Wildland Urban Interface Perimeter External Firewall System – *Wildfire Lithoshield*

Executive Summary:

We need more than firebreaks and vegetation clearance. For wildfire protection, we need a comprehensive external firewall system devoted to protect a community of homes, not just one property, which system may include features like a subterranean heat sink, horizontal heat flue, superior sprinkler system with robotic nozzles, automatic emergency notification, firebrand screens, windbreaks, emberbreaks and more. We call the solution a ***Wildfire Lithoshield***. Our traditional methods are no match for increased winds and heat driven by climate change. A simple 6-ft wall will only serve as a convenient lever for wind-driven wildfires to catapult the flames, heat and firebrands into the interior. Gated communities without comprehensive lithoshields offer little protection against the greatest hazards in hillside communities. Developers and architects should be held to a higher standard in areas with histories of wildfires. The threat of pyro-terrorists attacks creates a national security risk against valuable military assets, scientific resources and observatories and our overall economic stability, much like what occurred with the Twin-Tower 911 disaster.

Wildfire safety standards for California wildland urban interface (WUI) developments need to be updated. CAL-Fire wake up! A WUI perimeter wildfire lithoshield system may hopefully be on the drawing boards by urban planners today, especially when rebuilding our scorched earth neighborhoods from previous seasons. It's time to invest in our wildfire safety infrastructure. If not now, when are we going to learn? To put a damper on Diablo winds and Santa Ana winds, we can also synergistically repurpose wind turbines with strategic location patterns and by adding metallic screens and water sprays to hinder the passage of firebrands. Artificial Intelligence (AI) applications may help to accelerate the development of proposed solutions.

1) Problem Statement:

Although most urban developments in WUI areas are protected from wildfires to some degree by firebreaks in nearby wildlands and a defensible space of 100 feet or more in developed lots, as well as noncombustible barriers or walls protecting some residential lots, an external firewall structure in or near the WUI perimeter is absent from the scene. ***Here, we explore the idea of a comprehensive firewall system or lithoshield devoted to protect a community of homes, not just one property, which system may include features like a subterranean heat sink, horizontal heat flue, superior sprinkler system, automatic emergency notification, firebrand screens, and more.***

What happens when an irresistible wildfire force comes up against an Unsurmountable Lithoshield?

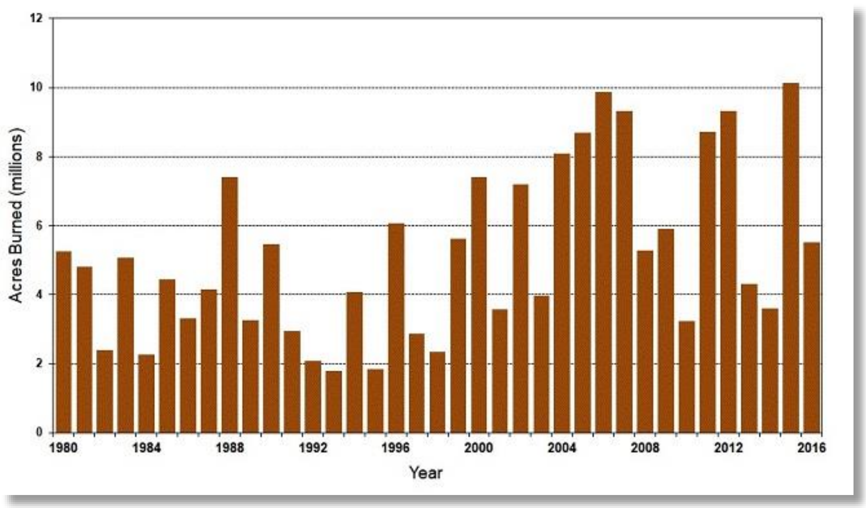
2) Research Objective:

The term 'firewall' is sometimes used to describe a firebreak in the wildlands. Now, we beg the question of whether an actual firewall structure or lithoshield offers added safety beyond that provided by an area simply cleared of vegetation. Does a firebreak adorned by a lithoshield offer more protection than the firebreak by itself? If so, what specific dimensions, designs, features and enhancements may be critical to improving the potential fire protection promised? By reducing risks, will insurance rates be reduced? By reducing risks, will the costs spent on firefighting and ecological losses also be reduced, not to mention the horrible loss of lives, as well.

A new climate change assessment for California published in late August, 2018 says that *the average area burned by wildfires will increase 77 percent by 2100, and the frequency of extreme wildfires—those that burn more than 25,000 acres—will increase by nearly 50 percent under a scenario with high global greenhouse gas emissions*. No relief in climate extremes anticipated in the near future.

Nationwide, between 1980 and 2016 the numbers of acres burned per year has nearly doubled. In 2017, there were 71,499 wildfires, compared to 65,575 wildfires in the same period in 2016, according to the National Interagency Fire Center. About 10 million acres were burned in the 2017 period, compared with 5.4 million in 2016. 2017 acres burned were higher than the 10-year average.

Number of Acres Burned in Wildfires, 1980–2016



Source: National Interagency Fire Center.

The trend of increasing acres burned nationally over the recent decades is also predicted to increase much like the grim forecast for California. A study published by NRDC in 2014 indicates that "Climate change could take a serious toll on the U.S. economy by expanding by 50 percent the area that wildfires burn —and raising projected damages by tens of billions of dollars a year by 2050." Since the number of actual fires has remained generally constant in recent decades, it appears that increasing heat and wind tend to outmatch the resources and technology currently applied to suppress wildfires. In the west, the mountainous terrain surrounding desert plains tends to magnify the heat even more and create dynamic waves of sunbaked gales.

We entertain and invite the important role of organizations like the NFPA and the US Forest Service, as well as those institutions involved in fire science research or responsible for urban planning and building codes to take part in testing the technology and formulating guidelines and codes to enable the added safety measures potentially offered by a WUI perimeter wildfire lithoshield system.

3) Project Description:

Placement

Exactly where any wildfire lithoshield system should be constructed is a critical question. Due to scarce resources and the benefit of timely solutions, an efficient plan may center around strategic areas, at the perimeter of a WUI area in the wildlands, which areas are designated as high fire risk or very high fire risk. This perimeter should be a narrowly defined area that is adjacent to vulnerable developed lots, but external to the lots themselves in most cases. Where might such a wall most effectively and efficiently be placed to offer the optimal protection for the urban area behind the wall in terms of topography and geology? The right-of-way and ownership of the area is also a consideration, as well as who is going to pay for it. ***Planning for such may be required with updated standards and regional building codes for those areas designated as wildfire high risk zones.***

Outside of WUI areas, some mountain crests, valleys and plains that seasonally create violent heat and wind storms with the propensity to threaten WUI developments, or serve as radial conduits along a sometimes very lengthy route, may be targeted for more preemptive tactics that include repurposed wind turbines as well as integrated lithoshields.

Location

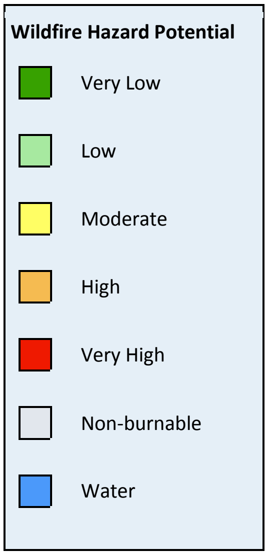
Some WUI areas may warrant more protection in different ways than others. There may also be particular developments that need protection but are not situated in locations where wall structures are practical or even feasible based on the topography or housing density, for example. A few cabins scattered in mountain resorts here and there may be very costly to protect for the amount of property at risk. A minimal threshold of developed assets density may need to be deployed in order to move the agenda. Consider some communities who may simply refuse to mar their view of the wildlands with a large concrete wall, despite the potential safety benefits.

Ecology and natural environs are the principal attraction for many people who have chosen to live in or near the mountains or other wildlands areas. Others may simply find their location to be a practical solution for employment or athletic activities. Urban sprawl and the high cost of property in premium regions, on the other hand, may force people to relocate into the boonies (*WUBoonies?*) whether they like it or not. Rising sea levels, whether actual, as in places like New Jersey, for example, or anticipated, may also be swelling the migration to higher grounds.

High Wildfire Hazard Zones

For identifying specific locations that may benefit from a comprehensive wildfire lithoshield system, and there are many, a good reference to start with is the Wildfire Hazard Potential map, developed by the U.S. Forest Service's Fire Modeling Institute to help inform assessments of wildfire risk or prioritization of fuels management needs across large landscapes, which map covers the entire United States. The map service displays those areas within the continental United States that have different levels of fire potential, categorized by five WHP classes of (very low – very high) and two non-WHP classes (non-burnable and water).

WHP Legend



Areas with higher WHP values represent fuels with a higher probability of experiencing torching, crowning, and other forms of extreme fire behavior under conducive weather conditions. According to the USFS, the data is not an explicit map of wildfire threat or risk; nor is it a forecast or outlook model for any particular season. When paired with spatial data depicting resources and assets such as communities, structures, or power lines, it can approximate relative wildfire risk to those resources and assets. It is instead intended for long-term strategic planning and fuels management.

Adaptive Infrastructure

When planning urban developments with high or very high WHP levels, the cost of building concrete wildfire lithoshield systems may be justified, if not demanded, just like the costs of water resources, water tanks, sanitation, streets, power utilities, extra fire hydrants and other fire protection resources, by the application of appropriate standards. Our infrastructure must adapt to modern threats and challenges, be they human-caused or natural, such as global warming and ecological instability. ***Are we sacrificially feeding dragons and sun gods with our precious resources, pets and very lives, in our pilgrimage to the mountain top?*** Very high WHP potentials may warrant lithoshields with greater dimensions and other features and enhancements than those in merely high or moderate WHP areas, taking the threat of torching or crowning into consideration.

Topography Placement Options

Within high fire risk WUI areas and remote areas with the propensity to threaten WUI developments, practical and strategic logistics such as topography will inform architectural and engineering placements and designs for wildfire lithoshield systems as discussed throughout this proposal. These placement options are enumerated in the following table arranged by topography which reveals the broad scope of this proposal. The ten items in this enumeration are not exclusive and will hopefully inspire additional adaptations and strategies as needed.

Table 1 Topographical Scope of Wildfire Lithoshield Placements

Topography Relevance	Purpose	Housing Proximity	Strategic Value	Practicality
1) Mountain crest in high pressure domain	Control wayward winds dynamics and protect against wildfires **preemptively**	Remote	High	Ambivalent
2) Mountain crest in high fire risk mountain wave areas	Control mountain wave wind dynamics and protect against wildfires **preemptively**	Remote	High	Ambivalent
3) Mountain - hillside crest by wind turbines	Reduce wind dynamics and protect against wildfires **preemptively**	Remote - proximate	High	High
4) Hillside crest by housing development	Protect housing against fire and heat	Proximate	High	Ambivalent
5) Hillside housing access road	Protect housing and vegetation against fire and heat	Proximate – near	Medium	High
6) Hillside roadway integration near housing	Protect housing and vegetation against fire and heat	Proximate – near	Medium	High
7) Hillside firebreak near housing	Protect housing and vegetation against fire and heat	Proximate – near	Medium	High
8) Hillside slope near housing	Protect housing and vegetation against fire and heat	Proximate – near	Medium	Low
9) Hillside base near housing	Protect housing against fire and heat	Proximate	High	Medium
10) Grassland - plains by wind turbines	Protect grasslands and rural housing **preemptively**	Proximate – remote	Medium	Medium

Wildfire Ignition Causes

According to the National Park Service, as many as 90 percent of wildland fires in the United States are caused by humans. A recent study, released in 2017 and led by Jennifer Balch of the University of Colorado, lowers the human-caused wildfires slightly down to 84 percent*:*

Table 2 Causes of Wildfires

Causes of Wildfires	Percent Human	WUI – (Est.)%	Percent Nature
Debris burning	29	29	0
Arson	21	10	0
Natural causes (lightning, lava)	0	0	16
Other human causes	13	13	0
Equipment use	11	11	0

Campfires	5	0	0
Children playing with fireworks or matches	5	5	0
Total Percent	**84**	**68***	**16**

**WUI Estimate % calculated through interpolation by this author, not Jennifer Balch*

The Fourth of July is the biggest day for wildfires, with 7,762 fires ignited on that date over the 21-year study period. Ironically, we celebrate Independence Day by threatening the same land we fought so hard to claim independently from England a couple hundred years ago.

Balch and her study co-authors looked at 1.5 million wildfires from 1992 to 2012 and found that the human-ignited fire season was three times longer than the lightning-ignited fire season and also added an average of 40,000 wildfires per year.

