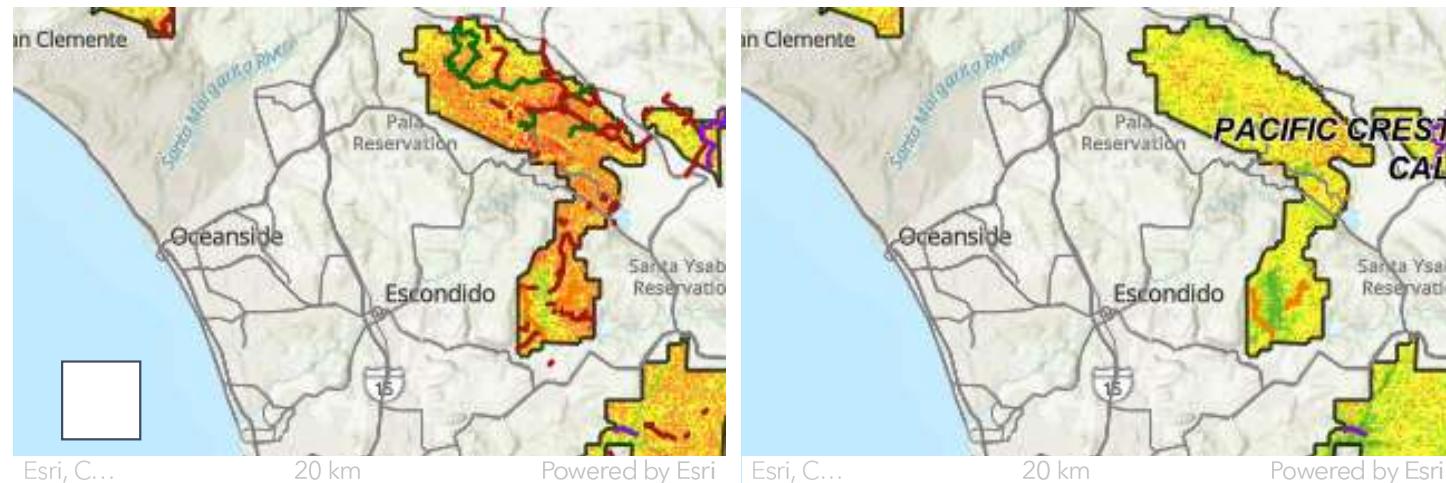
recreation. (Data sources for fire perimeter map: Cal Fire, USFS).

## Potential for Fire to Impact Recreation: Dry vs. Moderate Conditions

To understand the potential for fire to impact recreation on the Cleveland National Forest, we collected data and modeled recreation displacement likelihood using two weather scenarios. A "dry" and "moderate" scenario following Scott and Burgan 2005. Each recreation displacement likelihood map was created using the following five spatial data inputs: canopy height, flame length probability, heat per unit area, burn probability, and fire severity. Canopy height was used as a measurement of vegetation type most likely to cause long term disruption to recreation, that is fire killed tall trees are more likely to disrupt recreation than shrubs or grass fuel types. Flame length probability and heat per unit area were used to measure fire intensity and amount of energy released from a fire. Burn probability conveys the likelihood of a fire occurring at a given location across the landscape. Fire severity indicates how damaging a fire would be if an ignition occurred.



Historic Fires within the Cleveland National Forest



### Potential for Fire to Impact Recreation: Dry and Moderate Weather Conditions

In the map above, you can use the slider to switch between dry and moderate conditions. On the left is the potential for fire to impact recreation during dry conditions. On the right is the potential for fire to impact recreation during moderate conditions. The legend is in the bottom left corner, and you can zoom in and out using the plus and minus buttons in the bottom right corner. The dry and moderate scenarios are broken up into five categories: severe impacts on recreation (red), high impacts on recreation (orange), moderate impacts on recreation (yellow), low impacts on recreation (light green), and very low impacts on recreation (dark green). For more information about a specific place of interest (indicated by white or blue point icons) or to learn more about a particular trail or road, please click the layer. The map will display a table with additional information about the selected location, including model and input values. Additionally, click the link

