# Paradise Nature-based Fire Resilience Project

**Conservation Biology Institute**
**In partnership with TNC and Paradise Recreation & Parks District**

Appendix B: Wildfire Risk Reduction Buffer
Design and Analysis Methods

**June, 2020**

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## Overview of Buffer Design and Analysis Process

For this project, CBI employed a combination of data-driven spatial analysis with expert opinion captured in spatial data layers in a collaborative and simplified version of modeling.

At each step of the project, the team met to discuss methods, data, inputs, and local knowledge that could be used in the mapping and evaluation process. Dan Efseaff, Director of Paradise Recreation and Park District (PRPD), provided critical on-the-ground perspective and feedback to the mapping process.

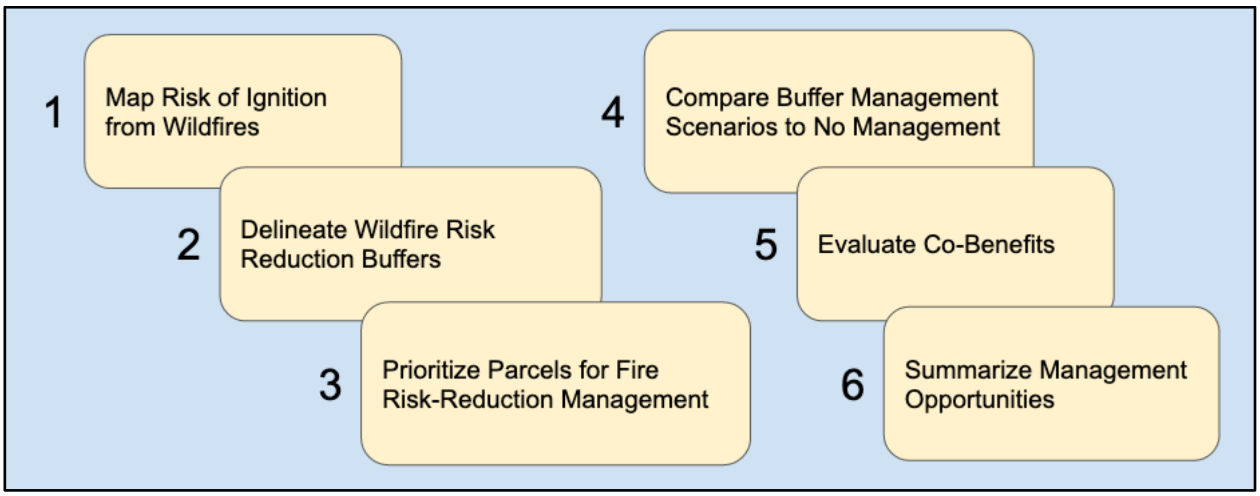



*Figure 1: Steps of the Analysis*

Below is an outline of the analysis steps (underlined steps denote names of important analysis elements):

1. Mapping Fire Risk
    a. Identified highest-risk wildland areas (Wildland Fire Probability) using an existing fire risk model;
    b. Modeled the risk of ignition in the urban areas by mapping parcels adjacent to or downwind of high-risk wildland areas;
    c. Classified results to identify urban areas at the highest risk (Urban Ignition Risk).

2. Creation of Wildfire Risk Reduction Buffers (WRRBs)
    a. Prioritized parcels for fire risk reduction, opportunities to work on publicly-owned land, and recreation value (Region-wide Risk-Reduction Prioritization)
    b. Analyzed Conservation Co-benefits;
    c. Used these two maps along with on-the-ground knowledge to guide WRRB designation.

   d. Used the Urban Ignition Risk, Region-wide Risk-Reduction Prioritization, and Conservation Co-benefit maps together with local knowledge of conditions on the landscape to delineate areas to form buffers between urban areas and wildlands.

3. <u>WRRB Risk-reduction Prioritization</u>
   a. Analyzed and ranked urban and wildland parcels within each WRRB for fire risk-reduction management based on fire risk and opportunities.

4. Compared <u>WRRB Management Scenarios</u> to No-Management Scenario for ignition risk-reduction and co-benefits
   a. Lowered the fire risk values in WRRB high-priority parcels in the Within-buffer Prioritizations to reflect risk-reduction actions in those parcels.
   b. Recalculated the Urban Ignition Risk values to map and quantify the fire risk-reduction benefits achieved by working on priority parcels.
   c. Compared results of Urban Ignition Risk with the Management Scenarios to Urban Ignition Risk with a no-management scenario.

5. Conservation and Recreation Co-benefits Evaluation
   a. Quantified the Conservation Co-benefits achieved by focusing management actions on priority parcels.

6. WRRB Management Plan Framework
   a. Summarized WRRB management opportunities, approaches, and elements that may affect the costs of achieving fire risk-reduction in each WRRB.

# Methods

## Study Area

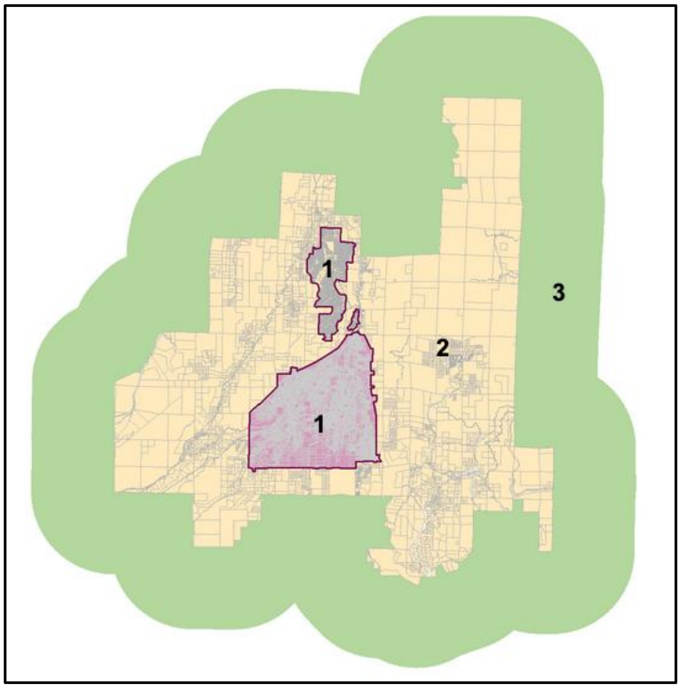



*Figure 2: Map of the study area for this project. 1 = urban areas, 2 = Paradise Recreation and Parks District region, and 3 = 5 km buffer.*

The following areas were designated for purposes of mapping and analysis:

1) Urban or developed areas
2) Paradise Recreation and Parks District region
3) 5 km buffer around PRPD Boundary

Areas #2 and #3 were evaluated together for "Wildland Fire Probability" and "Conservation Co-benefits", and area #1 was analyzed at the parcel level for "Urban Ignition Risk". Areas #1 and #2 were the focus of the prioritization of parcels for fire risk-reduction action and WRRB designation.

## Mapping Fire Risk

For this part of the project,  the goals were to 1) model the risk of ignition within the urban areas from fires occurring in the surrounding wildlands, and 2) to explore changes in ignition risks under various scenarios of land cover change, as would be the case if risk-reducing management actions were implemented on prioritized parcels with the goal of creating a buffer between the wildlands and the urban area.

No existing modeling frameworks adequately served our purposes. In particular, to support the exploration of different management scenarios, the Urban Ignition Risk model needed to be linked to fire probability in the surrounding Wildland Area where the Camp Fire and other past large, destructive wildfires have originated.

To create the Urban Ignition Risk model, we took a three-part approach (Figure 3):

1. Map the fire risk in the Wildland Area (Wildland Fire Probability)
2. Map the risk in the urban areas of ignitions coming from fires in the Wildland Area (Urban Ignition Risk)
3. Rank urban parcels according to their risk of ignitions to create a map with the urban parcels ranged for Ignition Risk.

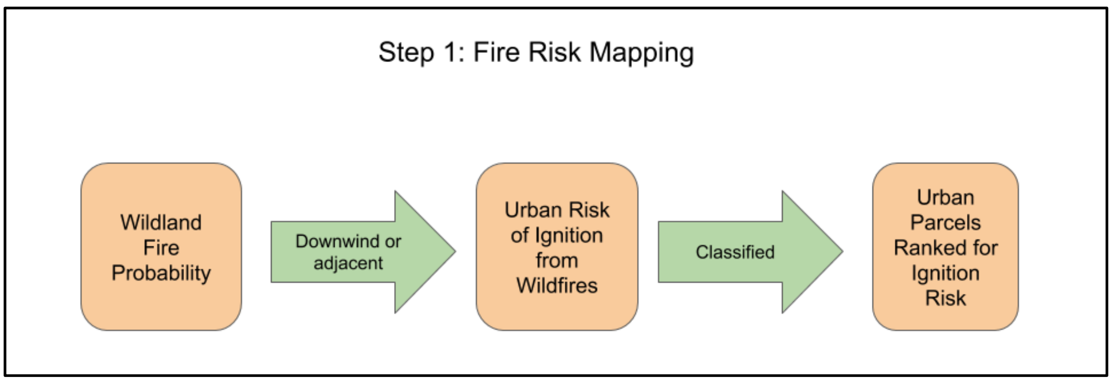



*Figure 3: Workflow for Fire Risk mapping for Paradise and Magalia*

## Wildland Fire Probability

For the Wildland Fire Probability model, we used selected model outputs from Syphard et al. (2018). This study modeled risk of ignition and vegetation burning in a statistical-correlative approach, incorporating all of the variables of interest: vegetation structure, type, and moisture; climate (annual minimum temperature and temperature seasonality, annual and summer precipitation, and climatic water deficit), human ignition sources (distance to roads and urban development); topography; past fires; and vegetation-fire dynamics modeled using MC2 (Bachelet et al. 2015) under two CMIP-5 climate scenarios: CNRM-CM5 ("cool/wet") and MIROC5 (complement/cover range of outputs) with the RCP 8.5 emissions scenario. These climate scenarios were chosen by Syphard et al., due to their relevance for California research (Kravitz 2017).

Please see (Syphard et al. 2018) for detailed methods.

Wind magnitude was not included in Syphard's fire risk model, because data were not available at that time. A future enhancement could potentially include the addition of wind magnitude and direction.

The Syphard et al. 2018 model provided two outputs:

1) All fires: the probability of all fires (no size limitations), and
2) Large fires: probability of fires >= 40 ha.

We used the "All Fires" output as recommended by Alexandra Syphard to ensure that we accounted for the full range of where fires were likely to ignite, selecting outputs from models runs that included MC2 dynamic vegetation models under the two climate scenarios (CNRM-CM5 and MIROC5) for the present 20-year time period of 2010–2039. The training data for the Syphard et al. All Fires model was compiled from the National Interagency Fire Program Analysis, Fire-Occurrence Database (FPA FOD), which includes the spatial coordinate information indicating the point of ignition for all fires across all land ownership types, with the date and size of fire included as attributes.

These model outputs were downscaled from 270m to a 90m grid array by resampling at the 90m cell to the highest fire probability value in the 270m cell.

The data were reclassified into three categories using model-specific thresholds. Many different approaches are used for selecting thresholds to categorize probability model outputs, ranging from arbitrary to those which balance and optimize omission and commission error rates (Liu et al. 2005).

