Risk Reduction From Forest Management Accounted For in First-Of-Its-Kind Wildfire Resilience Insurance: A Technical Report on the Analytics Used to Price and Underwrite Insurance in California

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Section 1 : Executive Summary

WTW have bound a parametric insurance policy for the Tahoe Donner Association with Globe Underwriting, with capacity provided by a Lloyd's of London Syndicate. This has been completed in collaboration with The Nature Conservancy and the Center for Law, Energy and Environment at UC Berkeley School of Law.

Improved insurance terms

This insurance policy has specifically accounted for the reduction in risk due to forest management ("fuel reduction"), with improved terms. In total, 1520 acres have been treated across the land owned by the Tahoe Donner Association since 2015. Most of the fuel reduction work has been mastication, thinning and limbing. A reduction of both gross premium (39%) and deductible (84%) has been achieved because of the fuel reduction work. This is the first insurance policy that we know of that explicitly accounts for fuel reduction work.

Parameter	Not accounting for fuel reduction	Accounting for fuel reduction (Quote)
Deductible (each-and-every loss)	USD 62,464	USD 10,000 (-84%)
Limit	USD 2.5m	USD 2.5m
Gross premium (incl. brokerage)	USD 90,000	USD 55,000 (-39%)

Broking argument

WTW has provided a broking argument reliant on observations, models and comparison of plausible scenarios with and without fuel reduction. These arguments were combined with Globe Underwriting's empirical analysis of burned area to realise a reduction in premium and deductible due to forest management.

It is important to recognise that this document should be taken as an example as to how fuel reduction ***can*** be accounted for, in an ultimately ***commercial*** decision to provide more favourable terms of insurance (e.g. lower premiums, lower deductibles, or higher limits), rather than as a scientific document.

Section 2 : Background

The Nature Conservancy

WTW have been working with The Nature Conservancy (TNC) and the UC Berkeley Center for Law, Energy and the Environment (CLEE) on promoting hazardous fuel reduction and vegetation management and how it may benefit buyers of wildfire insurance for at least the past four years.

The Nature Conservancy is a science-based conservation organization dedicated to protecting the lands and waters essential for all life. The TNC Forest Strategy team collaborates with the U.S. Forest Service and various public and private partners to enhance the resilience of Sierra Nevada ecosystems against increasingly severe wildfires. In 2021, WTW and TNC released the whitepaper "Wildfire Resilience Insurance: Quantifying the Risk Reduction of Ecological Forestry with Insurance"[1]. In this paper, we showed that considerable insurance savings should be achieved when hazard fuel reduction projects are implemented. We also demonstrated that wildfire risk models used by insurers for underwriting and pricing can account for the risk reduction benefit of landscape scale hazardous fuel reductions, with modelled reductions in average annual losses of between 20% and 40%.

In a groundbreaking effort, TNC has partnered with the Tahoe Donner Association, WTW, and Dave Jones, the Director of the Climate Risk Initiative at UC Berkeley's Center for Law, Energy and the Environment and former California Insurance Commissioner. Together, they have introduced an innovative insurance product that considers the wildfire risk reduction benefits of large-scale hazardous fuel reduction, including mechanical and hand thinning, beneficial fire, fuel breaks, and other vegetation management to reduce fuels. This is a first-time proof-of-concept, demonstrating that an insurance product can quantitatively capture the risk reduction benefits delivered by mitigation measures.

Consistent with TNC's broader purpose, and to demonstrate the value of hazardous fuel reduction projects for insurance product implementation, TNC has funded the premium for the wildfire resilience insurance product for one year for Tahoe Donner Association. This insurance makes funds available for post-fire rehabilitation costs for burned areas owned by Tahoe Donner Association, but as it is a parametric product Tahoe Donner Association is able to use the insurance proceeds as it determines.

The pilot program has validated the concept of fuel reduction leading to adjusted insurance terms and hopes to encourage greater investment in large-scale hazardous fuel reduction projects. It also aims to enhance the insurance industry's understanding of the quantifiable risk reduction benefits these projects offer, encouraging them to factor in these benefits when pricing and underwriting both new and existing insurance products.

Tahoe Donner Association

Tahoe Donner is one of America's largest homeowner's associations, with nearly 6,500 properties and 25,000 members enjoying over 7,300 acres in the Sierra Nevada mountains. Tahoe Donner is an eclectic community with a passion for outdoor recreation and a celebration of the "Tahoe lifestyle". Located 25 minutes from Lake Tahoe in Truckee, California, Tahoe Donner operates a wide variety of recreational facilities – some of which are for members only and others which are also open to the general public. Tahoe Donner is a vibrant and desirable mountain community providing attractive and well-maintained facilities, events, programs and leading customer service to its members, guests and public, all while maintaining accessible and healthy natural surroundings.

[1] https://www.scienceforconservation.org/products/wildfire-resilience-insurance

Tahoe Donner Association have protected themselves against the costs occurring after a wildfire (i.e., post-fire rehabilitation costs) which can be thousands of dollars per acre burned.

In this document, we present the effects of fuel reduction on wildfire risk, Tahoe Donner fuel reduction work, historical fires that have affected Tahoe Donner in the context of fuel reduction, and how Tahoe Donner's fuel reduction work allow for reductions to insurance premiums.

Section 3 : Effects of hazardous fuel reduction on wildfire risk

Hazardous fuel reduction projects (i.e., projects that include mechanical thinning, hand thinning, prescribed burns, fuel break establishment) can help lower the risk of wildfires in communities and make forests more resilient. By removing fuels, these methods can slow the spread of fire, reduce its severity, and improve access for firefighters to contain and manage fires effectively. Firefighters often rely on treated areas with reduced fuel loads, particularly when these areas are situated on ridges or near roads, to help manage wildfires.

Two of the main wildfire managers in California, the Department of Forestry and Fire Protection (Cal Fire) and the U.S. Forest Service, acknowledge the importance of fuel reduction projects. They are committed to treating one million acres annually by 2025 in *California's Wildfire and Forest Resilience Action Plan.* The State of California alone has appropriated $3.6 billion for hazardous fuel reduction. The United States Congress, with bi-partisan support, has appropriated over $5 billion for fire risk reduction management of federal lands, a significant share of which will be spent in national forests in California, and local governments and major private property owners are collectively spending hundreds of millions annually on fuel reduction.

Quotes from both organisations on the effectiveness of fuel reduction projects are below:

- Cal Fire: "Almost every day, Cal Fire, our partners, and our grantees are conducting hazards fuels reduction work through prescribed fire, manual and mechanical treatments. These efforts result in modified vegetation that change fire behavior, reduce impacts to ecosystems, and promote community resilience."

- U.S. Forest Service: "In many situations, treatments that reduce hazardous fuels make it easier to manage and contain wildfire and improve long-term forest health. By keeping fuel loads low, future fires burn at lower intensities."

The reduction in wildfire risk after fuel reduction projects can be understood through both observations of historical fires and representations in models. We present the evidence for reduction in wildfire risk from both observations and models. These pieces of evidence are later used to support the reductions to insurance premiums that have been achieved for the Tahoe Donner Association.

Observed effects of hazardous fuel reduction on fires

In the following section, we present the observed effects of hazardous fuel reduction on recent fires in California.

Caldor Fire (2021)

The Caldor (2021) fire burned over 220,000 acres (89,000 ha) to the south of Lake Tahoe. The fire has been described as a "devastating blaze" that "impacted communities across the landscape"[1]. The Caldor fire was extremely large, but there is at least one location where hazardous fuel reduction projects allowed sufficient fire suppression to control the fire's spread, saving 600 homes (see Figure 3-1 for the

[1] https://www.fs.usda.gov/about-agency/features/caldor-fire-defending-lake-tahoe-basin

fire perimeter compared to fuel reduction areas). Specifically, mechanical thinning and prescribed burns meant that flame lengths from the fire reduced from more than 100 ft to 20 ft, which allowed aggressive fire suppression to be effective. Therefore, the Caldor Fire was smaller and less damaging than it might have otherwise been because of fuel reduction work.

