Preliminary Draft

A MILLIMAN AND CORELOGIC REPORT

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Paradise Recreation and Parks District: The Implementation of the District Technical Analysis for the Wildfire Risk Reduction Buffer Project

Risk Reduction and Insurance Premiums

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Table of Contents

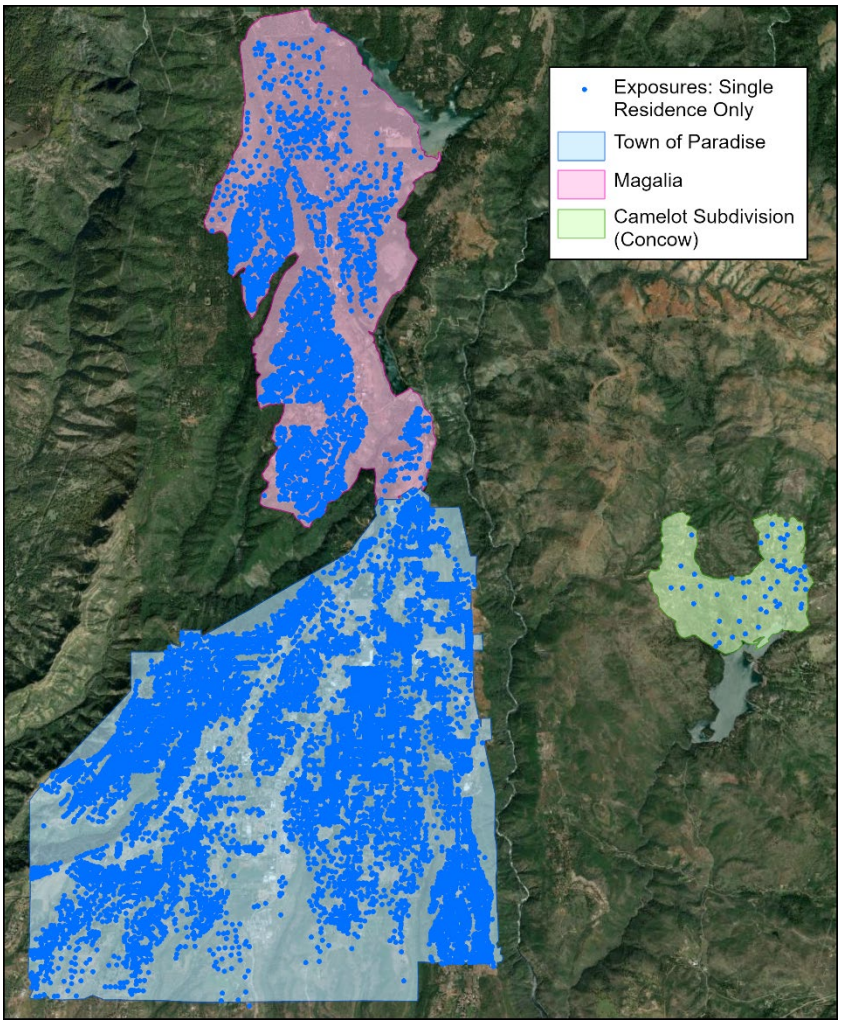
METHODOLOGY **1**
EXPOSURE BASE 1
CORELOGIC CATASTROPHE MODELS 2
Wildfire Catastrophe Models (Baseline) 2
Optimized Fire Pathway Interruption Mitigation Wildfire Catastrophe Model 3
MILLIMAN ACTUARIAL MODEL 3
Loss and Expense Components 3
Net Cost of Reinsurance 3
FINDINGS **5**
AVERAGE ANNUAL LOSS 5
EXCEEDANCE PROBABILITY (EP) CURVES 8
INSURANCE PREMIUM 10
Estimated Insurance Premium and Net Cost of Reinsurance 10
Benefit of Diversification 11
LIMITATIONS **12**
USE OF REPORT 12
DISTRIBUTION 12
DATA RELIANCES 12
MODEL RELIANCES 12
UNCERTAINTY 12
USE OF MILLIMAN'S OR CORELOGIC'S NAME 13
APPENDIX **14**
AVERAGE ANNUAL LOSS BY SCENARIO **1.1**
OCCURRENCE EXCEEDENCE PROBABILITY (OEP) CURVES BY SCENARIO 1.2
AGGREGATE EXCEEDENCE PROBABILITY (AEP) CURVES BY SCENARIO 1.3
TREATMENT MODIFICATION SETTINGS 1.4
SCENARIO DEFINITIONS 1.5
DEVELOPMENT OF INDICATED PREMIUM BY SCENARIO 2.1
DEVELOPMENT OF INDICATED AOP PREMIUM 2.2
EXPENSE SUMMARY - DEVELOPMENT OF PERMISSIBLE LOSS AND REINSURANCE RATIO 2.3
DEVELOPMENT OF ALAE RATIO 2.4
NET COST OF REINSURANCE 2.5
CATASTROPHE BOND PROFIT MULTIPLES ..... 2.

Methodology

Exposure Base

The region analyzed in this study includes the Town of Paradise, the nearby unincorporated communities of Magalia, and the Camelot subdivision of Concow. The borders for the selected region were determined by the Paradise Parks and Recreation District and are pictured below in Figure 1. Within the region, the analysis includes single family residences from the following three categories: 1) those that have survived the Camp Fire, 2) those that have been built back since the Camp Fire, and 3) those that burned down in the Camp Fire and have not yet been built back. Those that burned down in the Camp Fire and have not yet been built back are assumed to be built back in their same locations in the year of 2023, to reflect a fuller picture of housing stock for the purposes of this analysis. The data sources used to locate these structures include CAL FIRE's Damage Inspection (DINs)[1] data from the 2018 Camp Fire supplemented with CoreLogic's proprietary residential parcel and structure characteristics data. All locations were geo-coded by CoreLogic. Structures represented in the analysis are shown in Figure 1 as blue dots.

FIGURE 1: EXPOSURE MAP



[1] Cal fire damage inspection (DINS) data - dataset - California open data. https://data.ca.gov/dataset/cal-fire-damage-inspection-dins-data

To reflect the most realistic home-hardening mitigations in place, the structures that burned down in the Camp Fire are assumed to be rebuilt to IBHS Wildfire Prepared Home standards[2]. Structures that were not burnt down are assumed to have the same home-hardening mitigations in place as they did pre-2018 Camp Fire (provided by DINs data), unless CoreLogic's proprietary structure level data reflected a more recent status.

In this analysis, the Total Insured Values (TIVs) include the standard Homeowners insurance coverages of building (including the detached structures), contents, and time element (living expenses) which were based on the replacement cost value of each property contained in CoreLogic's proprietary property database.

Many of the variables needed to understand the vulnerability of a structure, such as location, are known. For those variables that are not known, CoreLogic either imputed a value or treated the value as unknown. When unknown the vulnerability is assumed to be the average case of the possible values of the variables or to represent the most prevailing feature for each exposure group.

CoreLogic Catastrophe Models

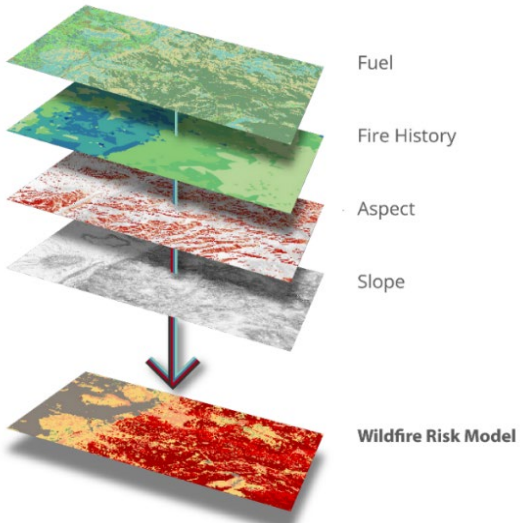
Wildfire Catastrophe Models (Baseline)

Extreme wildfire events are sufficiently uncommon that historical data cannot simply be averaged to estimate the risk of future losses. Further, changes in climate conditions and the built environment renders historical data inapplicable to make forecasts without adjustment. A way to address these problems is to use catastrophe models. Catastrophe models are probabilistic models that incorporate the scientific understanding of the wildfire hazard, as well as detailed information about the exposures, and use modern computing power to simulate thousands or even millions of stochastic events. The simulated outcomes are summarized to provide a view into low-frequency, high-severity risks. For a more in-depth discussion of catastrophe models, see Dietzen and Chamberlain (2022)[3].

