Paradise Nature-Based Fire Resilience Project

Final Report

Conservation Biology Institute
In partnership with The Nature Conservancy and Paradise Recreation & Parks District

June, 2020

Publicly-sharable copy
Maps removed to respect landowner privacy; for a complete version, please contact CBI.

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Executive Summary

Project Objectives

As the Sierra Nevada foothill communities of Paradise, Magalia, and Concow-Yankee Hill rebuild after the devastating Camp Fire of 2018, the community has an opportunity to incorporate strategies to increase its resilience to fire and climate change, enhance the safety and well-being of its residents, and successfully steward the surrounding natural areas that make it a beautiful place to live.

This project sought to establish whether there is there a scientific justification for a “defensible space” zone around a community – one that can provide both a boundary for urban growth to reduce habitat fragmentation and impacts and enable safer communities for people. In addition, this project used Paradise, CA as a case study to develop a model prioritization schema.

Approach

CBI, The Nature Conservancy, and the Paradise Recreation and Parks District partnered to explore community design elements with the intention to test the concept that a community can be protected from ignitions from wildland fires with the use of Wildfire Risk Reduction Buffers (WRRBs) between the urban area and the wildlands.

We defined WRRBs as zones comprised of green land uses or "greenbelts" of parkland, orchards, and other low ignition-risk land uses, combined with wildland properties managed for fire risk reduction.

We explored how WRRBs could reduce urban ignition risks while offering additional benefits, including open space for recreation, emergency refuges and staging areas for fire-fighting, and conservation benefits by decreasing edge effects of human settlements.

The project had three main activities:

1. Review of the scientific and other published literature. The CBI team surveyed the relevant peer-reviewed scientific and other (mostly state and local government) literature concerning land use approaches to fire risk reduction. This report, delivered as a separate document, discusses information found in 129 publications covering the period 1973 to 2020.

2. Wildfire Risk Reduction Buffer mapping and design. CBI facilitated seven online meetings with TNC and Paradise Recreation and Parks District staff to co-design WRRBs around the Paradise and Magalia urban areas. We used a combination of available data and local knowledge to prioritize parcels for fire risk-reduction management. We compared the risk of ignition from wildfires under the towns' former land-use arrangements to scenarios in which the prioritized parcels were converted to lower fire risk through land cover management. The products of this

effort are: Wildfire Risk Reduction Buffers, prioritized parcels, management scenarios, and analyses of potential benefits, management opportunities, and approaches.

3. Engagement with stakeholders. The Paradise Technical Advisory Committee (Paradise TAC) was convened in two online meetings to present and discuss the results of this project. They were invited to review the draft report and provided input into the Management Options section.

High Level Findings

Literature Review

- There is ample published science about the increased risk of catastrophic fire due to the combination of climate change and human development in the wildland-urban interface, and strong support for the role of land use planning in community fire safety.

- There is a recent call by scientists for a change in approach to living with fire, in particular: to accept that fire is an important element of California's ecosystems, understand the coupled nature of human-ecosystem processes, and shift the focus toward preparing communities for the inevitable impacts from wildfire.

- There is very little in the scientific literature specifically about the greenbelt buffer concept, but a wealth of information in the gray literature describing characteristics of defensible space and strategic urban design that are applicable to designing greenbelt buffers.

- There is support in the scientific literature for the concept that urban growth boundaries improve natural area stewardship by decreasing edge effects from human incursion. Additionally, the argument is made by fire scientists that both human safety and conservation goals are best served by embracing the coupled nature of the relationship between fire and human development and making forest management decisions based on natural fire regimes.

Please see Appendix A: Literature Review.

Buffer Design and Analysis

- The model results, as well as the conversations with the Paradise TAC, support the hypothesis that reducing flammability of land cover in the region between the wildland area and urban area in Wildfire Risk Reduction Buffers reduces risk of ignition in the urban area.

- According to this model, which emphasizes the effects of strong winds, focusing on reducing fire risk in the upwind areas adjacent to the town would provide maximum ignition risk-reduction benefits. We used the north-easterly "Jarbo Gap" wind direction in our analysis, but this process could be modified to explore priority locations for other wind directions or scenarios, as suggested by the Paradise TAC.

- The models and the conversations with the Paradise TAC support the concept that lands managed for fire risk-reduction could also provide additional benefits such as open space for recreation, refuges for people in times of emergencies, staging areas for fire-fighting, and habitat and refuge for wildlife species.

- The maps, visualizations, and conceptual framework resulting from this effort are useful (and are already being used) to assist the strategic rebuilding of the community for fire resilience and safety, evaluate potential costs, and communicate plans to the community.

- The conceptual framework, analysis method, and the transparent process we used to integrate expert opinion with data-driven modeling are potentially useful for planning fire risk-reduction in other wildland-urban interface communities. The models and analyses can be replicated and modified by anyone with GIS skills. Different data could be used to create the inputs, or additional data could be added to refine them.