As a benefit of thinning the forests near WUI developments and other features of the proposed wildfire lithoshield system, we surmise that fires ignited near or in the occupied areas may have less of a chance to spread into the wildlands due to the reduction of fuel at the perimeter. By extrapolating data from the Balch study, we contend that most human-caused wildfires would fall into this space except for campfires at 5 percent and possibly a portion of deliberate arson at 21 percent.

Although a dedicated arsonist may seek remote wildlands to secretly ignite a wildfire, we know that many arsonists are witnessed in the act of suspicious behavior near or within the WUI developments, locations that are convenient in well-traveled roads and trails. Incendiaries left behind also establish forensic evidence to pinpoint ignition locations. ***If we split the arson cases in half we get about 10 percent which adds up to 68 percent for all WUI located wildfire ignitions, perhaps a bit more for cases of natural lightning and such in the WUI. That totals to roughly 68-70 percent of all wildfires that we can manage and prevent within the WUI perimeter or adjacent to it with the proper tools and standards applied.***

Fires that start in the urban developments proper, including those at the hands of arsonists, may be hindered from spreading into the wildlands if the lithoshield structure intervenes, especially when enhanced with the bi-directional Superior Sprinkler System, described below.

Potential Solution

In summary, the proposed Wildfire Lithoshield as well as carefully targeted preemptive means have the potential to:

1. Protect humans and their property against human folly and negligence in WUI areas, responsible for the greatest portion of wildfires estimated at 68-70 percent,
2. Protect the wildlands from about half of humans bearing incendiaries, the culprits of 21 percent of wildfires, as well as larger numbers of human negligence-caused wildfires estimated at 68-70 percent in total, and
3. Protect humans from occasional naturally-caused seasonal fires accounting for about 16 percent of all wildfires.

Design

The principal advantage of a traditional firewall is the control of radiant heat including flaming fuels which will be physically blocked and possibly absorbed or reflected by the structure. Depending on the type of material, a thicker wall may potentially block or absorb more heat than a thinner wall. Firebreaks also contribute to such control by removing immediate fuels and generating neutral space where such radiant heat and flames will dissipate. A firewall can also obstruct the movement of firebrands at the level of the wall, whereas firebreaks offer no barriers to any particles carried by the wind. Adding the two together in parallel will potentially double their combined protective capacity in a summative manner or possibly they may interact in such a way to produce geometric results. Since these systems border the wildlands, and may extend for hundreds of meters, it's also important to provide a bridge or porthole for wildlife to straddle or circumvent lengthy barriers. Although the proposed lithoshields may not reduce the incidence of wildfires, the potential for substantially mitigating the number of acres burned and the losses related thereto are promising.

Climatic Extremes Challenge

Extreme winds and heat especially in the Western States require adaptive infrastructure solutions. According to a new climate change assessment for California: *the average area burned by wildfires will increase 77 percent by 2100, and the frequency of extreme wildfires—those that burn more than 25,000 acres—will increase by nearly 50 percent under a scenario with high global greenhouse gas emissions*. *In the areas that have the highest fire risk, wildfire insurance is estimated to see costs rise by 18 percent by 2055.* The wildfire lithoshield system we propose is designed to guard against mountain waves and high pressure systems known as Diablo Winds and Santa Ana Winds along the Sierra Nevada, which historically drive many wildfires in California and are also addressed in the new assessment. These solutions also apply to a wide scope of topographical scenarios common to a range of ecological regions.

1. ***Heat:*** What sets this strategy apart from traditional firefighting tactics is the recognition that the vast majority of intense heat generated in a wildfire is not confined to the fire front, but is broadly distributed in large volumes of hellfire heat in vectors and wind streams widely extended in all three dimensions away from the fire front, and more so in wind-driven fires common to this climate. In many cases, dangerous heat also precedes and primes the vegetation to ignite the initial fuel source. The logistics proposed, ***for not just containing but also quenching these volatile heat vectors,*** center around key aspects of the wildfire lithoshield system, including the subterranean heat sink, horizontal heat flue, superior sprinkler system and wind turbine integration. The basic premise with regard to wildfire heat is that *containment is not enough, and should only be recognized as a final protective perimeter*. ***We need sufficient heat quenching and treated dispersal only into safe locations like subterranean heat pits, not spewing raw into the air to keep firebrands and dangerous fuels warm and cozy.***
2. ***Wind:*** In addition to a sizeable wall structure with various reflecting surfaces, strategic ***preemptive solutions*** to mitigate dangerous winds that often prime the landscape for wildfire ignition, are designed with integrated lithoshields and wind turbines on mountain crests and grassy plains.
3. ***Firebrands:*** Our focus on the hazards of firebrands includes tactics integrated with the lithoshield such as firebrand screens, water sprays and cooling the firebrand incubator as well as promoting innovatively repurposed wind turbines. We daringly extend this discussion to include possible mobile 3D heat containment tactics, as well.

The objective: 3D comprehensive solutions, above and below the ground, for the big three threats of wildfires: heat, wind and firebrands. In the interest of data sharing, let's also connect our superior sprinkler system information sensing and gathering process with Big Data systems in the Internet, from 3D to *3DC* (3D Cloud) as well as multiple robotic nozzles with remote control capabilities. Though the solutions offered have the capacity to effectively manage the challenges of known climate extremes, they can also be calibrated for more temperate climates in various regions.

Comprehensive Wildfire Lithoshield System

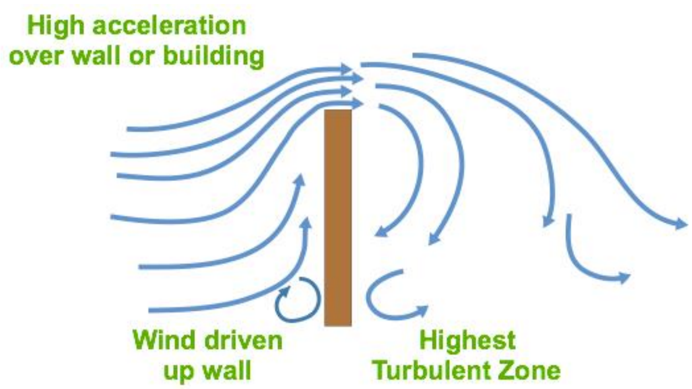
Our model of a comprehensive wildfire lithoshield system includes the following components and configurations:

1. Wall Structure,
2. Subterranean Heat Sink,
3. Horizontal Heat Flue,
4. Technological Solutions,
5. Firebrands Protection,
6. Superior Sprinkler System,
7. Flood Control & Retaining Walls,
8. Thinning & Firebreaks,
9. Wind Turbine Integration.

Lithoshield Wall Structure

Clearly, the wall would need to be fire resistant to the highest standards. The height of the wall is an important parameter that may be critical to functionality. Does a wall have to be 30 feet tall to protect against 30 foot flames? Rectitude, slant and curvature may also be strategically significant since an approaching fire usually accompanies or generates a great deal of wind and powerful plumes. For example, if the wall is intended to protect a housing development at the crest of a mountain of fuel below, should it lean towards the fuel? What if the wall and the development is at the base of the mountain. Should it lean the other way?

Standard Nonflammable Wall



A standard 6-ft. landscape wall provides a lever to catapult wind, flames and firebrands to the interior. It may help to protect against some predators, vermin, floods and bullets, but winds and wind-driven wildfires are only elevated and plummeted directly below in chaotic turbulence. As noted in ecolandscaping.org, wind also dries out soils and vegetation quickly. Additionally, wind increases plant transpiration, requiring the plant to use more water. High wind can shred plant leaves and sand particles can sandblast the entire plant. In agriculture, experts have learned to use semi-permeable vegetation screens and wind fences or windbreaks to at least mitigate the winds in a sustainable manner. Fire resistant wind fences are also available as discussed below.

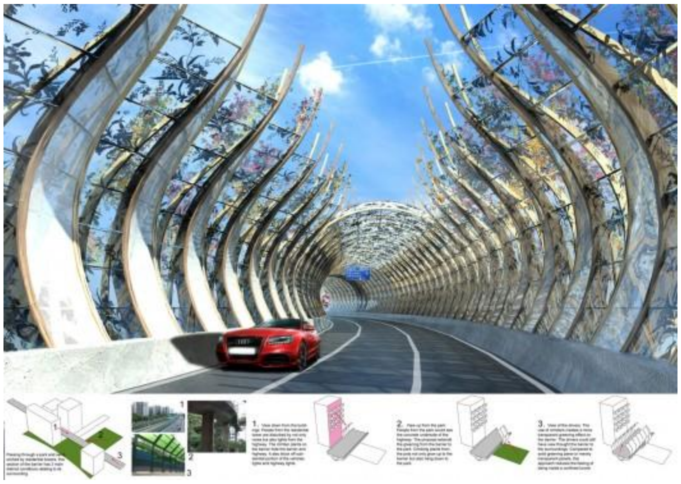
Fortress Firewall

The idea of erecting large walls for protecting cities has been around for a while, as shown in this scene of fortress walls in the ancient town of Apollonia in Bulgaria. These fortresses were built to forestall invasions by enemy invaders. Now we anticipate firewalls or lithoshields to protect against the natural landscapes surrounding our urban developments which landscapes have unwittingly been transformed into an agent for wildfires mostly caused by humans, either deliberately or accidentally. We may get some interesting design ideas from the images of fortresses in our history books, as well.

Sound Mirror

Before the inventions of radar and sonar, this behemoth was ingeniously designed as a sound mirror to detect invading aircraft off the coast of Great Britain, constructed between 1927 and 1930. The parabolic shape collected and magnified sound waves in the air over the English Channel and directed them at a microphone positioned just in front of the parabola. You can also use it as a hearing aid if you stand exactly in the right position. This 30-foot chunk of masonry might do as a super wildfire lithoshield, with a few refinements and the addition of the essential heat sink and heat flue. *Here you will see some more practical archetypes we propose, as well*.

Forest Corridor



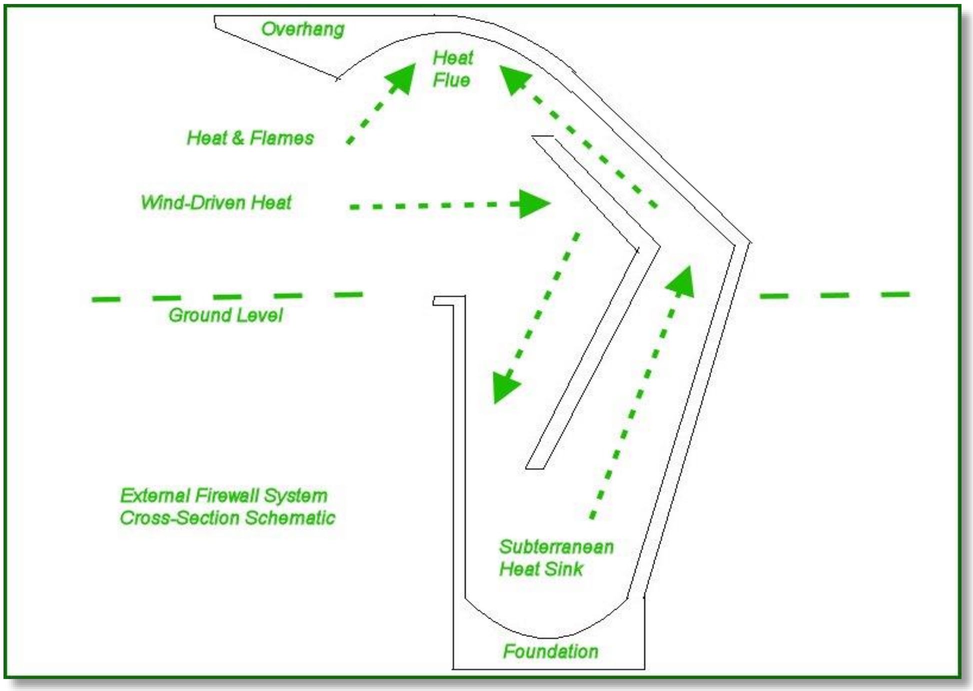
Today, we expect a little more from our public infrastructure. Instead of magnifying sound, this intriguing forest corridor serves as a sound barrier, and also generates electricity as passing vehicles wiggle adjacent panels. The pendulum system generates electricity from surrounding wind and turbulence from the passing traffic. Great design from [BREAD Studio] in Hong Kong, China.

Our proposal to integrate wildfire lithoshields with [wind turbines] can also generate some electrical juice which will help pay for construction costs.

Subterranean Heat Sink

Blocking radiant heat is one thing, but if such heat is allowed to simply roll over the structure, as with a simple nonflammable barrier, and continue to flow in the same direction with almost the same intensity, how much protection will be provided? Firewalls within a building have at least a ceiling and roof or additional stories above them to seal off the flames and heat to some extent and contain them within the structure on one side of the wall. Not so with simple nonflammable barriers or walls out in the open.