This analysis uses CoreLogic's 30-meter resolution high definition U.S. Wildfire Model, released in August 2022, included in the Risk Quantification and Engineering (RQE™), version 22.1 ("CoreLogic Wildfire Model"). The model was initially developed in 1998 and has been regularly updated and enhanced since that initial release.

The CoreLogic Wildfire Model covers the states of Arizona, California, Colorado, Florida, Idaho, Montana, New Mexico, Nevada, Oklahoma, Oregon, Texas, Utah, Washington and Wyoming. The current model characterizes the fuel load in California, Oregon, and Washington using LANDFIRE 2016 Remap fuel data. This characterization of wildfire fuel represents a significant improvement in the fuel characterization compared to prior versions of the dataset.

FIGURE 2: BASELINE STRUCTURE DISTRIBUTION



Source: https://www.corelogic.com/wp-content/uploads/sites/4/downloadable-docs/wildfire-report_0919-01-screen.pdf

The model considers the science behind fire ignition and spread, the local conditions of a property such as vegetation cover, topography, and other factors that drive wildfire risk. The fire vulnerability or building damage is based on primary property characteristics like the structure type, occupancy type, age, and number of stories, and secondary structural modifiers such as vegetation clearance, roofing fire class, and the presence of fire resistive windows or siding. Figure 2 illustrates some of the pieces that comprise a wildfire risk model.

2 Learn more about IBHS Wildfire Prepared Home: Wildfire Prepared Home, a Program of IBHS - Resources

3 Dietzen, G., Chamberlain, M. Taking Catastrophe Models Out of The Black Box (2022). https://www.milliman.com/en/insight/taking-catastrophe-models-out-of-the-black-box

The analysis of the described portfolio of single family homes represents the baseline analysis, against which this study will compare the results from a similar study utilizing a CoreLogic Wildfire Model that was modified to capture the effects of the XyloPlan's Optimized Fire Pathway Interruption Mitigation (introduced and discussed here[4]).

Optimized Fire Pathway Interruption Mitigation Wildfire Catastrophe Model

CoreLogic's U.S. Wildfire Model (the baseline model) described above was modified to reflect the proposed complete implementation of XyloPlan's Optimized Fire Pathway Interruption Mitigation. This treatment plan was reflected in the Optimized Fire Pathway Interruption Mitigation Wildfire Model by updating the fuel model to represent the proposed treatment. An analysis of the same exposure described above was then run using the Optimized Fire Pathway Interruption Mitigation Wildfire Model. The results of the two CoreLogic wildfire model runs (the baseline and the Optimized Fire Pathway Interruption Mitigation case) form two inputs to Milliman's modeling.

Milliman Actuarial Model

A major concern of current and future residents of the study region is the availability and affordability of insurance. While the reduction in wildfire risk arising from the proposed Optimized Fire Pathway Interruption Mitigations is desirable in itself, it is also important because of the potential for reduction in insurance rates. Using the Core Logic model's Average Annual Losses ("AALs"), which represent the expected loss cost over a one-year time period, along with industry data, Milliman estimated the premium that would reflect an average insurer's full costs under each scenario.

Loss and Expense Components

A premium consists of a loss component and an expense component. The loss component (also called "pure premium") is an estimate of the average amount that insurers must pay to indemnify the policyholder. The expense component is an estimate of the expenses incurred when paying and processing claims, as well as those associated with acquiring, underwriting, and servicing policies. Additionally, a profit provision is included, which provides for the required return on capital, with the expense component.

Milliman used the CoreLogic Wildfire Model AALs as an estimate of the wildfire expected losses under each scenario. Since the AALs are ground-up losses (loss amount excluding any deductibles or retentions), the resulting premium reflects the cost to insure properties, and does not take into account policy characteristics like limits and deductibles which shift the financial burden between the insurer and the insured. To the extent that deductibles and limits exist on a policy, the premium that an insured pays would be decreased accordingly.

The non-catastrophe all other perils (AOP) portion of losses was estimated based on the pure premiums in the ISO Fast Track Plus Report, which aggregates Homeowners insurance loss data and trends by state and form. The pure premiums were then loaded for expenses to produce an estimated average premium. The details are shown in Exhibit 2.

The expense component of the premium was taken from California (and countrywide where not state-specific) industry aggregations[5]. This includes commissions, acquisition costs, allocated and unallocated loss adjustment expenses, premium taxes, licenses and fees, and other general expenses. Milliman selected to include a 5% profit and contingency provision with expenses, which historically has been a typical profit and contingency provision[6] for most lines of property and casualty insurance. All expenses are assumed to be variable, so the indicated premium equals the pure premium divided by one minus the variable expense and profit provision.

Net Cost of Reinsurance

Typically, in states other than California, the expense provision includes the net cost of reinsurance. Currently, the California Department of Insurance does not permit reinsurance costs to be included in approved rates, which is a key impediment to insurers writing business in areas of high wildfire risk within California. However, the California Insurer

[4] XyloPlan (2024). Paradise_Fire Pathways Risk Assessment and VTP.pdf - Google Drive

[5] Commission and premium tax are from industry aggregate California Exhibit of Premiums and Losses (Statutory Page 14), while other quantities are from industry aggregate countrywide Insurance Expense Exhibit (IEE).

[6] Actuarial Standards Board (2011). Actuarial Standard of Practice No. 30, Appendix 1. https://www.actuarialstandardsboard.org/wp-content/uploads/2014/02/asop030_148.pdf

Commissioner's proposal of the "Sustainable Insurance Strategy[7]" includes mention of the "need to recognize reinsurance to accurately reflect the cost of writing insurance in California." The implementation of this strategy is currently in progress and expected to be completed by December of 2024. To date, there is no public proposal of regulation to reflect the net cost of reinsurance in ratemaking. Any current updates on proposed regulation can be found at the following website: SustainableInsuranceStrategy (ca.gov).

The estimated premium was calculated with and without reinsurance cost and shows the expected deficit to insurers due to rates not being permitted to reflect reinsurance costs. The net cost of reinsurance is estimated using Insurance Linked Securities (ILS). ILS are "financial securitizations of insurance risks"[8]. One common type of insurance-linked securities are catastrophe bonds, or "cat bonds". Through catastrophe bonds, insurers or reinsurers (the "sponsors") are able to transfer insurance / reinsurance risk to investors. Like traditional fixed-income securities, catastrophe bonds require a collateral ("principal") and provide interest payments in return. Unlike traditional fixed-income securities, catastrophe bonds specify a natural disaster—if this prespecified event does not occur, the bonds are no different from their traditional counterparts in that the principal is returned. However, if the prespecified event occurs, the sponsor's right to the principal is "triggered", meaning that investors will lose some or all of their principal and unpaid interest payments. Because of this, the expected excess return investors receive on catastrophe bonds is analogous to the profit load that reinsurance companies charge the ceding insurance company. Catastrophe bonds can be used to estimate the profit load a reinsurer may demand. Milliman reviewed catastrophe bonds issued from April 1, 2018 to March 31, 2024 from Lane Financial LLC's annual securitization reviews. A curve was fit to the profit multiples versus average probability of attachment and exhaustion of the bonds.

The net cost of reinsurance must be calculated in layers because the profit load increases as the probability of attachment decreases. For each layer, the net cost of reinsurance is equal to the expected loss in the layer multiplied by the average profit multiple in the layer. The expected loss in the layer is equal to the occurrence exceedance probability curve loss multiplied by the percent of total reinsurance amount that the layer encompasses. For each layer, the area under the curve is calculated to estimate the average profit multiple by layer. This calculation is shown in appendix Exhibit 2, Page 5.