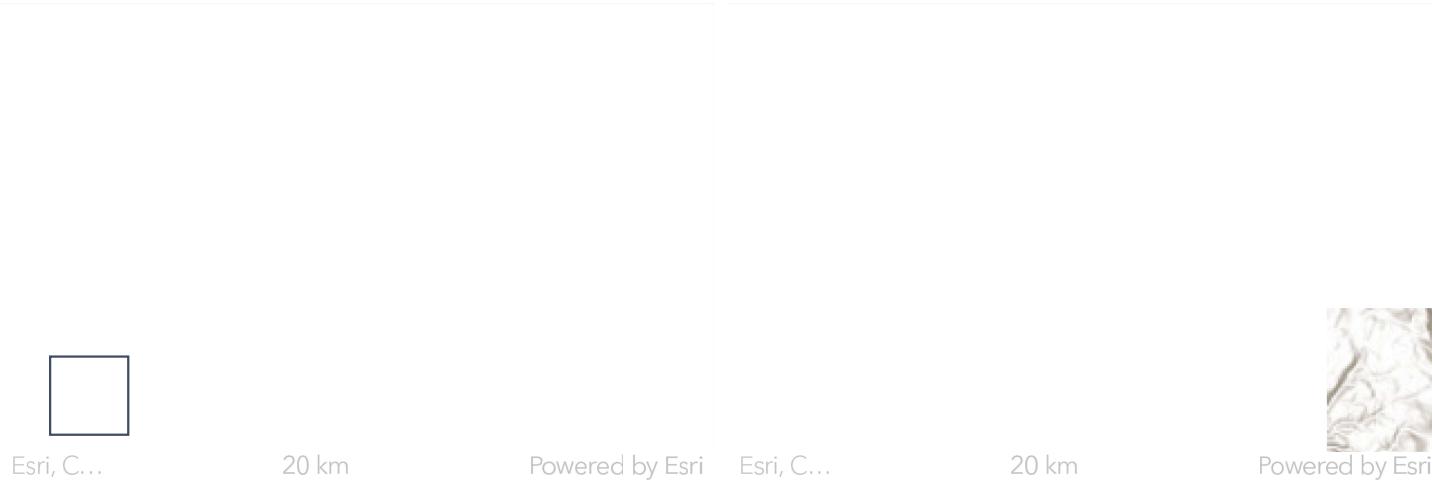
below to view an interactive web app that will allow you even more freedom to interact with the map above. [Link to an interactive web map with full dry and moderate potential for fire to impact recreation scenario datasets.](#)

The dry and moderate conditions were based on (Scott & Bergen, 2005). More specifically while utilizing FlamMap to create dry and moderate condition scenarios dead fuel moisture levels, live woody fuel moisture levels, and herbaceous fuel moisture levels were changed to represent either dry or moderate conditions. Dry conditions being fully cured, and moderate conditions being 1/3<sup>rd</sup> cured.

## Burn Probability

Burn probability provides information on where fire is most likely to occur within the Cleveland National Forest boundary given a random ignition within a landscape. We restricted our fire modeling to within the forest boundary because our data is most accurate within the boundary and we cannot report fire information outside the forest boundary with any confidence. We created the burn probability layer using FlamMap fire behavior modeling software (Finney 2006) using 10,000 randomly placed ignitions within the modeling landscape. FlamMap then runs a separate fire growth simulation for each ignition point creating 10,000 burn polygons. Burn probability is then the result of how many

times an area (pixel) is burned divided by the total number of ignitions placed within the landscape.



Burn Probability: Dry (left) and Moderate (right) weather conditions.

In the map above, you can use the slider to switch between dry and moderate conditions. On the left is burn probability during dry conditions. On the right is burn probability during moderate conditions. The legend is in the bottom left corner, and you can zoom in and out using the plus and minus buttons in the bottom right corner. The dry and moderate condition scenarios are broken up into five categories: highest probability (red 80 - 100% of Max), high probability (orange 60 - 80% of Max), moderate probability (yellow 40 - 60% of Max), lower probability (light green 20 - 40% of Max), and very low probability (dark green 0 - 20% of Max). For more information about a specific place of interest (indicated by white or blue point icons) or to learn more about a particular trail or road,

please click the layer. The map will display a table with additional information about the selected location, including model and input values. Additionally, click the link below to view an interactive web app that will allow you even more freedom to interact with the map above. [Link to an interactive web map with full dry and moderate potential for fire to impact recreation scenario datasets.](#)

## Flame Length Probability

Flame length probability is an input variable produced by FlamMap in combination with burn probability. Flame length probability is calculated from the flame length observed when a land unit (pixel) is burned divided by the total number of times the pixel burns. Flame length probability essentially shows the most likely flame length if the area burns and the range of flame lengths possible when the area (pixel) is burned during potential wildfires.