Figure 1 External Firewall System Lithoshield Cross-Section Schematic



This is what sets the wildfire lithoshield system apart from essentially two-dimensional walls on a surface. Instead of simply bouncing hot air and fumes into the open air stream above, would there not be some advantage acquired by blocking their advance and reflecting them down into the earth in a subterranean heat sink where more heat and fumes can safely be absorbed below the ground, along with possibly a few firebrands?

Whereas the concrete wall structure itself is capable of absorbing some heat and reflecting other heat, the ground below is practically unlimited in heat absorbing capacity and only a couple of shovels away. The same trench needed for the foundation can simply be enlarged to afford ample space for some hot air to bounce around and cool off before it is allowed to safely flow back into the space above through filtered vents, which filters may help to capture firebrands and other debris. Possibly, the exhaust vents will be elevated in the wall structure and directed towards the wildlands, where, again the cooling air and fumes may be recycled in the same draft as they mix with warmer air straight from the fire front.

The cross-section schematic is presented only to give a very rough visual presentation of the ideas described as the subterranean heat sink and the horizontal heat flue and how they may be positioned relative to the entire structure. ***These are the guts of the system with regard to heat and fire control and disposition: digesting heat and wind and converting some to useful kinetic energy while dispersing and absorbing other streams into the cooler walls, reflectors and air spaces within the bowels of the heat sink below and vents of the heat flues above. And much of it recycled in the process, by design, and mixed with cooler air along the way until finally being filtered, twisted and belched via the superior exhaust vent.*** The heat flue draws hot air and flames through the overhang at a slight incline and at a 90 degree deflection from its entry point to the left of this schematic. Internal reflectors redirect incoming wind-driven hot air streams down into the heat sink where they will lose a few calories before bouncing around and exiting through the same heat flue.

This system is designed to protect residential properties on the right side of the wall structure as presented above, based on the orientation of the heat sink intake system. If the fire is advancing from the residential side of the wall, the main protection for the wildlands would be the Superior Sprinkler System and the coordinated thinning and firebreaks discussed below. For maximum protection in both directions two similar structures facing opposite ways could be designed to share a common subterranean heat sink with a V-shaped profile. Also, for fire fronts descending on a hillside, variations in the overhang could be made to extend it at a higher angle and longer distance. It's all a matter of simple geometry and heat dynamics, and, of course, specialized engineering skills for dealing with the details.

Extending the hood several feet ahead of the structure as an overhang will capture more heat and flames that may not have the advantage of collateral winds. Since these heat vectors will be mostly directed in an upward direction due to heat dynamics, this strategy would be critical for capturing heat and flames advancing on a hillside, for example.

Shaping the hood with an additional bend or advanced wind reflector may allow for effectively guiding approaching flames and heat either towards the heat sink or laterally along the hooded flue depending on the approaching direction and intensity of the advancing flames and wind. In general, it is likely that most wind-driven heat will be absorbed by the heat sink whereas other heat that is lofted simply by heat dynamics would be re-routed through the heat flue system.

Naturally, hot air and flames tend to soar vertically into the air while connecting with fuel sources on the ground. Here we shape the contour of the lithoshield to guide the horizontal vectors into an optimal downward path to their final resting place, in terms of their caloric content. The only energy we need is the kinetic forces already provided by the advancing wildfire. Of course, taller walls will have more capacity to tag more hot air streams and firebrands to redirect them down below.

V-Shaped Structure

Fuel driven flames advancing in a declining direction on a hillside, to the right of the above schematic drawing, can be adequately contained by the substantial back side of the wall structure, without the benefit of a heat sink, while their remaining fuel is exhausted and their residual heat dissipated vertically in the air. Because of the substantial fuel break imposed by the lithoshield structure and most likely a parallel firebreak or road, there would be very little likelihood that the declining front would be able to jump over the barrier. Even a small amount of downward wind or eddies caused by the mountain wave effect may be sufficiently neutralized. The back side of the wall will also deflect declining winds and heat above and away from the hillside for more protection.

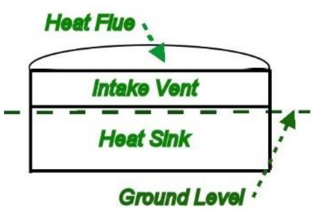
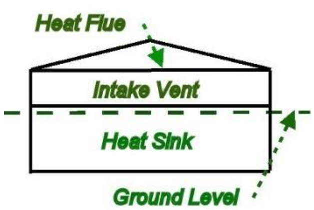
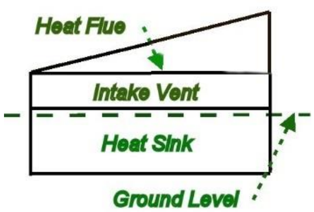
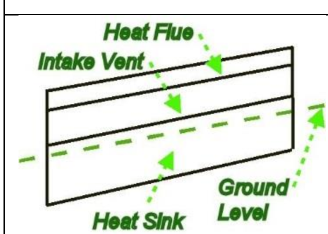
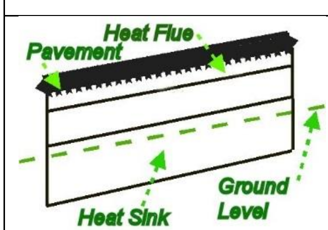
For ideal hillside installations in windy terrains, the back side of the structure could also be designed with an additional barricade several meters in height for more protection in the vertical direction. The overhanging heat flue structure on the downside left and the vertical barricade on the upside right would combine to form a **V-shaped profile** above the ground. ***Ultimately, the upside could simply mirror the downside, flues and all, and share a common heat sink. Maximum protection in all terrains.***

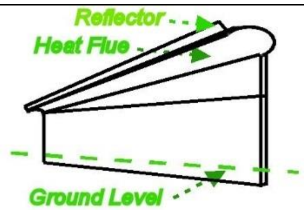
Horizontal Heat Flue

Building a lithoshield along a hillside, for example, will support a wall structure likewise inclined with an extended hood facing the advancing fire. On flat plains or mountain crests, other architectural designs can optimally guide the hot air to a path of safe dispersal. Based on topography, numerous frontal architectural profiles may be suitable including the six archetypes enumerated below:

Frontal Architectural Profiles

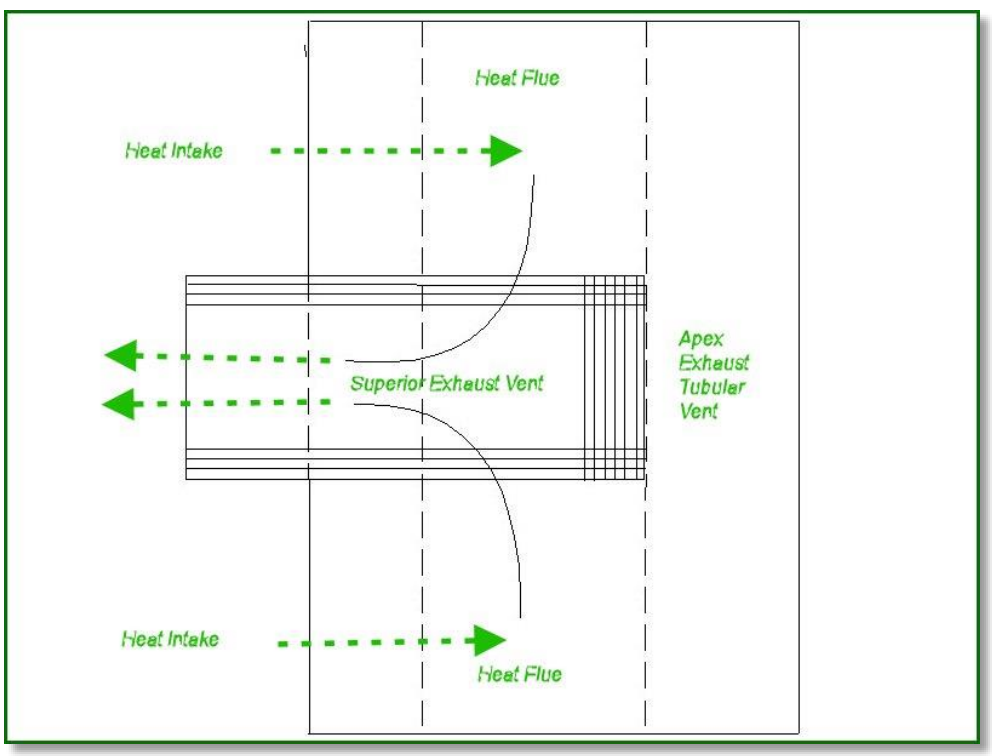
Table 3 Wildfire Lithoshields Architectural Profile Options

Architectural Profile Schematic	***Key Features***	***Description***
	• Level plane • Elliptical top • Elliptical flue	**1) *Level plane - Elliptical top*** with heat flue occupying the arched space. Foundation flat on **level plane** or nearly level. Exhaust vent at highest point of the ellipse near center.
	• Level plane • Isosceles top • Isosceles triangle flue	**2) *Level plane - Geometric top*** shaped like an **isosceles triangle** over the intake vent and foundation as the base. Foundation level on fairly **level plane.** Heat flue occupying entire triangular space. Exhaust vent at highest end of heat flue.
	• Level plane • Inclined top • Right triangle flue	**3) *Level plane - straight inclined top*** (not curved) shaped like a **right triangle** over the intake vent and foundation as the base. Foundation level on fairly **level plane.** Heat flue occupying entire triangular space. Exhaust vent at highest end of heat flue.
	• Inclined plane aligned with road • Top parallel to adjacent inclined road • Flue inclined with road	**4) *Inclined plane - roadway aligned top*** following the inclination of a roadway or firebreak on a **hillside plane** with foundation also so inclined. Exhaust vent at top end.
	• Inclined plane aligned with road • Top integrated with superior inclined road • Flue inclined with road	**5) *Inclined plane - Roadway integrated structure*** follows roadway inclination and constructs lithoshield directly below roadway to rebuild road as top layer of lithoshield. Provides opportunity to expand roadway.

	• Level plane • No heat sink • Reduced protective capacity	**6) *Barebones* – *No heat sink*** for terrains where heat sink not practical or for small individual lots. Flue base is inclined above a level wall. Exhaust vent at high point of flue. Reflector bounces more heat and flames into the heat flue.
Other options include combined segments of the profiles above for irregular topographies or to wrap around a lot on a hillside with **multiple inclinations**	for both level and inclined edges. Whenever possible in combined segments, it's best to integrate the heat flues and subterranean heat sinks for maximum	uninterrupted space in order to absorb and extinguish more heat. One ultimate heat flue exhaust vent at the highest point would be the ideal architecture, however multiple exhaust vents may be the only practical solution for some situations.

By applying the same principles of 1) inclining the heat flue ceiling, and 2) placing the heat flue exhaust vent at the highest point available, many functional variations, combinations and alternatives may be designed, as well. Wherever you can build a path or firebreak, by digging a little deeper, you can also build a super-protective lithoshield. Even without a heat sink, a lithoshield with only an ample heat flue can increase your chances of surviving an advancing wildfire to a considerable degree. A few robotic nozzles will improve your chances even more, as discussed in minimum lithoshield configuration.

Figure 2 Apex Heat Flue Exhaust Top View Schematic



Hillside Safe Heat Disposal

A convenient path of construction may be similar to an access road that gently wraps around a hillside with minimum degrees of incline. Such hillside access roads may also be suitable placements for wildfire lithoshield systems as we propose. The overhanging hood will function as a heat flue with an open bottom channeling the fire and fumes laterally for possibly several hundred feet, or even more if it is tucked beside the entire length of a hillside access road, for example. *The greater the length, the greater the volume of uninterrupted cubic space and linear surface area both in the heat flue and heat sink.*

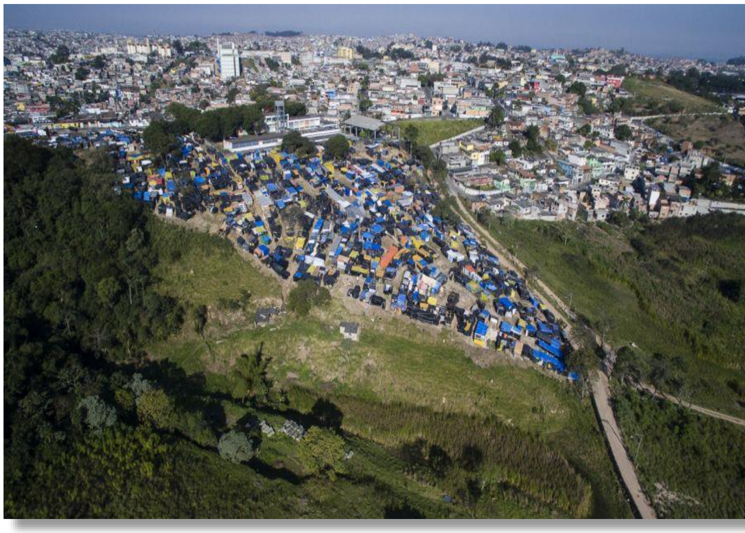
Figure 3 A swimming pool is all that remains of a hilltop home after being burned by the Delta wildfire that swept through Shasta County, Friday, Aug. 10, 2018. (AP Photo/Michael Burke) ABC30 News

By extending the heat flue system to the very top of the hillside with only one ultimate vent at the crest and above any housing or vegetation, the exhausted air will be positioned in most likely the safest space possible since vulnerable fuels will be below their trajectory. This may be seen as a virtual chimney or smoke stack which belches out heat and smoke in a safe manner. ***In some cases, where the landscape does not provide a suitable elevation for a safe lithoshield flue, a physical smoke stack can be integrated for added safety.***

Winding hillside access roads may also be integrated with wildfire lithoshields in one solid structure. *Please see Roadway Integration for more discussion on this topic.* The dynamics of rising heat will serve to trap most of the heat and flames within the hood. The extended flue along the road may capture more of the heat that would not otherwise be successfully redirected towards the subterranean heat sink and will likewise re-channel those fumes released through the heat sink exhaust vents. *Please see schematic rendering above for Apex Exhaust Vent.*

Hillside Housing

Figure 4 Shacks with tarp roofs dot the hillside of MTST's Paulo Freire Occupation on the outskirts of São Paulo. Image by The Megacity Initiative. Brazil, 2015.