For this analysis, it is assumed that insurers of the selected study region purchase reinsurance that has a 5% probability of attachment and a 0.5% probability of exhaustion. In other words, there will be a 1 in 20-year chance of a loss that is large enough to trigger the reinsurance and a 1 in 200-year chance of a loss so large that it exceeds the available reinsurance. In practice, reinsurance coverage is expressed in dollars (e.g. an attachment point of $5 million and a limit of $1 billion). However, the representation of reinsurance structure in terms of attachment and ruin probabilities allows for a consistent view of risk appetite, so that reinsurance costs under different scenarios can be compared.

It is important to note that the analysis assumes an insurer operating solely in the selected study region. Without the benefit of diversification, which is discussed in a later section, this hypothetical insurer would experience a high cost of reinsurance. For insurers that operate in multiple geographically diverse regions, the tail risk will decrease and cost of reinsurance will reduce correspondingly.

[7] Lara , R. (2023, December). California's Sustainable Insurance Strategy. https://ains.assembly.ca.gov/system/files/2023-12/insurance-commissioner-ricardo-lara-california-sustainable-insurance-strategy-presentation-to-assembly-insurance-committee-12-13-2023.pdf

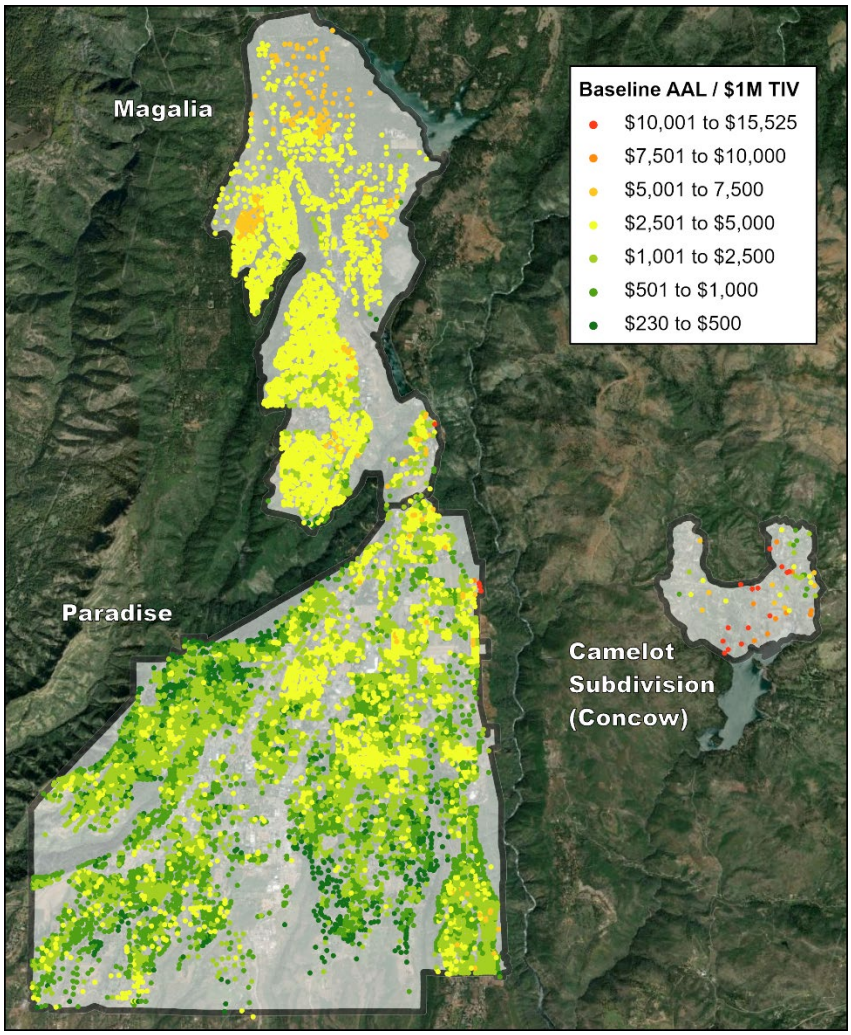
[8] Captive.com (2015). Insurance-Linked Securities (ILS) Market Explained. https://www.captive.com/articles/insurance-linked-securities-(ils)-market-explained

Findings

Average Annual Loss

The CoreLogic Wildfire Model results show, as a baseline, single family residences in the selected study region could have expected *average* annual losses ranging from $79 to over $21,000. This translates to about $17 million, in aggregate, for the whole study region. Since property values differ by location, it is helpful to divide AALs by the total property TIVs, so that the resulting metric is comparable across different areas of the study region. Figure 3 below shows a map of the AAL per million dollars of TIV in this baseline scenario in a diverging color scale, where the spectrum from green to red represents structures with the lowest to highest AAL to TIV ratios.

FIGURE 3: BASELINE CORELOGIC WILDFIRE MODEL AAL / $1M TIV BY LOCATION

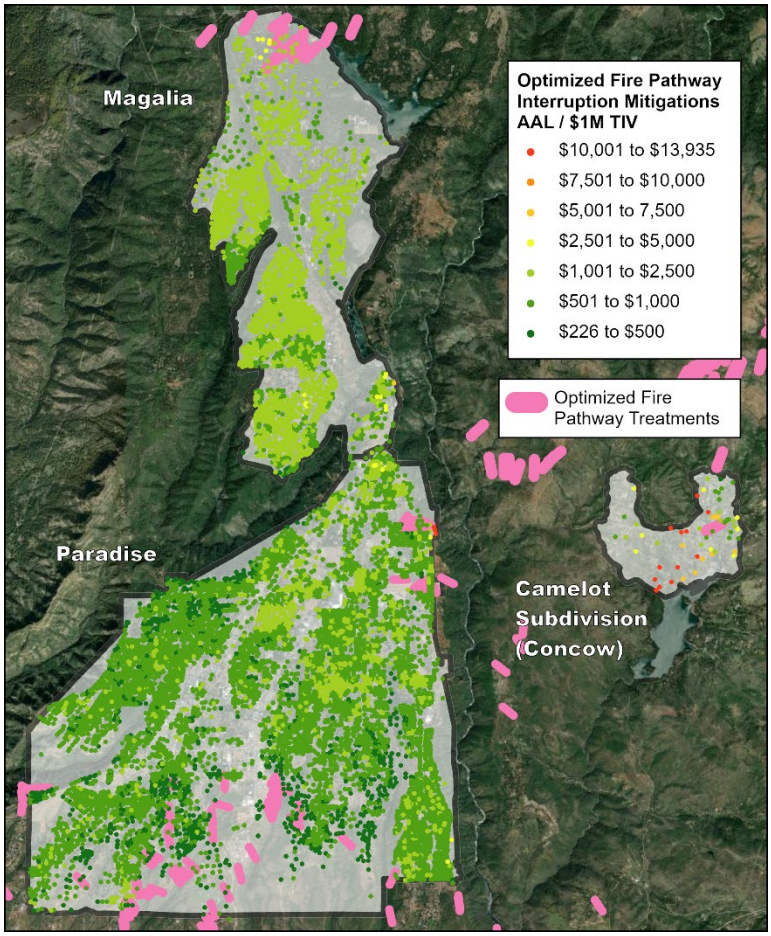


In general, structures on the northeast border of the Town of Paradise, structures in Magalia, and structures in the Camelot subdivision of Concow have higher expected losses as a fraction of their TIV. In addition to the location-based risk, secondary structure modifiers, such as year built and roof type contribute to the determination of AAL. As previously mentioned, the baseline exposure assumes structures that were burned down in the Camp Fire were built back to IBHS Wildfire Prepared Home standards in 2023, and thus are given respective secondary structure modifiers in the model. Structures that did not burn down reflect their actual reported year built and characteristics pre-Camp Fire (unless

CoreLogic's database reflected a more recent status) and are given those respective secondary structure modifiers in the model. In general, more mitigated, newly built structures will have lower AALs per million dollars of TIV.

A second scenario was then modeled to reflect the proposed Optimized Fire Pathway Interruption Mitigation as discussed above in "Optimized Fire Pathway Interruption Mitigation Wildfire Catastrophe Model". The locations of the structures and secondary structure modifiers remained the same as the baseline. Figure 4 shows the AAL per million dollars of TIV calculated for this scenario.