- 1 (< 0.365) Lowest Fire Probability
- 2 (0.365 to 0.50) Medium Fire Probability
- 3 (>0.50) Highest Fire Probability

We used the 10 percentile training presence threshold (0.365) to separate the low and medium fire probability classes. With this threshold, all pixels with predicted fire probability less than the predicted value for the lowest 10% of fire sample points used to train the model are classified as 'low' (the 'low' class includes the bottom 10% of fire sample points). The maximum sum of training sensitivity (true positive classification rate) and specificity (true negative classification rate) threshold (0.50) was used to divide the medium and high fire probability classes. The performance of this threshold in transforming continuous outputs from presence-only models into binary outputs has been shown to be robust and consistent (Liu, White, and Newell 2013; Cao et al. 2013; Liu, Newell, and White 2016).

The two resulting datasets (from both climate models) were reclassified in three categories 1 (lowest), 2, and 3 (highest). The two reclassified model outputs were then added together into a single Wildland Fire Probability layer with possible summed values of 2 (lowest) through 6 (highest), (see Figures 4 and 5).

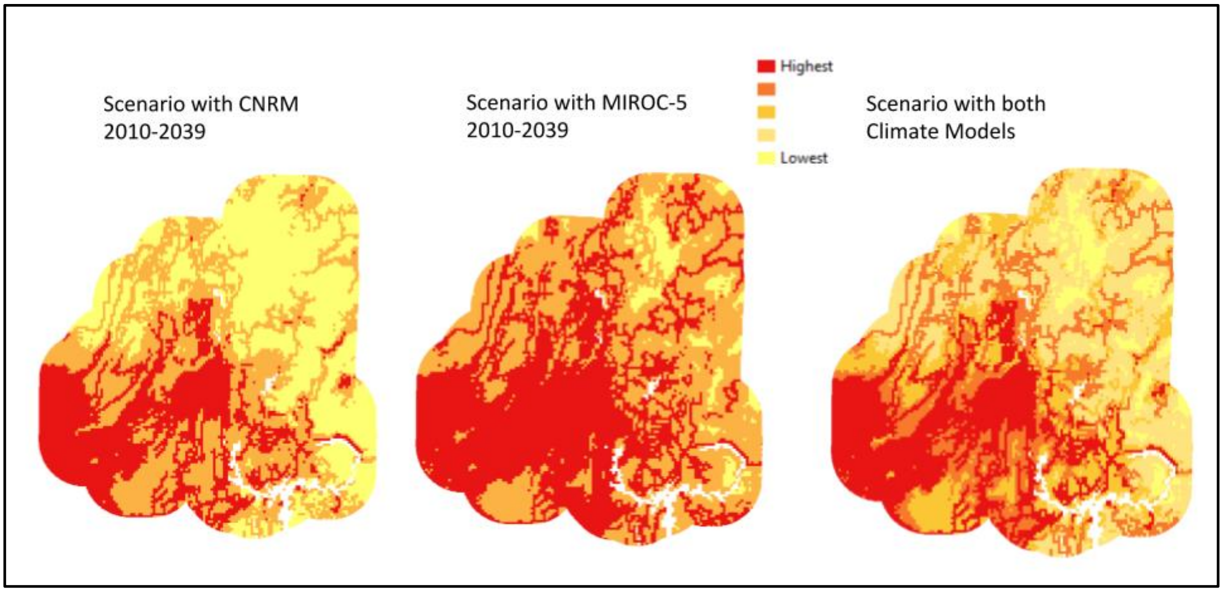



*Figure 4: Classified fire probability model outputs, separate and combined (Syphard et al. 2018).*

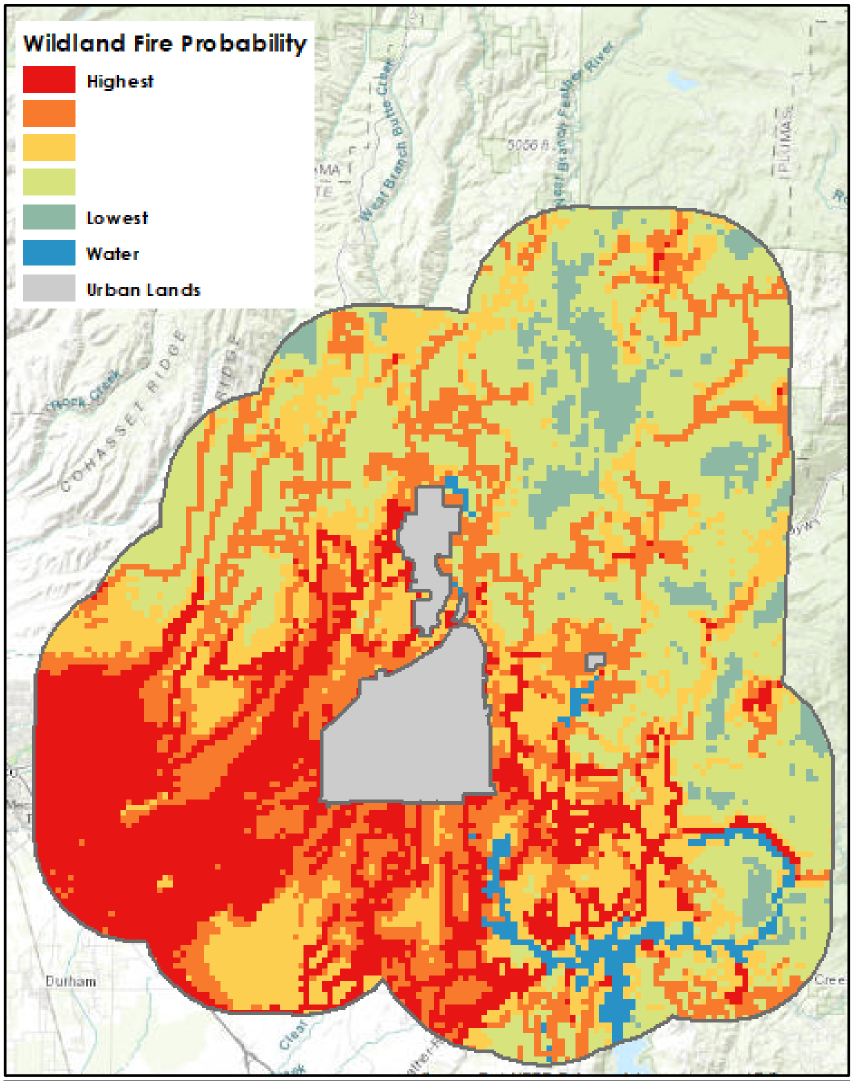



*Figure 5. Final Wildland Fire Probability Map for the Paradise region. Click here to open the dataset in Data Basin*[1]

1 All linked maps in this report are stored in a private workspace in Data Basin (databasin.org) and require permission to open. To request permission please email deanne.dipietro@consbio.org.

## Urban Ignition Risk

We estimated Urban Ignition Risk using two definitions of risk of ignition from wildfire occurring outside of the urban area: 1) ignition by proximity to the flame front and 2) ignition by wind-born embers. We did not attempt to model risk of burning (sensitivity) within the urban area due to the complexities of fire behavior in the built environment (see the Literature Review for discussion of exposure versus sensitivity, and factors that come into play within the built environment). In addition, an analysis of sensitivity was outside of our project goal to evaluate the benefits of risk-reduction buffers surrounding an urban area.

To represent these threats, we created two input datasets:

1) Flame Front Ignitions: Adjacent to High-Fire-Risk Wildland Areas
2) Wind-driven Ignitions: Downwind of High-Fire-Risk Wildland Areas

Flame Front Ignitions: Adjacent to High-Fire-Risk Wildland Areas

Risk of direct ignition from the flame front was mapped by identifying parcels that are adjacent to high risk cells from the Wildland Fire Probability map (Figure 5). We applied a binary classification (yes or no); urban parcels adjacent to high risk wildland cells were assigned a value of 3 for high ignition risk and 0 for low or no ignition risk. Including this non-wind-driven input captured parcels that may not be downwind from high risk cells but if they are directly adjacent to a high fire risk location they are at risk of ignition based on proximity.

Wind-driven Ignitions: Downwind of High-Fire-Risk Wildland Areas

The wind-driven ignition risk input was created by selecting high risk cells in the Wildland Fire Probability map (Figure 5) and using Santa Ana Wind Direction data from the Desert Research Institute, which captures Average Direction (as U and V values) over a 10-day period during an extreme event in 2004-2013 to create wind vectors from the high-risk Wildland cells. Euclidean distance was applied to generate values along these vectors that decrease with increasing distance from high-risk wildland cells (Figures 6 and 7). This means that parcels that are a short distance from a high-risk wildland cell and are in SW wind trajectory (making them downwind) would have the highest ignition risk value. This calculation assumes that ember flight distance decays linearly. Note: We discussed how one could investigate a more sophisticated degradation equation to estimate the behavior of wind-born embers. This is a complex topic and was set aside for a future effort due to restrictions in time and funding.

The outputs of the euclidean distance calculations were classified using natural breaks to these three “Wind-driven Ignition Risk” categories:

- 3 (0 - 1500 m/1.5 km) = High Ignition Risk
- 2 (1501m/1.5km - 3100 m/3.1 km) = Medium Ignition Risk
- 1 (>3100 m/3.1 km) Low Ignition Risk

The resulting values were assigned to intersecting parcels.

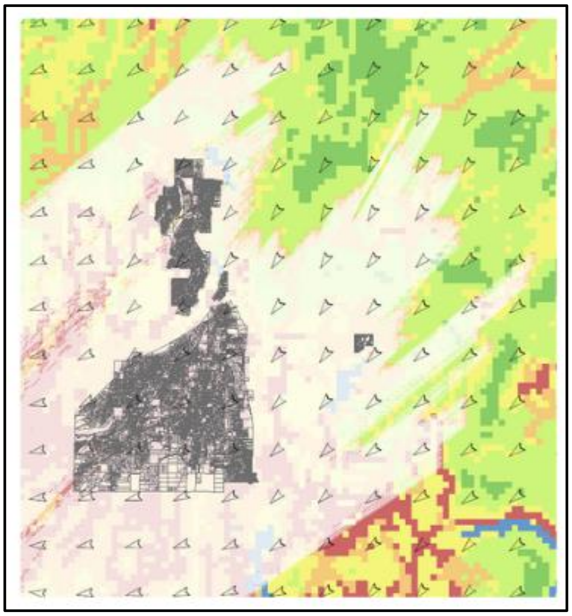
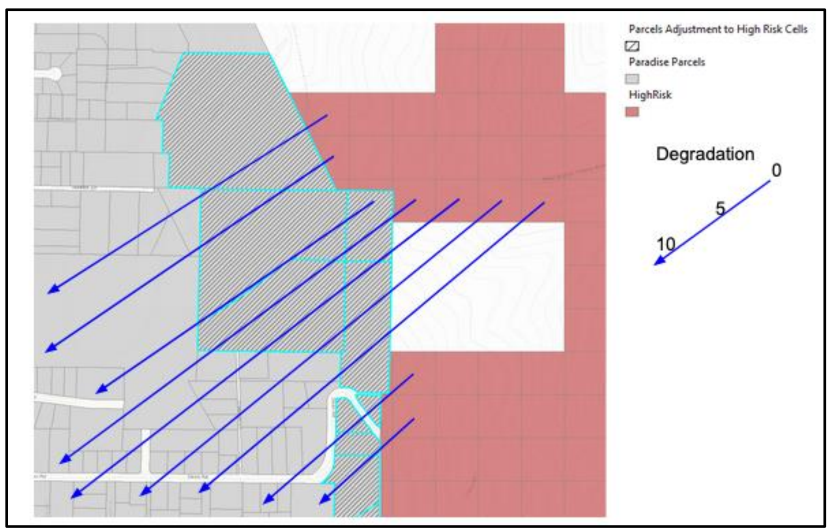


*Figure 6 (left). Graphic showing wind direction from the Santa Ana Wind dataset and hypothetical trajectories through the town of Paradise.*

*Figure 7 (right). Graphic depicting hypothetical downwind analysis of ignition risk for urban parcels using euclidean distance calculation. Ignition risk degrades with distance from the point of origin in a high-risk wildland cell.*



The two Ignition Risk inputs were summed for a single Urban Ignition Risk map: Adjacency to high fire risk wildland areas were given a value of 1; downwind from high fire-risk wildland areas values ranged from 1-3, for a total possible of 4. See Figure 8 for the final result for Urban Ignition Risk.