Please see Appendix B: Wildfire Risk Reduction Buffer Design and Analysis for analysis method details.
Note: Appendix B must be requested due to sensitive content.

Stakeholder Engagement

- Working closely with Dan Efseaff, Paradise Recreation and Parks Department District Manager, provided us with extensive first-hand knowledge of features on the landscape and within the community important for identifying parcels for fire risk-reduction work. The information was captured into maps using Data Basin's map annotation tools and converted to spatial data used in the prioritization analysis. See the Paradise Nature-Based Fire Resilience Data Basin Group

"Local Knowledge" section[1] for this information in its original and processed forms.

- Conversations with the Paradise Technical Advisory Committee revealed a wealth of expert knowledge among planners and the fire-fighters supporting the community. The greenbelt buffer concept is considered common sense. Different groups are currently collaborating to some extent but there exist many opportunities for partnerships and ways to move forward in a more strategic manner.

- Paradise TAC members felt strongly that acquiring urban-edge residential parcels and changing land use patterns was of utmost importance, and that the results of this project helped forward that conversation in the community. One TAC member said that there exists a "small window in time to undo many poor planning choices that were made long before the Town of Paradise formed. The strategic parcels you have identified are a great start in providing a reset for at least some of the inherited issues."

- We concluded that the challenge lies not in convincing people that these planning measures would help, but in finding ways to overcome the barriers to accomplishing them.

Please see Appendix C: Paradise TAC Notes and Feedback.
Note: Appendix C must be requested due to sensitive content.

Recommendations

We recommend use of the maps (both printed and in Data Basin) in conjunction with the information in the Management Opportunities section of this report and the Literature Review for planning fire risk-reduction actions in and around Paradise and Magalia.

Interaction with the maps and data will support exploration of options in conversation with community members, planners, and land owners. The maps can be used to convey the concepts of greenbelts and ignition risk reduction, and the potential for benefiting from coordinated strategies. Partnerships can be readily identified by looking at the owners of clusters of priority parcels, and the focus on these clusters naturally encourages a "neighborhood approach" involving people living in, responsible for, or using those locales. Each WRRB area has different characteristics that suggest opportunities for collaboration, approaches for 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.

[1] See the explanation of Data Basin and how to gain access to this restricted resource in the Results section below.

Recommended uses of these materials include:

- For planning parcel acquisition, easements, and partnerships with private and public landowners for the purpose of fire risk reduction actions and infrastructure development, and for tracking progress toward the building of buffers to protect high density areas of communities.

- For supporting interactive conversations and collaborative fire risk reduction decision-making. The maps help visualize focal areas and highlight potential options for management in those areas by providing land ownership, vegetation cover, topographic, and other characteristics of the landscape.

- For generating support for funding requests or community participation. In addition to providing helpful visualizations of fire resilience infrastructure, the maps provide a compelling argument for targeting parcels in clusters anchored by key parcels and for completing unbroken stretches of parcels to create a protective barrier.

- The model results should be used in conjunction with local knowledge. They should not be interpreted as direct guidance or an end-point, but rather used as a "conversation-starter" (see the Limitations of the Models section of this report). We encourage the users to extrapolate the ignition risk results with other wind directions simply by imagining or drawing different wind vectors to identify areas potentially protected by risk-reduction actions taken in a given area.

Results

Wildfire Risk Reduction Buffers (WRRBs)