Some of the roads surrounding this development and shanty town may be suitable for the proposed solution of a comprehensive wildfire lithoshield system tucked below the road. This particular site is in São Paulo, Brazil where there's a demand for affordable housing. The lithoshield system can also be constructed on any slope or plain without the convenience of a road or firebreak with which to merge, such as in the foreground of this photo. In some parts of the world, hillside housing is more affordable, in others, it comes at a premium. *Homeless squatters need protection, too!* Location, Location, Location. *Wildlands, Housing, WUBoonies, Tent Cities, Squatters, Homeless People.*

Roadway Integration

In addition to the option of building lithoshields adjacent to winding access roads, the roadway itself may be integrated with the lithoshield and extend over the top. This may be necessary in hillsides with steep cliffs, for example, which is where more intense fires are likely to occur. The added weight of the roadway may require pillars extending from the base to the overhanging hood and superior roadway. Occasionally, roadways along steep cliffs may already have supporting pillars in their foundation.

The integrated roadway-lithoshield may also accommodate an expansion of the roadway. Expanding the roadway in this manner will more readily facilitate the passage of emergency vehicles, which is often problematic in hillside emergencies. On some steep hillsides, it may be necessary to forego the heat sink integration due to the engineering challenges involved, although this omission should be avoided unless absolutely necessary. ***In those sections without a heat sink, the protection provided by the extended overhang and heat flue system, as well as the sprinkler system with properly spaced robotic nozzles, should reduce the threat of advancing fires to a significant degree.***

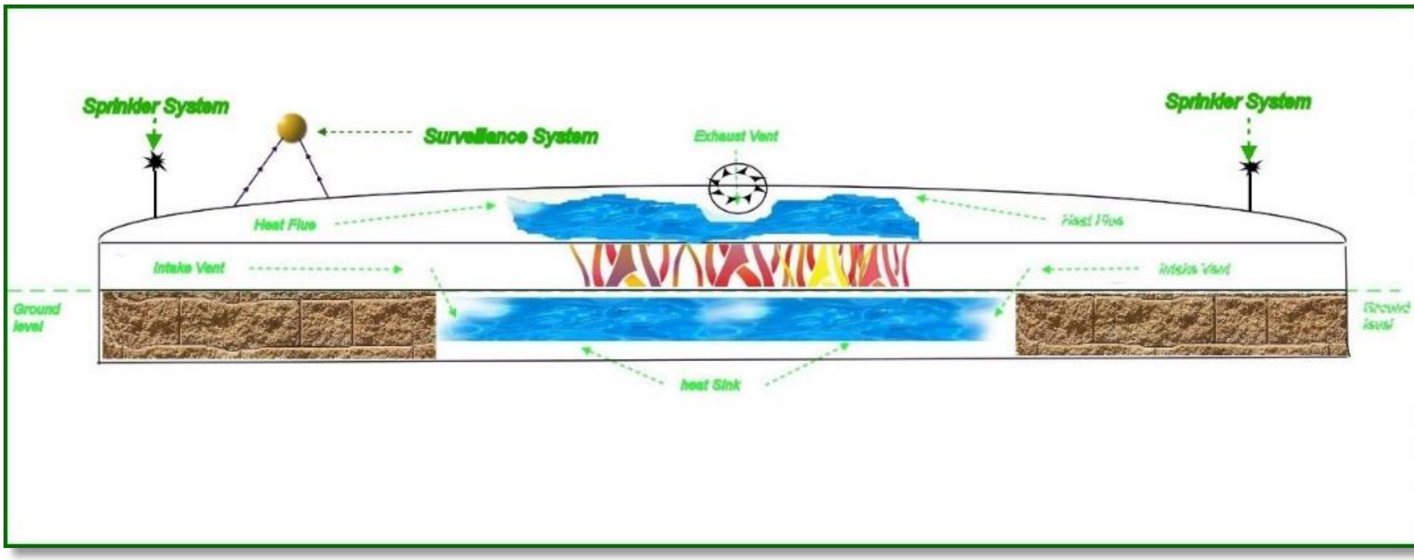
***Positioning the wall below the road will also serve to protect the road and its travelers, assuming the fire approaches from below. This may be critical for protection during an evacuation, for example*.** See Hillside Housing for an example of suitable hillside roadways.

Level Plane Structures

On a level plane, such as at the base of a hill, crest of a mountain or in a plain, the same inclined flue effect may be accomplished simply by slanting and inclining the flue profile in the shape of an isosceles triangle or right triangle in the desired direction or forming an elliptical design with an arched heat flue. In any case, at the crest of the inclined structure, the hood will be reshaped and extended outward from the wall towards the flaming front.

Mountain Crest Lithoshield

Figure 5 Front View Schematic of Mountain Crest Lithoshield – elliptical shape suitable for all level terrains



A mountain crest lithoshield on a level ridge may have an elliptically shaped top forming the heat flue as depicted in the above schematic rendering. The entire width from this perspective may range from 100 to 500 meters or more. More length and height, as well as depth in the subterranean heat sink below ground, increases the cooling capacity proportionally. The height of the lithoshield above ground may range from 5 to 10 meters. The exhaust vent at the central apex flushes out cooler air in the opposite direction of the intake vents. Components include the superior sprinkler system with multiple robotic nozzles and remote control capabilities and surveillance system with thermal imaging, RGB and heat sensors. Connectivity with HPWREN and other emergency networks are anticipated. Additionally, firebrand screens will be included in the exhaust vents and exterior positions.

This is the answer to the question of the irresistible wildfire force coming up against an unsurmountable lithoshield. *It is also a preemptive means of reducing the vacuum effect of the mountain wave that causes havoc down below and either helps to initiate new fires or supports the advance of existing fires.* ***Thus, it will be at work, shaping wind and cooling air, year round, as well as providing remote views of the landscape for all to see.***

Figure 6 New Cameras Installed on SCE Telecom Tower in Orange County to Monitor Wildfire Activity May 9, 2018

Challenge: Should our mountain crest *firecams* be used only for looking at and analyzing fires from a distance, or should we also at least have the *capability* to aid in suppressing the advance of those fires within our reach with currently available remote control technology?

If wind turbines or external equipment towers, antennae, etc., are also located on the same mountain crest or grassy plain, two lithoshields may be needed to protect the equipment from both sides. They can also be shaped to wrap around the protected instruments, leaving adequate space for access and maintenance. For protection from high pressure Diablo winds flowing through the Sierra Nevada, for example, the intake vents will be aligned to face the direction of the source. ***This design will also work well for grassy plains or to protect housing at the base of hillsides or mountains.*** On a slight incline the same model will work just as well as long as the exhaust vent is located at the highest point of the heat flue ellipse.

Figure 7 Griffith Observatory Exposed to Wildfire Causes Evacuations

A wildfire in the hills came dangerously close to the Griffith Observatory on May 10, 2007.[8] On October 15, 2017, brush fires approached the Observatory Trail, but were extinguished before causing any structural damage. [9] On July 10 2018 the Griffith Park Observatory was evacuated after a brush fire burned 25 acres and damaged cars but was extinguished before it damaged any buildings. More examples of wildfire threats and actual damages to observatories are reported in National Security Risk. Lithoshields can be installed along the surrounding roads and slopes for secure protection. As discussed above, other linear shapes are recommended for greater inclines such as alongside hillside access roads and firebreaks, as well as roadway integration. See additional architectural profiles for more information.

Technological Solutions

Integrated Heat Sink and Heat Flue

With this combined system of heat sink below and heat flue above, almost no flames and very little heat that approaches the lithoshield structure will be allowed to directly roll over the structure in the original direction, and the air that is finally flushed out of the flue system at the crest will be much cooler and directed in the opposite direction. This system will essentially decapitate the flames and separate them from hot gaseous fuels in the mix. ***Even more importantly, it will quench huge amounts of intense heat that would otherwise continue in the same direction as the fire front, as highlighted in Table 4.*** For additional frontal view archetypes of the lithoshields we envision, please see Architectural Profiles. Now let's look a little more deeply at the technological challenges of *hellfire heat*, *wayward winds* and *fluorescent firebrands* that our combined structural lithoshield has to face, and the novel strategies needed for effective solutions.

Hellfire Heat Quencher

In Charts for Interpreting Wildland Fire Behavior Characteristics, by Patricia L. Andrews and Richard C. Rothermel, of the US Forest Service Intermountain Forest and Range Experiment Station Ogden, UT 84401, this table, published in September 1982, relates the amount of heat intensity to within a range of flame lengths in wildfires.

Table 4 Fire suppression interpretations of flame length and fireline intensity

Flame Length Feet	Fire Intensity Btu's / Ft² / S	Interpretation
< 4	< 100	Fire can generally be attacked at the head or flanks by persons using hand tools. Handline should hold the fire.
4-8	100-500	Fires are too intense for direct attack on the head by persons using hand tools. Handline cannot be relied on to hold fire. Equipment such as plows, dozers, pumpers, and retardant aircraft can be effective.
8-11	500-1,000	Fires may present serious control problems-torching out, crowning, and spotting. Control efforts at the fire head will probably be ineffective.
> 11	> 1,000	Crowning, spotting, and major fire run's are probable. Control efforts at head of fire are ineffective.

This chart helps us recognize the amount of Btu's per Ft² per second that are generated in a wildfire and that we need to handle and hopefully quench with our heat sink and heat flue system as the front approaches. Each Btu that is not quenched will essentially be free to add more intensity to the molecules or gases that contain it, or such gases may mix with other streams where they will share Btu's to either warm or cool one another depending on their relative heat intensity to begin with. Like warming up a cup of coffee with a fresh serving from the pot.

Subterranean heat sinks are also used to cool some homes often by recirculating warm air from the attic down to underground tubes that are spread over a large area to maximize the square footage of contact with cooler underground earth. This model efficiently dissipates Btu's of heat from one undesirable space of air in the attic to harmless subterranean areas in the earth through the intermediary surfaces of underground tubing. Whereas the tubing above ground may be insulated, the underground tubing is designed to allow for the optimum transfer of heat through the tubing walls. Some systems combine geothermal heat and cooling capacity for both heating and cooling a home, for example.

In our model of combined heat flues above and heat sinks below, we actually dissipate some Btu's of heat directly into the air through the heat flue vents, as well. This is by design because we know that a lot of flames and heat will not passively flow into the heat sink intake system without the help of lateral winds. Fortunately, our thermal imaging sensors will detect excessive heat from the exhaust vents and automatically dose them with water to keep the heat under control. Whereas many wildland fires are accompanied and promoted by high speed winds, the direction of the winds may not always be oriented towards the intake system at the face of our heat sinks. The best we can do with these warmer streams of air is to break them up somewhat and spread them out to dissipate the heat over a larger cubic area and different direction where we can at least reduce the velocity and intensity of hot air streams advancing in the direction of the fire front. ***Any excessive heat in a 360^o scope will be detected and cooled off with multiple robotic nozzle sprays.***

To quench a thousand Btu's per Ft^2 per second *(hellfire heat)* underground is no easy matter. We know that the deeper and greater volume and internal surface square footage contained within our heat sink, the more Btu's we can quench.