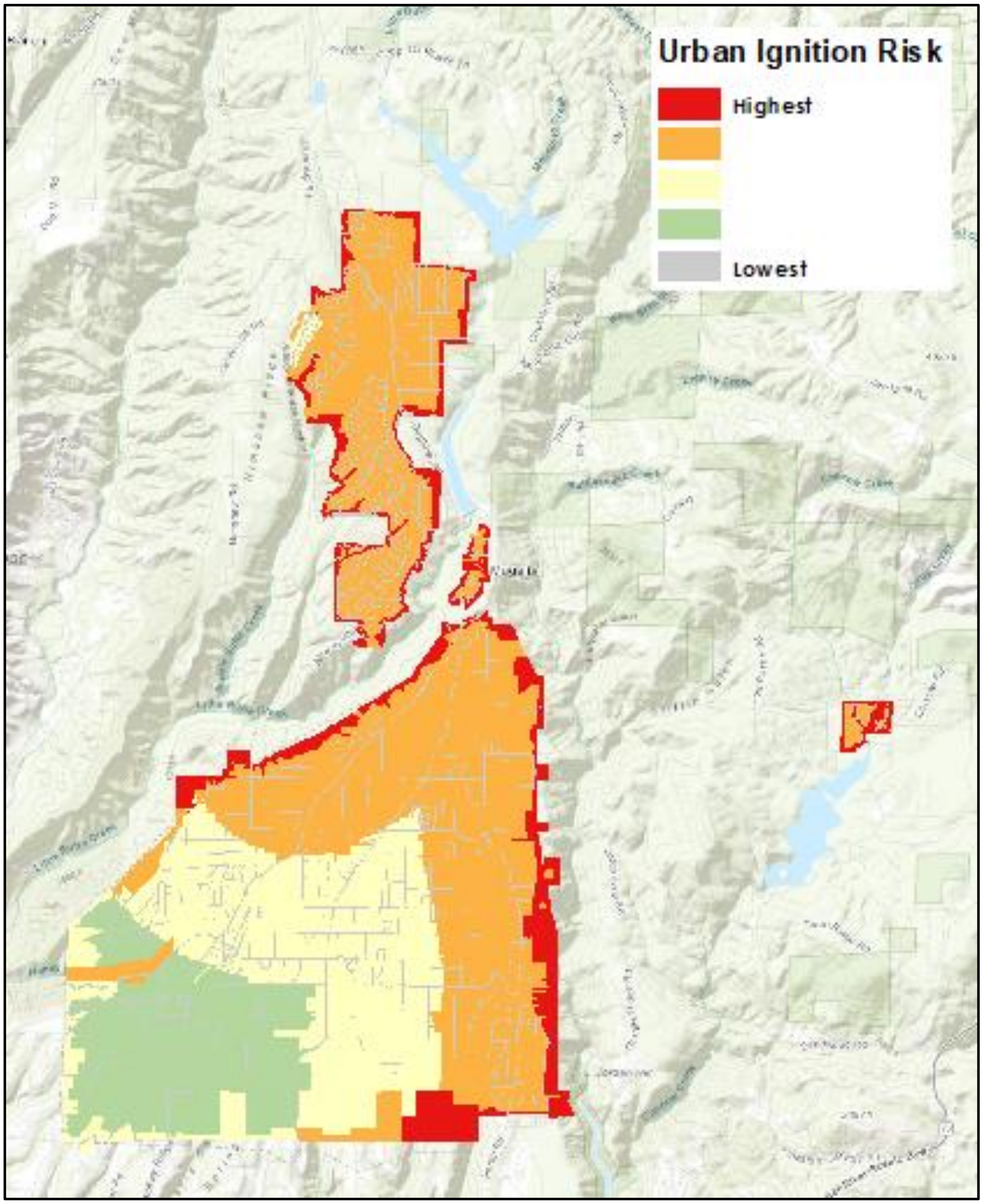



*Figure 8: Map of Urban Ignition Risk in the towns of Paradise and Magalia. Click [here]() to open in Data Basin.*

## Creation of Wildfire Risk Reduction Buffers (WRRBs)

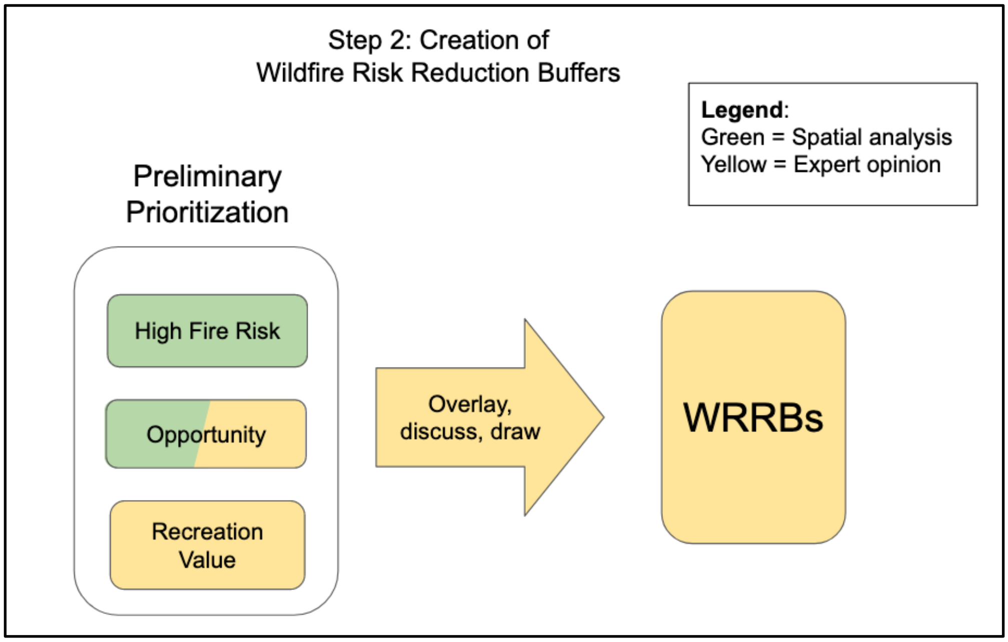



*Figure 9. Workflow for the WRRB delineation process*

## Preliminary Prioritization

We analyzed and ranked wildland parcels across the region for fire risk-reduction management action based on fire risk and potential opportunities afforded by public ownership or local interest in land use change as identified by Dan Efseaff, District Manager of Paradise Recreation and Parks District (see "Potential Parcels of Interest for Paradise Recreation and Parks Department" data layer in the private Data Basin group). The "local-interest" parcels identified by Dan were given a value of .5 to reflect uncertainty about those potential opportunities. We did not add value to parcels adjacent to the highest-ranking parcels in this step, because the objective was only to see these values across the whole study area for guiding WRRB delineation, not to begin identifying parcels for acquisition or management action yet.

The values for the input layers were set as follows:

**Opportunity:**

- Using Butte County Assessor parcel data clipped to the study region (Butte County Association of Governments 2019), PRPD-owned and other publicly-owned parcels were given 1 point.

- The 55 parcels identified by Mr. Efseaff as having potential opportunities for fire risk-reduction and disaster mitigation management were given .5 point. The decision to assign only .5 point was made to avoid over-emphasizing this anecdotal information. These parcels and notes about specific features of interest may be explored in this layer in Data Basin: Opportunity Parcels - Paradise, CA. Examples of these opportunities included the possibility of managing land as fire risk-reduction buffers while also achieving other community goals such as providing open space for hospital patients, connecting roads critical for escape from disasters and for fighting fires, and staging areas for fighting fires.

**High Fire Risk:**

- Classes 5 and 6 from the Wildland Fire Probability analysis were assigned 1 point, other areas were set to 0.

**Recreation Value:**

- Areas with potential recreation value identified by Dan Efseaff were assigned 1 point.

**Preliminary Risk-Reduction Prioritization Roll-up**

Summing these three input layers generated Region-wide Risk Reduction Priority rankings of 0 - 3, with 0 being the lowest priority, binned and categorized as follows:

- 2.5 - 3 = Rank 4, Highest Priority
- 1.5 - 2 = Rank 3
- 0.5 - 1 = Rank 2
- 0 = Rank 1, Lowest Priority

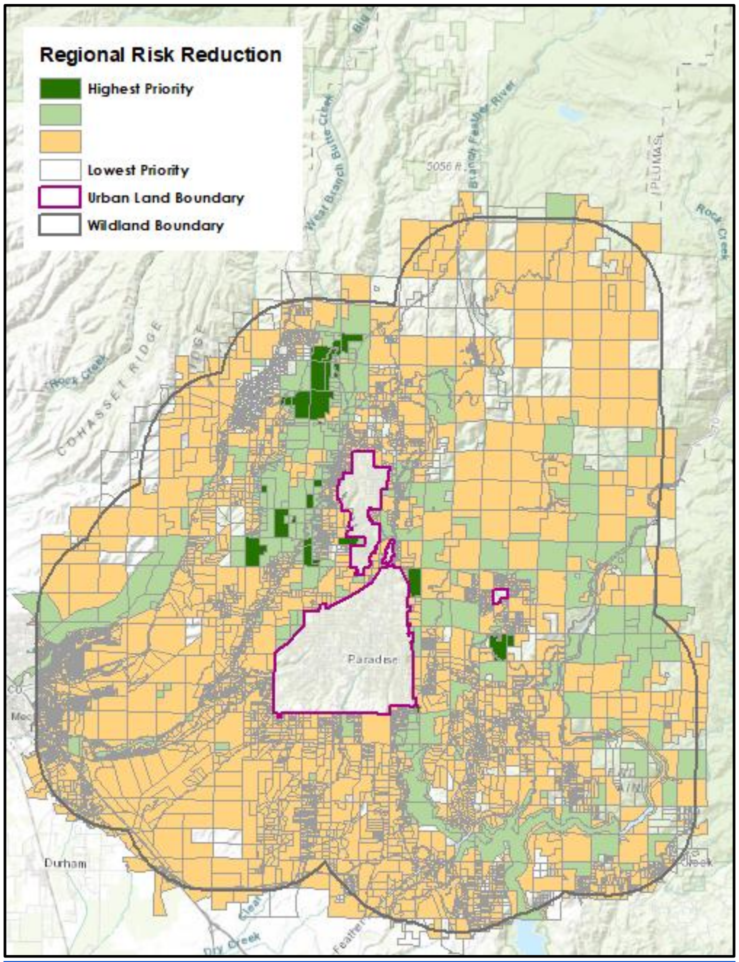



*Figure 10. Map showing the Preliminary Risk-reduction Prioritization from a scale of 0 (lowest priority) to 3 (highest priority). Click here to open in Data Basin.*

## Delineation of WRRB Areas

Wildfire Risk-Reduction Buffers, or WRRBs, were delineated in an expert-driven process in collaboration with PRPD and TNC partners using CBI's Data Basin online mapping platform. We began with a concept design for a community protection area surrounding Paradise provided by Dan Efseaff (see the "Rim Creek Park Concept - Paradise, California" layer in Data Basin) and refined the WRRBs by drawing around those and other areas of interest. Areas of interest included parcels identified as high priority areas for fire risk reduction in the Preliminary Risk-reduction Prioritization Analysis and steep canyons east of Paradise that appear to funnel wind toward the residential areas. We defined the edges of the WRRBs using significant geographic features, and in areas without significant features we followed the edge of parcel boundaries (Figure 11).