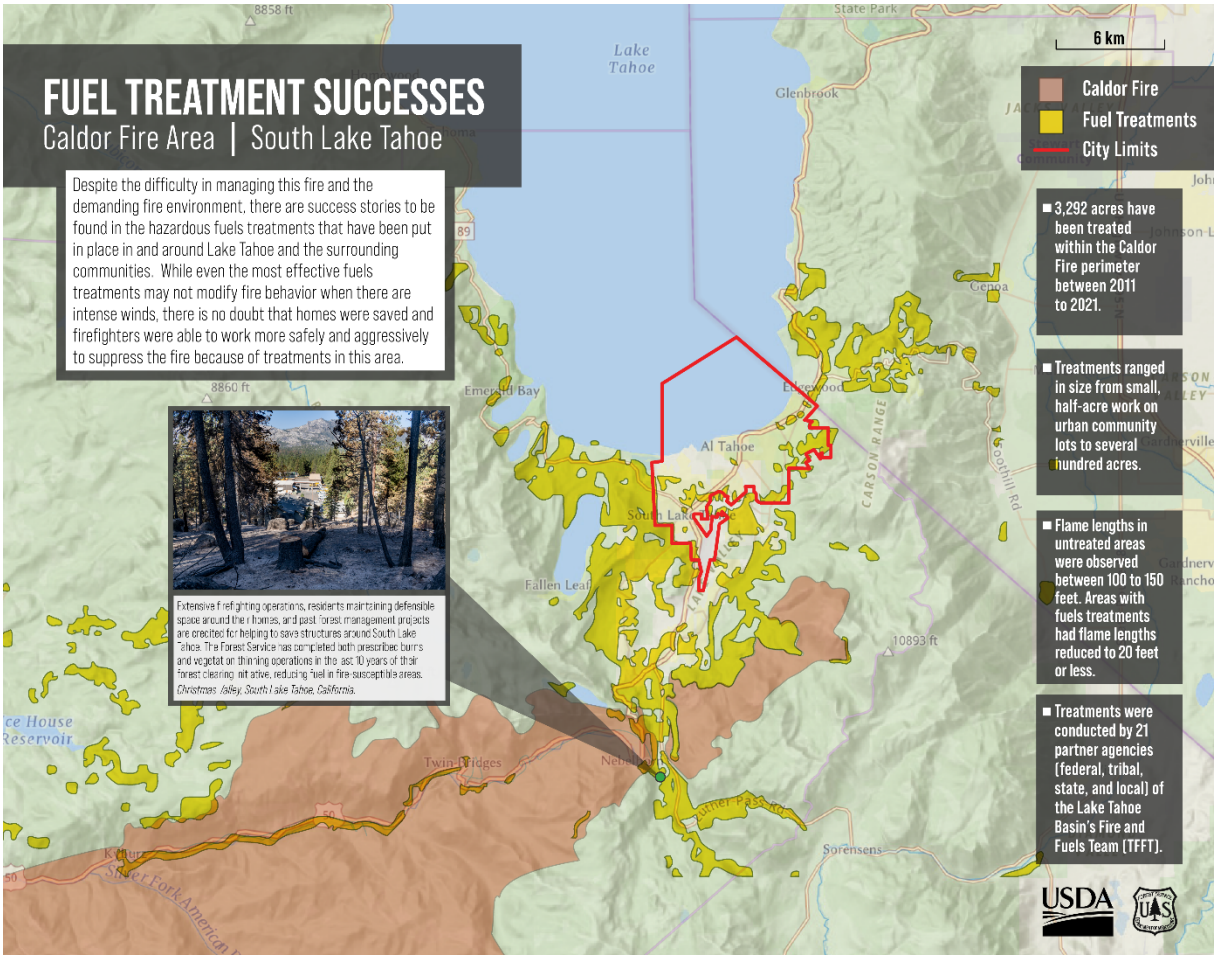


Figure 3-1 The Caldor (2021) fire burned area (red region) compared to the hazardous fuel reduction locations (yellow region) near South Lake Tahoe.

Dixie Fire (2021)

The Dixie (2021) fire is California's largest wildfire, encompassing over 960,000 acres (389,000 ha). To quantify the effect of fuel reduction on burn severity, the burn severity across 171 plots in 12 locations that burned during the Dixie (2021) fire were compared to the amount of pre-fire fuel reduction treatment that had been completed[1]. The areas that had been mechanically thinned (i.e., removing trees in overcrowded regions) and where prescribed burning had been applied (i.e., removing surface fuel using low severity fire) had much lower basal area mortality and scorched canopy than those areas that were untreated. This indicates that hazardous fuel reduction work can lead to an observable reduction in fire severity.

[1] Shive, K.L., Coppoletta, M., Wayman, R.B., Paulson, A.K., Wilson, K.N., Abatzaglou, J.T., Saberi, S.J., Estes, B. and Safford, H.D., 2024. Thinning with follow-up burning treatments have increased effectiveness at reducing severity in California's largest wildfire. Forest Ecology and Management, 572.

Summary of observed effects

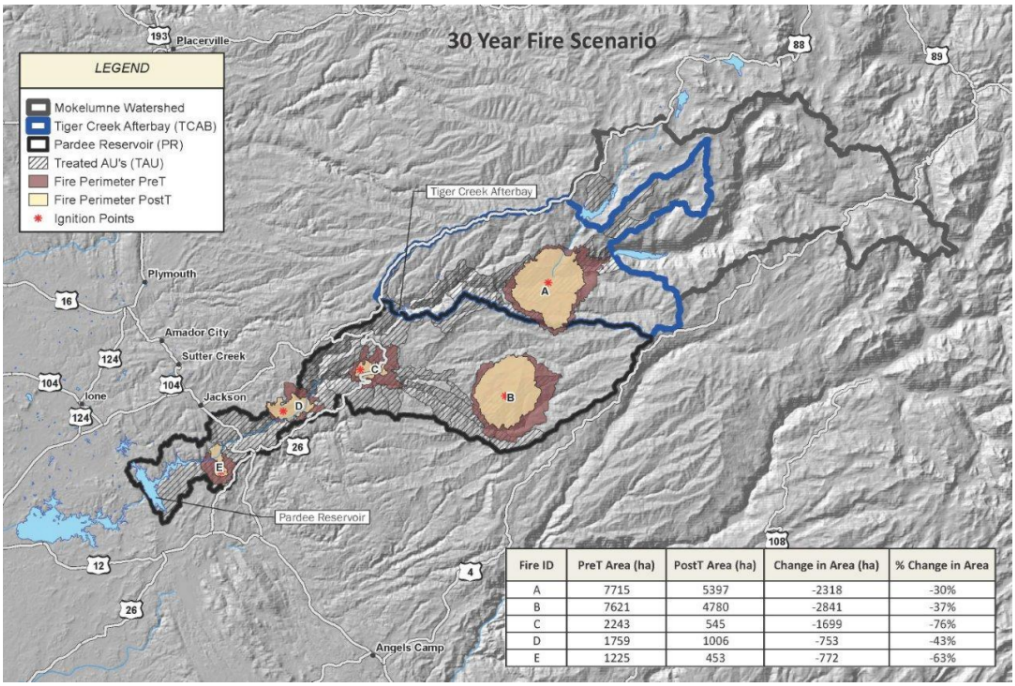
In observations of the Caldor (2021) and Dixie (2021) fires, areas with prescribed burning and mechanical thinning had lower burn severity than areas with no fuel reduction. In the case of the Caldor (2021) fire, this reduction in burn severity allowed fire suppression that reduced the burned area and saved at least 600 homes.

Effects of hazardous fuel reduction on wildfire risk in modelling studies

In the following section, we present the effects of hazardous fuel reduction on wildfire risk from modelling studies. These models were produced for specifically California case studies in the Central and Northern Sierra Nevada.

Wildfire modelling in the Mokelumne Watershed

In a report produced for the Mokelumne watershed in the Central Sierra Nevada, wildfire models show a decrease in total burned area after hazardous fuel reduction. In the report, 5 fires were modelled that could occur over "the next 30 years" at the time of modelling (i.e., 2013–2043)[1] (Figure 3-2). Two scenarios were compared: one *without* fuel reduction and one *with* fuel reduction. Using the same ignition points, the simulated fires were 30–76% smaller with fuel reduction than without fuel reduction. Therefore, the fire behaviour model provides justification that hazardous fuel reduction could be effective at reducing fires size even in a much warmer future climate.