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20 km

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20 km

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### Flame Length Probability: Dry and Moderate Weather Conditions

In the map above, you can use the slider to switch between dry and moderate conditions. On the left is flame length probability during dry conditions. On the right is flame length probability during moderate conditions. The legend is in the bottom left corner, and you can zoom in and out using the plus and minus buttons in the bottom right corner. The dry and moderate condition scenarios are broken up into six categories: highest probability (red: flame lengths greater than 12 ft), high probability (orange: flame lengths between 8 ft and 12 ft), moderate probability (yellow: flame lengths between 6 ft and 8 ft), low probability (light green: flame lengths between 4 ft and 6 ft) lower probability (green: flame lengths between 2 ft and 4 ft), and lowest probability (dark green: flame lengths less than 2 ft). For more information about a specific place of interest (indicated by white or blue point icons) or to learn more about a particular trail or road, please click the layer.

The map will display a table with additional information about the selected location, including model and input values.

Additionally, click the link below to view an interactive web app that will allow you even more freedom to interact with the map above. [Link to an interactive web map with full dry and moderate potential for fire to impact recreation scenario datasets.](#)

## Heat Per Unit Area

Heat per unit area is also produced during the FlamMap modeling. Measured in BTU/ft<sup>2</sup>, heat per unit area provides insight into how much energy will be produced if the area (pixel) burns.



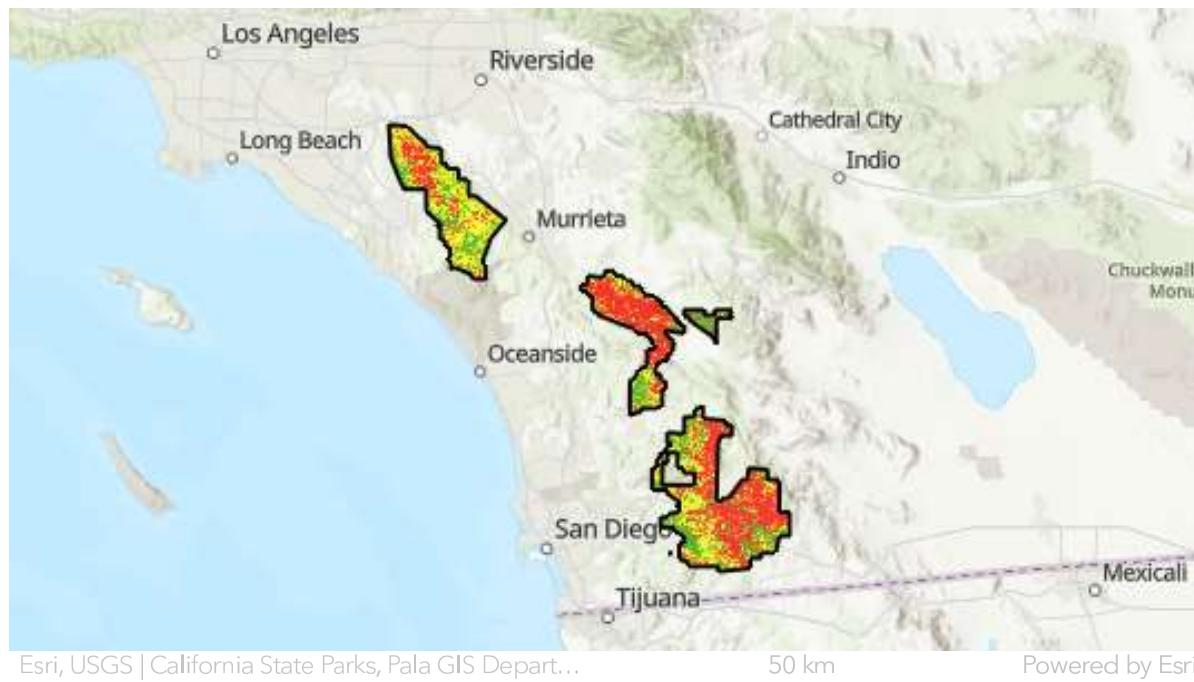
Heat Per Unit Area: Dry (left) and Moderate (right) weather conditions