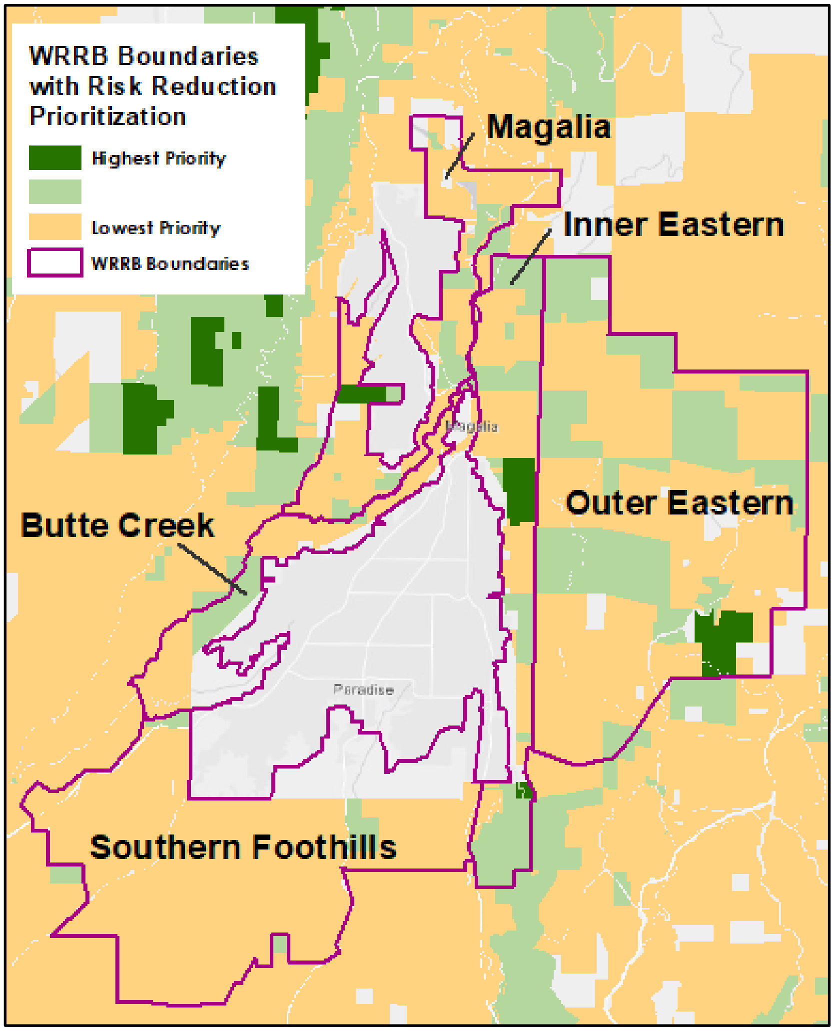



*Figure 11. The five WRRBs overlaid on the Preliminary Regional Risk-Reduction Prioritization map. Click [here](#) to open in Data Basin.*

## Prioritizing Parcels Within the WRRBs for Fire Risk-Reduction Action

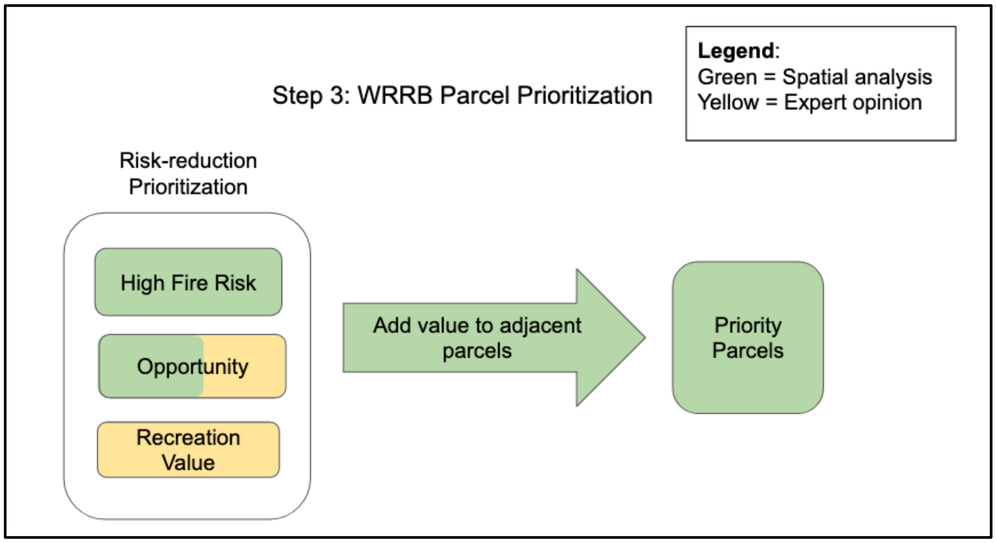



*Figure 12. Diagram depicting the WRRB parcel prioritization schema and workflow.*

We analyzed and ranked urban and wildland parcels within each WRRB for fire risk-reduction management action based on fire risk and opportunities afforded by public ownership or local interest in land use change as identified by Dan Efseaff, Director of Paradise Recreation and Parks District (see "Potential Parcels of Interest for Paradise Recreation and Parks Department" data layer in the private Data Basin group).

Below are the four criteria for prioritization. The first three are the same as used in the Preliminary Region-wide Prioritization analysis described above, to re-cap:

**Opportunity:**
- PRPD-owned and publicly-owned parcels assigned a value of 1,
- Parcels of interest identified by Dan Efseaff assigned a value of 0.5

**High Fire Risk:**
- Classes 5 and 6 of the Wildland Fire Probability map (see Figure 5) were assigned a value of 1, other areas were set to 0, and urban parcels that fell inside the WRRB with an Urban Ignition Risk class 3 or 4 (i.e. "High") received a value of 1.

**Recreation Value:**
- Areas with recreation values identified by Dan Efseaff were assigned a value of 1.

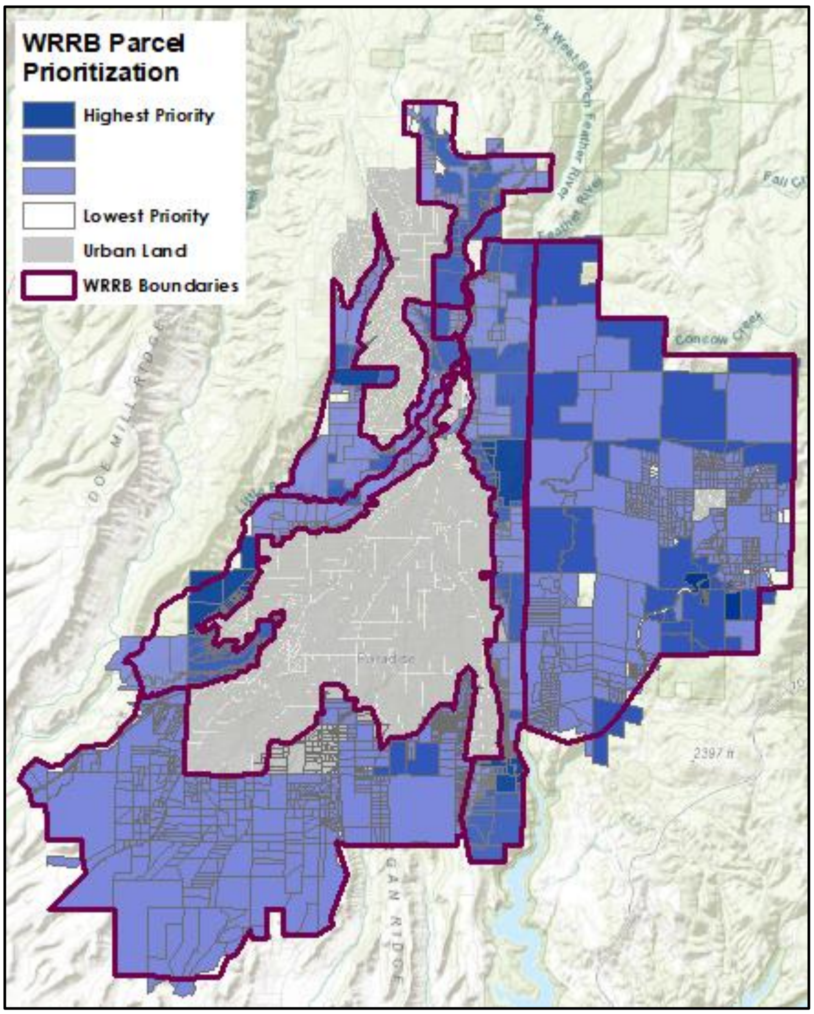
We then added another criterion, "Adjacent to High Priority Parcels". This was done to guide management actions toward clustered groups of parcels.

**Adjacent to High Priority Parcels:**

- Parcels adjacent to the highest-priority parcels were given an additional value of 1

**Parcel Prioritization Roll-up:**
These criteria were summed, resulting in the lowest possible value of 0 and the highest possible value of 4, binned and categorized as follows:

- 2.5 - 3 = Rank 4, Highest Priority
- 1.5 - 2 = Rank 3
- 0.5 - 1 = Rank 2
- 0 = Rank 1, Lowest Priority




Parcels with a value of 4 are considered high priority parcels for management action.

Targeting these parcels for conversion to irrigated land uses, fuels reduction, or management as defensible space could reduce ignition risk from wildland fires and potentially provide open space or recreation value to the community.

*Figure 13. Map showing parcels prioritized for fire risk reduction action within the WRRBs. Click [here]() to open in Data Basin.*

## WRRB Management Scenario Comparisons

We analyzed the resulting reduction in Urban Ignition Risk achieved by implementing on-the-ground actions that would reduce fire risk in the prioritized parcels. These fire risk-reduction actions could include: changing land cover to "green" uses such as parks, orchards, or agriculture; fuels-management actions appropriate for improving defensible space, such as grazing, thinning, shaded firebreaks, and prescribed burning; or hardened facilities, and simply not re-building residential homes on those lands. For comparison we created several scenarios in which successful fire risk-reduction management is assumed to be done in prioritized parcels within the WRRBs.

The WRRB Management Scenarios are:

1. No Fire Risk Reduction Management
2. Inner Eastern WRRB with high-priority parcels managed for fire risk reduction.
3. Inner Eastern WRRB with high- and medium-priority parcels managed for fire risk reduction.
4. Inner Eastern and Outer Eastern WRRBs combined with high-priority parcels managed for fire risk reduction.
5. Magalia WRRB with high- and medium-priority parcels managed for fire risk reduction
6. Butte Creek WRRB with high-priority parcels managed for fire risk reduction
7. Southern Foothills WRRB with high-priority parcels managed for fire risk reduction

To simulate the result of risk-reduction management, the fire probability values were modified (reduced) in the WRRB parcels chosen for the scenarios to reflect risk-reduction actions in those parcels: Wildland Fire Probability values of "highest" were changed to "medium" and "medium" to "lowest". This is based on the assumption that risk-reduction actions effectively reduce the fire risk in those parcels.