Fire ID	PreT Area (ha)	PostT Area (ha)	Change in Area (ha)	% Change in Area
A	7715	5397	-2318	-30%
B	7621	4780	-2841	-37%
C	2243	545	-1699	-76%
D	1759	1006	-753	-43%
E	1225	453	-772	-63%

Figure 3-2 30-year (2013-2043) scenario and the corresponding five fires.

[1] Buckley, M., N. Beck, P. Bowden, M. E. Miller, B. Hill, C. Luce, W. J. Elliot, N. Enstice, K. Podolak, E. Winford, S. L. Smith, M. Bokach, M. Reichert, D. Edelson, and J. Gaither. 2014. "Mokelumne watershed avoided cost analysis: Why Sierra fuel treatments make economic sense." A report prepared for the Sierra Nevada Conservancy, The Nature Conservancy, and U.S. Department of Agriculture, Forest Service. Sierra Nevada Conservancy. Auburn, California. Online: http://www.sierranevadaconservancy.ca.gov/mokelumne.

Fire Behavior Modelling in the Northern Sierra Nevada

In a separate report, the effects of forest thinning and prescribed fire in the French Meadows landscape-scale fuel reduction project in the Northern Sierra Nevada were modelled. It was shown that fire intensity considerably reduces when hazardous fuel reduction work is completed. When simulating forest fires across a region without fuel reduction and with fuel reduction (mechanical thinning and prescribed burns), the flame lengths associated with those fires considerably decrease (Figure 3-3)[1]. Typically, flame lengths less than 4 feet are easier to suppress because they can be extinguished with direct attacks from firefighters. Therefore, the combination of decreased fire intensity can lead to better outcomes from fire suppression efforts and produce forest stands that are more resilient to wildfire.

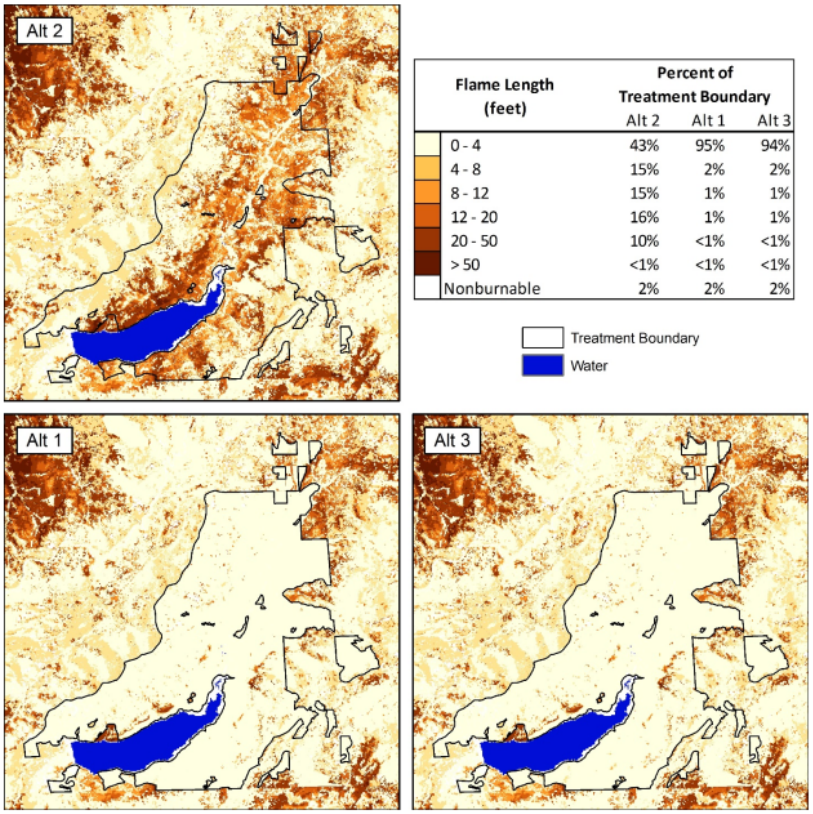


Figure 3-3 Flame length classes within the treatment boundary (black outline region). Alt 2 = no treatment, Alt 1 = Forest management, Alt 3 = Forest management. The difference between Alt 1 and Alt 3 is the amount of mechanical thinning compared to hand thinning

WTW/TNC Whitepaper

In the WTW/TNC whitepaper *Wildfire Resilience Insurance: Quantifying the Risk Reduction of Ecological Forestry with Insurance*, we concluded that hazardous fuel reduction can lead to considerable reduction in wildfire size and severity which should lead to savings on insurance premiums[2]. From observations and modelling studies of the effects of fuel reduction on wildfire size and severity, we concluded that sensible assumptions for reductions in wildfire area after fuel reduction would be:

[1] Smith, E. 2018. Tahoe National Forest, American River Ranger District French Meadows Project. Fire & Fuels Specialist Report. Sacramento, California, The Nature Conservancy.
[2] Martinez, N., Young, S., Carroll, D., Williams, D., Pollard, J., Christopher M., Carus, F., Jones, D., Heard, S., Franklin, B., Smith, E., Porter, D., 2021. Wildfire Resilience Insurance: Quantifying the Risk Reduction of Ecological Forestry with Insurance.

- total burned area may reduce by 40% and,
- the area of high severity burn may reduce by 75%.

These values were chosen after considering modelling of wildfires across California with and without hazardous fuel reduction.

The WTW/TNC paper found that landscape scale fuel reduction reduced modelled average annual insurance losses by about 40%. Depending on the insurance structure applied, this resulted in insurance premium savings 6-36% for parametric insurance. Through a separate modelling analysis in the same report, it was found that insurance premium savings of 41–52% could be achieved for indemnity homeowner insurance.

Moody's RMS and American Forest Foundation modelling

A joint report by Moody's RMS and the American Forest Foundation, showed that 21–59% of annual average losses to infrastructure due to fires could be avoided if fuel reduction projects were implemented in Grass Valley, in the Northern Sierra Nevada[1]. These reductions in annual average losses were in part due to assumptions of reduced fire size, reduced ember intensity, and increased likelihood of effective fire suppression. As such, substantial risk reduction to infrastructure was quantified through this modelling, which broadly agreed with the WTW/TNC whitepaper.

[1] Williams, M., Dyszynksi, J., Quantifying Avoided Losses to Hard Infrastructure from Hazardous Fuels Reduction: Supporting a business case for landscape-scale fire risk mitigation.

Section 4 : Tahoe Donner Association hazardous fuel reduction and historic fires

Fuels reduction work completed by Tahoe Donner Association

The Tahoe Donner Association, one of the largest homeowner associations in the United States, has an ongoing program for hazardous fuel reduction to reduce the risk of wildfires impacting the community and its recreational assets. The fuel reduction work completed by the Tahoe Donner Association has been extensive over at least the past 40 years. We show the work completed between 2020–2024 (Figure 4-1) and 2015–2020 (Figure 4-2) as this is most relevant to the current wildfire risk. In total, 1520 acres have been treated across the entire Tahoe Donner Association region since 2015. Most the fuel reduction work has been mastication, thinning and limbing.