FIGURE 4: OPTIMIZED FIRE PATHWAY INTERRUPTION MITIGATION CORELOGIC WILDFIRE MODEL AAL / $1M TIV BY LOCATION



In general, we see lower AALs due to the implementation of Optimized Fire Pathway Interruption Mitigation as compared to the baseline. Note that the reduction in modeled AAL demonstrated in this study is not uniform. The reduction in modeled AAL differs from location to location for many reasons including:

- The AALs are calculated considering a large number of hypothetical events that are intended to capture the full range (e.g. severity, frequency, ignition location, and weather conditions) of wildfire events that may impact the study area. The reduction in risk from the Optimized Fire Pathway Interruption Mitigation can be expected to differ from (real or modeled) wildfire to wildfire. As different hypothetical wildfires result in different distributions of damage, it is expected that the resultant benefits will differ from location to location and wildfire to wildfire.
- The reduction in AAL for structures that have low risk to begin with is more volatile than it is for high risk structures when measured in relative terms.

- The modeled treatment plan does not eliminate the risk to the study area from all wildfires. Insofar as any treatment plan cannot preclude some impact to the study area from all wildfires, the modeled benefits are expected to vary across the protected area.

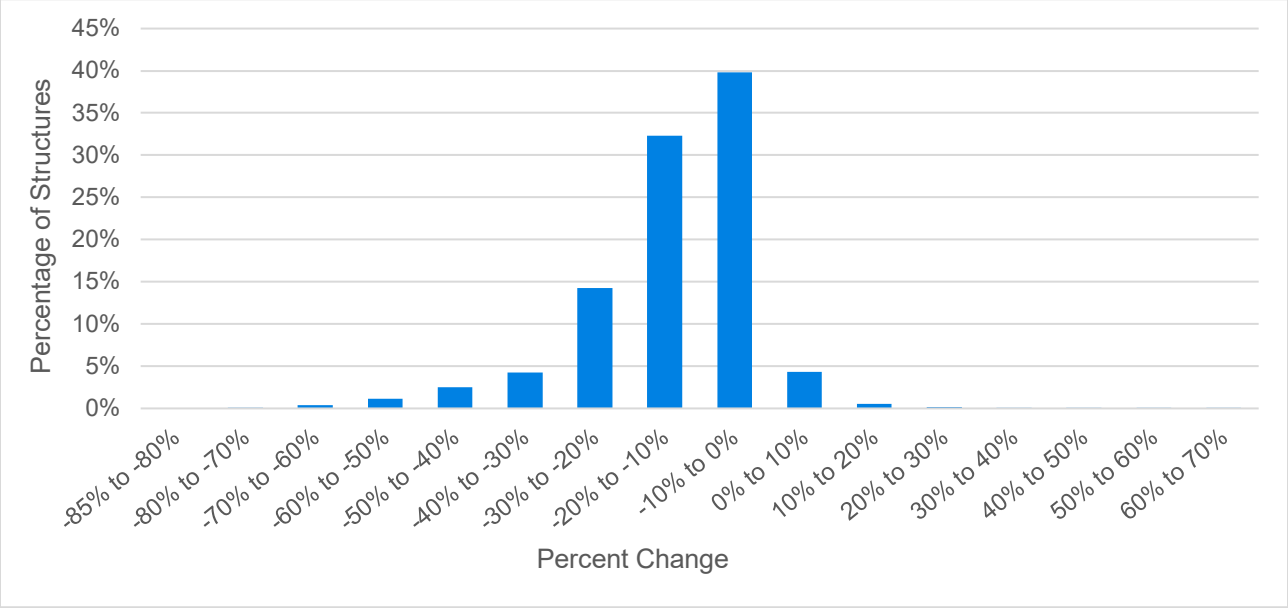
As shown in Table 1, implementing the Optimized Fire Pathway Interruption Mitigation can reduce average losses by 15.7%.

TABLE 1: SUMMARY OF AGGREGATE AVERAGE ANNUAL LOSS BY SCENARIO

SCENARIO	ESTIMATED TOTAL AAL	DIFFERENCE FROM BASELINE
Baseline	$17.3 M	0%
Optimized Fire Pathway Interruption Mitigation	$14.6 M	-15.7%

It is also helpful to consider the distribution of risk reduction. Figure 5 below, shows a histogram of the percentage reduction in AAL resulting from the Optimized Fire Pathway Interruption Mitigation. The bars show the distribution of percentage change in modeled AAL by structure resulting from the Optimized Fire Pathway Interruption Mitigation.

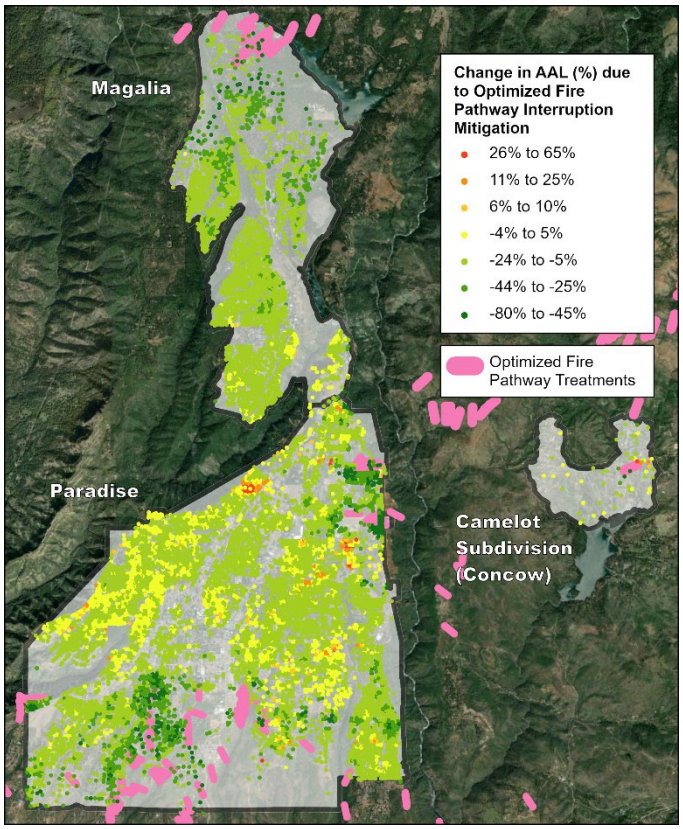
FIGURE 5: HISTOGRAM OF PERCENT CHANGE IN AAL DUE TO OPTIMIZED FIRE PATHWAY INTERRUPTION MITIGATION

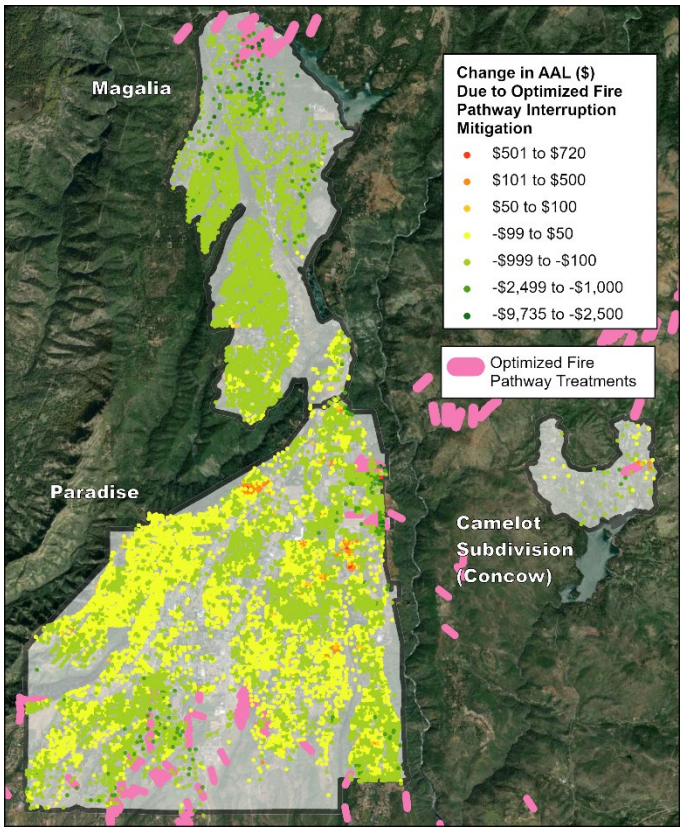


As illustrated in Figure 5, more than 70% of structures see a 0% to 20% decrease in AAL. More than 50% of the structures show a decrease of greater than 10% , with more than 20% of structures seeing a decrease of more than 20% in AAL. The remaining 5% of structures see an increase in AAL. Since the AALs are calculated on a location basis, there are several factors that can cause the percent change in AAL to vary. These factors include the proximity of structures to the wildland/urban interface (WUI), the effectiveness of the treatments to mitigate all impactful fires for a given location, and the specific features of the geography such as terrain conditions (slope, aspect and ground elevation), fuel, and defensible space/distance between properties. It should be noted that the small population of locations for which the modeling determined an increase in AAL represent locations for which the fire pathway treatment resulted in (for some modeled fires) a modified pathway to these locations that resulted in higher fire intensities impacting these properties.