We then used these new values to recalculate the Urban Ignition Risk in the same manner described above, using a downwind simulation and analyzing adjacency. The new Urban Ignition Risk map was then compared to the original map to quantify change in ignition risk due to changes in the fire probabilities within the WRRBs due to the risk-reduction actions (see Table 1, below).

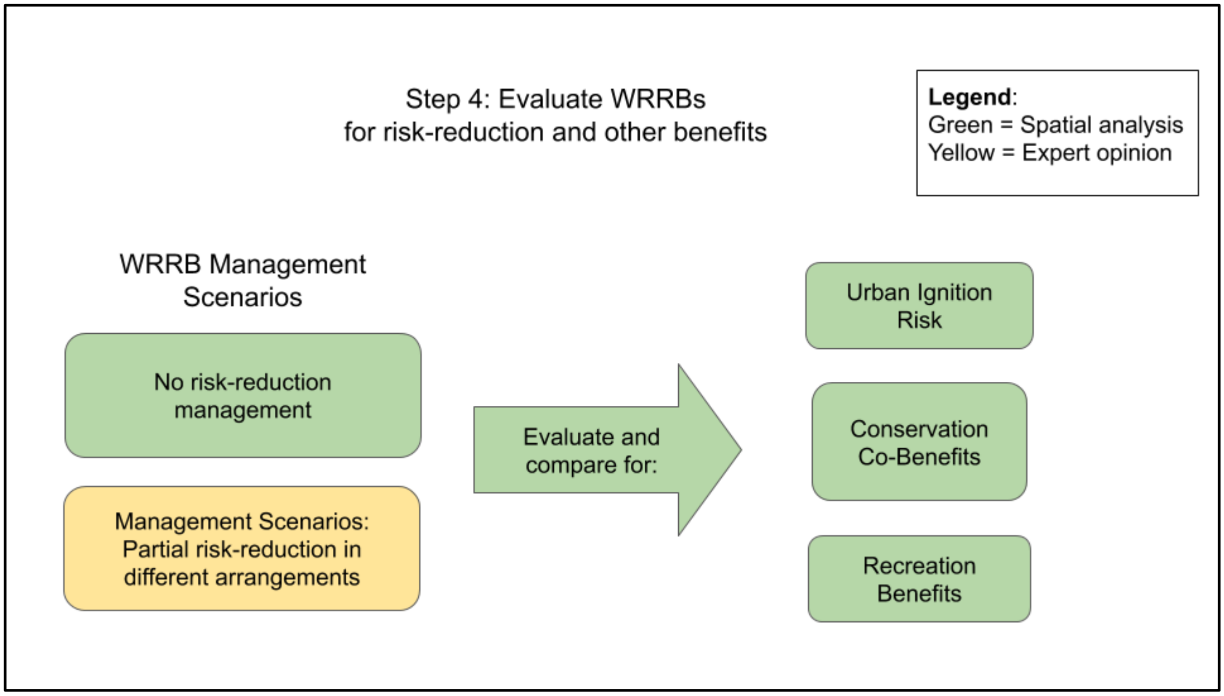



*Figure 12. WRRB Management Scenario evaluation workflow*

# Results

## Comparison Across WRRB Management Scenarios for Potential Fire Risk-reduction

Each WRRB Management Scenario was compared to the "No Management" Scenario to evaluate the change in acres in each Urban Ignition Risk category in the Paradise and Magalia communities combined. Below is a summary of the changes in acres and % in the "High" and "Medium" Urban Ignition Risk categories, indicating the reduction in Urban Ignition Risk that could potentially be achieved by managing the prioritized parcels for fire risk-reduction in those WRRBs.

| WRRB Management Scenario | | Med-high Ignition Risk Category | Highest Ignition Risk Category |
|---|---|---|---|
| **Inner Eastern** | High + Medium Priority Parcels | -36% | -64% |
| **Magalia** | High + Medium Priority Parcels | -22% | -47% |
| **Inner + Outer Eastern** | High Priority Parcels | -28% | -15% |
| **Inner Eastern** | High Priority Parcels | -27% | -13% |
| **Butte Creek** | High Priority Parcels | -5% | -1% |
| **Southern Foothills** | High Priority Parcels | +1% | -5% |

*Table 1: Summary of Urban Ignition Risk change expressed as % of acres for each WRRB management scenario.*

## WRRB Management Scenario Comparison Maps

### Scenario #2: Inner Eastern Buffer with high priority parcels

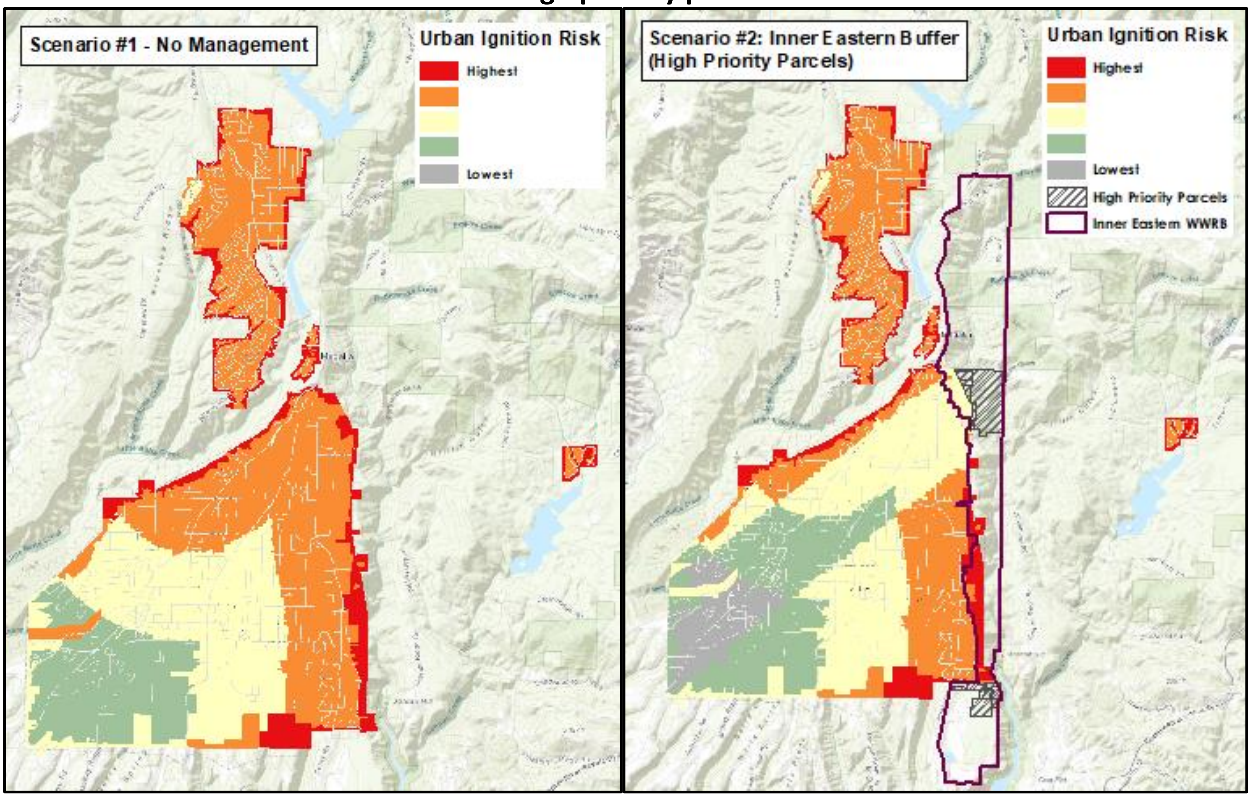



*Figure 14. Urban Ignition Risk under No Management (left) compared with Urban Ignition Risk under Scenario #2 Inner Eastern Buffer with fire risk reduction actions implemented in high priority parcels (right).*

**Scenario #3: Inner Eastern Buffer with medium and high priority parcels**

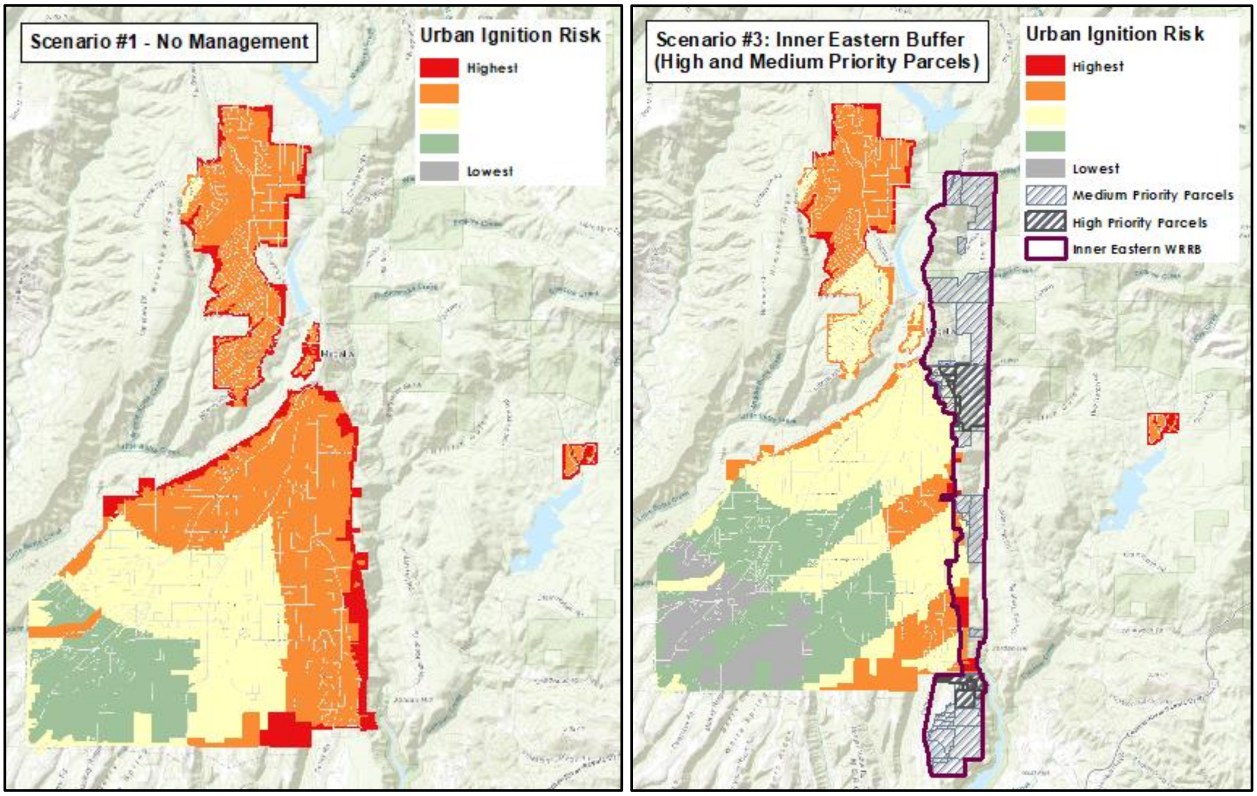



*Figure 14: Urban Ignition Risk under No Management (left) compared with Urban Ignition Risk under Scenario #3 Inner Eastern Buffer with fire risk reduction actions implemented in medium and high priority parcels (right).*