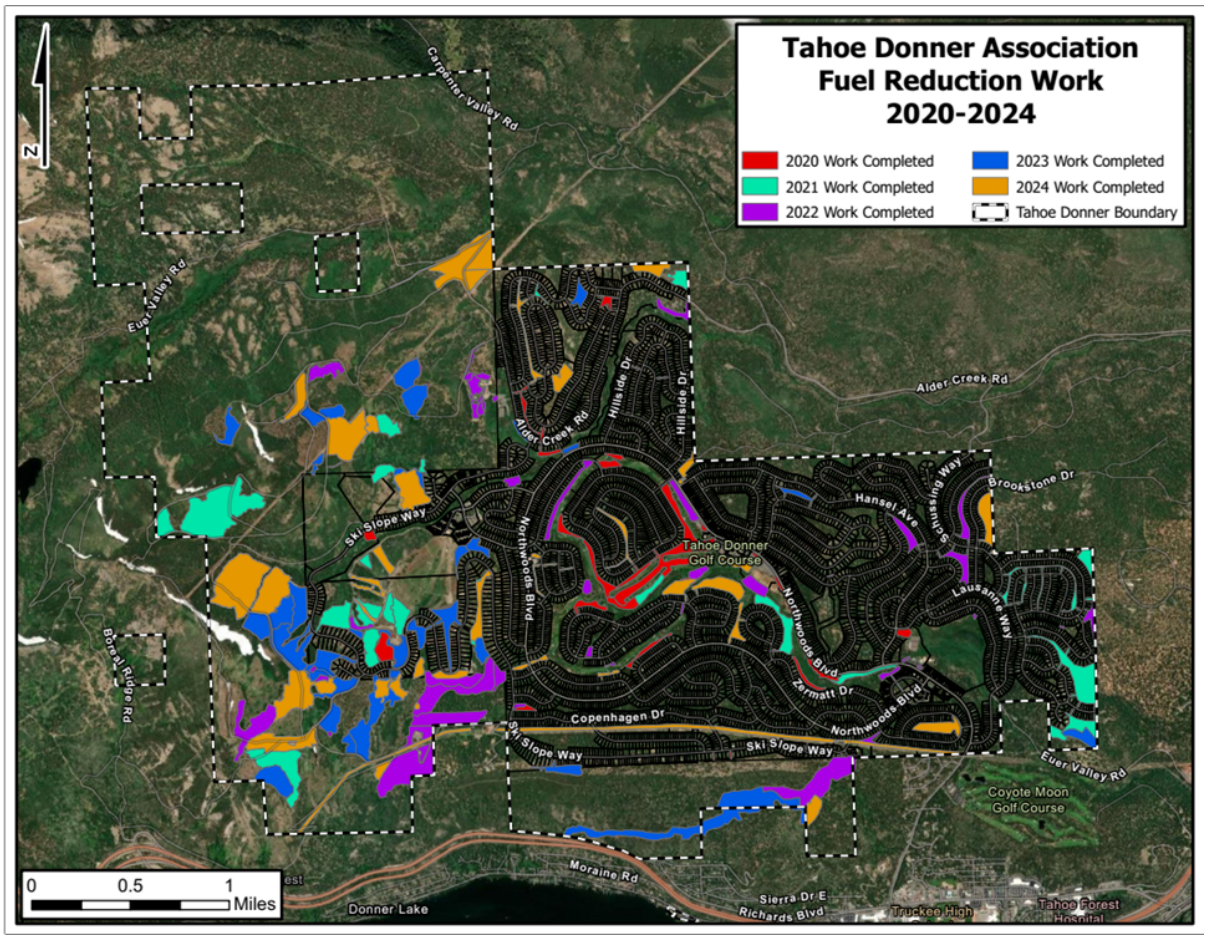


Figure 4-1 Hazardous fuel reduction work completed by Tahoe Donner Association since 2020.

How hazardous fuel reduction has reduced wildfire risk for the Tahoe Donner Association

Next, we show how fuel reduction relates to the wildfire risk specifically for the Tahoe Donner Association. The overall concept is that forest fire intensity reduces when the fire spreads to forests that have been thinned, which leads to more successful fire suppression. This has meant that more recent

fires are smaller than historic fires. We assert in this report that at least 3 forest fires that could have severely impacted the Tahoe Donner Association did not significantly affect their forested land (and residential buildings) because of fuel reduction projects that allowed successful fire suppression.

Tahoe Donner Association ("Tahoe Donner") is in northern California, north-east of Donner Lake and north of the I-80 highway. The highway is a main source of fires due to human activity. For example, the Donner (2003) fire is thought to have started as the result of an abandoned illegal campfire near the I-80 highway[1]. The prevailing wind is south-westerly, meaning that fires spread towards the north-east of their ignition point. The Tahoe Donner Association is located north-east and up-hill from the I-80 highway. There is a 250-m elevation increase over an approximate 700-m distance, leading up to a narrow ridge (Figure 4-3). The community is then located northwards and downslope of this ridge. This downwards slope is shallower than the upwards slope, with an elevation decrease of approximately 100-m over a 700-m distance. The hazardous fuel reduction has been completed at the peak of the ridge and to the area northwards and downslope.

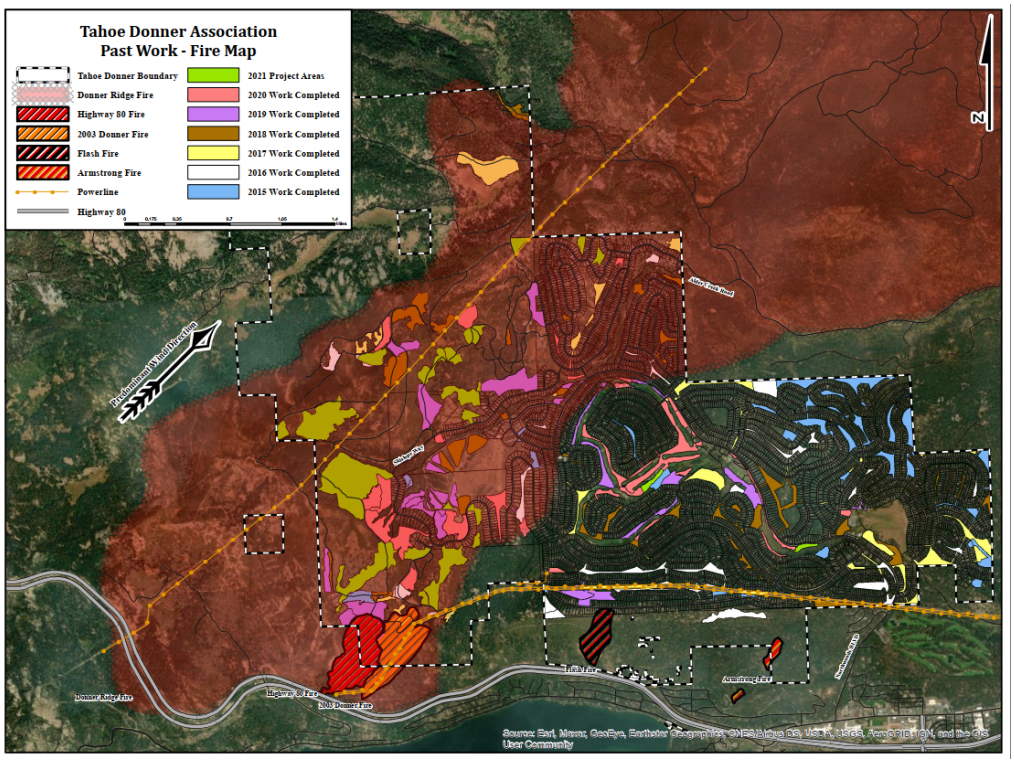


Figure 4-2 Historic fires affecting Tahoe Donner and hazardous fuel reduction work between 2015–2020. Red shaded region = Donner Ridge (1960). Please refer to the key to identify other historic fires.

[1] https://www.sierrasun.com/news/close-call-100-acre-fire-suppressed-before-reaching-tahoe-donner-subdivision/

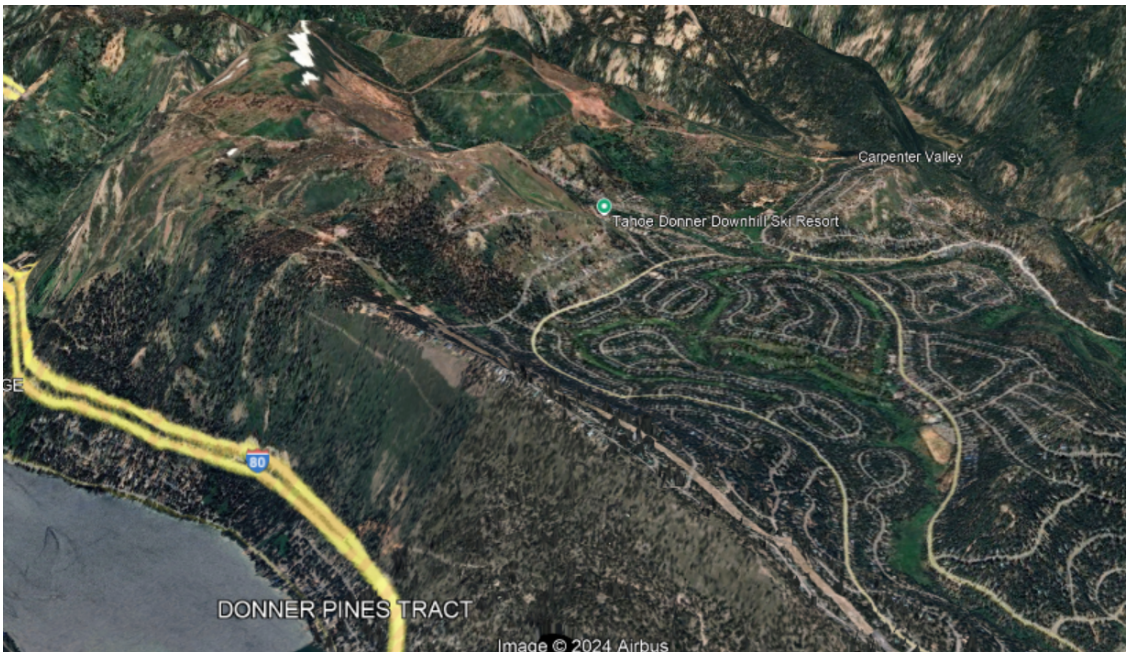


Figure 4-3 The I-80 is shown to the left of the image, and then a steep forested incline leads up to a ridge. North of this incline is a downward slope, leading to the Tahoe Donner Association community (looking north-westwards).