Figure 6 below shows the change in AAL from the Baseline scenario to the Optimized Fire Pathway Interruption Mitigation scenario.

FIGURE 6A (LEFT): CHANGE IN AAL DUE TO OPTIMIZED FIRE PATHWAY INTERRUPTION MITIGATION, IN PERCENTAGE OF BASELINE AAL
FIGURE 6B (RIGHT): CHANGE IN AAL DUE TO OPTIMIZED FIRE PATHWAY INTERRUPTION MITIGATION, IN DOLLARS





Comparing Figures 6A and 6B, we can see that the percentage and dollar reduction in AAL do not always align. For example, many properties along the northwestern border of the town receive a sizable percentage reduction in AAL, but not a large dollar reduction. The converse can also be true: properties with smaller percentage reduction in AAL can have a large dollar reduction in AAL. This phenomenon is discussed in the recent whitepaper written by Milliman[9] and published by the Casualty Actuarial Society, which shows that low risk territories may see a larger reduction in risk, while higher risk territories may see a larger reduction in dollars. This is because in higher risk areas, extreme events tend to be more severe, so the risk reduction power of individual property mitigation is limited. However, in high-risk territories, expected losses are significant to begin with, so any reduction translates to a larger dollar amount.

Exceedance Probability (EP) Curves

The expected loss is just one aspect of risk. To understand what losses *could* be, instead of what losses *are expected to be on average*, one needs to consider EP Curves. EP Curves are another key metric produced by probabilistic catastrophe models. They provide the likelihood that a loss of a given size or greater will occur in any year—the annual exceedance probability. This is often summarized by key return period loss levels. For example, a 1% annual probability of exceedance corresponds to a 100-year return period loss (i.e. 1/100 = 1%).

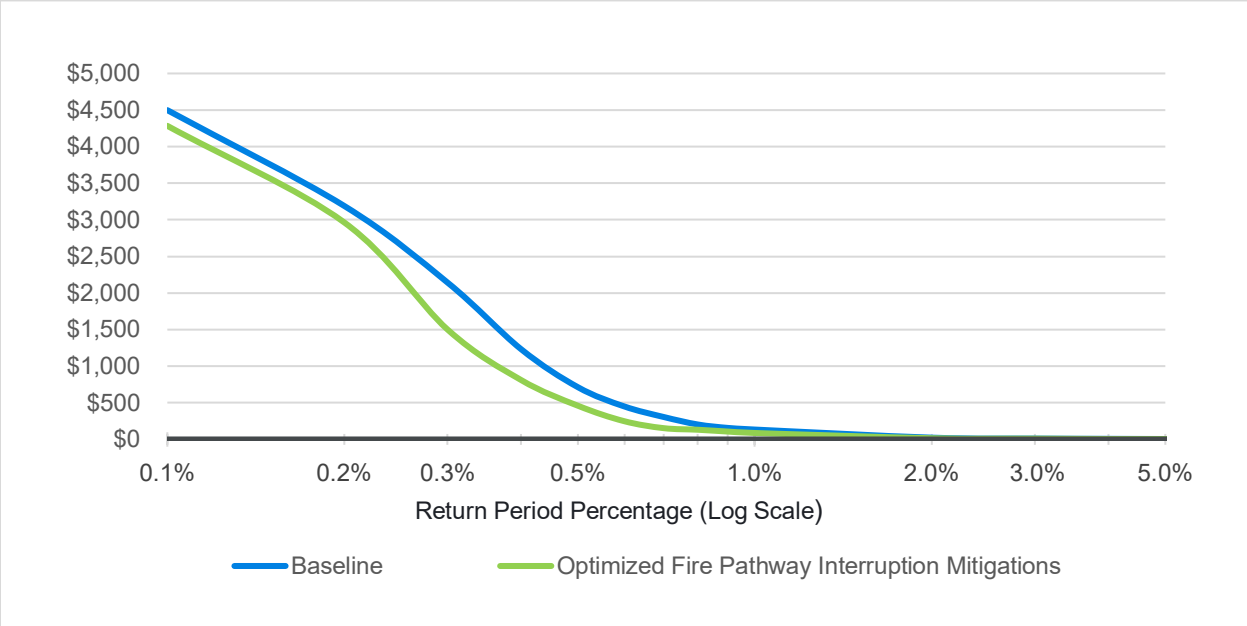
[9] Brinkmann et al (2022). Catastrophe Models for Wildfire Mitigation: Quantifying Credits and Benefits to Homeowners and Communities, p. 35-36. Retrieved November 30, 2022. https://www.milliman.com/en/insight/catastrophe-models-for-wildfire-mitigation

The EP curves were reviewed on an Aggregate Exceedance Probability ("AEP") and Occurrence Exceedance Probability ("OEP") basis. AEP curves are based on the total aggregate losses for a given year, while OEP curves are based on the largest single loss for a given year. While recent history has demonstrated that it is common for there to be multiple impactful regional wildfires in a given year, the probability of multiple such fires to directly impact a region with the size of the study region is relatively small compared to the probability of a single fire impacting that area. As a result, the AEP curves and OEP curves are very similar. The discussion focuses on the AEP curves but the conclusions based on the OEP curves would be identical.

Figure 7, below, shows the AEP curve for the two scenarios.

The blue line shows the baseline scenario: In this scenario, the selected study region should expect a 1 in 100-year loss of $136 million. The Camp Fire, which destroyed over 90% of structures in the Town of Paradise, is analogous to the magnitude of a 1 in 1000-year loss in the model results, where close to 90% of the Total Insured Value (TIV) is destroyed.

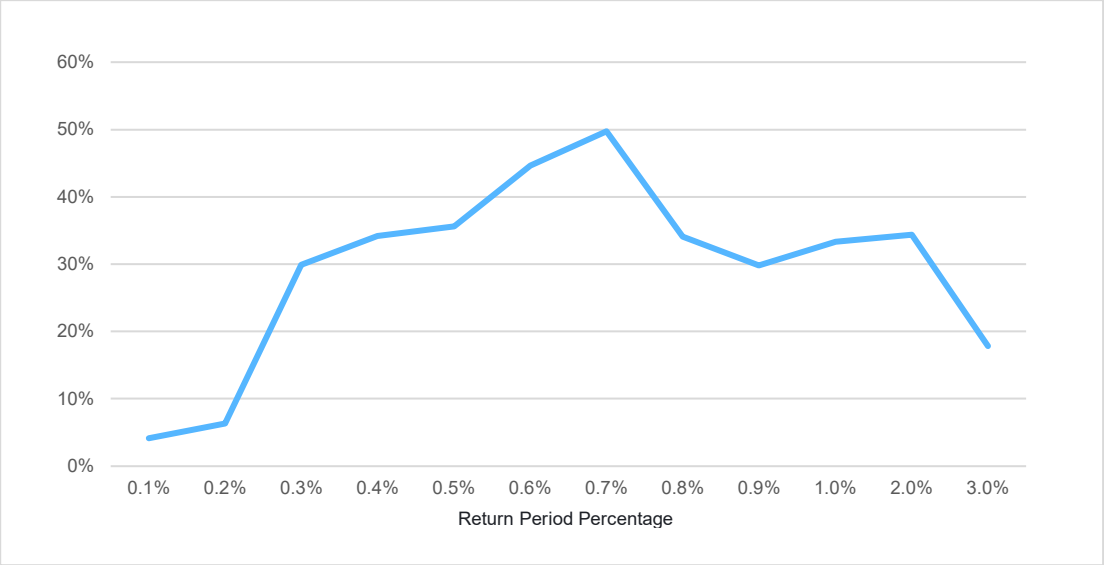
FIGURE 7: AGGREGATE EXCEEDANCE PROBABILITY CURVE



The Optimized Fire Pathway Interruption Mitigation is expected to not only decrease the average annual losses, but also reduce some of the worst-case outcomes by as much as half. For example, in the baseline scenario, a 1 in 100-year loss is expected to be $136 million in aggregate. If mitigation is performed as in the Optimized Fire Pathway Interruption Mitigation scenario, this figure decreases by 35% to $89 million.