In the map above, you can use the slider to switch between dry and moderate conditions. On the left is heat per unit area during dry conditions. On the right is heat per unit area during moderate conditions. The legend is in the bottom left corner, and you can zoom in and out using the plus and minus buttons in the bottom right corner. The dry and moderate condition scenarios are broken up into six categories: highest HPUA (red: HPUA > 10,000 BTU/ft<sup>2</sup>), high HPUA (orange: HPUA 6,000 - 10,000 BTU/ft<sup>2</sup>), moderate HPUA (yellow: HPUA 3,000 - 6,000 BTU/ft<sup>2</sup>), low HPUA (light green: HPUA 1,000 - 3,000 BTU/ft<sup>2</sup>), lower HPUA (green: HPUA 300 - 1,000 BTU/ft<sup>2</sup>), and lowest HPUA (dark green: HPUA 0.1 - 300 BTU/ft<sup>2</sup>). For more information about a specific place of interest (indicated by white or blue point icons) or to learn more about a particular trail or road, please click the layer. The map will display a table with additional information about the selected location, including model and input values. Additionally, click the link below to view an interactive web app that will allow you even more freedom to interact with the map above. [Link to an interactive web map with full dry and moderate potential for fire to impact recreation scenario datasets.](#)

## Fire Severity

We used the fire severity potential maps produced for the state of California by the California Fire Severity mapping project (CFS; Taylor et al. 2021, Drury et al. in prep) to provide

information on potential fire severity if the area burns. The CFS is an empirical based model that uses the information on prior fires, weather, and topography to estimate the most likely fire severity if the area burns under a specific set of past fire severity in historically burned areas, weather and topography (Taylor et al. 2021, Drury et al. in prep).



### Potential Fire Severity within the Cleveland National Forest

In the map above, you can see the fire severity model for Cleveland National Forest. The legend is in the bottom left corner, and you can zoom in and out using the plus and minus buttons in the bottom right corner. Fire severity is broken up into three categories: highest severity (red), moderate severity

(yellow), low severity (green). For more information about a specific place of interest (indicated by white or blue point icons) or to learn more about a particular trail or road, please click the layer. The map will display a table with additional information about the selected location, including model and input values. Additionally, click the link below to view an interactive web app that will allow you even more freedom to interact with the map above. [Link to an interactive web map](#) with full dry and moderate potential for fire to impact recreation scenario datasets.

## Canopy Height

The canopy height layer that was used while modeling the potential for fire to impact recreation was developed by Salo Sciences (<https://salo.ai/>). Canopy height was used as a measurement of vegetation type most likely to cause long term disruption to recreation, that is fire killed tall trees are more likely to disrupt recreation than shrubs or grass fuel types. In addition, landscapes with high canopy heights indicate that fires could have larger flames, higher levels of heat per unit area, increased fire severity, and a higher likelihood of burn probability.



Esri, USGS | California State Parks, Pala GIS Depart...

50 km

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### Canopy Height within the Cleveland National Forest

In the map above, you can see the fire severity model for Cleveland National Forest. The legend is in the bottom left corner, and you can zoom in and out using the plus and minus buttons in the bottom right corner. The model is broken up into six categories: canopy heights of 25 - 80m (dark green), canopy heights of 15 - 25m (green), canopy heights of 10 - 15m (light green), canopy heights of 5 - 10m (brown), canopy heights of 2 - 5m (orange), canopy heights of 0 - 2m (yellow). For more information about a specific place of interest (indicated by white or blue point icons) or to learn more about a particular trail or road, please click the layer. The map will display a table with additional information about the selected

location, including model and input values. Additionally, click the link below to view an interactive web app that will allow you even more freedom to interact with the map above. Link to an interactive web map with full dry and moderate potential for fire to impact recreation scenario datasets.