This means that fires typically start on the road, spread north-eastwards and uphill through trees, before reaching the relatively flat terrain. This pattern can be seen for the Donner Ridge (1960) fire, and more recent Eighty (2007) and Donner (2003) fires (Figure 4-2, Figure 4-4).

Figure 4-4 The Eighty (2007) fire (left), Donner (2003) fire (middle) and Flash (1978) fire (right), on a 3D map of the region (looking north-eastwards).

There has been a marked difference between more recent fires (Figure 4-2, Figure 4-4) and the older Donner Ridge fire (Figure 4-2). Of note, the Donner Ridge (1960) fire is the largest fire in the historical record that has affected the land currently owned and managed by the Tahoe Donner Association. However, we would suggest that the Eighty (2007), Donner Fire (2003) and Flash Fire (1979) are much more representative of the current risk.

Both the Tahoe Donner Association risk manager (who has over 30 years' experience as a professional fire fighter including leading a fire department) and the Truckee Fire Protection District confirmed that recent fires are much smaller than the Donner Ridge (1960) fire because of the hazard fuel reduction that has been consistently implemented by the Tahoe Donner Association. The more recent fires started on the I-80 and spread north-eastwards (as with the Donner Ridge (1960) fire). However, when these fires reached the top of the ridge the forests had been thinned by the Tahoe Donner Association. This reduction in fuel availability then reduced the intensity of the fire (i.e., reduced flame lengths). *Note that this behaviour was also seen in the Caldor and Dixie fires and reproduced in various modelling studies.* This reduction in flame length then allowed fire suppression efforts to successfully extinguish the fires (note that the fires were extinguished at the top of the ridge, Figure 4-4). This sentiment is echoed by firefighters, from a newspaper report[1] after the Donner (2003) fire:

"Winds out of the southwest coupled with the steep terrain in the area made controlling the fire difficult for ground crews. Firefighters on the ground cited the Tahoe Donner fuels reduction program as a major reason the fire did not burn farther into the subdivision…In an attempt to lessen the risk to homes along the ridgeline in Tahoe Donner, the Tahoe Donner forestry department thins large stands of trees near the ridgeline and attempts to clear brush away from tree trunks to prevent a ground fire from spreading quickly into the tree tops."

As such, the risk of Tahoe Donner to wildfires that originate on the I-80 has been considerably reduced, and we would suggest that there is a considerably reduced risk of a repeat of the Donner Ridge (1960) fire.

Wider area fuel reduction

Mechanical thinning and prescribed burn have been undertaken by other entities that are responsible for hazardous fuel reduction across the Tahoe Donner region (Figure 4-5). This has been completed by:

- the Tahoe Donner Association in the immediate surrounding areas of TDA land,
- Truckee Fire Protection District (TFPD),
- TFPD partners (Lahontan, Martis Camp),
- US Forest Service (Tahoe National Forest),
- Truckee Donner Land Trust.

The further work that has been undertaken should reduce the wildfire risk from fires approaching from the south and the north. In the WTW whitepaper, we considered that benefits from fuel reduction may occur over an area 3 times the size of the treated area.

[1] https://www.sierrasun.com/news/close-call-100-acre-fire-suppressed-before-reaching-tahoe-donner-subdivision/

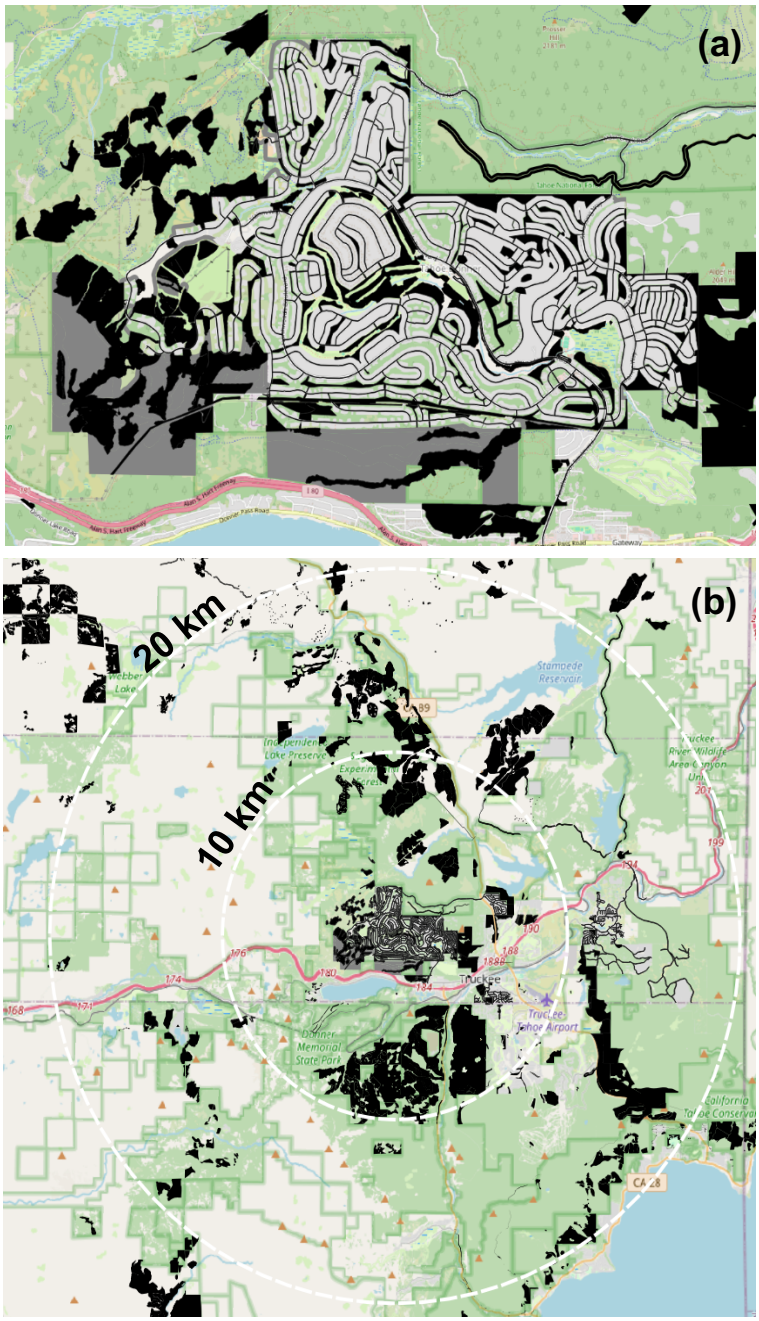


Figure 4-5 (a) Grey: Insured area. Black: Fuel reduction work completed between 2014-2023 by different organisations across the Tahoe Donner region, including the Tahoe Donner Association. Note: not all fuel reduction work across the entire region may be shown. (b) The wider region, including and inner white dashed circle = 10 km radius from the centre of the Tahoe Donner Association, and the outer white dashed circle = 20 km radius from the centre of the Tahoe Donner Association.