The effectiveness of risk reduction techniques generally decreases for the most extreme events. Figure 8, below, shows the reduction in OEP curve loss amounts by return period for the Optimized Fire Pathway Interruption Mitigation scenario. In general, the maximum reduction is achieved in mid-to-lower return periods (less extreme events). The risk reduction started to decrease around the 167-year return period through the 1000-year return period. This is intuitive: in events like the Camp Fire, the extreme level of convection, radiation, and ember cast will likely overpower much of risk mitigation techniques. Home hardening features like class A fire roofs and fire resistive sidings are generally not designed to be fireproof, but rather to delay ignition so that firefighters have more time to react and residents have time to remove themselves from the structure. Moreover, with large fires and high wind conditions, ember spotting becomes the main source of fire transmission, so defensible space and buffers will become less effective.

FIGURE 8: PERCENT REDUCTION FROM BASELINE IN OEP CURVE LOSS AMOUNTS BY RETURN PERIOD



Insurance Premium

Estimated Insurance Premium and Net Cost of Reinsurance

The indicated total premium was calculated for each scenario using the AAL output of CoreLogic's Wildfire Model and industry data.

As discussed above, the CDI does not allow the Net Cost of Reinsurance to be reflected in Homeowners premiums. For this analysis, indicated total premium is shown alongside the Net Cost of Reinsurance to illustrate the deficit an insurer would expect from excluding this cost. The details of the calculation and its components are shown in Exhibit 2. Both versions of indicated total premiums (including and excluding Net Cost of Reinsurance) and the premium deficit of excluding Net Cost of Reinsurance are shown in Table 2, below. As discussed in the methodology section, this analysis assumes no benefit of diversification, so the resulting estimated cost of reinsurance and premium deficit should be treated as the high ends of the range of possible values.

TABLE 2: SUMMARY OF ESTIMATED AVERAGE PREMIUM, PER EXPOSURE

SCENARIO	ESTIMATED AVERAGE PREMIUM BY EXPOSURE		PREMIUM DEFICIT
	INCLUDING NET COST OF REINSURANCE	EXCLUDING NET COST OF REINSURANCE	
Baseline	$5,027	$3,848	23.5%
Optimized Fire Pathway Interruption Mitigation scenario	$4,172	$3,445	17.4%

The difference between the scenarios is driven by the wildfire AALs and the Net Cost of Reinsurance. The baseline scenario has a higher wildfire premium and a higher Net Cost of Reinsurance based on the calculation discussed in the Methodology section. On the other hand, the Optimized Fire Pathway Interruption Mitigation scenario has lower indicated premiums as well as lower Net Cost of Reinsurance. The lower cost of reinsurance is due to the reduction in losses in the tail of the distribution, as discussed in the EP Curves section. Because extreme events in this scenario have much lower losses than extreme events in the baseline scenario, the expected ceded portion of losses is much lower, even if the selected study region maintains the same reinsurance structure (5% probability of attachment and 0.5% probability of ruin). As a result, the expected premium deficit due to Net Cost of Reinsurance not being included

is also lower in the Optimized Fire Pathway Interruption Mitigation scenario. In other words, insurance premiums will tend to be more in line with the indicated total cost of risk transfer if risk reduction measures are put into effect, and companies can be more confident that their rates are closer to adequate for the risk.

However, in both scenarios modeled, there is still a premium deficit when the cost of reinsurance is excluded from the premium. The deficit caused by not being able to include these costs in the premium is a key reason why insurers are reluctant to write in high wildfire risk areas, such as Paradise.

Table 3 below shows the aggregate premium calculated for the study region for each scenario. This is calculated by taking the average premium shown in table 2 and multiplying it by the number of exposures in the study region. This table shows that in aggregate, the entire study region is estimated to save about $4.5 million in premium with net cost of reinsurance excluded (which is how insurance is currently priced as of the time of this report), and $9.5 million in premium with net cost of reinsurance included (which is how we would expect insurance to be priced based on the proposed changes of the Sustainable Insurance Strategy, discussed in the Methodology section of this report). Note that these calculations are based on the study region, which as noted in the Exposure Base section, is not reflective of the housing stock currently on-the-ground, but rather a hypothetical estimate of what it would look like once it is entirely built back to pre-Camp Fire density. However, this information can still be useful for the community leader making decisions as to whether or not to implement treatments, based on a cost benefit analysis.

TABLE 3: SUMMARY OF ESTIMATED PREMIUM, IN AGGREGATE FOR STUDY REGION

SCENARIO	ESTIMATED PREMIUM IN AGGREGATE	
	INCLUDING NET COST OF REINSURANCE	EXCLUDING NET COST OF REINSURANCE
Baseline	$ 55,985,258	$ 42,847,085
Optimized Fire Pathway Interruption Mitigation scenario	$46,459,032	$ 38,358,199
DIFFERENCE	$9,526,225	$4,488,886

Benefit of Diversification

As noted in earlier sections, this case study assumes a hypothetical insurance company that operates solely in the study region. In reality, insurance companies write policies in geographically diverse areas, so that their portfolios are diversified. The danger of having a concentrated portfolio is that one large event like the 2018 Camp Fire can wipe out the whole book. On the other hand, a portfolio that has, say, 10% of its policies in the study region, would only have 10% of its portfolio experience losses in an event like the 2018 Camp Fire.

The value of diversification lies in the statistical independence of insured properties. In the case where a company's portfolio is geographically diverse, it is unlikely that one catastrophic wildfire event will affect multiple geographies. While the expected loss to TIV ratio will stay the same despite diversification[10], EP curves are sub-additive. In other words, a geographically diverse insurer would charge the same premium (not including the Net Cost of Reinsurance) as one that is not geographically diverse, but the former should expect less severe extreme events. An estimation of the benefit of diversification is highly dependent on the specific correlation assumptions of the losses and is beyond the scope of this discussion, but it is important to know that diversification is a key aspect to successful risk management for any insurer.

[10] The expected value of a sum of random variables is the sum of the expected values of the random variables, regardless of correlation.

Limitations

USE OF REPORT

The data and exhibits in this report are provided to support the conclusions contained herein, are limited to the scope of work specified by the Paradise Parks and Recreation District associated with the California Resilience Challenge Grant, and may not be suitable for other purposes. Milliman and CoreLogic are available to answer any questions regarding this report or any other aspect of our review.

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DATA RELIANCES

In performing this analysis Milliman and CoreLogic relied upon information obtained from the Paradise Parks and Recreation District, CDI, IBHS, and other sources. Milliman and CoreLogic have not audited or verified this data and information. If the underlying data or information is inaccurate or incomplete, the results of the analysis may likewise be inaccurate or incomplete. In that event, the results of the analysis may not be suitable for the intended purpose.

Milliman and CoreLogic performed a limited review of the data used directly in the analysis for reasonableness and consistency. Milliman and CoreLogic did not find material defects in the data. If there are material defects in the data, it is possible that they would be uncovered by a detailed, systematic review and comparison of the data to search for data values that are questionable or relationships that are materially inconsistent. Such a detailed review was beyond the scope of this assignment.