Intramural Water Circulation

To prevent our heat sink from simply becoming a furnace to warm subsequent air streams, we may need to use a supplemental cooling system such as circulating water in pipes within the containing walls and interior reflectors, as well. The cooling water will come from a local reservoir or tank and be recycled in the circuit. Such a cooling system will more quickly recharge the cooling capacity of the interior surfaces. In a sense we may look at this internal cooling system as a ***firewall within a firewall***, or a ***heatwall***, more precisely, providing more control by adjusting the amount of water we circulate within this system, as needed.

Internal Chamber Sprinklers

Water can also be sprayed directly into the heat sink chamber, serving several purposes:

1) Suffocating any flames by separating and chilling their fuels in the air,
2) Consuming Btu's of heat to convert water drops into steam and vapor,
3) Kinetically pushing entering air in optimal directions,
4) Soaking firebrands to extinguish any flames and smoldering charcoal,
5) Flushing firebrand debris and other particulates down the drain,
6) Giving the exposed surfaces of the heat sink a nice cool shower and draining away any heat shared by contact,
7) Adjusting the cooling capacity by controlling the water pressure as needed.

Additional internal reflectors may be used to also increase the square footage of contact to dissipate heat. Special types of bricks or cement may also help to absorb or transfer more heat without completely decomposing or combusting. ***Of course, one of the most efficient resources is simply to increase the total horizontal length of the entire lithoshield structure to cube the entire cross-section footprint by its length.*** The Superior Sprinkler System is also designed to cool volumes of warm air that surmount the heat sink and flue structure by wide sprays of water directly above.

This strategy is innovate because, other than direct assaults on fire fronts and defensive firebreak expansions, currently no existing fire protection systems in the wildlands are designed for, or capable of, disarming immense volumes of hot air streams by dissipating, quenching or redirecting Btu's of heat in a managed fashion either into the air or into the ground below.

Of course, extinguishing flames at the front is a paramount necessity, but it only partially addresses all the vast amounts of collateral heat in the area. This may be obvious, but should be documented, nonetheless. Our existing systems are clearly effective in extinguishing flames with water and chemicals, but ***the surrounding volumes of hot air and vaporized fuels are not directly assaulted or restricted other than being dosed by some cool water sprays and vapors concentrated in small targets***. Fire retardants have also proven to be effective by blocking access to vegetation fuels at the front, but the hot air above continues to flow in the same direction and intensity until it finds more fuel ahead or eventually dissipates to a less hazardous intensity.

Defensive Controlled Burning

Figure 8 Firefighters from Sacramento Metro burn around an old cabin in Ackerson Meadow near Yosemite National Park, California on August 28, 2013. The enormous Rim Fire became the sixth-largest wildfire in recorded California history at 192,500 acres. UPI/Al Golub

Defensive firebreaks are critical to form a battlefront for containment, but here we can only draw a line in the sand with fuel-less gaps while laboriously digging out glowing hotspots, and then we dare the expanding fires to cross our line with a prayer and a curse.

Unfortunately, we often resort to fighting fire with fire with controlled burning on the battlefront, which simply exacerbates the accumulation of dangerous heat that may sometimes flow in unexpected directions. ***We need to realize that it's not only the flames that matter, it's the tremendous volume of invisible heat that spreads the threat and desiccates the moisture wherever the winds blow. Not very clever!***

Seasonal Prescribed Burning Risks

With alarming trends of increased wildfire damages, most likely related to climate change, this may be a good time to take another look at the benefits and risks of seasonal prescribed burning in our wildlands and farmlands. ***In addition to the risks of occasional accidental control failures and air quality hazards, we also need to reevaluate the very predictable costs of dumping huge volumes of CO_2 into our global greenhouse.***

Figure 9 - Buffelgrass Controlled Burn Tucson, AZ

Let's also take another look at some of the alternatives to burning that have been well documented. Climate change suggests that what may have been a safe season for burning in the past, is no longer as safe. Or the safer period may be changing to different months and fewer months, which may also need to be carefully determined with specific criteria every year. Some mistakes in planning prescribed burning are described in Prescribed Fire Lessons Learned from the USDA Forest Service in 2005, which indicates that about 1% of prescribed fires result in escapes (fire escaped beyond planned area) or near misses:

> *It is estimated that Federal land management agencies complete between 4,000 and 5,000 prescribed fires annually. Approximately ninety-nine percent of those burns were 'successful' (in that they did not report escapes or near misses). This can be viewed as an excellent record, especially given the elements of risk and uncertainty associated with prescribed fire. However, that leaves 40 to 50 events annually we should learn from. This report is intended to assist in that effort.*

In 2016, the Office of Inspector General (OIG) conducted an audit of the
Forest Service Wildland Fire Activities – Hazardous Fuels Reduction*: Our objectives were to assess FS' controls over selecting hazardous fuels reduction projects, assess the impact of Community Wildfire Protection Plans on that selection, and follow up on FS' corrective actions in response to our 2006 audit.* The findings are summarized in part here:

> *The Forest Service (FS) lacks a consistent, cross-agency process for selecting its highest priority hazardous fuels reduction projects for completion. FS units do not use scientifically-based risk assessments to select projects; they do not document the processes used for selecting projects; and the Washington Office (WO) does not review project decisions made at the regional and district level. FS' methodology for tracking accomplishments leads to inadequate data, and as a result, FS reported to Congress that it treated 3,703,848 acres for hazardous fuels reduction*

during fiscal years (FY) 2012-2014, when it actually treated 3,600,389 acres, an overstatement of 103,459 acres (2.8 percent)…

Can we live with buffelgrass in the Sonoran desert until such time we find less dangerous means of control including robotic weeders and no-till machines, although no doubt buffelgrass itself presents a wildfire fuel risk? For grassy weeds, a simple string trimmer may do the trick, preferably battery powered.

Figure 10 - Herbicide application to control buffelgrass with a backpack sprayer

Herbicide weed control products have also been used by public land managers. Care has to be taken to prevent ecological damages by any herbicide or pesticide in our wildlands. Of course, a number of species are also threatened by wildfires whether prescribed or accidental. Humans may also be at risk by exposure to many pesticides, including the popular Roundup and its active ingredient glyphosate, allegedly posing a risk of cancer. Glyphosate based herbicides have been successfully used to help control buffelgrass in Arizona since 2004, according to the National Park Service. Notice that this park worker is not wearing any mask to protect her from the chemicals strapped to her back, though she is wearing gloves and some type of eyewear. Since she seems to be using a drip method, as opposed to a spray, the hazard may be reduced. Prescribed burns and herbicide applications are both hazardous to those workers involved, as well as the community, but the cancer risks for those handling glyphosates are more insidious.

A recent Pacific Standard story titled "PRESCRIBED BURNING: FIGHTING FIRE WITH FIRE IN THE AMERICAN WEST" dated OCT 13, 2017, stated that … *only 1 percent of wildfires each year actually burn forest lands directly adjacent to areas where fuels reduction was carried out. That means that the more than $350 million spent annually on fuels reduction results in virtually no difference in the destructive capacity of wildfires:*

> *The U.S. Forest Service is responsible for more than 190 million acres of land, and fuels reduction efforts are targeted, tree-specific, and almost entirely manual. They are performed on an acre-by-acre basis, and they must be repeated every 10 years to deal with new forest growth. The result is that only a tiny fraction of forests categorized as "high-risk"—with little documentation of the logic behind that designation—sees fuels reduction. Additionally, it is impossible to predict whether t*hese patches will coincide with the location of next summer's heat waves, the primary driver of annual wildfire geography.

In Southern California, the National Park Service (NPS) does not use prescribed fire in the Santa Monica Mountains due to the natural fire regime of this ecosystem. As stated by the NPS:

> *In the last forty years fire managers have promoted the idea that prescribed fire is necessary to protect ecosystems and communities by restoring fire's natural role in the environment to thin forest stands and to reduce hazardous fuels. This is true for western forests where the natural fire regime was frequent, low intensity surface fires started by lightning, and for many other ecosystems like southern longleaf pine forests, Florida palmetto scrub, and the Great Plains tall grass prairies. However, it is not true for the shrubland dominated ecosystems of southern California and the Santa Monica Mountains. …*
>
> *Many studies have shown that repeated fires at short intervals will eliminate chaparral shrub species and can promote establishment of non-native annual weeds. On the other hand, studies of long unburned chaparral show no decline in the ability of the community to recover, even after more than a century without fire. "Old-growth" stands of unburned chaparral have unique characteristics and are a valuable natural resource.*

Net effect of prescribed burning as currently deployed: *Negligible protection benefit, added greenhouse gases, increased health hazards from smoke pollution, in addition to the wasted cost of the operation itself in terms of safety objectives.* Hopefully more productive use of personnel and resources could be deployed in needed projects, such as safer vegetation treatment alternatives in areas more strategically located. Though safer, more sustainable treatment methods may be more costly per acre, the focus on areas in proximity to the WUI should produce more effective results in terms of protection. Thus the cost-benefit ratio will be enhanced as well as yielding a net ecological improvement: Smarter planning and land management in a sustainable manner.

There may also be some advantage to clear or thin long strips of vegetation as opposed to simply large, shapeless or roundish areas, in order to increase the likelihood of intersecting the path of a future wildfire, as described in the Geometrically Enhanced Mega Firebreak (GEMF) section. Possibly, Artificial Intelligence may be useful for helping to design the best geometric design that is most likely to be effective in this regard and to help with other design models to be tested in a more efficient virtual mode, as opposed to brick and mortar trials or downscaled wind-tunnel tests.

In any design model for thinning or vegetation treatment, it's critical to first identify whether a major objective is to protect housing or other valuable assets, and, if so, to build a protective system with that goal in mind and the specific locations to be protected as parameters for the design. This does not discount the value of some vegetation treatment projects that have other types of land management goals or ecological pursuits not related to the protection of real property or other physical assets.

However, if any such projects are planned, the impact on safety for real property or other valuable assets in the area should be carefully assessed, as well.

Careful judgements need to be made and documented if there are unresolvable conflicts between protecting the environment and protecting valuable human assets and the related priorities for any planned projects. Documentation should also identify the nearest residential development or other vulnerable assets closest to the planned project regardless of intended protection. Vulnerable assets may include observatories, communications towers, radar antenna, high-power lines, wind turbines, monuments, parks, squatters' settlements, etc.

Firebrand Incubator

This helps to explain why containing a wildfire is so difficult regardless of the amount of water and fire retardants we pour over the front. The tremendous hellfire heat continues to advance in huge volumes, with or without flames, unabated. *Although firebrands also contribute to advancing fronts and spot fires, their partnership with huge volumes of intense heat makes them all the more likely to ignite vulnerable fuels.* ***Like schools of fluorescent piranhas, the embers are coddled and disseminated in the millions by rivers of hot air streams that keep them warm, like an incubator, and sustained in a smoldering state for ultimate ignition.*** The tremendous heat allows small amounts of combustible gases and charcoal to glow and smolder to extend their incendiary life. *Only by our chilling interventions can we expose these glowing embers to temperatures so low that combustion can no longer occur or the fuel is completely consumed. Please see Wildfire Combustion Process below for more details.*

Firebreaks by themselves also have no capacity to interfere with the movement or intensity of hot air streams and flames, other than to allow for a neutral space deprived of fuel where the heat will passively dissipate. Even without firebreaks, warm air generally seeks higher altitudes and naturally dissipates with cooler volumes of air above. ***In many wind-driven fires, however, a vacuum effect over the crest of hillsides known as a "mountain wave" sucks in hot air streams close to the surface which increases the fire risk and confines vertical heat dissipation.***

Mountain Wave Effect

Figure 11 The Mountain Wave Rendering by Weather.gov

Quoting from Weather.gov: *Air flowing across a mountain range usually rises relatively smoothly up the slope of the range, but, once over the top, it pours down the other side with considerable force, bouncing* *up and down, creating eddies and turbulence and also creating powerful vertical waves that may extend for great distances downwind of the mountain range. This phenomenon is known as a mountain wave. Note the up and down drafts and the rotating eddies formed downstream.*

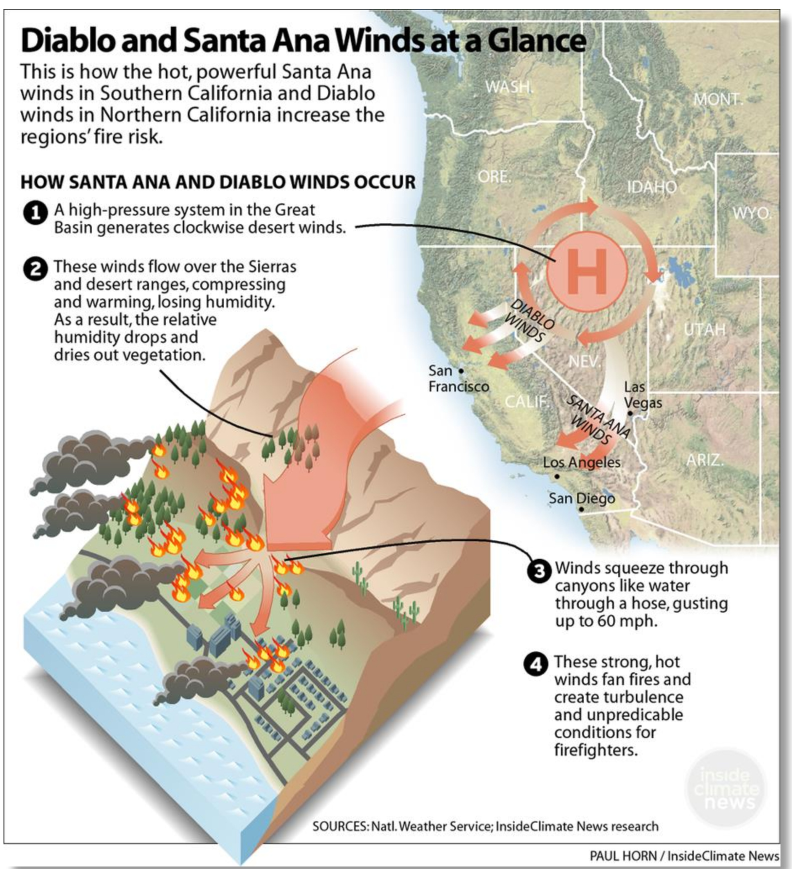
High Pressure Diablo Winds

On the coast of California, many wind storms labeled "Diablo Winds" as well as "Santa Ana Winds" are driven by high pressure cells centered in the high desert of the Great Basin of Nevada and parts of Utah. High-pressure air that builds over that region generates winds that flow toward lower-pressure air over California and the coast.