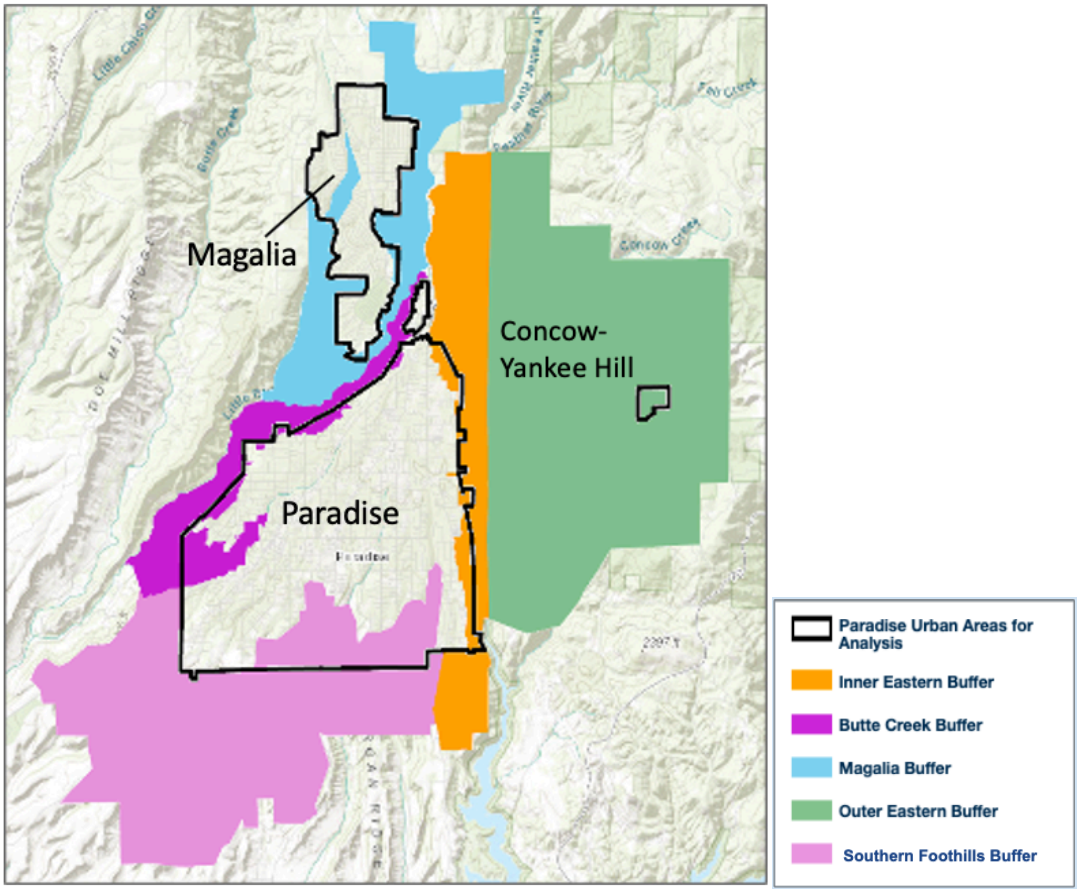

Figure 1. The five Wildland Risk-Reduction Buffers around the densest residential areas of Paradise, Magalia, and Concow-Yankee Hill.

Figure 1 above presents the Wildfire Risk-Reduction Buffers co-produced by the project team. Each WRRB area has different landscape and ownership characteristics that suggest opportunities for fire risk reduction collaboration, land use and vegetation management, and potential for providing conservation and recreation co-benefits. Please see the Management Opportunities section below for a discussion about each WRRB.

Prioritization Schema and Parcel Prioritization

After collaboratively exploring prioritization criteria and the data available for the prioritization analysis, the project team decided upon this formula for prioritizing parcels for risk-reduction action:

Fire Risk + Opportunity + Recreation Value

A combination of available data and local knowledge was used as inputs for evaluating these categories. An existing high-resolution fire probability model was use in the Fire Risk category. Local knowledge and public land ownership comprised the "Opportunity" category and local knowledge was the sole input into the "Recreation Value" category. Values for each of these categories were summed and the result was used to rank the parcels. We added a point to parcels adjacent to the highest-priority parcels for a final prioritization of parcels for fire risk-reduction action.

WRRB Management Scenario Risk-Reduction Comparisons

We developed a method to map Urban Ignition Risk by ranking areas downwind and adjacent to high-risk locations identified by the wildland fire probability model. We then compared Urban Ignition Risk with no fire risk reduction management to six scenarios in which WRRB prioritized parcels' fire risk values were reduced based on the assumption that changing land cover to lower flammability cover types such as irrigated parkland, or conducting fuels treatments, would reduce the fire risk in those parcels.

The resulting changes in number of acres in the highest risk categories are summarized below, with the most effective scenarios at the top. Note that this was done with north-easterly winds; the results would be different with other wind directions used in the Urban Ignition Risk map. This should be considered only one example of all the possible wind directions.

An interesting result is that working on more parcels (both high and medium priority) in the Inner Eastern Buffer provides more benefit than working on only high-priority parcels in the Inner Eastern and Outer Eastern buffers combined, indicating that focusing on creating as solid a band of lower fire risk closer to the town is the most effective strategy.

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 in acres and % for each WRRB management scenario. Note that the scenarios were all evaluated with Urban Ignition Risk based on a north-easterly wind direction. Basing Urban Ignition Risk on a south-westerly wind would result in the Southern Foothills buffer coming out as highly important.

WRRB Management Scenario Comparison Maps
All scenarios were represented in maps compared side-by-side with the no-risk-reduction scenario to easily visualize the effects on Urban Ignition Risk.

Conservation and Recreation Co-Benefits Evaluation

Conservation Co-benefits

We arrived at the following formula for ranking parcels for their Conservation Co-benefits:

Connectivity + Level of Protection + Biodiversity

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.

These results may be used to support planning, seek funding, or encourage the creation of partnerships to focus in these areas.