MODEL RELIANCES

This analysis is based on the CoreLogic Risk Quantification and Engineering U.S. Wildfire Model, version 22.1. To the extent that the model used is biased, the resulting analysis may be biased.

UNCERTAINTY

Differences between the projections and actual amounts in this report depend on the extent to which future experience conforms to the assumptions made for the analyses. It is certain that actual experience will not conform exactly to the assumptions to be used in these analyses. Actual amounts will differ from projected amounts to the extent that actual experience is better or worse than expected.

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Appendix

See attached exhibits.

Paradise Recreation and Park District
California

Average Annual Loss by Scenario

Item	Notes	(1) Baseline	(2) Optimized Fire Pathway Interruption Mitigations
A. Total Average Annual Loss	(Notes 1, 2)	$17.3	$14.6
B. Total TIV	(Note 1)	$8,128	$8,128
C. Exposures		11,136	11,136
D. Average Annual Loss / Exposure ($)	(A) / (C)	$1,554	$1,310

Notes:
1. Dollar amounts are in millions ($000,000). Row D is in dollars.
2. Average annual losses reflect total ground up coverages.

Paradise Recreation and Park District
California

Occurrence Exceedance Probability (OEP) Curves by Scenario

		(1)	(2)
		Occurrence Exceedance Probability Curve Loss	
Return Period (Years)	Exceedance Probability	Baseline	Optimized Fire Pathway Interruption Mitigations
1,000	0.10%	$4,470	$4,285
500	0.20%	3,167	2,966
333	0.30%	2,137	1,498
250	0.40%	1,235	813
200	0.50%	714	460
167	0.60%	453	251
143	0.70%	308	155
125	0.80%	202	133
111	0.90%	153	107
100	1.00%	133	89
50	2.00%	25	16
33	3.03%	13	10
25	4.00%	9	7
20	5.00%	6	6
17	5.88%	6	4
14	7.14%	4	3
13	7.69%	4	2
11	9.09%	2	1
10	10.00%	1	0
7	14.29%	0	0
5	20.00%	0	0
3	33.33%	0	0
2	50.00%	0	0

Paradise Recreation and Park District
California

Aggregate Exceedance Probability (AEP) Curves by Scenario

Return Period (Years)	Exceedance Probability	(1) Aggregate Exceedance Probability Curve Loss: Baseline	(2) Aggregate Exceedance Probability Curve Loss: Optimized Fire Pathway Interruption Mitigations
1,000	0.10%	$4,499	$4,285
500	0.20%	3,191	2,966
333	0.30%	2,140	1,498
250	0.40%	1,235	813
200	0.50%	714	461
167	0.60%	453	251
143	0.70%	308	155
125	0.80%	205	133
111	0.90%	158	108
100	1.00%	136	89
50	2.00%	25	17
33	3.03%	13	11
25	4.00%	9	7
20	5.00%	7	6
17	5.88%	6	4
14	7.14%	4	3
13	7.69%	4	2
11	9.09%	2	1
10	10.00%	1	0
7	14.29%	0	0
5	20.00%	0	0
3	33.33%	0	0
2	50.00%	0	0

Paradise Recreation and Park District
California

Treatment Modification Settings

Secondary Modifier	Scenario: Baseline	Scenario: Optimized Fire Pathway Interruption Mitigations
Large scale fuel modifications	No	No
Optimized treatment locations	No	Yes
Varied age class mosaic	No	Yes
Rotating multi-year maintenance of treatments	N/A	Yes
Maintenance of treatments scaled to match local capacity	N/A	Yes

Paradise Recreation and Park District
California

Scenario Definitions

Item	(1) Baseline	(2) Optimized Fire Pathway Interruption Mitigations
A. Mitigation	Assumption is that if a home had > 50% damage during the Camp Fire, it was rebuilt in 2023 to meet IBHS Wildfire Prepared Home standards and defensible space requirements. If < 50% damage during the Camp Fire, then current property characteristics are collected from CoreLogic's data base.	Assumption is that if a home had > 50% damage during the Camp Fire, it was rebuilt in 2023 to meet IBHS Wildfire Prepared Home standards and defensible space requirements. If < 50% damage during the Camp Fire, then current property characteristics are collected from CoreLogic's data base.
B. Exposure	Entire town of Paradise and areas of Magalia and Concow selected by the Paradise Parks and Recreation District. See map within report.	Entire town of Paradise and areas of Magalia and Concow selected by the Paradise Parks and Recreation District. See map within report.
C. External Buffers	No	No
D. Climate	Current	Current
E. Fuel Treatments	No	Yes (See Page 4)

Paradise Recreation and Park District
California

Development of Indicated Premium by Scenario

Item	Notes	(1) Baseline	(2) Optimized Fire Pathway Interruption Mitigations
A. Wildfire Pure Premium	(Note 1)	$1,554	$1,310
B. Permissible Loss Ratio	(Page 3)	60.7%	60.7%
C. Indicated Wildfire Premium	(A) / (B)	2,561	2,157
D. AOP Premium	(Page 2)	1,287	1,287
E. Indicated Total Premium Excluding Cost of Reinsurance	(C) + (D)	3,848	3,445
F. Net Cost of Reinsurance	(Page 5)	1,180	727
G. Indicated Total Premium Including Cost of Reinsurance	(E) + (F)	5,027	4,172
H. Premium Deficit from excluding Cost of Reinsurance	[(G) - (E)] / (G)	23.47%	17.44%

Notes:
1. Row A is calculated by dividing the average annual loss by the exposure, which are both provided in Exhibit 1, Page 1.

Paradise Recreation and Park District
California

Development of Indicated AOP Premium

Item	Notes	Amount
A. Fast Track NonCAT Pure Premium	(Note 1)	$781
B. Permissible Loss Ratio	(Note 2)	60.7%
C. Indicated AOP Premium	= (A) / (B)	$1,287

Notes:
1. Pure premium of year ending 2023 Q4, from from Fast Track Plus, Homeowners Loss Data and Trends, California, policy forms 1-3 and 5 combined.
2. Row B is from Page 3.

Paradise Recreation and Park District
California

Expense Summary - Development of Permissible Loss and Reinsurance Ratio

Item		Notes	(1) Industry	(2) California	(3) Selected
A.	Commissions	(Note 2)	12.5%	12.3%	12.3%
B.	Unallocated Loss Adjustment Expense	(Note 2)	6.9%		6.9%
C.	Other Acquisition	(Note 2)	5.4%		5.4%
D.	General	(Note 2)	4.5%		4.5%
E.	Premium Taxes, Licenses, and Fees	(Note 2)	2.3%	2.3%	2.3%
F.	Profit & Contingency	(Note 2)	5.0%	5.0%	5.0%
G.	Total Expense and Profit, excluding Reinsurance Expense	= Sum of (A) to (F)			36.4%
H.	ALAE (as a % of Loss)	(Note 3)			4.8%
I.	Permissible Loss Ratio	= (1-(G)) / (1+(H))			60.7%

Notes:
1. Quantities are for the Homeowner Multiple Peril line of business, stated as percentages relative to the line of business premium.
2. Items A - E for column (1) come from P&C Industry IEE for 2023 and for column (2) come from California State Page 14 for 2023. Item F is selected by Milliman.
3. ALAE Ratio from Page 4.

Paradise Recreation and Park District
California

Development of ALAE Ratio

Peril	Item	Notes	(1) 2021	(2) 2022	(3) 2023	(4) Selected
Homeowners - Multiple Peril						
	Direct Losses Incurred	(Note 1)	$4,532,835,068	$6,345,774,558	$7,998,601,470	
	Direct DCCE Incurred	(Note 1)	270,887,358	280,043,900	329,809,786	
	DCCE Ratio	(Note 2)	6.0%	4.4%	4.1%	4.8%
	ALAE Ratio	(Note 3)				4.8%

Notes:
1. Direct Losses Incurred and Direct DCCE Incurred from California Annual Statement.
2. DCCE ratio calculated as Direct DCCE Incurred / Direct Losses Incurred.
   Selected DCCE Ratio equals average DCCE Ratio of 2021, 2022, and 2023.
3. ALAE ratio is assumed to be comparable to DCCE ratio.