Section 5 : Wildfire Resilience Insurance Structure for Tahoe Donner Association

The Wildfire Resilience Insurance structure covers forested lands owned by the Tahoe Donner Association. A detailed vector polygon (which we refer to as the “shapefile”) was developed which outlines the insured areas (Figure 5-1). The total insured area is 1,346 ha and the total insured value is $4.8 million, which is split between approximately equal areas of “low” and “high” value (Table 5-1). Tahoe Donner provided the values per acre based on an estimate of costs of remediation and potential lost revenue associated with burned acreage. Low value areas comprise of forested regions in the vicinity of the Tahoe Donner Association, covering 625 ha with a prescribed value of $2500/acre, totalling $1.6 million in insured value. High value areas are comprised of trails, the ski slope and wooded areas close to Tahoe Donner housing, covering 721 ha with a prescribed value of $4500/acre, totalling $3.2 million in insured value. If anywhere in the shapefile is within a fire perimeter, then pay-out the burned area within the shapefile (in acres) multiplied by $4500/acre for high value areas and $2,500/acre for low value areas, up to the limit of the policy.

Table 5-1 The insured area, prescribed value and insured value for “low” and “high” value areas, and the total insured area for Tahoe Donner Association.

Location	Area (acres)	Value (USD/acre)	Insured value (USD)
Low value	624.9	2500	1,562,250
High value	720.6	4500	3,242,700
Total	1,345.5	n/a	4,804,950

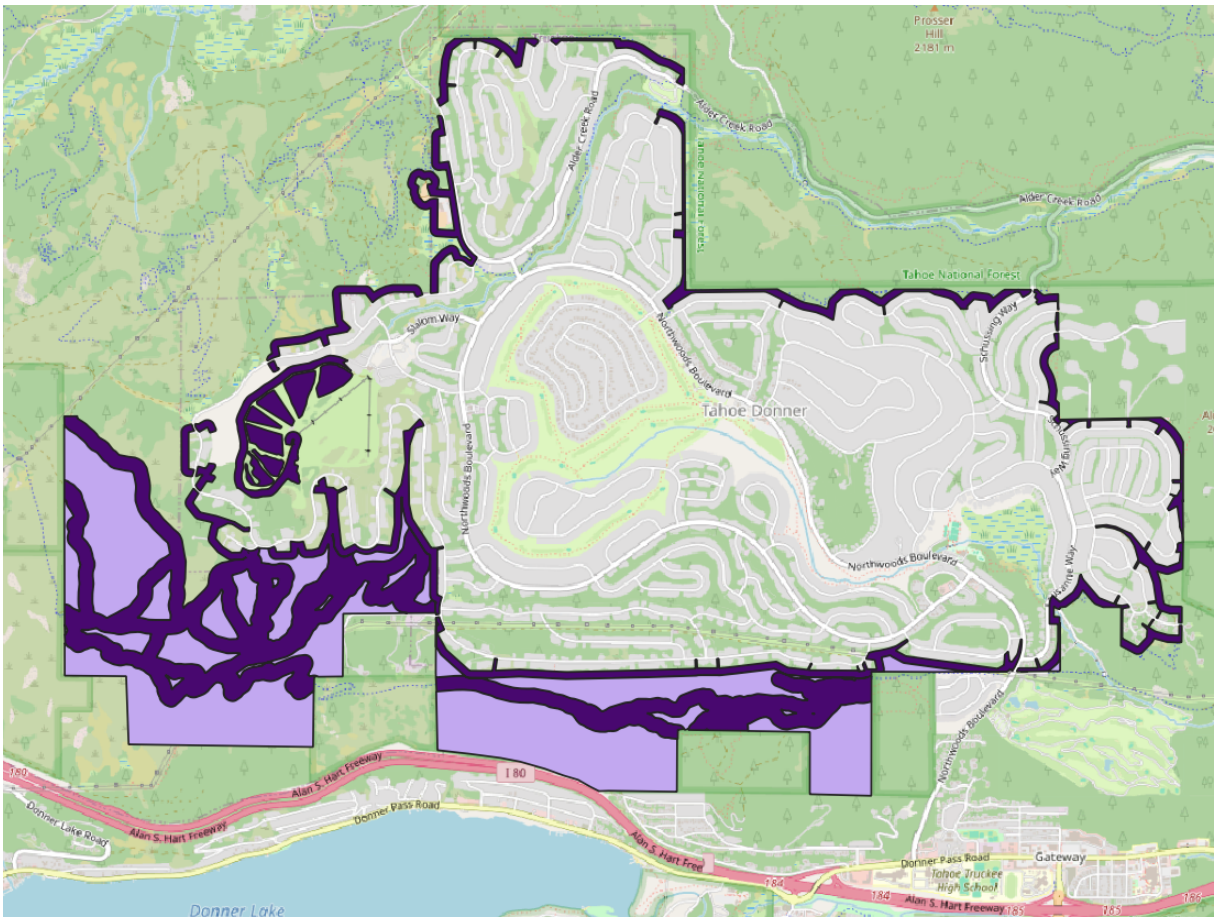


Figure 5-1 The insured forested area for Tahoe Donner Association. Light purple = $2500/acre, Dark purple = $4500/acre.

WTW have calculated the as-if losses from four historic fires that have occurred over the insured area (Table 5-2). We have used the CalFire database of fire perimeters for these calculations.

Using the insured values and area stated above, we calculate that the largest fire (Donner Ridge, 1960) would have caused ground-up losses of $2.121 million (Table 5-2). This is comprised of 249 acres of "low value" area, equating to $622,500 of losses, and 333 acres of "high value" area, equating to $1,498,500 of losses. Using the same calculation procedure three more recent fires, the Flash (1979), Donner (2003) and Eighty (2007) fires would have led to ground-up losses of between $85,000–200,000 (Table 5-2).

Table 5-2 A breakdown of as-if losses from four historic fires that have affected the insured region using the CalFire database.

Year	Fire Name	Low Value Area Burned (acres)	Low Value Insured Loss (USD)	High Value Area Burned (acres)	High Value Insured Loss (USD)	Total Insured Loss (USD)
1960	Donner Ridge	249	622,500	333	1,498,500	2,121,000
1979	Flash	21	52,500	8	36,000	88,500
2003	Donner	43	107,500	21	94,500	202,000
2007	Eighty	24	60,000	6	27,000	87,000

Section 6 : Effects of fuel reduction on wildfire resilience insurance terms

WTW has provided a worked example of reduction to insurance premiums after fuel reduction work for the Tahoe Donner Association. First, we show that the meteorological conditions between each the Donner Ridge (1960), Donner (2003) and Eighty (2007) fires were similar, and we conclude that different weather conditions did not result in the different resultant burned areas. Then, we argue that the difference in the burned area was because of fuel reduction and successful fire suppression and produce a plausible alternative to the Donner Ridge (1960) fire if it were to occur again in 2025. We then show how insurance terms could feasibly be adjusted given the lower losses when considering this alternative scenario in comparison to only using the historical as-if losses.

Comparison of historical fire conditions

WTW has collated the key features of the Donner Ridge (1960), Donner (2003) and Eighty (2007) fires (Table 6-1). The three fires ignited on the I-80, in the early afternoon and spread north-eastwards. The Donner Ridge (1960) and Eighty (2007) fires occurred in mid-late August, when the maximum temperature was 26–27°C (80–81°F), which is 6–7 °C (12–13 °F) higher than during the Donner (2003) fire in mid-October. In all three fires the prevailing wind was south-westerly, meaning that the fires spread north-eastwards. The highest wind speeds occurred during the Donner Ridge (1960) fire. These meteorological parameters are taken from a gridded simulation with coarse 25-km horizontal grid spacing (ERA5). As such, these wind speeds should only be compared relative to one another, because the actual wind speeds during the fires could have been much greater. Indeed, one report of the Donner Ridge (1960) fire states that a westerly 70-mph gust started the spread of the fire[1]. It can be argued that the slightly higher wind speeds (+10–25%) during the Donner Ridge (1960) fire would have contributed to a faster spreading and harder to contain fire than either the Donner (2003) and Eighty (2007) fires. Nevertheless, we consider that the meteorological conditions during each of the three fires were broadly consistent and cannot explain why the Donner Ridge (1960) fire was not contained for 4 days, but the Donner (2003) and Eighty (2007) fires were quickly contained.

Table 6-1 Key features of the Donner Ridge (1960), Donner (2003) and Eighty (2007) fires.