## ArcGIS Story Map Data Sources & Web Maps

For this project we decided on making two separate maps for USFS personal to use to better understand the impacts of fire on recreation throughout the Cleveland National Forest. The first map is simpler and includes the two different potentials for fire to impact recreation dry and moderate scenarios. While also including the inputs that went into those scenarios. In addition, we also made a map with the above-mentioned data, but it also includes some more datasets such as rate of spread, canopy base height, and existing vegetation to name a few.



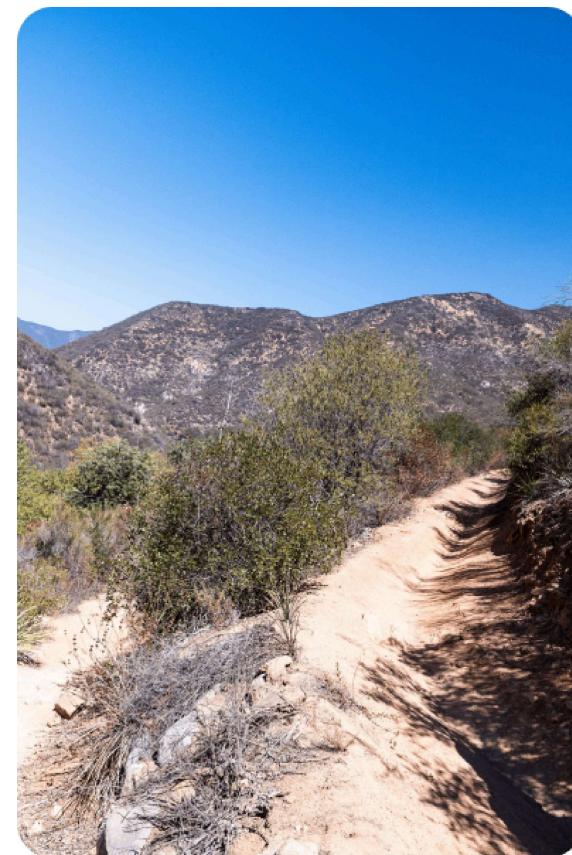
San Juan Trail-Trailhead

[Link to Simple Map](#)

[Link to All Data Map](#)

## Map Tools

These maps are interactive. You can turn on and off layers and overlay past fire boundaries with the different datasets. You can also use a measurement tool to draw polygons and calculate the size of a specific area you are interested in, or the distance between two high or low severity regions. Finally, you can also use a print tool to export an image of a specific region of the map. This output can have a detailed legend if you wish it to, and the map outputs a georeferenced image for Avenza which can be helpful during field work.



San Juan Trail

## Data Sources and Methodologies for Modeling

We used multiple different data sources and methodologies to produce the dry and moderate condition scenarios for the potential for fire to impact recreation in the Cleveland National Forest. The data sources include LANDFIRE, Salo Science, USGS, MTBS, USGS National Elevation Dataset, BCM, FRAP, USDA Hazardous Fuel Treatment Reduction polygons, GRIDMET, and Landsat.

FlamMap FBO and MTT models were used to produce desired dry and moderate condition data outputs: burn probability, flame length probability, and heat per unit area. Dry conditions were set to have very low dead fuel moisture content and fully cured live herbaceous and woody fuel. Moderate conditions were set to have moderate dead fuel moisture and moderate live herbaceous and woody fuel. The two scenarios were based on the standard fire behavior fuel models. Salo Science canopy height data was used when creating the potential for fire to impact recreation dry and moderate scenarios. Fire severity was calculated through a multistep Google Earth Engine and R process. Esri ArcGIS Pro ArcGIS Desktop Suitability Modeler was used to create the potential for fire to impact recreation dry and moderate condition models. Burn probability, fire severity, canopy height, flame length probability, and heat per unit area were entered in with equal weight on the models to create the dry and moderate condition scenarios.

The points of interest, trails, and roads shapefiles were either downloaded from the USFS clearinghouse or Caltrans .

**The findings and conclusions in this story map are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.**

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