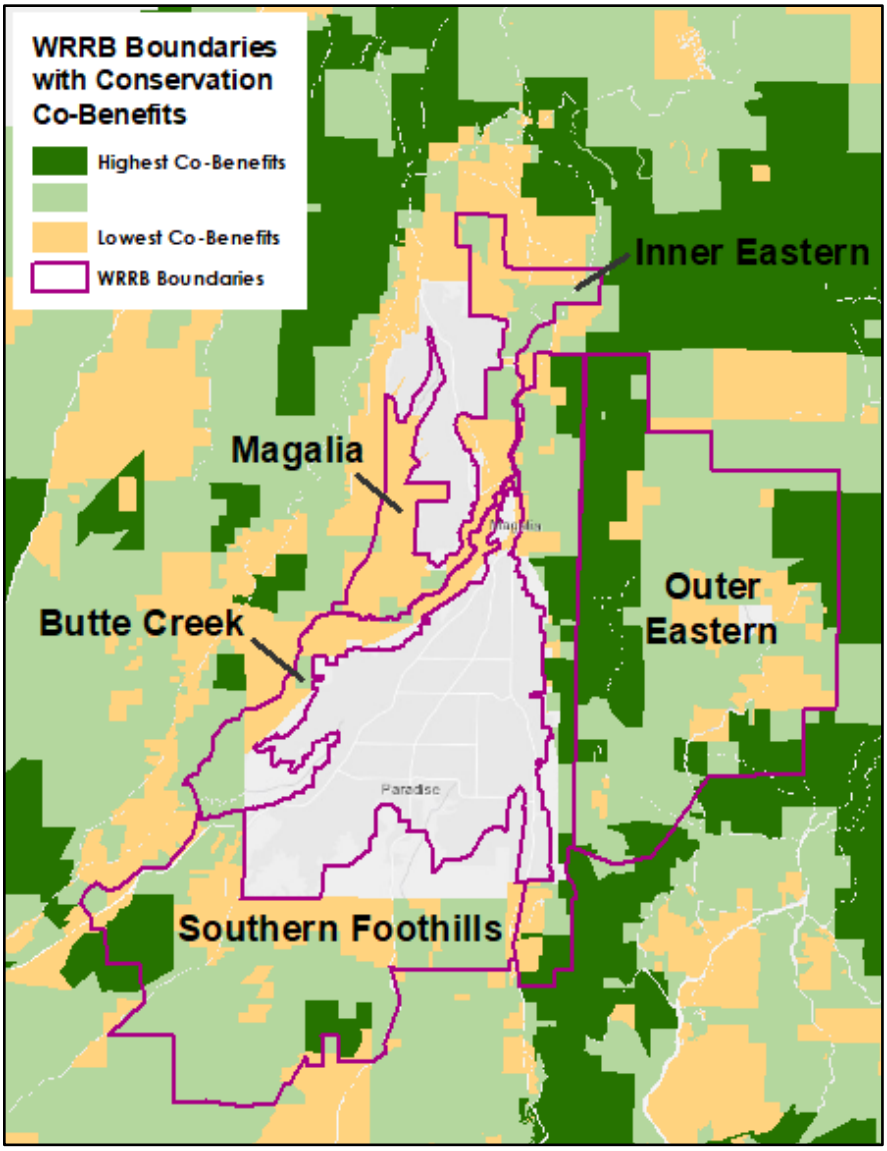

Figure 2. Parcels ranked for Conservation Co-benefits overlaid with the WRRB boundaries.

Recreation Co-Benefits

Recreation Value was an element used in the Parcel Prioritization schema, and was also evaluated as a co-benefit. Table 3 below 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 3: Summary of acres of land in the Recreation category in the parcels overlapping each of the WRRBs

WRRB Profiles and Management Opportunities

After delineating the WRRBS, prioritizing parcels for risk-reduction action, and evaluating the WRRBS for their conservation and recreation co-benefits, we summarized characteristics of each WRRB with information useful for planning management action.

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. These WRRB profiles are useful to support conversations about possible next steps for fire risk management in each WRRB.

A comprehensive cost-benefit analysis was beyond the reach of this project, and would require an economist and additional data. However, the information below combined with local knowledge could support informed discussions about management costs. Please see Appendix D: Land Management Tools for Fire Risk Reduction for tools and approaches for accomplishing fire risk reduction.

Factors that impact opportunities, approaches, and costs are:

- Land ownership type - See Table 4 below 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

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 4: Land ownership summaries for the five WRRBs.

Note: Maps have been removed due to sensitive content. Please refer to the buffer map on page 25.

Inner Eastern Buffer

The Inner Eastern Buffer is a 4,030 acre strip of land overlapping the eastern border of the town of Paradise and extending northward to the east of Magalia. It includes privately-owned urban parcels on the transition from the relatively flat mesa or plateau area that the town of Paradise occupies and extends eastward plunging into the steep topography of the Feather River Canyon. Lands in the wildland area include large parcels owned by public entities, primarily Bureau of Land Management (BLM), or by Pacific Gas & Electric (PG&E). According to VegCAMP (California Dept. of Fish and Wildlife, California Dept. of Forestry and Fire Protection Fire and Resource Assessment Program (FRAP) 2015) which reflects conditions before the Camp Fire, vegetation is primarily hardwood forest and woodland, with some conifer forest and chaparral scrub. The elevation ranges between a maximum of 1,292 meters and minimum of 263 meters.