Feature	Donner Ridge (1960)	Donner (2003)	Eighty (2007)
Fire ignition location	I-80	I-80	I-80
Cause	Human, burning slash	Human, power line accident	Power line accident
Time and Date	2:30 pm, 19 Aug 1960	1:45 pm, 18 October 2003	2:00 pm, 22 Aug 2007

[1] Bock, Jane H., and Carl E. Bock. "Natural reforestation in the northern Sierra Nevada-Donner Ridge burn." In Proceedings Annual Tall Timbers Fire Ecology Conference, vol. 9, pp. 119-126. 1969.

Wind direction at ignition	SW, 235°	SW, 220°	WSW, 260°
Maximum hourly average 10-m wind speed on day of ignition	5.8 m/s (13 mph)	5.4 m/s (12 mph)	4.6 m/s (10 mph)
Maximum hourly 2-m air temperature on day of ignition	26 °C / 80 °F	20 °C / 68 °F	27 °C / 81 °F
Direction of fire spread	North-eastwards	North-eastwards	North-eastwards
Fire containment	Very little fire containment until 4 days after the fire started.	Fire was contained after encountering forest with fuel reduction.	Fire was contained after encountering forest with fuel reduction.

An Alternative Donner Ridge (1960) fire

WTW considers that the key difference between the Donner Ridge (1960) fire and the Donner (2003) and Eighty (2007) fires was that the more recent fires encountered forest that had undergone extensive fuel reduction work in the same regions as outlined in Figure 4-2, Figure 4-3 and Figure 4-5. This fuel reduction meant that the fire intensity (i.e., flame lengths) reduced, and fire suppression efforts were able to contain the fires before they spread into the region owned and managed by the Tahoe Donner Association (Figure 5-1). It is also worth noting that fire suppression techniques have grown in complexity and size since 1960 (e.g. aircraft, personnel), allowing these more recent fires to be more successfully suppressed.

There would also be similar motivations and assumed ability to suppress fires for a fire affecting the Tahoe Donner Association as the Caldor (2021) fire. In both cases there is considerable interest in suppressing the fire because of nearby residential buildings, and fuel reduction work would allow fire suppression to at least “bump” the fire away from these structures and out of Tahoe Donner’s land. As such, we draw on observations of that the Caldor (2021) fire was successfully suppressed in areas of considerable fuel reduction.

Using the fact that the Donner (2003) and Eighty (2007) fires were contained *once they encountered regions of fuel reduction*, we have produced a very simple alternative to the Donner Ridge (1960) fire that assumes that if a fire were to start again in the same location under the same weather conditions, then it would be extinguished once it encounters regions of fuel reduction. As such, we allow the alternative fire to extend from south-west to north-east, and we do not alter the original perimeter until the fire:

1) “encounters” a region of fuel reduction,

2) is between two regions of fuel reduction,

3) or is between the actual fire perimeter and a region of fuel reduction.

Shortly after one of these three conditions is fulfilled, we assume that the fire would be extinguished. Most importantly, to the north-east of the ridge, in the south-western region of the insured area, there is considerable fuel reduction, which according to our assumptions would mean that the alternative fire could be successfully extinguished. Therefore, we argue that it would be reasonable to assume that if a fire that were to be ignited in a similar location, under similar weather conditions as the Donner Ridge (1960) fire, then it could be much smaller than occurred in 1960 and burn less of the Tahoe Donner Association insured region.

There is no set distance after encountering fuel reduction that we assume fires are extinguished – re-drawing the boundary of an alternative Donner Ridge fire is largely a qualitative exercise that highlights how the fire could be suppressed, given the pattern of behaviour seen with the Donner (2003) and Eighty (2007) fires. We encourage others to consider different alternatives that seem more plausible, or to include the alternative perimeter as described in this report with a weighted probability.

This is an analysis that would certainly be improved with fire behaviour modelling and fire spread modelling, but we would expect these results *to not be unreasonable*, given Tahoe Donner's fuel reduction work. Importantly, it allows us to estimate how an alternative scenario of the Donner Ridge (1960) fire would result in lower losses under the proposed insurance structure.

By producing an alternative scenario that accounts for fuel reduction work, we estimate that a repeat of the Donner Ridge (1960) fire in current conditions would result in a total insured loss of USD 1m, rather than USD 2.1m (Table 6-2). When considered as part of the fire history, this reduction in loss leads to a 46% reduction in the annual average loss between 1960 to 2024 (Table 6-3). Although this example of the possible effect of fuel reduction did not require site specific fire behaviour modeling, the final reduction in loss to the client is surprisingly aligned with what we might expect from the observed effects of fuel reduction and fire suppression in the Caldor (2021) fire (Figure 3-1) and from simulations (Figure 3-2, Figure 3-3), and mirrors features of fires that have affected the Tahoe Donner Association in more recent history (Figure 4-4).

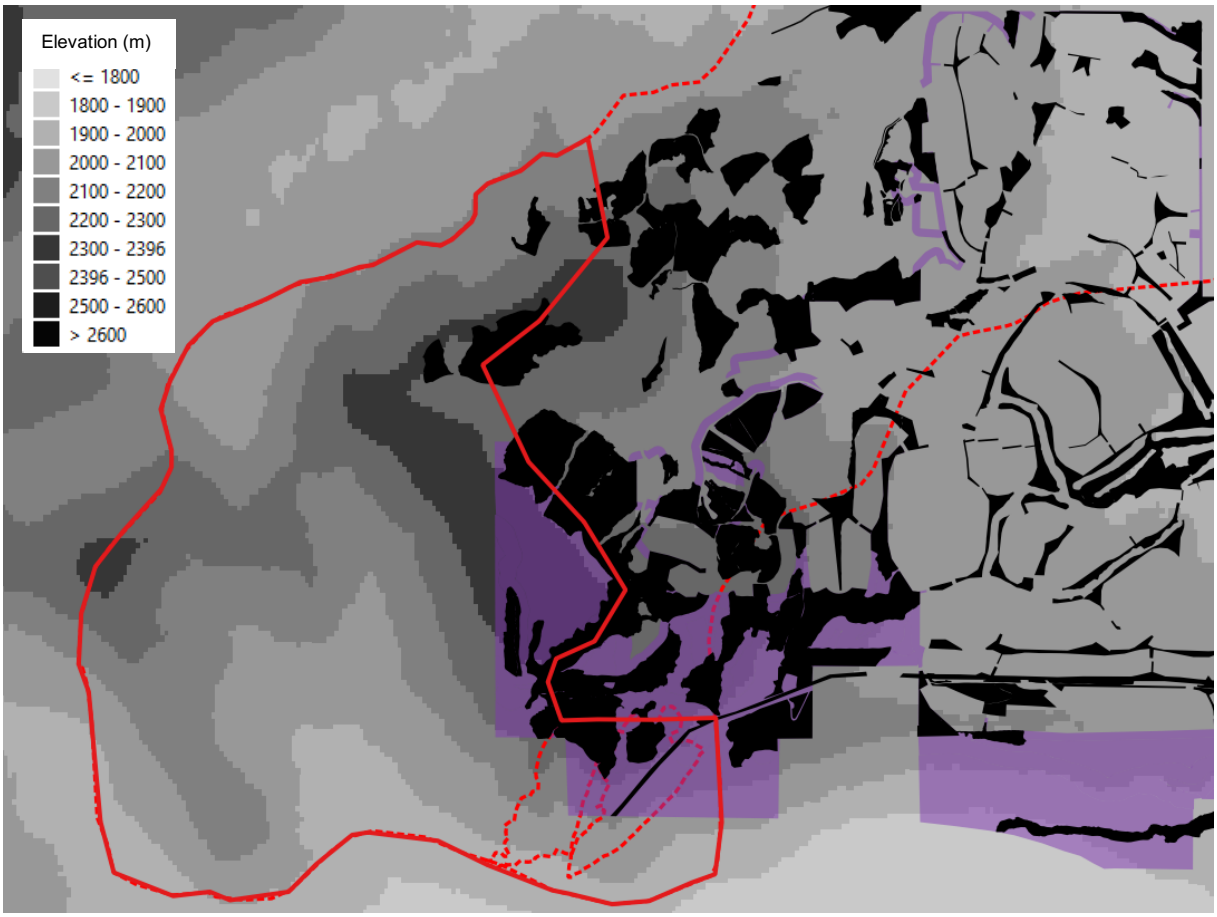


Figure 6-1 An example alternative to the Donner Ridge (1960) fire if it were to occur again after fuel reduction completed by Tahoe Donner. Solid red line = fire perimeter. Dashed red lines = actual fire perimeters. Purple = insured region. Black regions = fuel reduction, Grey = elevation.