**Scenario #4: Inner Eastern and Outer Eastern Buffers together, high priority parcels**

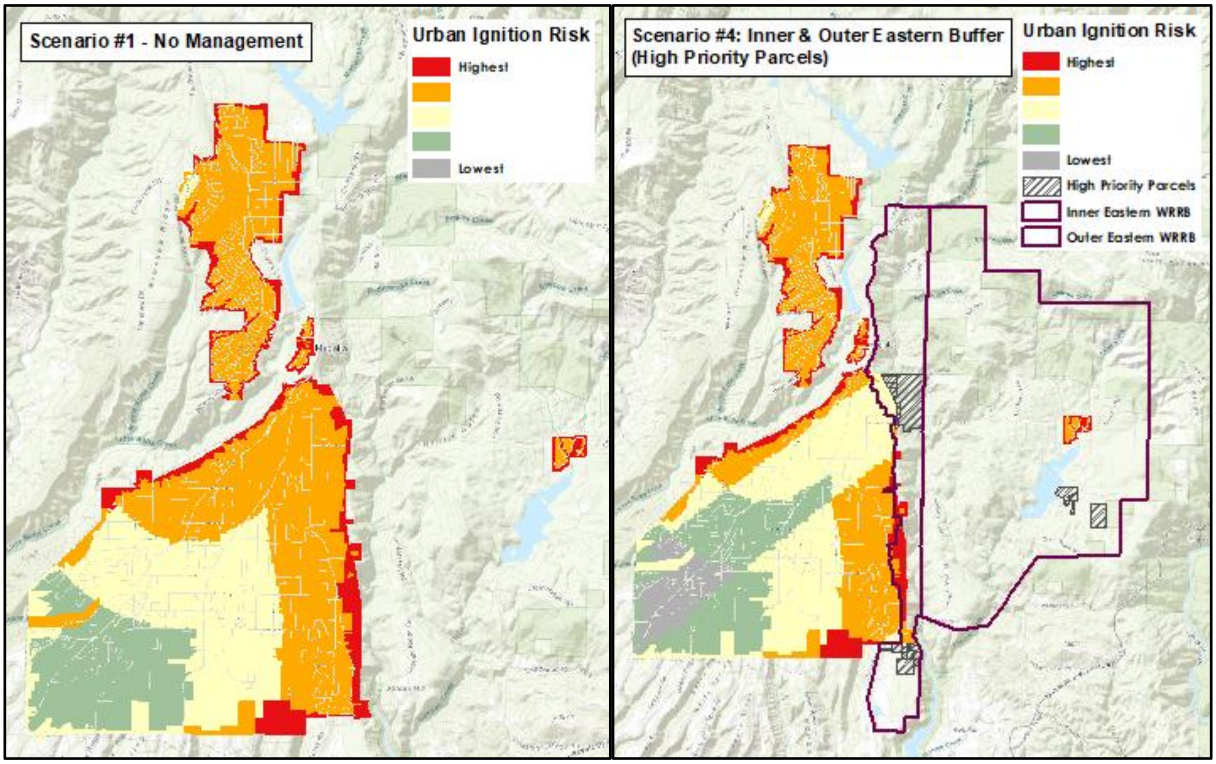



*Figure 15: Urban Ignition Risk under No Management (left) compared with Urban Ignition Risk under Scenario #4 Inner and Outer Eastern Buffer with fire risk reduction actions implemented in high priority parcels (right).*

**Scenario #5: Magalia medium and high priority parcels**

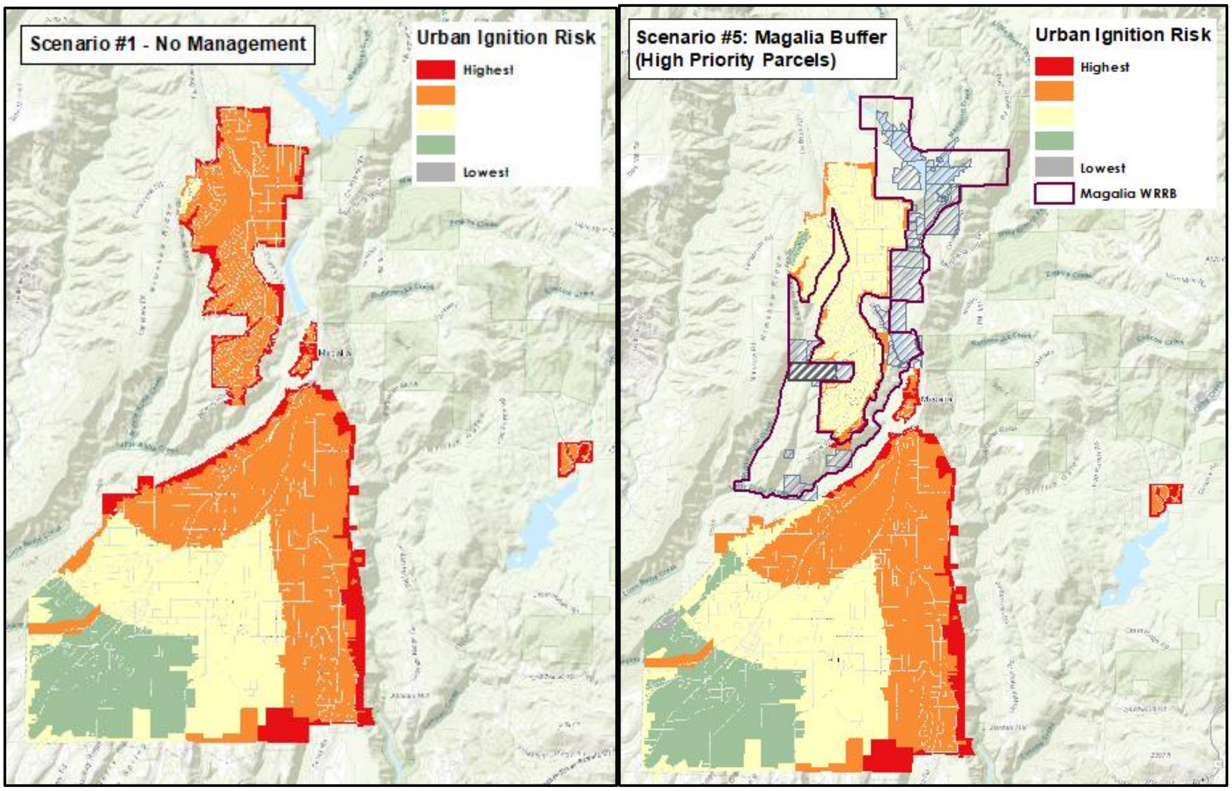
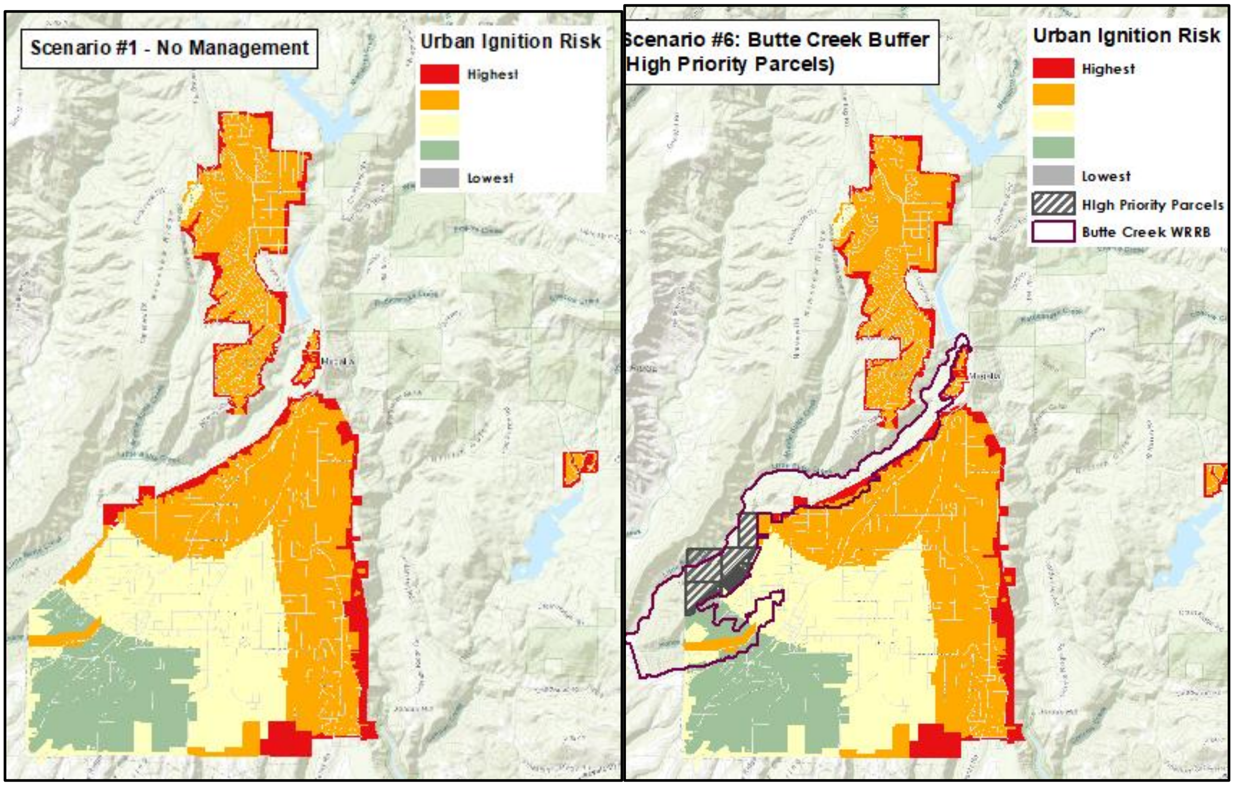



*Figure 16: Urban Ignition Risk under No Management (left) compared with Urban Ignition Risk under Scenario #5 Magalia Buffer with fire risk reduction actions implemented in medium and high priority parcels (right).*