This is an area that burned early in the first hours of the Camp Fire, which ignited in the wildlands northeast of Paradise (Pulga area) during an intense north-easterly wind event. Neighborhoods on this eastern edge sustained heavy structure losses. The neighborhoods on that side of town are also farthest from the main road out to the southwest, making this arguably the most hazardous section of Paradise in terms of fire safety. Managed well, this WRRB may reduce fire risks for the entire town by reducing ignitions from wind-blown embers and allowing better access for fuels projects and fire access during emergency events.

The prioritization model identifies four large parcels owned by BLM as high- or medium priority due to their high fire risk and public ownership. These and surrounding or nearby private lands could become focal clusters for WRRB management. Potential management opportunities include coordinating with BLM to conduct habitat-sensitive fuels reduction and open space management for recreation on those parcels. Certain parcels, both private and publicly-owned have been identified in the local community as strategic for achieving multiple benefits, such as open space for patients at a nearby hospital as well as a staging area for fire-fighting and fuels reduction, and connecting and improving roads to enhance public safety and access.

The establishment of an Area of Critical Environmental Concern (https://www.blm.gov/programs/planning-and-nepa/planning-101/special-planning-designations/acec) could be considered. ACEC designations highlight areas where special management attention is needed to protect important historical, cultural, and scenic values, or fish and wildlife or other natural resources. ACECs can also be designated to protect human life and safety from natural hazards. An example of this was created as part of the Desert Renewable Energy Conservation Plan (https://www.energy.ca.gov/programs-and-topics/programs/desert-renewable-energy-conservation-plan), in which an ACEC was designated in partnership by California state agencies and BLM to protect habitat from solar energy development. ACECs can only be designated during the land-use planning process.

Outer Eastern Buffer

The Outer Eastern Buffer is a 13,591 area in the wildlands east of Paradise. Although there are areas with relatively high densities of homes (i.e. in the Camelot Subdivision), this area is noted for its rural character and large parcels. 24% of the WRRB is in public ownership, mainly by BLM and U.S. Forest Service, and large parcels are owned by timber companies.

The topography of this area is relatively steep canyon land with a mix of conifer forest, hardwood forest, and shrub vegetation types. Deep canyons may contribute to a wind-tunnel effect directed at the town of Paradise. A striking vegetation feature of the Concow Basin is "the Concow serpentine arch" which forms a crescent shape across the north and northeast of this buffer. This sparsely forested geologic feature acts as a natural fuel break and experienced some of the best tree survival anywhere in the basin. Some of the parcels marked here as "high" priority are actually largely serpentine and would not require fuels treatments (W. Rougle pers. comm.)

This is an area with a history of recent 10-year cycles of intense fires since 1998 (2008 and 2018). The combination of high fuel loads and heavy winds in this area contributed to the rapid spread and spotting of the Camp Fire. The area has limited road access and evacuation routes. This area has been a source of discussions for potentially innovative vegetation management, including the active conversion or management to other vegetation communities.

Public-agency and public-private partnerships to designate land for habitat-sensitive fuels management, especially on large parcels in clusters, is an approach worth considering for this buffer, as well as the possibility of changing timber management practices in dense conifer forest to allow for the vegetation to convert to hardwood forest or woodland with a more frequent, less intense fire regime. The establishment of an Area of Critical Environmental Concern is also a concept appropriate for this region, together with the Inner Eastern Buffer.

Magalia Buffer

The Magalia Buffer is a 3,833 acre region almost surrounding the developed area of Magalia. Vegetation is primarily conifer forest, with some shrub and hardwood forest toward the southern, lower elevation region. The elevation ranges between 263 and 1,907 meters and topography varies between flat mesa incised by steep canyons associated with feeder streams to either Butte Creek or the Feather River.

Opportunities in this buffer offer the potential to reduce the wind-driven ignition threat to Magalia while enhancing community refuge areas and escape routes. Parcels identified as high-priority by the model include large U.S. Forest Service and BLM-owned parcels that could also provide conservation and recreation co-benefits. A large parcel owned by the Paradise Irrigation District containing Magalia Reservoir Dam is identified as important for maintaining the connection for the community of Magalia to Skyway Road, the main escape route.

Public-agency partnerships in this buffer have the potential to provide multiple benefits for all partners as well as public safety and recreational opportunities for the local community with access and trails on public land.

During the fire a modest fuels reduction project instigated by the Butte County Fire Safe Council on Paradise Irrigation District (PID) US Forest Service (USFS), and the Paradise Recreation and Park District (PRPD) land is noted as a successful example of reducing the intensity and spread of the fire.