Wayward Winds

Moving further west, the *wayward winds* descend over mountainous terrain to lower elevations, which causes them to compress and become hotter and drier. The winds pick up speed as they descend and funnel through canyons or across peaks along the Sierra Nevada mountains that are lower than their neighbors. *The mountain wave vacuum effect over mountain crests amplifies these vectors even more.* Sustained wind speeds in the 60-70 MPH range are common in these areas. Other parts of California have set record gusting wind speeds up to 199 MPH without a tornado or hurricane.

Figure 12 Diablo and Santa Ana Winds across Sierra Nevada Mountains – Click for more details



Clearly, the mountain wave effect is very powerful, even without the added forces generated by high pressure systems, such as the *Diablo Winds* and *Santa Ana Winds*. ***By the strategic placement of an external wildfire lithoshield system at the crests of mountains and hills, the mountain wave vacuum effect may be neutralized preemptively to baffle the winds and reduce the heat that may otherwise contribute to the ignition of new fires, or the expansion of existing fires down below. Significant wind management may also be augmented by installing wind turbines integrated with lithoshields.*** *Please see Wind Turbine Integration below.*

Extreme Fire Hazard Risk

Extreme fire hazard risks may develop in the downdraft areas below the crest when a fire front advances on the updraft side of the mountain, which risks may be obscure. *Caution should be exercised in the deployment of any crews or apparatus in the area. Mandatory evacuations for proximate residents may be warranted. The possibility of wind sheers may preclude the passage of aircraft in these turbulent air spaces. The use of live thermal infrared imaging in the area may help to more accurately assess the threat of exposure. Please see more on Thermal Infrared Imaging, and what extreme fire hazard conditions look like in explosive scenes below.*

Like firebreaks, our wildfire lithoshield systems are not mobile as are firefighting apparatus, crews or aircraft. We cannot mobilize this system to the front, so the strategic placements of this system's installations is critical. This disadvantage is balanced by the fact that the lithoshield system will always be ready for instant and automatic deployment without the additional time and costs of dispatching emergency services, although the system will be designed to automatically alert such emergency services, as well, whenever a fire is detected.

Firebrands Protection

The threat caused by firebrands in the WUI is very significant. However, even a 100-foot wall or firebrand screen would not offer full protection against all firebrands that often number in the millions, as shown in this infrared video. In this short video, take note of the brief moment when the camera lens is switched to RGB and back to infrared. The operator also invokes the 4-letter *H* word in his comments: *Oh, the **heat**'s crazy now!* In the firebrand incubator discussion, we emphasize the dependence of firebrands on hellfire heat to disseminate them and coddle them with the heat necessary to sustain a smoldering state and ignite fires. Quenching the ambient heat will go a long way towards disarming firebrands, as well.

WUI Pathways

The ways firebrands can ignite a structure in the WUI are varied. In a 2015 study on Pathways for Building Fire Spread in the WUI, the author, Michael Gollner, reports that *Firebrands, also called burning embers, are now thought to be one of the primary sources of ignition in the wildland-urban interface. They present hazards because they can either directly ignite components of vulnerable structures or can ignite nearby vegetation and other combustibles which can subsequently ignite the structure via radiant heating or direct flame contact (Quarles, 2012). There does not appear to be a consensus on the percentage of ignitions caused by embers, primarily because it is difficult to determine after-the-fact what caused each individual home or structure to burn down during a fire*.

Studies that show how the size of firebrands can predict the length of smoldering time have been published in the Fire Safety Journal showing that: *The results have shown that the increase in the particle size leads to the increase in the smouldering time*. Another study published in the International Journal of Wildland Fire investigates the dynamics of the buoyant plume generated by a bushfire and its ability to transport firebrands. The study shows that: *plume dynamics have a marked effect on the maximum spotting distance and determine the amount of lateral and longitudinal spread in firebrand landing position*. In one study (Clements, 1977) it was found that: *firebrands that had a high percentage of samples flaming in flight and on landing also tended to have higher terminal velocity*.

Wildfire Combustion Process

Firebrands in wildfires are produced towards the end of a cycle known as the Glowing phase and the Smoldering phase of the Combustion Process – the same cycle that they help to re-propagate in spot fires. Here we highlight the critical factors of ***heat and temperature*** to maintain these phases:

1) Two stage process. Within a wildland fire, the processes of pyrolysis and combustion occur simultaneously (Ryan and McMahon 1976 in Sandberg et al. 1978).
   a) Pyrolysis. When first heated, fuels produce water vapor and mostly noncombustible gases (Countryman 1976). Further heating initiates pyrolysis, the process by which heat causes chemical decomposition of fuel materials, yielding organic vapors and charcoal (ibid.). At about 400F. (204 C)., significant amounts of combustible gases are generated. Also at this temperature, chemical reactions start to produce heat, causing pyrolysis to be self-sustaining if heat loss from the fuel is small. Peak production of combustible products occurs at when the fuels are about 600 F. (316 C.) (ibid.).
   b) Combustion. Combustion is the process during which combustible gases and charcoal combine with oxygen and release energy that was stored in the fuel (Countryman 1976) as heat and light.
2) Phases of combustion. The following summary is derived from Ryan and McMahon (1976 in Sandberg et al. 1978), except where noted. For a more complete discussion of the phases of combustion, see Sandberg et al. (1978).
   a) Pre-ignition phase. In this phase, heat from an ignition source or the flaming front heats adjacent fuel elements. Water evaporates from fuels and the process of pyrolysis occurs, the heat-induced decomposition of organic compounds in fuels.
   b) Flaming phase. Combustible gases and vapors resulting from pyrolysis rise above the fuels and mix with oxygen. Flaming occurs if they are heated to the ignition point of 800 to 900F. (427 to 482 C.), or if they come into contact with something hot enough to ignite them, such as flames from the fire front (Countryman 1976). The heat from the flaming reaction accelerates the rate of pyrolysis. This causes the release of greater quantities of combustible gases, which also oxidize, causing increased amounts of flaming (Ryan and McMahon 1976 in Sandberg et al. 1978).
   c) **Glowing phase**. When a fire reaches the glowing phase, most of the volatile gases have been driven off. Oxygen comes into direct contact with the surface of the charred fuel. As the fuel oxidizes, it burns with a characteristic glow. ***This process continues until the temperature drops so low that combustion can no longer occur, or until all combustible materials are gone.***
   d) **Smoldering phase**. Smoldering is a very smoky process occurring after the active flaming front has passed. ***Combustible gases are still being released by the process of pyrolysis, but the rate of release and the temperatures maintained are not high enough to maintain flaming combustion***. Smoldering generally occurs in fuel beds with fine packed fuels and limited oxygen flow such as duff and punky wood. An ash layer on these fuel beds and on woody fuels can promote smoldering by separating the reaction zone from atmospheric oxygen (Hartford 1993).

Firebrands are not specifically mentioned in this description, but it's clear that the chemical and thermodynamic processes for the glowing phase and the smoldering phase apply equally to vegetation fuels either airborne or moribund below. Suppressing heat will compromise the ambient temperatures needed to sustain these phases.

Although firebrands can be lofted to very high altitudes and are known to ignite spot fires even miles away from their origin, before they can do any damage they must first come down to ground level, the level of our lithoshield, and they must still possess adequate fuel and heat to sustain a glowing or smoldering state after their long journey*. This is our playing field, for all those installations adjacent to housing developments. The same arena where vulnerable fuels, housing, people and other assets of value need to be protected.*

Within the lithoshield structure, partial protection may be enhanced by a wall that helps to push the hot air either below into a subterranean heat sink or laterally along a hooded heat flue. Those air streams that surmount these obstacles may be redirected in vertical directions to intercept and carry some firebrands away from a direct path to vulnerable structures. Both directions, in sequence, may be the best option. In other words, start by redirecting the hot air into the subterranean heat sink below or along the extended heat flues to cool it off and capture some firebrands, and then channel the exhaust into advantageous directions likely lofted by the remaining heat.

Beneficial Air Streams

Various designs, curvatures and other features may more effectively promote ***beneficial air streams***. *By diverting firebrands and their incubating warm air streams away from the housing development at least temporarily, the heat and fuel contained in the firebrands may significantly be reduced by the time they reach vulnerable structures or combustibles. Mixing up the air in turbulent swirls may also provide more oxygen and heat to some firebrands, like an ethereal catalyst, accelerating their burnout rate.* ***One way to promote such turbulence may be to include turbine-like blades or fins on the internal surface of heat flue exit vents at the apex to twist the hot air as it is expelled.*** These strategies are intended to use the fire's own energy in the forms of wind and heat to the advantage of protection. *Please see the schematic rendering of the heat flue apex exhaust top view.*

Metallic Firebrand Screens

Metallic screens near or at the top of the lithoshield, depending on its design, may also be helpful to trap those firebrands caught up in low-level currents (*our playing field*). The metal may also be heated by the stream of heat which may serve as a hot physical catalyst, as well, to burn out the embers upon contact. Screens in other locations will also be advantageous, placed in the heat flues and at the heat sink exhaust vents, for the same purpose. These screens can also be designed to manage wind dynamics as do wind fences or windbreaks. A fire resistant wind fence atop our external lithoshield, that can also filter out firebrands, may do the trick. Attenuating wind flow will by itself significantly reduce fire combustion hazards beyond the fence.

Windbreaks - Emberbreaks

In some housing developments, it may be desirable to also deploy very large firebrand screens, like those used around some golf courses and in industrial settings to manage dust, for example, possibly independent of a lithoshield. Metallic windbreaks or wind fences and shelters can not only attenuate dangerous winds, but can also hinder the passage of embers, depending on the design. In agriculture, rows of trees surrounding crop fields are often used as windbreaks to protect the soil from being blown away by winds and protect the crops from desiccating in the wind. Sometimes farms are protected by artificial wind fences, as well.

Using an impermeable wall has proven to be of little use for this purpose since the high pressure that builds up on the windward side of the wall causes the wind to elevate and simply jump over the wall and drop below on the leeward side in chaotic turbulence. Natural barriers such as trees need to be spaced out to prevent the simple catapulting of wind over the obstruction. The spacing of barriers allows the admitted flow to elongate the distance of attenuated wind partially supported by the original source. The protected area is loosely proportional to the height and density of the barriers. However, using trees in proximity to housing developments may also increase the hazard of firebrands since they are combustible fuels. For this reason, to protect WUI housing developments, the safest alternatives may be nonflammable metallic windbreaks or *Emberbreaks* as we call them or lithoshields with sprinklers, or combinations of both.

Figure 13 – Perforated Aluminum Sheet Metal Garden Fence

Some wind fences may be temporarily rolled out or erected when needed. A perforated aluminum sheet metal garden fence, as illustrated above, may serve the purposes of landscaping design, privacy fencing, wind attenuation and firebrand filtration, all in one. As good neighbors, we can protect closely spaced buildings from firebrand spread next door. Much larger metal windbreaks for industrial applications can also be seen on the Internet. Also helpful may be powerful vertical water jets to wet down firebrands in the sky, as incorporated in the Superior Sprinkler System described below. Repurposed wind turbines also have the potential to filter massive amounts of firebrands as well as reduce excessive wind hazards as discussed below.