**Scenario #6: Butte Creek Canyon Buffer with high priority parcels**



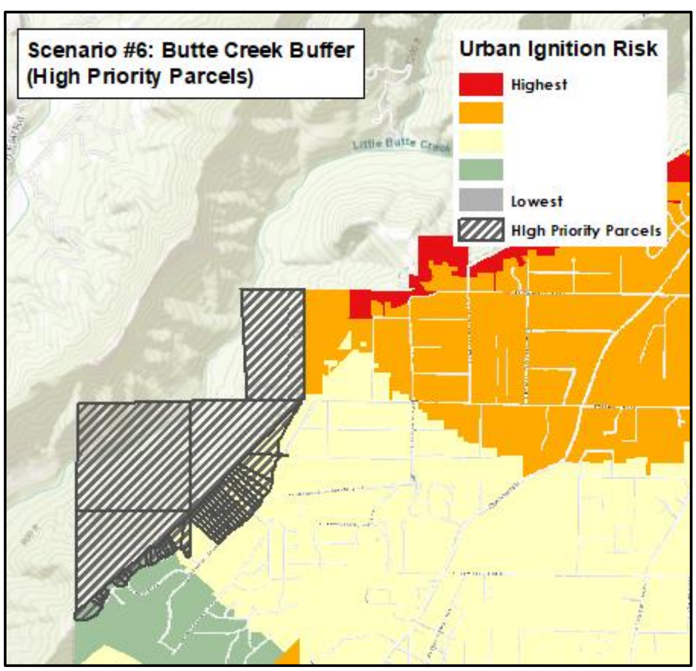
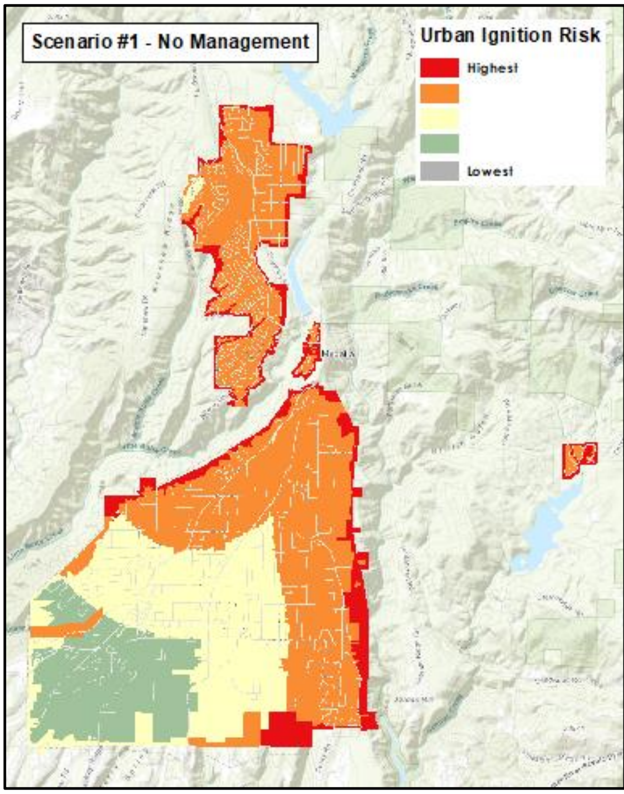
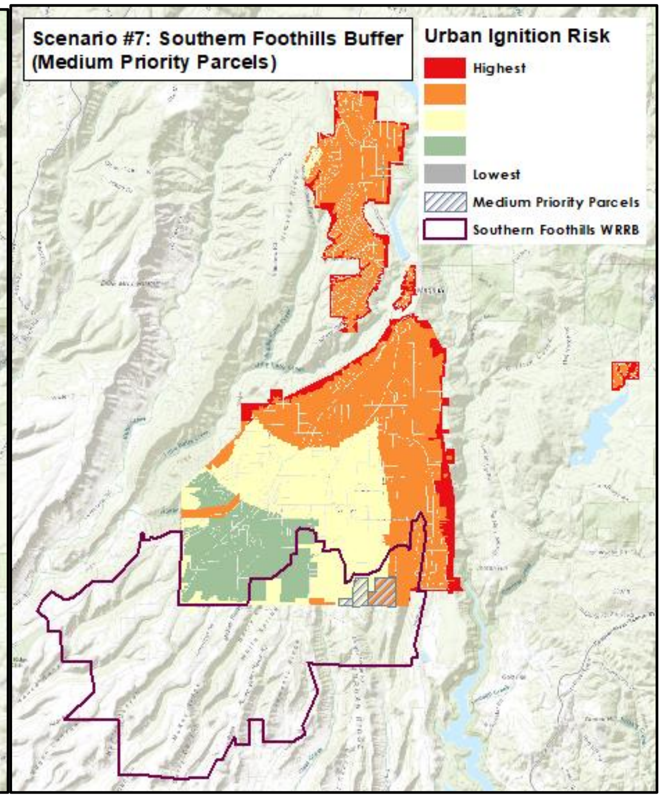




*Figure 17: Urban Ignition Risk under No Management (upper left) compared with Urban Ignition Risk under Scenario #6 Butte Creek Buffer with fire risk reduction actions implemented in high priority parcels (upper right with a close-up at left).*

## Scenario #7: Southern Foothills Buffer with high priority parcels



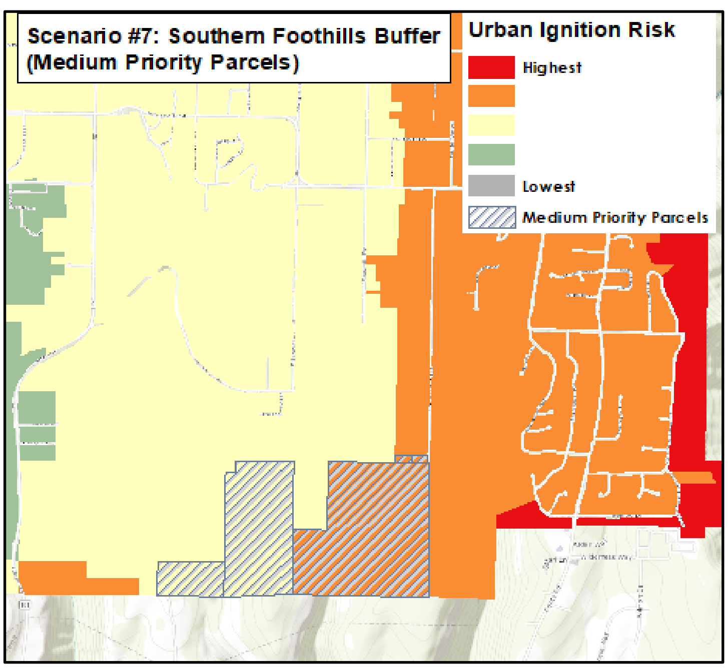




*Figure 18: Urban Ignition Risk under No Management (upper left) compared with Urban Ignition Risk under Scenario #6 Southern Foothills Buffer with fire risk reduction actions implemented in high priority parcels (upper right with a close-up at left).*

## Conservation Co-Benefits Evaluation

Benefits of Wildfire Risk Reduction Buffers can include additional ecological values achieved through management of the prioritized lands for wildlife habitat. We created the following three inputs to create the Conservation Co-benefits map:

- **Connectivity Value**
- **Biodiversity Value**
- **Level of Protection**

Source data is described below.

**Connectivity Value:**
This metric captures the value of the parcel for its potential role in wildlife habitat connectivity. We used the TNC Omniscape Landscape Connectivity dataset (The Nature Conservancy 2018), with the features grouped and classified as follows as recommended by Dick Cameron:

- All Channelized, High Intensified – given 3 points (High)
- Low, Med Intensified – given 2 points (Med)
- All Diffuse – given 1 point (Low)

**Biodiversity Value:**
This metric captures the number of species that potentially utilize the parcel as habitat. We used data generated by Krause, Gogol-Prokurat, and Bisrat (2015) for their Northern Sierra Nevada Foothills (NSNF) Wildlife Connectivity Modeling Project. These data incorporate information for 30 focal species, including 9 passage species (species that move through the corridor) and 21 corridor dwellers (species that may take more than one generation to move through a corridor).

For the Biodiversity input layer we used number of species divided evenly into the following classes:

- 21-30 species given 3 points (High)
- 11-20 species given 2 points (Med)
- 1-10 species given 1 point (Low)

Note: We considered using the ACE 3 Terrestrial Biodiversity Summary but decided it was too coarse for our purposes.

**Level of Protection:**

Level of Protection from the Protected Areas Database PAD-US CBI Edition, California v.2.1b, Conservation Biology Institute (2016) was used to assign a conservation co-benefit value to parcels. PAD-US is an aggregated spatial dataset that includes federal, state, local and private conservation lands in fee ownership. These lands are managed for various levels of protection represented by GAP status:

- GAP 1 - Managed for a natural state
- GAP 2 - Managed for a natural state with some disturbances
- GAP 3 - Allows for extractive uses
- GAP Unassigned - lands without a clear management designation

In the project area only GAP 2, GAP 3, and Unassigned are present. For the purposes of this analysis we assigned a Conservation Co-benefit value to the parcels based on GAP status, as follows:

- GAP 1 was not used because there were no occurrences in the study region
- GAP 2 was given 3 points (High)
- GAP 3 was given 2 points (Med)
- GAP Unassigned = 1 point (Low)

**Conservation Co-benefit Roll-up:**

To summarize conservation values for lands surrounding Paradise and Magalia, the three inputs described above were summed for a rolled-up “Conservation Co-benefits” layer, with values ranging from 0 - 9, binned and categorized as follows:

- 7-9 = Highest Conservation Co-benefits
- 4-6 = Medium Conservation Co-benefits
- 0-3 = Lowest Conservation Co-benefits

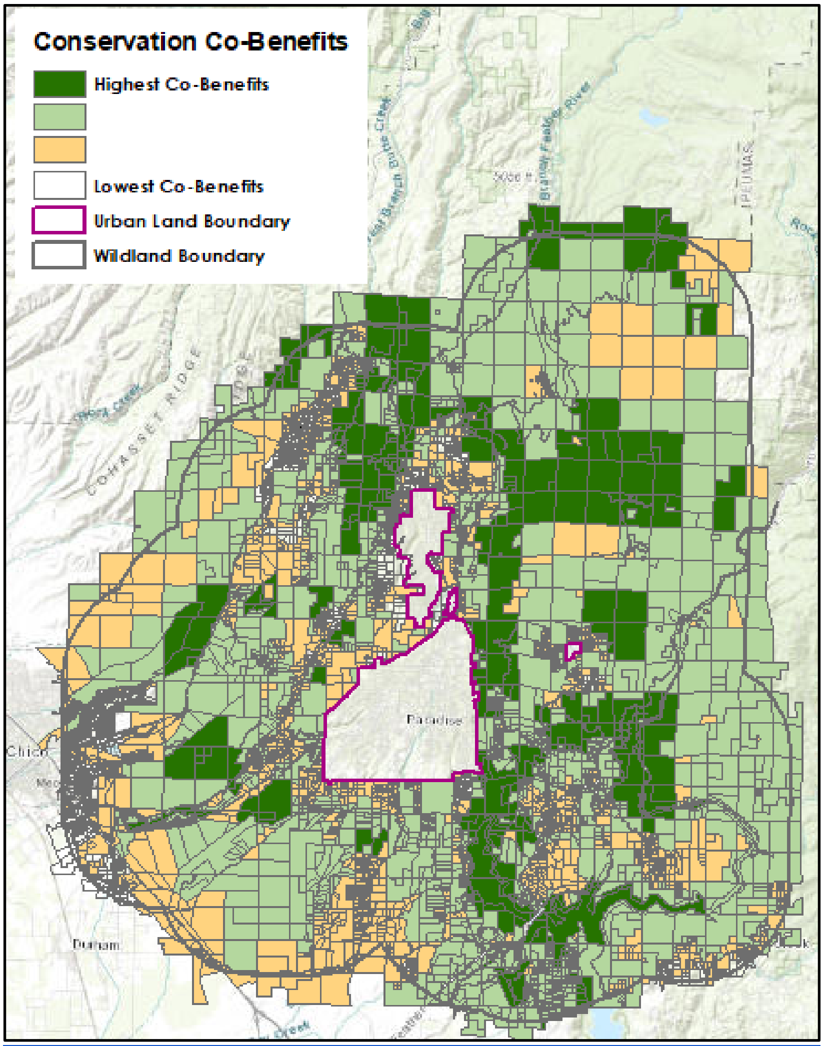



*Figure 19. Map showing parcels ranked for Conservation Co-benefits. Click here to open in Data Basin.*

For each WRRB, we quantified the Conservation Co-benefits and Recreation Values to provide an indication of relative conservation and recreation benefits potentially available by focusing management actions on priority parcels in the WRRBs.

This analysis prioritizes parcels at a coarse scale to identify parcels with the potential to serve as a wildfire buffer as well as impact conservation values for the community. This is a simplified evaluation that assumes that fuels-reduction treatments are conducted in a manner sensitive to habitat values, and that re-purposing urban parcels for greenbelt land use helps prevent the degradation of valuable habitat in an effort to protect the town from wildland fires (see the Literature Review about this complex topic, especially the concept of a "coupled system"). It should be considered a starting point only for consideration of priorities and methods for fire risk-reduction actions in conjunction with habitat management, and not a substitution for on-the-ground knowledge of habitat conditions and species requirements.