Paradise Recreation and Park District
California

Net Cost of Reinsurance

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Occurrence Exceedance Probability Curve Loss (Note 1)					Expected Loss in Layer (Note 3)	
Return Period (Years)	Baseline	Optimized Fire Pathway Interruption Mitigations	P(attach) = 1 / (1)	P(exhaust) = Prior (4)	Profit Multiple in Layer (Note 2)	Baseline	Optimized Fire Pathway Interruption Mitigations
1000	$4,470.05	$4,284.53	0.10%				
500	3,166.65	2,966.01	0.20%	0.10%	22.44	$3.82	$3.63
333	2,136.98	1,498.13	0.30%	0.20%	14.40	2.66	2.24
250	1,234.69	813.16	0.40%	0.30%	10.84	1.68	1.15
200	714.20	459.94	0.50%	0.40%	8.79	0.97	0.64
167	453.23	251.03	0.60%	0.50%	7.44	0.58	0.35
143	307.85	154.75	0.70%	0.60%	6.48	0.38	0.20
125	201.86	133.04	0.80%	0.70%	5.74	0.26	0.14
111	152.55	107.02	0.90%	0.80%	5.17	0.18	0.12
100	133.04	88.70	1.00%	0.90%	4.72	0.14	0.10
50	25.04	16.42	2.00%	1.00%	3.32	0.79	0.53
33	12.65	10.40	3.03%	2.00%	2.13	0.19	0.14
25	8.76	6.51	4.00%	3.03%	1.60	0.10	0.08
20	6.48	5.77	5.00%	4.00%	1.30	0.08	0.06
17	5.90	4.40	5.88%	5.00%	1.11	0.05	0.04
14	4.35	3.01	7.14%	5.88%	0.96	0.06	0.05
13	4.04	2.28	7.69%	7.14%	0.86	0.02	0.01
11	1.94	1.04	9.09%	7.69%	0.78	0.04	0.02
10	1.27	0.49	10.00%	9.09%	0.70	0.01	0.01
7	0.03	0.01	14.29%	10.00%	0.57	0.03	0.01
5	0.00	0.00	20.00%	14.29%	0.43	0.00	0.00
3	0.00	0.00	33.33%	20.00%	0.30	0.00	0.00
2	0.00	0.00	50.00%	33.33%	0.21	0.00	0.00

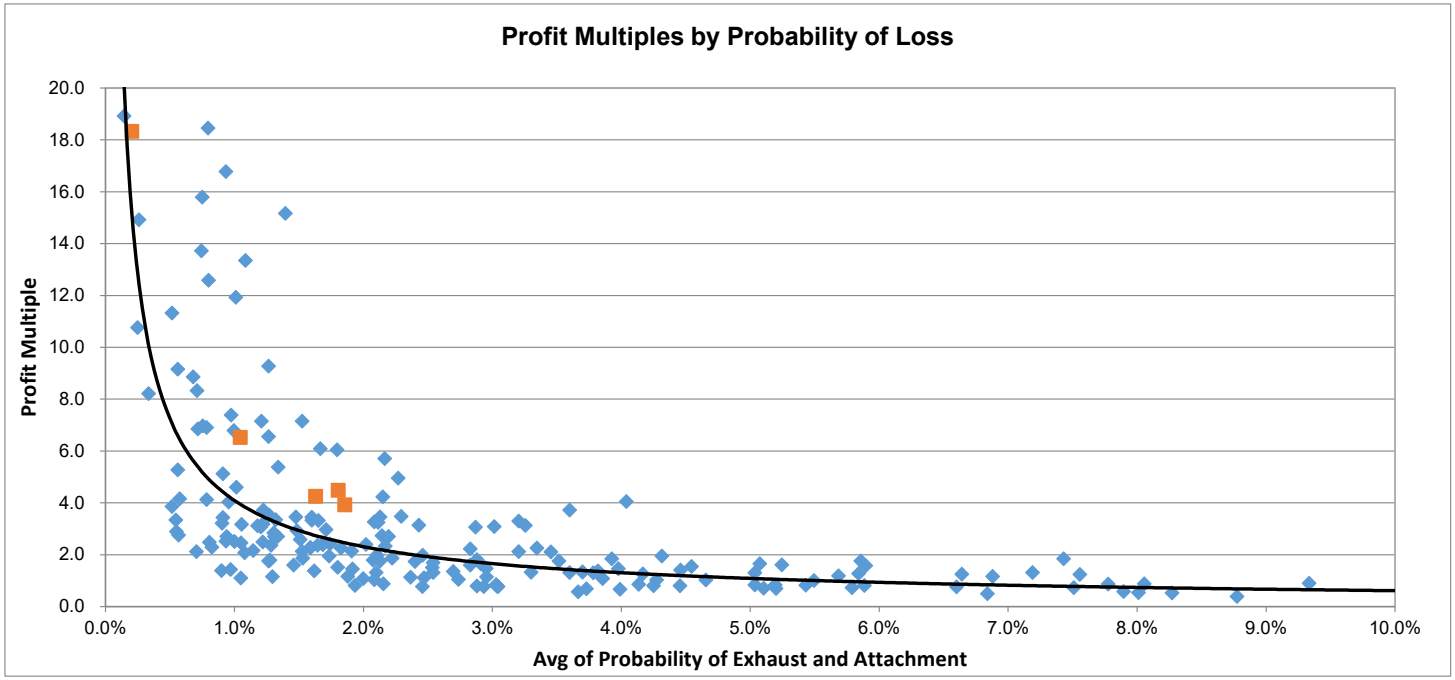
(9) Net Cost of Reinsurance ($M) (Note 4)	$13.14	$8.10
(10) Average Net Cost of Reinsurance-to-AAL Multiplier (Note 5)	3.5748	3.4300
(11) Number of Exposures (Exh 1, pg. 1)	11,136	11,136
(12) Average Net Cost of Reinsurance per exposure ($) (Note 6)	$1,179.79	$727.45
(a) Coefficient (Page 6)	0.09917	
(b) Exponent (Page 6)	-0.82928	
A. Integral exponent, (Page 6)	0.1707	
B. Integral coefficient, (Page 6)	0.5809	

Notes:
1. Data is from Exhibit 1, Page 2.
2. Column (6) = {[B x (4) ^ A] - [B x (5) ^ A.]} / [(4) - (5)].
3. Column (7) = [(4) - (5)] x Avg of [(2) and Prior (2)]. Columns (8) calculated similarly.
4. Row (9) Baseline = summation of (6) x (7) for each row from selected return periods of 20 - 167. This selection assumes insurers of region purchase reinsurance from a 5.00% P(attach) to a 0.5% P(exhaust). Each scenario is calculated similarly.
5. Row (10) Baseline = (9) / Total of (7) of selected return periods 20 - 167. Each scenario calculated similarly.
6. Row (12) = (9) x 1,000,000 / (11).

Paradise Recreation and Park District
California

Catastrophe Bond Profit Multiples

Based on Data from Catastrophe Bonds Issued on U.S. Exposures from 2018 to 2024



Notes:

1. Data based on cat bonds issued from April 1, 2018 to March 31, 2024, from Lane Financial LLC, Annual Securitization Reviews.
2. Includes all bonds covering U.S. exposures with a probability of loss between 0.14% and 17.55%; excludes bonds with no stated profit multiples.

   Orange points represent wildfire cat bonds SD Re Ltd (Series 2021-1 A), SD Re Ltd. (Series 2021-1 B), SD Re Ltd. (Series 2020-1), SD Re Ltd. (Series 2018-1), and Cal Phoenix Re Ltd. (series 2018-1).
3. The equation of the fitted curve is $y = 0.0992\ x^{-0.829}$.
4. The equation to determine average Profit Multiple over specific interval: Avg PM = ${}^{b}\int_{a} 0.0992\ x^{-0.829} dx$ / (b-a).
   Evaluated from a to b, the integral equals 0.581 b 0.171 -0.581 a 0.171 / (b-a)