Range of Impact

The range of impact differs for each of wind, heat and firebrand interventions, which tools should be utilized strategically. Urban planners please take note. Windbreak fences or emberbreaks have a short range impact on wind mitigation based on the size of the filter or fence device, but a long range affect on firebrand control. As opposed to the somewhat unlimited supply of wind due to meteorological causes, firebrands have a fixed though plentiful supply based on the fuel combusted.

Once a firebrand is filtered, though, it is permanently neutralized, and the vast majority of them can be trapped with existing metallic windbreak technology. ***In an ironic way, the wind itself can be seen as a tool to help trap as many firebrands as possible. Find a windy mountain crest or valley and build your emberbreaks to suck in that wind and capture as many embers as possible. The more wind, the more firebrands to be permanently neutralized.*** Heat calories that are quenched in the heat sinks of a lithoshield are also permanently eliminated as their energy is transferred to subterranean surfaces and water that flows safely through the guts of the lithoshield. The heat that flows unchecked will often come back to haunt you, possibly with a cadre of embers.

As mentioned in Topography Placement Options, there is a strategic benefit to placing lithoshields along with firebrand screens and repurposed wind turbines, on mountain crests, even if remotely located. If a wildfire were to occur near the mountain crest, many of the embers would be captured and neutralized before they could spread their smoldering menace to nearby or even distant forests and neighborhoods. Much of the heat will also be erased and the lithoshield will offer secure containment far beyond that provided by firebreaks alone.

Heat management and robotic nozzles will also extend the safety net to nearby vegetation as well as to wind turbines or communications equipment that happen to share the same mountain crest. Hillside housing developments in the WUI can benefit from both short range and long range protections. Regional mountains and valleys can enjoy a full range of infrastructure to manage winds and filter firebrands. More locally, housing structures can be surrounded by lithoshields and firebrand screens. Smaller metallic windbreak fences can be placed between each lot to avoid the spread of flames in a domino chain pattern. A variety of external lithoshield designs and locations are suggested based on a range of topographies as outlined in Frontal Architectural Profiles. These designs are intended to better manage the natural flow of heat and wind on slopes as well as to take advantage of existing or planned roads and firebreaks.

Photonic-Laser Firebrand Fence

Photonic fences are currently being tested in agriculture to fend off certain insects that destroy crops. A developer, Joe Pratt, describes his technology in Citrus Industry: “Photonic fence is a multi-modal system that uses several different types of light in order to detect, track, identify and, if desired, kill specific target insect species in flight”. The fences have the capacity to identify specific species which are individually zapped with photons and also to clear the safe passage of beneficial insects such as so many pollinators, bees and everything else that passes through the sensitive fenced areas.

This type of technology, once tested and refined to a practical format, may provide a relatively safe method of zapping individual firebrands in flight between fence posts. Firebrands that are glowing or smoldering have a very distinct profile when compared with other small flying objects, birds and insects, so that distinguishing the target against other objects should be a low-risk objective to accomplish. Initial tests with a 10 x 100 foot fence in a citrus grove against Asian citrus psyllids showed positive results. Although this technology may turn out to be too expensive for firebrand defense in residential areas, as compared with other protections such as water jets, for example, there may be a few high end developments that may be willing to underwrite the cost for added protection.

Superior Sprinkler System

Unlike a sprinkler system in a building, which is generally required for buildings more than two stories or 30 feet, a Superior Sprinkler System would be an enhancement for the proposed wildfire lithoshield system and will be external and superior to the lithoshield and nearby structures. This sprinkler system will be automatically executed with the detection of heat or smoke of advancing flames, as well as thermal imaging and RGB surveillance cameras to direct multiple robotic nozzles, and is designed to protect nearby housing, as well as wildlands vegetation. Water nozzles will focus on four strategic targets:

1. Fire front fuel – low level jets
2. Firebrands and heat air space – high level wide sprays
3. Real property improvements - housing – focused gyrating sprays
4. Heat sink chamber – internal sprays both wide and focused
5. Exhaust Vent – focused sprays

Fire Front Fuel

Long range water jets will immediately begin to soak advance fuel sources as soon as heat is detected by heat sensors or thermal imaging. The benefits of thermal imagery are more sensitive detection as well as better directional locations for focused sprays using robotic nozzles. Low-level sprays above the fuel profile will also mitigate the intensive heat and flames generated by the fire. Directional locations detection will support focused soaking on outstanding heat sources. If the lithoshield structure is integrated with a hillside road and located below the road, the sprinkler jets or robotic nozzles oriented towards the road may be elevated to avoid spraying directly into traffic or may be substituted with sprinklers on the other side of the road.

Firebrands – Heat Air Space

Wide-angle jets may be sprayed at higher angles with powerful jets to intercept firebrands detected by thermal imaging. They may also be directed at fuming air streams, which often include firebrands, to cool them down somewhat. ***Even when combustion-level heat is not detected, the system can be calibrated to cool off and extinguish concentrations of smoldering firebrands in the air before they consummate their haphazard mission, as long as they're in reach.*** As water sprays are converted into steam, Btu's of heat from the air are consumed in the process. Cooler, more humid air is less of a risk to structures behind the wall than hotter, drier air, offering a direct assault to quench unabated volumes of heat, in addition to the heat sink and flue system.

Real Property

Heat and thermal imaging sensors to initiate this system will detect abnormal heat from either side of the wall for more protection. More nozzles that focus directly on the property behind the wall or that may gyrate in all directions are obviously beneficial, as well, unless the distance between the wall and the property is too great. In such cases, additional nozzles on the ground closer to the structures may be devoted exclusively to support direct structure protection. This feature may also provide peace of mind to property owners who may wish to ignore evacuation warnings in order to protect their property with water hoses. Robotic nozzles can more efficiently and effectively focus water where highest heat sources are located.

Heat Sink Chamber

Focused and wide sprays will be used to both cool hot air as it enters the heat sink vents and to kinetically redirect the air in optimal directions to maximize contact with cooling surfaces. Any glowing embers will also meet their fate as they drown in the flushing streams. *Please see more details in the Hellfire Heat Quencher discussion.*

Exhaust Vent

Before being completely emancipated into the free space above, the treated exhaust will be given an ultimate baptismal spray of water to keep it honest in the path towards redemption from the status of hellfire heat as it belches out of the superior exhaust vent. Thermal imaging will also alert our robotic nozzles to the trespass of excessive heat that manages to circumvent heat flues along the way in order to police this misbehavior with a little disciplinary squirt here and there.

Efficient Resource Management

Sprinkler systems that some people install for their roofs are helpful at times, but can also reduce water pressure needed by firefighters if not executed judiciously. The Superior Sprinkler System integrated with the wildfire lithoshield system should be designed normally to focus only on areas near the approaching front. ***Especially with the advanced precision of robotic nozzles, this will manage the water resources more efficiently than multiple home owners in the community spraying their roofs in a random fashion.*** It will also help to protect the front line of defense closest to the wildlands perimeter and mitigate the risk of peripheral fires linking to adjacent homes in a domino-chain fashion.

Automatic Emergency Notification

Triggering this system may also invoke automatic notification to emergency services and possibly local residents of this event. The sensitivity of these sensors should be calibrated to avoid going off with the smoke of a backyard barbeque. (In some blocks adjacent to the wildlands perimeter, perhaps the backyard barbeque or any open fire should be restricted?) *Please see WUI Perimeter High Risk Zones for more proposed restrictions.*

Robotic Nozzles

Robotic nozzles are a new generation of what have traditionally been known in the firefighting industry as "remote controlled monitors" or "water cannons". One model is the FlameRanger shown in this video at a warehouse interior, which is another example of an advanced, fully automatic robotic nozzle system developed by Swedish robotic nozzle manufacturer, Unifire AB. In 2007, the Kansas Forest Service Fire Shop at Kansas State University made their own Wildland Fire Remote Monitor "to find an alternative to having firefighters ride on the outside of a moving vehicle to spray wild fires." The linked document shows all the parts off the shelf needed to make your own do-it-yourself with a little bit of welding. Assembly instructions included. But they also admit that "The Kansas Forest Service version lacks one feature most commercial models have – the ability to remotely adjust the water stream."

This application of a robotic nozzle will be installed on or near the lithoshield, not on a mobile vehicle as shown below, and will include several nozzles placed in strategic locations with automatic and remote control options as described above. Like traditional firewalls, we do not seek a wildfire, but we prepare for the occasion when it arrives at our doorstep. However, we do hope that our firefighters in Kansas and elsewhere have since found a margin in their budget to include some of the sophisticated equipment currently available, especially if it provides more efficiency and safety for our precious firefighters as they traverse our firebreaks.

Figure 14 Unifire's unique F50-ST Side Turret

According to Unifire, the system is capable of automatically detecting a fire, finding and tracking its position in real time and in three dimensions, and guiding the nozzles to spray water or foam with precision onto the fire. Moreover, any conceivable spray pattern can be applied to the fire by programming. A new challenge, the company says, is to determine the best practices in how to most effectively program the spray patterns to be applied to the fire. Another model recently designed includes the ability to control robotic nozzles with your smart phone, tablet, laptop or even over the Internet. ***Remote control in the hands of the local firefighting agency will maximize efficient coordination provided that adequate connectivity is established.***

In addition to the Unifire brand shown above, a number of other suppliers are available including Akron Brass, Potter Roemer, Guardian Fire Equipment, Angus Fire, Complete Design Fire Solutions, Atilim Makine, HD Fire, Williams Fire & Hazard Control, Task Force Tips, Brilliant Engineering Works, FireDos, Sentrix Technology and other companies. Features vary among the suppliers. A few suppliers also provide fire protection equipment suitable for do-it-yourself solutions at home including Frontline Wildfire, Fire Pump & Hose and Home Firefighting Systems. This proposal does not rank nor endorse any supplier or brand. What is important to this proposal are features critical to this application and to document a well-established and capable industry.

AV - Thermal Imaging

In addition to heat sensors, thermal infrared and AV RGB surveillance imaging cameras should be mounted in protected canopies to help identify profiles of wildfires or structural fires in the proximate range. These cameras may also be part of a security surveillance system to protect the structure from malicious vandalism or misuse, such as the coopting of resources by capricious youths or unfortunate homeless individuals, in addition to incendiaries or profiles of individuals possibly engaged in arson. *Innocent barbeques and fireworks in view may also be identified and profiled for appropriate alerts to local public safety authorities*. ***Let's face it, this is the battlefront of defense against wildfires… No fires, smoke, excessive heat, fireworks or incendiaries may cross this line unchecked – in either direction!***

In ecologically sensitive areas, the cameras may also help to track the passage of endangered species or possibly their failure to find favorable passageways around the lithoshields. Artificial intelligence may also be applied to identify specific species of concern in the region using a camera trap. *Since these systems border the wildlands, it's important to provide a bridge or porthole for wildlife to straddle or circumvent any lengthy barriers.*

3D Cloud

These sensory systems and cameras may also be hooked up to Internet Cloud big data systems integrated with satellites that inform fire protection applications in a coordinated network on a global scale. Not only should local sensors inform the network as part of an early fire detection camera system, but reciprocal status data should be shared in both directions. Information to support immediate and timely fire protection on the ground should be the top priority as well as short-term simulation forecasts. ***Regional wildfire detection systems, such as those of the ALERTWildfire network and HPWREN, using infrared and RGB cameras and other sensors, may also benefit by installing wildfire lithoshield systems to protect their expensive equipment, often exposed to wildfires.***

Early Wildfire Detection Networks

New high-bandwidth technologies are now coming online to transmit high quality video information from fire detection towers to fire stations. HPWREN has built high-speed wireless networks in San Diego, Imperial, Orange, and Riverside Counties, enabling hundreds of cameras and meteorological stations to stream critically important data to servers connected with each other by the CENIC backbone, and providing wide-area wireless internet access throughout southernmost California. See UCTV.tv video.

This information will be shared with similar lithoshield systems installations throughout the region as appropriate. For example, if resources are sufficient, preemptive wide-angle nozzle sprays may be initiated in targeted areas when threats are proximate, and other fire protection assets should be readied. Local command agencies will maintain a comprehensive view and control options for all integrated assets. Existing networks to integrate may include:

1) **ALERTWildfire**: **(network map)** a consortium of three universities -- The University of Nevada, Reno (UNR), University of California San Diego (UCSD), and the University of Oregon (UO) -- providing access to state-of-the-art Pan-Tilt-Zoom (PTZ) fire cameras and associated tools to help firefighters and first responders:
   a) (1) discover/locate/confirm fire ignition,
   b) (2) quickly scale fire resources up or down appropriately,
   c) (3) monitor fire behavior through containment,
   d) (4) during firestorms, help evacuations through enhanced situational awareness, and
   e) (5) ensure contained fires are monitored appropriately through their demise.
2) **Multi-Hazard Early Warning Systems (MHEWS):** World Meteorological Organization including
   a) **Bangladesh:** The Bangladesh Cyclone Preparedness Program
   b) **Cuba:** The Tropical Cyclone Early Warning System of Cuba
   c) **France:** The French Vigilance System
   d) **Germany:** The Warning Management of the Deutscher Wetterdienst
   e) **Japan:** Multi-Hazard Early Warning System in Japan
   f) **Shanghai, China:** The Shanghai Multi-Hazard Early Warning System
   g) **United States:** Multi-Hazard Early Warning System of the United States National Weather Service

3) **HPWREN**: HPWREN functions as a collaborative, Internet-connected cyberinfrastructure. The project supports a high-bandwidth wireless backbone and access data network in San Diego, Riverside, and Imperial counties in areas that are typically not well-served by other technologies to reach the Internet. This includes backbone locations, typically sited on mountain tops, to connect often hard-to-reach areas in the remote Southern California back country.