Butte Creek Buffer

The Butte Creek Buffer is a 2,458 acre strip of land adjacent to the western edge of Paradise. It overlaps the flat mesa of Paradise and includes urban parcels along the western edge of town, and continues down into Butte Creek Canyon. Vegetation is mostly hardwood forest and woodland, with a small amount of conifer forest, and 99% of the buffer is privately-owned. This WRRB impacts ignition risk in both Paradise and Magalia. The region may be more important during vegetation or slope driven fire events rather than wind-driven events; however, these areas still burned intensely during the Camp Fire.

The opportunities for fire risk-reduction in this buffer include purchase or rezoning of small privately-owned parcels in the urban areas along the western edge of Paradise to manage as greenbelt lands to reduce ignitions and increase defensible space for residential areas. Easements or landowner agreements could provide access for fuels reduction in the canyons and allow for integrated management of these lands for improving access to steep slopes for fuels reduction and fire-fighting efforts.

Large parcels owned by private conservation groups may offer the opportunity for partnerships to restore habitat and natural fire regimes as well as open access for recreation.

Southern Foothills Buffer

The Southern Foothills Buffer is a 10,701 acre region adjacent to and overlapping the southern border of Paradise and extending out across the mainly flat grasslands region to the south and west. The sloped plane and relatively gentle topography of Paradise becomes more eroded and punctuated by waterways. Vegetation is primarily hardwood woodland, with grasslands and hardwood forest. The elevation ranges from 43 to 508 meters.

This area presents less of a threat of wind-blown embers during a north-easterly Jarbo Gap wind event. However, this dry area with its flashy grassland fuels could pose a threat during the more common southerly wind scenarios. Due to its flatter topography and location relative to the most populated area (in the direction of escape from wind-driven fire), this WRRB presents the possibility for developing additional parklands that could serve as emergency refuge areas.

Predominantly in private ownership (98% of the acreage is privately-owned), conservation easements and partnership agreements with landowners are potential tools for changing the land cover to reduce ignition risk and fire intensity, with prescribed burning, invasive plant management, and grazing potential methods for fuels management. Mechanisms to improve grazing may be an important tool to help manage these areas in a more economical manner. Outright purchase of parcels could be reserved for strategic locations for parklands or access to steep areas. Road connectivity improvements would benefit fire-fighters and citizens in a fire event.

Engagement with the Paradise Technical Advisory Committee

At the end of the project a joint team of CBI, TNC, and PRPD staff presented the results of the project to the Paradise Technical Advisory Committee and invited their feedback.

Two online meetings one week apart were conducted in place of the originally planned in-person workshop due to COVID-19 restrictions; the first meeting for the purpose of presenting the materials, and the second for conducting an interactive conversation. The conversation and follow-up feedback on the literature review and a draft of this report provided insights into the possibility of implementing innovative community design and partnerships for conservation-minded fuels management in the wildlands. TNC and PRPD intend to continue this conversation forward as the communities of Paradise and Magalia plan and implement the rebuilding of their towns.

In the first meeting on April 13, 2020, Deanne DiPietro and Kai Foster of CBI, Ryan Luster of TNC, and Dan Efseaff of PRPD presented the project goals, methods, and results. A follow-up email was sent to the TAC members with the draft literature review, draft version of this report, and a folder of maps in PDF format, and the request to review the materials.

In the second meeting on April 30, 2020, the project team conducted an interactive discussion, asking the TAC members for their feedback on the project results and to discuss the use of the materials going forward as a possible aid to planning as the communities of Paradise rebuild post-fire.

The conversation was lively and the maps and products from the project, as well as the ability to collaboratively manipulate the maps in Data Basin, were well-received as useful tools for the community's planning and partnership conversations going forward.

It was clear from the discussion that the concepts of employing strategic land use planning and cooperative wildland fuels management were already on the minds of several members, and not new to the group. Many comments were made about specific locations and ideas for applying these approaches, and there was mention of active work being done and partnerships being formed. There was also discussion about barriers and challenges. For example, there was interest in implementing shaded fuel breaks in wildland areas adjacent to the town, but an example of a previous attempt being thwarted by the inability to get all landowners involved. Several TAC members agreed that the small residential properties on the periphery of the town play a key role in the creation of buffers, and voiced the concern that opportunities to purchase or restrict building of homes on those parcels may soon be lost.

There was discussion about the philosophical issue of whether to try to plan for the most severe events, which are arguably so severe that it may be impossible to make much of a difference in their outcome, or would it be more helpful to plan for the events that we know are more likely (south-westerly and

south-easterly wind driven events, in particular) and that we have a better chance of controlling. These other scenarios can certainly be modeled (see Future Enhancements section, below). It is feasible to use the maps without running new models by simply drawing in the new desired wind-direction vectors and examining the potential impacts of reducing fire risk on urban properties. Conversely, one could draw vectors from the urban areas *upwind* for any given wind direction, and then look for parcels to prioritize based on their fire risk ranking in the fire probability map. Different types of planning may apply to those scenarios given the likely severity, but any and all improvements made to the community's ability to battle, withstand, and survive non-catastrophic events are likely to help in the case of the most extreme events, and vice-versa.