Table 6-2 The calculation of an alternative outcome to the Donner Ridge (1960) fire with fuel reduction and more successful fire suppression.

Year	Fire Name	Low Value Area Burned (acres)	Low Value Insured Loss (USD)	High Value Area Burned (acres)	High Value Insured Loss (USD)	Total Insured Loss (USD)
1960	Donner Ridge	249	622,500	333	1,498,500	2,121,000
N/A	**Donner Ridge Alternative**	203	507,500	101	454,500	962,000

Table 6-3 The annual average loss from 1960 to 2024 with the actual historic data and alternative "fuel reduction" scenarios of fires over history.

Scenario	**Annual Average Loss (USD)**
Historic (Actual)	38,400
Fuel reduction (Alternative)	20,600 (-46%)

Reduction to insurance premium because of fuel reduction work

An example of how this information can be used when setting rates is outlined (Table 6-4). First, we calculate the annual average loss from fires that have affected Tahoe Donner since 1960 using the "actual historic" fire perimeters and with the "fuel reduction scenario" for the alternative Donner Ridge fire. To determine a limit that might be suitable, we consider that there should be sufficient pay-out for all actual historic wildfires and that wildfire insurance net rate on-line would be a minimum of ~2%. For a net premium budget of USD 50,000, this results in a maximum limit of USD 2.5m. Using USD 2.5m as a target limit, we calculate an annual average loss of USD 38,000 for the historic fires and USD 20,000 for the fuel reduction scenario. Considering a net loss ratio of 40% (equivalent to a 20–25% standard deviation loading in addition to the annual average loss), we calculate a net premium of USD 96,000 with the historic fires, and USD 52,000 with the fuel reduction scenario. This is a potential saving of 47% on the net premium for a limit of USD 2.5m. Note that we do not consider a deductible in our analysis.

Table 6-4 A breakdown of premium and limit estimates for the Tahoe Donner Association.

Parameter	**Historic (Actual)**	**Fuel reduction scenario**
Limit	USD 2.5m	USD 2.5m
Annual average loss	USD 38,400	USD 20,600 (-46%)
Target net loss ratio	40%	40%
Net premium (excl. brokerage)	USD 96,000	USD 52,000 (-46%)
Net rate-on-line (excl. brokerage)	3.8%	2.1% (-46%)

Section 7 : Placement terms and further supporting analysis

Additional analysis provided by Globe Underwriting

To give an 'as-if' insurance pricing had there been no fuel and forest management strategy in place, Globe considered the evidence provided by WTW and an independent empirical insured forest analysis. Globe Underwriting reassessed fire loss data for a portfolio of 4.2m acres of forestry assets that was collated over the last 10–20 years. Using a consistent methodology across all example forest locations for the last 20 years, the fire loss costs for the forest site(s) based on burn scar data were compared with a buffer of land surrounding the applicants' asset. The asset data is proprietary and there was no information provided on the forest management occurring on these sites. This makes Globe's analysis different than WTW in that it does not explicitly account for the difference due to fuel reduction work. However, we assume that because these are insured assets, the forest sites are likely being managed with some combination of fuel reduction, other forestry, and/or fire management. Globe Underwriting applied a loading of 60% based on a combination of the WTW analysis (Table 6-4) and their own empirical comparison of the risk reduction in areas of insured and non-insured forestry. Ultimately, the analysis by Globe Underwriting and WTW resulted in the 39% reduction in gross premium and 84% reduction in deductible.

Quote

The quote that was provided by Globe Underwriting broadly followed the terms as laid out in Table 6-4. Globe Underwriting were able to provide the following terms for the Tahoe Donner Association, as outlined in Table 7-1. Most notably, the quote listed two options: Option one with Tahoe Donner's fuel reduction activities and Option two, a theoretical premium and deductible price with no fuel reduction. The deductible reduced by 84% and the gross premium reduced by 39% with fuel reduction activities, primarily due to a reduction in the net premium offered of 37.5%. The reduction of gross premium of 39% is lower than the reduction of 46%, but mainly because the terms that do not account for fuel reduction is slightly lower than WTW calculated (Table 6-4). As such, we would consider that a premium reduction of approximately 40% has been achieved that is directly related to the reduction in risk due to fuel reduction.

Table 7-1 A breakdown of quoted gross premium, limit and deductible for the Tahoe Donner Association by Globe Underwriting.

Parameter	Not accounting for fuel reduction	Accounting for fuel reduction (Quote)
Deductible (each and every loss)	USD 62,464	USD 10,000 (-84%)
Limit	USD 2.5m	USD 2.5m

Gross premium (incl. brokerage)	USD 90,000	USD 55,000 (-39%)
Gross rate-on-line (incl. brokerage)	3.6%	2.2% (-39%)

Parametric index

The parametric index relies on the calculation of the change in Normalized Burn Ratio (dNBR) using Sentinel 2 satellite imagery. The loss is calculated based on imagery before and after a fire, with differential pay-outs for low severity burn (dNBR = 0.1–0.27) and moderate (dNBR = 0.27–0.66) and high severity burn (dNBR = 0.66+). For areas affected by low-severity burns, the payout is USD 750/acre for low-value insured areas and USD 1350/acre for high-value insured areas. This lower payout for low-severity burns makes sense, as the expectation is that post-fire rehabilitation costs for areas burned at low severity be lower.

There are benefits using satellite imagery for a parametric index. The first benefit is that the pay-out is based on objective measurements from open-source data, meaning that there is transparency in the basis of the index. Second, losses can be calculated quickly (usually in 5–14 days). Third, the benefits of satellite imagery scale very well over very large areas. For example, some very large clients may insure areas of more than 1 million acres, and suffer from fires that are up to 100,000 acres in area. In this instance, satellite imagery allows a much more rapid and consistent assessment than might be possible through traditional loss adjustment. These benefits allow satellite imagery to be particularly well suited to be used for parametric forest fire insurance.

However, no methodology is perfect, and all parametric insurance involves basis risk. In this instance, the insured area is only 1,300 acres, and there is the possibility that satellite imagery, even with 10-m × 10-m pixel sizes, may not have the necessary resolution to adequately capture smaller burned areas. Second, we are using satellite imagery in an area that broadly has quite variable topography. In this topography, satellite imagery may not as effectively profile burn severity as in flatter regions. Third, while satellite imagery captures severity soon after the fire, tree mortality may not become apparent until one or two years later, potentially altering the severity classification.

We note that a possible attractive alternative for other similarly sized clients in California would be to use burn perimeters from CalFire, the dataset that was used for much of the analysis in this report. Nonetheless, for this policy, the parametric index as outlined above, is most likely adequate to determine the burned area and losses that Tahoe Donner may suffer over the policy period.

Section 8 : Further material

The following references provide additional information on forest treatment techniques and impacts on wildfire risk.

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At WTW (NASDAQ: WTW), we provide data-driven, insight-led solutions in the areas of people, risk and capital. Leveraging the global view and local expertise of our colleagues serving 140 countries and markets, we help organizations sharpen their strategy, enhance organizational resilience, motivate their workforce and maximize performance.
Working shoulder to shoulder with our clients, we uncover opportunities for sustainable success—and provide perspective that moves you. Learn more at wtwco.com.

ABOUT TAHOE DONNER
Tahoe Donner Association is one of the largest homeowner associations in the country, spanning over 7,300 acres and 6,473 private properties in the Sierra Nevada Mountains. The community boasts more than 60 miles of trails and 5,048 acres of open space. Forest Management work began in 1992, and in 2008, Tahoe Donner introduced the first fully self-funded defensible space inspection program, inspecting more than 1,000 properties each year. The team created a free roadside chipping program, and completes thinning, pile burning, and progressive fuel break work both with a dedicated internal staff, including a registered professional forester, and using partners. Tahoe Donner is nationally regarded as a leader in this field and provides educational outreach and physical vegetation management services to enable homeowners to maintain a Firewise condition around their homes. Learn more about Tahoe Donner Land Management here**.**

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