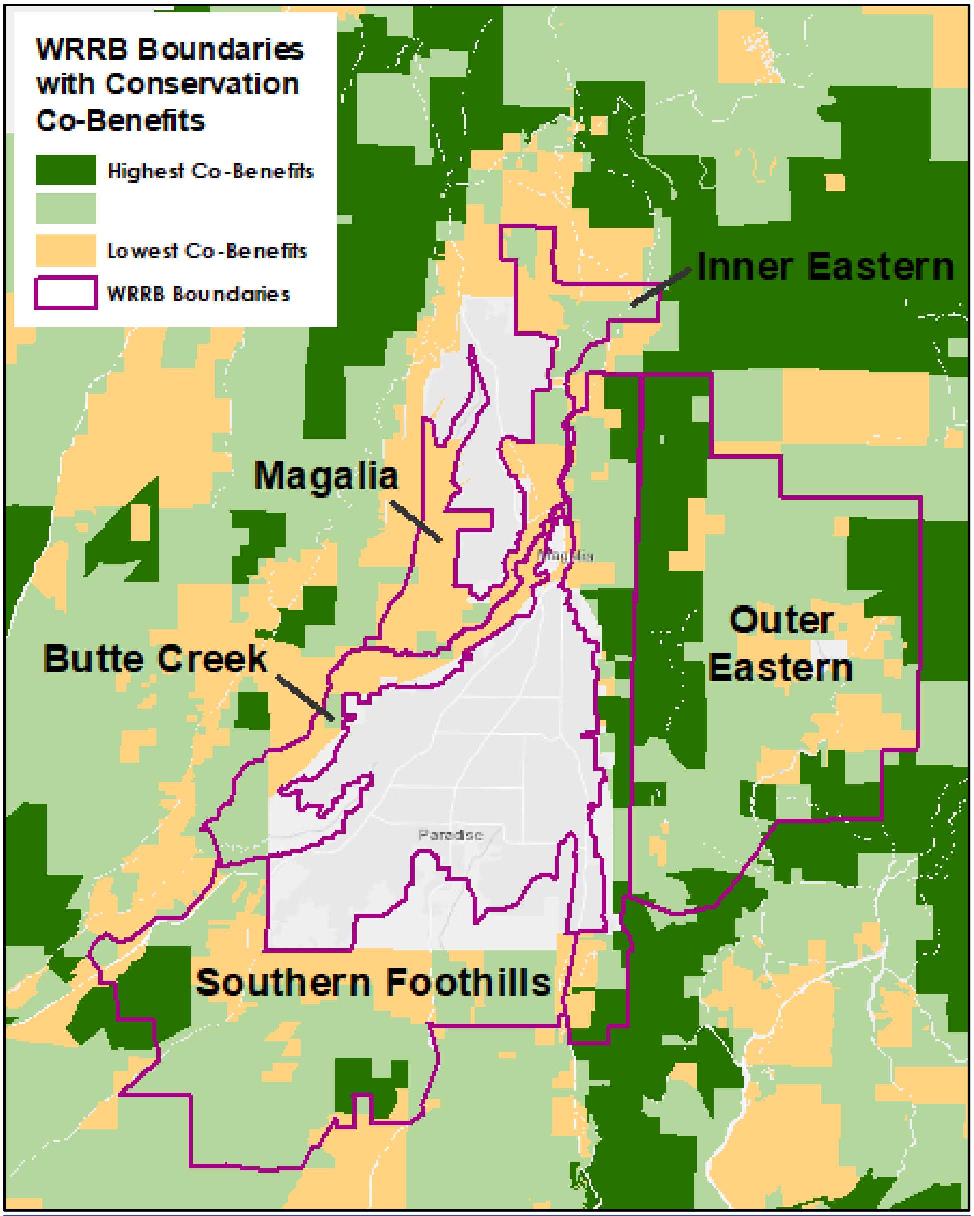



*Figure 20. Map showing the five WRRBs overlaid on the Conservation Co-benefits map. Click [here] to open in Data Basin.*

Table 2 below presents the acreage in each WRRB in the Conservation Co-benefit categories, as well as % of total acres in the High and Medium categories. The Outer Eastern WRRB stands out with respect to this metric.

| **Conservation Co-Benefit Value by Parcel** | | | | | |
|---|---|---|---|---|---|
| **WRRB** | ***Total Parcel Acres*** | ***Low acres*** | ***Medium acres*** | ***High acres*** | ***High + Med, %*** |
| Outer Eastern | 13,375 | 2,851 | 9,551 | 293 | 74% |
| Southern Foothills | 8,953 | 2,402 | 6,525 | 0 | 73% |
| Inner Eastern | 3,479 | 1,547 | 1,718 | 0 | 49% |
| Butte Creek | 1,649 | 797 | 536 | 0 | 33% |
| Magalia | 3,725 | 2,439 | 352 | 0 | 9% |

*Table 2. Acres of each WRRB in the categories for Conservation Co-benefit value by parcel, with percent of total acres in the High plus Medium categories.*

Table 3 below presents the acreage in each WRRB in the Connectivity Value categories, as well as % of total acres in the High category. Butte Creek and Outer Eastern WRRBs stand out with respect to this metric.

| **Connectivity Value** | | | | | |
|---|---|---|---|---|---|
| **WRRB** | ***Total acres*** | ***Low, acres*** | ***Med, acres*** | ***High, acres*** | ***High, %*** |
| Outer Eastern | 13,591 | 5,450 | 297 | 5,369 | 40% |
| Butte Creek | 2,458 | 174 | 120 | 583 | 24% |
| Inner Eastern | 4,030 | 1,452 | 88 | 263 | 7% |
| Southern Foothills | 10,701 | 4,181 | 1,541 | 809 | 8% |
| Magalia | 3,833 | 624 | 16 | 11 | 0% |

*Table 3: Acres of each WRRB in the categories for Connectivity value, with percent of total acres in the High category.*

Table 4 below presents the acreage in each WRRB in the Protected Area categories, as well as percent of total acres in the combination of GAP 2 and 3 categories. Inner Eastern and Outer Eastern WRRBs stand out with respect to this metric.

| Level of Protection | | | | | |
|---|---|---|---|---|---|
| **WRRB** | ***Total acres*** | ***Med, acres*** | ***High, acres*** | ***High + Med, acres*** | ***High + Med, %*** |
| Inner Eastern | 2,458 | 842 | 1 | 843 | 34% |
| Outer Eastern | 13,591 | 3,278 | 7 | 3,285 | 24% |
| Magalia | 4,030 | 609 | 0 | 609 | 15% |
| Butte Creek | 10,701 | 36 | 0 | 36 | 0% |
| Southern Foothills | 3,833 | 8 | 0 | 8 | 0% |

*Table 4: Summary of Level of Protection in each WRRB by acre and percent of total acres in the combination of the High and Medium categories.*

**Biodiversity:**
The dataset (California Department of Fish and Wildlife 2015) used for our Conservation Co-benefits "Biodiversity" model input indicates usage by 30 focal species as habitat or movement corridors. In many cases the polygons overlap and an acreage summary is not very informative. Summaries of species noted in each WRRB are presented below by taxonomic group. Note that all of the WRRBs are high in biodiversity according to this dataset, which is not surprising due to the diversity of habitats and relatively low human footprint.

| | **Focal Mammals** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WRRB** | **Black Bear** | **Bobcat** | **Black-tail jack Rabbit** | **Dusky-footed woodrat** | **Gray fox** | **Mtn lion** | **Mule deer** | **West'n gray squirrel** | **CA Ground squirrel** | **CA Kangaroo rat** | **Pallid bat** | **Total Focal Mammals** |
| Butte Creek | | | | X | X | | X | X | X | X | X | **7** |
| Inner Eastern | | X | X | X | X | X | X | X | X | | X | **9** |
| Magalia | X | | | X | | X | X | X | X | | X | **7** |
| Outer Eastern | | X | X | X | X | X | X | X | X | | X | **9** |
| Southern Foothills | | X | X | X | X | X | X | X | X | | X | **9** |

*Table 4: Focal mammals by taxonomic group for each WRRB.*

| | **Focal Reptiles** | | | | |
|---|---|---|---|---|---|
| **WRRB** | **Western pond turtle** | **Gopher snake** | **Coastal horned lizard** | **So. Alligator lizard** | **Total Focal Reptiles** |
| Butte Creek | X | X | X | X | **4** |
| Inner Eastern | X | X | X | X | **4** |
| Magalia | X | | | | **1** |
| Outer Eastern | X | X | X | X | **4** |
| Southern Foothills | X | X | X | X | **4** |

*Table 5: Focal reptiles by taxonomic group for each WRRB.*

| | Focal Birds | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WRRB** | **Acorn wood-pecker** | **CA Quail** | **CA Thrasher** | **Cooper's hawk** | **Lark sparrow** | **Mtn quail** | **No. Pygmy owl** | **Spotted towhee** | **Wood duck** | **Yellow-billed magpie** | **Total Focal Birds** |
| Butte Creek | X | X | X | X | X | | X | X | X | X | **9** |
| Inner Eastern | X | X | X | X | X | X | X | X | | | **8** |
| Magalia | X | X | X | X | X | X | X | X | | | **8** |
| Outer Eastern | X | X | X | X | X | X | X | X | X | | **9** |
| Southern Foothills | X | X | X | X | X | | X | X | X | X | **9** |

*Table 6: Focal birds by taxonomic group for each WRRB.*

## Recreation Value

Recreation Value was an element used in the Parcel Prioritization schema, but can be considered a co-benefit. Table 7 summarizes the total acres identified as having recreation value in each WRRB, and the percent of the total acres. Butte Creek and Inner Eastern WRRBs stand out with respect to this metric.

| Recreation Value by Parcel | | | |
|---|---|---|---|
| **WRRB** | ***Total Parcel Acres*** | ***Rec Value Acres*** | ***Rec Value %*** |
| Butte Creek | 1,649 | 984 | 60% |
| Inner Eastern | 3,479 | 1,074 | 31% |
| Southern Foothills | 8,953 | 741 | 8% |
| Outer Eastern | 13,375 | 609 | 5% |
| Magalia | 3,725 | 113 | 3% |

*Table 7: Summary of acres of land in the Recreation category in each of the WRRBs.*

## Management Opportunities

Each WRRB area has different characteristics that suggest opportunities for collaboration, land use and land cover management, conservation and recreation co-benefits, and additional potential benefits for the Paradise community such as development of egress and refugia in fire events and fire-fighting staging areas.

A comprehensive cost-benefit analysis was beyond the reach of this project, and would require an economist as well as additional data. Factors that impact opportunities, approaches, and costs are:

- Land ownership type (See Table 8 for acres and percent in private and public ownership)
- Vegetation and land cover type
- Zoning, protection, and other land use designations
- Topography
- Parcel size
- Current use of the land
- Landowner interests

In the Project Final Report we offer summaries of major WRRB characteristics with a brief discussion of the potential opportunities and approaches identified in each WRRB. See also Appendix D: Land Management Tools for Fire Risk Reduction. We hope this is useful in informing a more in-depth and locally-driven planning process.

| WRRB | Total Acres | Private Land, Acres (%) | Public Land, Acres (%) |
|---|---|---|---|
| Butte Creek | 2,458 | 2,422 (99%) | 36 (1%) |
| Inner Eastern | 4,030 | 3,187 (79%) | 843 (21%) |
| Magalia | 3,833 | 3,223 (84%) | 609 (16%) |
| Outer Eastern | 13,591 | 10,304 (76%) | 3,287 (24%) |
| Southern Foothills | 10,701 | 10,508 (98%) | 193 (2%) |

*Table 8: Land ownership summaries for the five WRRBs.*

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