These next steps were identified for the Paradise TAC:

- Encourage the strategic, neighborhood approach.
- Conduct more focused conversations about roles and direction before reconvening TAC.
- Consider rolling out the project results to the larger community, after meeting first with town officials about messaging.

Data Basin: Environment for Collaboration and Interactive Use of the Maps

Data Basin is Conservation Biology Institute's online application for sharing and collaboratively creating maps and spatial data. The platform was used throughout the project to present, manipulate, discuss, and annotate maps for use in the prioritization and scenario analyses.

The Paradise Nature-Based Fire Resilience Project Data Basin Group is a private workspace where all interim and final results from this project are shared. Access to the contents of the Group requires membership. This resource will continue to be hosted indefinitely and may be used in future collaboration and planning by the Paradise community. Conservation Biology Institute is always committed to supporting these uses.

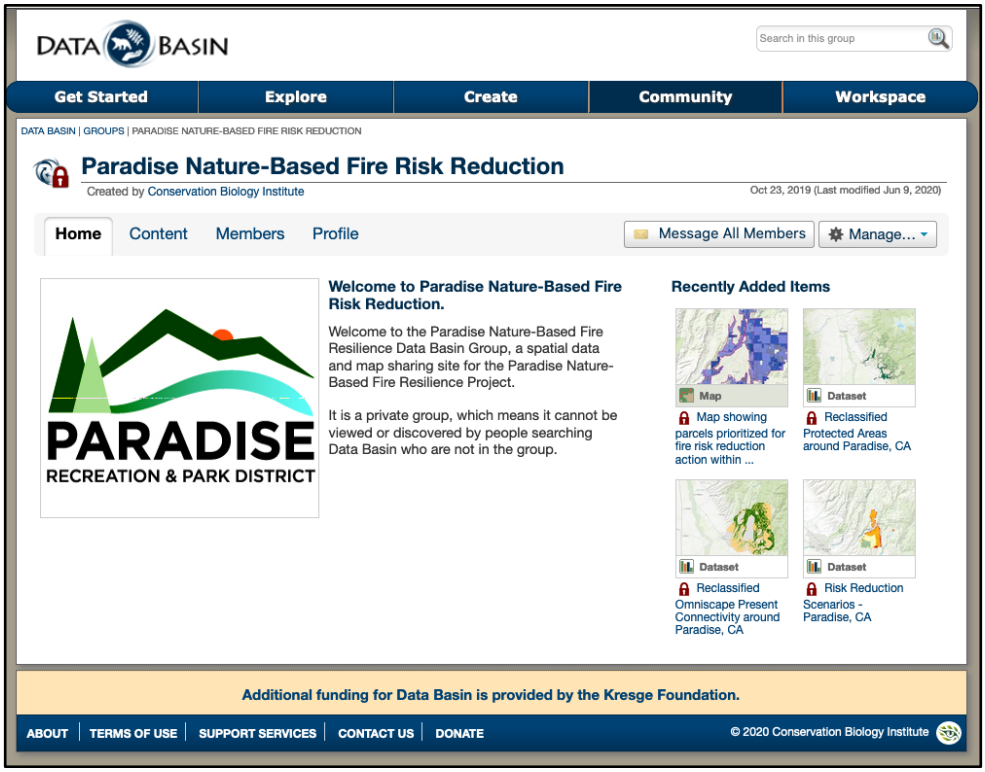

Figure 3. The Data Basin Group used in this project, where all maps and data for the project may be found. The Data Basin platform supports download of the data and creation of new maps by users.

Limitations and Future Directions

The results of this project are intended as a beginning rather than an end-point for a conversation about what can be done to help the communities of the Paradise region live with inevitable future wildfire, protect human lives and property, and enhance habitat in the surrounding wildland area.

Limitations of the Models

First and foremost, it is important for all who seek to understand and use these results to know that maps and models are only as good as the data that went into them. Models, no matter how sophisticated, are only “thought-experiments”. They are useful for asking “what if” type (scenario) questions, especially when compared across scenarios for drawing broad conclusions about relative differences, and for bracketing the range of future conditions that are feasible.

There are oversimplifications in every step of these analyses. Examples include:

- In the analysis of ignition risk-reduction achieved in the Management Scenarios, we assumed that risk-reduction management actions conducted on the priority parcels reduce the probability that those parcels will present an ignition threat to the urban areas. This is a broad assumption that does not take into account the many types of possible management actions and the associated impacts -- especially considering that conditions change through time.

- The Conservation Co-benefits analysis is a coarse estimate of the habitat value on those parcels as interpreted by the underlying datasets. The estimates are broad-brush and static and may not represent the actual habitat quality or species present at a given time. The estimate also says nothing about the types of management actions and whether they enhance or protect habitat on that particular parcel. The analysis also does not attempt to address trade-offs that could produce conservation co-benefits elsewhere, such as could be achieved through the use of greenbelt buffers adjacent to the urban area instead of traditional fuel-reduction techniques that are harmful to native habitat surrounding the urban area. Even more complex is the dynamic nature of the relationship between human activities and wildfire regimes-- please see the Literature Review for a discussion of this coupled Socio-Ecological System.

- Recreation Value-- there were no usable available data, so we used local expert opinion to identify a subset of the parcels with potential recreation value if made accessible or developed with trails, etc. Trails data, if they become available in the future, could be used for mapping recreation value.

- Except for the Recreation Value (which was given a 0.5 point instead of 1 to account for uncertainty), all inputs were weighted equally, and categories were divided in the simplest manner (three bins, equally divided). These could be adjusted with weightings to reflect the varying importance of the different categories. While we assign numerical values to various input data based on both expert judgement and statistical classes, these values are meant to convey only the relative importance of individual features. They do not serve as the actual basis for quantifiable values, effects, or outcomes. For example, if an area is assigned a value of 3 for risk reduction benefit, we do not assume that it provides 3 times the risk reduction benefit of an area with a score of 1. This property may provide 10%, 80% or 400% or risk reduction benefit, but for purposes of this analysis, we just presume it will be more valuable relatively than a property with a value of 1.

- The data used in the models reflect pre-Camp Fire ground conditions. The land cover types and conservation values were altered temporarily by the fire, and long-term changes may possibly persist. These highly dynamic landscape characteristics present a complication for modeling of present and future conditions. The Syphard et al. Fire Probability Model, used as the basis for the Wildland Fire Probability and Urban Ignition Risk models, employed a dynamic vegetation

model called MC2 that accounts for an ongoing feedback relationship between climate, vegetation growth, fire, and subsequent vegetation re-growth.

- There are many scientific uncertainties and data gaps that underlie basic assumptions of risk reduction in our model, such as the relationship between buffer width, vegetation characteristics, and urban ignition risk reduction. Wildfire characteristics are dynamic both within an event and across years, and so while we can design buffers with certain width and vegetation/fuel characteristics, they will provide risk reduction benefits if they effectively reduce ignition sources from embers or the flame front. While we can use the best available science today to design for risk reduction, the degree to which these buffers provide benefits in 10 or 20 years or under extreme conditions is uncertain.

Potential Future Enhancements

Below are some possibilities for enhancing and improving the analyses, should that be desired.

Updating the Wildland Fire Probability and Ignition Risk Maps

The Wildland Fire Probability Model could be updated to reflect post-fire conditions when such data become available, and also include the newly available wind magnitude data. The Urban Ignition Risk and Parcel Prioritization maps would then be updated based on this new model. Also, developing simple scenarios of distances that embers will blow under different wind conditions and directions will help evaluate how robust our property prioritization is to various conditions.

The Technical Advisory Committee pointed out that there are other strong wind patterns that have driven many past fires in the region (see comments by Wolfgang Rougle and Jim Brochears in the Appendix), in particular, winds from the south-west and south-east. These additional wind scenarios could be modeled for additional planning, especially for planning in the Southern Foothills buffer. It may be worth examining the comparative frequencies of these different wind event and resulting fires in the past to help understand the relative probability of these events occurring in the future, for planning purposes.

Additional Management Scenario Analyses

The WRRB Management Scenarios could be further explored and refined with local knowledge to better match the desires of the community. We chose the high-priority parcels or high and medium-priority parcels, but scenarios with any other combination of parcels could be set up and tested. For example, local planners could select the parcels they are interested in testing for Ignition Risk-reduction, using the prioritization analysis as guidance only. This would involve changing the fire risk values in the

selected parcels and re-creating the Urban Ignition Risk map to evaluate the effects of selecting those parcels for management.

Changing the Prioritization Schema

One could refine any of the analysis categories with different, better, or additional data. We especially tried to set up the analysis framework so the inputs could be swapped out-- the categories (eg., "Opportunity" and "Recreation") can be kept the same and the overall analysis framework used again with different underlying data, or additional data. Elements could be moved around as well-- for example, the Recreation category could be considered a Co-benefit together with Conservation instead of being used in the Parcel Prioritization step, or the Parcel Prioritization could be done with both the Risk-reduction Prioritization elements and the Conservation Co-benefits combined.

Additional Data Inputs
Additional analysis inputs that we talked about early in the project but did not include:

- Escape routes. There was discussion about conducting an analysis of the level of difficulty involved in driving a vehicle out of an area and away to safety, but it was not attempted. Another possible component, should this be attempted, could be distance to refuge sites. Refuges and escape routes could be included in the prioritization such that parcels adjacent/upwind from escape routes get a higher priority.

- Real estate value. It was originally envisioned to conduct a cost analysis and we talked about getting access to the estimated values of the properties. This was not attempted due to the changing situation in Paradise after the Camp Fire and difficulties associated with access to and reliability of such data.