Flood Control – Retaining Walls

Minimally, a concrete lithoshield structure must be a harmonious player in the flood control systems currently at place at each location. Obviously, it should not cause any damming that can create subsequent overflows and flooding, which may require appropriate drains and conduits. On some hillsides and valleys such a structure may double as a significant asset to improve flood control for those below. For many WUI developments in relatively flat lands, or steppes, flood control may be an important concern, as well, especially in areas with monsoons and flash floods, as in Arizona, New Mexico and Texas. Flood control in areas like Houston and other states in the South is a major concern, as well, due to regions with very low sea levels.

Retaining Walls

Additionally, since geologists know that all hillsides will eventually collapse in time, these structures can provide the stabilizing services of heavy-duty retaining walls, as well, including protection from mudslides, landslides and snow slides in different seasons.

Thinning & Firebreaks

To build such a wall, some type of adjacent roadway would be helpful, if not necessary, hence a firebreak. Integration with a hillside access road has also been explored in Roadway Integration. If a firebreak already exists in a suitable location, that may be a good place to install the wall, as well. A roadway of some kind will also be necessary for maintenance. The width of the firebreak may be designed in correlation to the anticipated wildfire risk potential, much like the height of the lithoshield in the planning process.

Thinning – Fuel Breaks

On the wildland side of the wall, thinning the vegetation to some degree for several hundred feet would be a significant improvement in safety by simply reducing the amount of fuel available near the development to be protected. Fuel breaks may also provide the equivalent protection where a change in vegetation type, such as from forest or shrubland into grassland, is applied. According to Cal-Fire Fuels Treatment: *A shaded fuel break is constructed in a forest setting. Typically, the tree canopy is thinned to reduce the potential for a crown fire to move through the canopy. The woody understory vegetation is likewise thinned out. The shade of the retained canopy helps reduce the potential for rapid re-growth of shrubs and sprouting hardwoods and can reduce erosion.*

There are several studies that show the merits of forest thinning, including a study described by the University of Pennsylvania in 2012 as Research shows managed fire benefits forest carbon sequestration. Focused thinning near the lithoshield will thereby serve two purposes:

1. to help protect the urban development by reducing available wildland fuel and,

2. to help manage our forests for improved carbon sequestration.

The space between the lithoshield and the urban development would also need to be completely cleared as defensible space, or else the wall would serve no practical purpose.

Wind Turbine Integration

Wind turbines are often placed in areas that are concomitant with high fire risk locations such as windy hillsides. These are often ideal locations for wildfire lithoshield systems, as well. A synergy of wind and heat management will be obtained by the impact of the turbine blades that suck kinetic energy from the wind which is transferred to the turbine engine as it converts it to electromagnetic energy. If located on a mountain crest, this may also strategically impede the dangerous mountain wave effect as a preemptive strategy.

A wildfire that advances towards the turbine has added heat and wind vectors at ground level below the blades which will be perfect targets for lithoshield installations. These vectors would not be useful to generate wind turbine energy due to their low altitude. The exhaust from the heat flues of the lithoshield will be ejected directly into the path of the turbine blades above which will further mitigate extant heat. A match made in heaven, or that other diablo hideout below, talking about matches, as shown in this wildfire scene located in Australia:

Figure 15 Water bombing aircraft at Waterloo Wind Farm, 2017/01/17

Another complementary feature about wind turbines is that they can and will change direction to blow with the wind, whereas the walls are obviously stationary. However you can also build lithoshields back-to-back in a V-shaped formation to cover both directions, if needed. ***Lithoshields can also protect the turbines from flames that may put them out of commission. Additionally, they can protect the wildlands from wind turbine fires that occasionally ignite within the turbines themselves.*** Another convenience is the access road required for all wind turbines, a perfect location in juxtaposition for the alinement of the wildfire lithoshield system.

Repurposing Wind Turbines

Not only do we repurpose wind turbines by applying them in this fashion for fire protection, but we also ***multipurpose*** them, as well, without compromising their productivity in generating power. ***Now, all we need is to somehow attach firebrand screens to the turbine blades that will extend when needed.*** The large area covered by the blades has the capacity to capture huge volumes of firebrands beyond the range of the lithoshield, and, if designed appropriately, may gather up even more kinetic energy and heat from the firebrands.

Firebrand Extinguishing Water Jets

In addition to firebrand screens, an array of water spray jets can be laced along the trailing edge of each blade and automatically triggered by the lithoshield surveillance system whenever firebrands or approaching flames are detected. The water spray will extinguish any glowing or smouldering particles in the firebrands and cause the firebrands to more quickly collapse to the ground with the added water increasing their weight.

Wind-Water-Well

Even low levels of humidity can be condensed and collected through refrigeration directly from the atmosphere using the energy pulled out of the wind with the turbines. Storing this moisture in tanks can make it available for the Superior Sprinkler System described above as well as the Water Jets adorning the turbine blades. An independent water source using totally green energy to combat fires, firebrands and dangerous heat is the ultimate eco-plus sustainable solution in this era of climate change. An example of using other energy sources such as biomass to power the process of condensing water from air is brilliantly portrayed with the WEDEW model, using wood as the raw energy fuel. The WEDEW model as portrayed claims the ability to make 2,000 liters of potable emergency water every 24 hours at a very low cost. By using only wind and air as sources of energy and moisture with our wind turbine model, the resource cost is nearly zero and a net gain to the ecology. Another benefit to the environment is an avoidance of greenhouse gases and heat for generating energy and refrigerating moisture, in addition to preventing or helping to contain wildfires and hell-fire heat.

In some areas, there may also be sufficient water production by this means to apply to external needs such as human consumption and agriculture, as well. The old windmill concept now transformed to a ***Wind-Water-Well***, with the help of a little modern engineering. Here we are sucking both kinetic energy and moisture from the same source. Talking about synergy. Even if the air is relatively low in humidity, the higher flow of wind around wind turbine areas provides an advantage of greater quantities of air and moisture passing by per hour, provided that the moisture receivers are well distributed in the turbine apparatus, that is, more square footage of surface upon which to condense and collect humidity. And with a wind turbine with huge blades, the amount of available surface is more than ample. Since this model enjoys an abundance of innate energy, refrigerating larger surfaces is well within reach. Increased winds will factor exponentially to the total water productivity potential. Water bottlers in the future may build their own Wind-Water-Wells and brag that *air-water is cleaner than spring-water*.

Figure 16 - Vertical wind turbine VAWT, helical vertical wind turbine

A built-in efficiency of this design is the use of air intake vents along the front of each blade, which will reduce the amount of internal pumps needed to move the air for processing. Water filtering and purification will be housed in the support pillar. A vertical axis wind turbine may offer the advantage of centralized mechanics for this adaptation, however both vertical axis (VAWT) and horizontal axis (HAWT) models will offer efficient production of potable water. In either case, the blades need to be large enough to include intake vents and refrigerated surfaces and tubing to collect condensed moisture, and also integrate the water jets. The centrifugal force within the blades as they rotate can also help to move water along the blades for water jets.

A hybrid system alternative may be to simply use an off-the-shelf wind turbine and plug the juice into the WEDER box which will collect the needed air to extract water independently, without any other source of fuel, wood or energy needed. The water will then be applied to the sprinkler system of the lithoshield. The power from the wind turbine will also be useful for the surveillance system and robotic nozzles automation systems. In some remote areas, both the water and power from these appliances may be critical. *To avoid competition with local firefighting demand for water pressure, an independent source of air-water will avoid the need to draw from scarce water supplies and may even contribute with fire hydrants directly from air-water tanks.*

Implications of this repurposed wind turbine model lead to the expansion of locations of wind turbine farms both in the plains, as discussed below, and to hillsides and mountain tops, especially when integrated with lithoshields. The multipurpose wind turbine idea will be discussed further below.

Wildfires in Great Plains

Figure 17 Wildfires increase in Great Plains

The increase in wildfires in the Great Plains in Nebraska and other states is also a major threat where the average area of land annually burned by wildfire has grown by more than 400% between 1985 and 2014 as reported by the Nebraska Farmer. Co-author Dirac Twidwell, an ecologist who specializes in rangeland and fires, says the recent study is part of a larger effort to better understand the connections between human activity and the grasslands ecosystem of the Great Plains. "The Great Plains will be the next wildfire frontier," he says. "We're the next Rocky Mountains. We're the next California."

Although mostly rural, the strategic placement of wind turbines and lithoshields will help to preemptively mitigate such threats for the grasslands in the plains and rural neighborhoods.

4) Data Collection:

Implementation

Locating areas that need lithoshield structures may be a lot easier than determining the best placements and specific design elements for optimum protection. Since the space is generally outside of residential lots governed by local building codes, other standards similar to those applicable to sound walls on freeways, as well as highways, bridges and flood control may be more applicable at the initial stages of design. Even within building code requirements there are endless architectural options available, such as those observed in the myriad of sound walls on our freeways across the USA and other parts of the world, as shown in one example below. The U.S. Army Corps of Engineers may also be called upon for needed resources and expertise, especially on federal lands, as well.

Figure 18 Soundwall Design Example in Hong Kong by ESKYIU - Designers: Eric Schuldenfrei and Marisa Yiu

At each location, urban civil engineers, planners, landscape architects, fire professionals, scientists, local developers and community stakeholders may need to all pull together as a team to solve this complex 3D puzzle to reflect the parameters and unique landscape at hand, including ecological considerations. A wall is, in general, a simple structure; but there is no such thing as a generic wildfire lithoshield system, especially on hillside terrains. The options may be overwhelming once you start looking at wind dynamics at play, whether it should lean one way or another, possible enhancements as those described above, and even decorative elements like we see on many noise abatement walls by our freeways, or the example shown above, or even the amazing history of fortresses. In some locations, it may also be necessary to guard against landslides and floods, as well as seismic hazards, requiring special geologic engineering clearances, as well. Ecological constraints must also be observed. Will an Environment Impact Report be required for each wall?

Technical Issues and Science

One of the big questions on the table at this initial stage is whether a wildfire lithoshield system as proposed can potentially offer significant protection against firebrands, especially for installations adjacent to housing developments? The height of the wall and other features also offer opportunities for testing. For example:

1. How does a firebreak with a parallel wall structure compare in effectiveness with a firebreak with no wall?
2. How frequently have fire fronts jumped over firebreaks in the past either by radiant heat, flames, firebrands, or other means?
3. What is the known failure rate of firebreaks based on firebreak width, vegetation type, wind speed and other risk factors?
4. Can lithoshield structures specifically protect against radiant heat in ways beyond the capacity of firebreaks?

5. What advantages can be measured by using the lithoshield to redirect advancing heat and flames into a subterranean heat sink?
    a. How large does the heat sink need to be for effectiveness?
    b. How many Btu’s of heat can it absorb or dissipate based on the proposed design alternatives or other alternatives?
6. How effective may lateral heat flues at the top of the lithoshields be in channeling fire and heat to a point of safe redirection?
    a. What dimensions and shapes for the heat flue are critical for efficacy?
    b. How does the heat flue without a heat sink like the Bearbones model compare against a simple nonflammable barrier of similar height in safely blocking or redirecting fire and heat?
7. How tall does a structure with a heat sink and horizontal heat flue have to be to control flames and prevent hazardous heat rolling over the structure when such heat and flames are approaching at
    a. Various flame and heat wave heights up to 30 feet or more?
    b. Various sustained wind speeds up to 80 mph or more?
    c. Various gust wind speeds up to 200 mph or more?
    d. Various angles in relation to the orientation of the lithoshield?
8. How effectively can turbulent air streams generated at exhaust vents with turbine-like blades cause firebrands to combust and dissipate their fuel content?
    a. Will such turbulent air streams be able to affect firebrands more distant from the lithoshield system structure, as well?
9. When controlling for other factors, how does the ambient temperature of air surrounding firebrands directly predict the sustained heat contained within glowing firebrands and their smoldering state over time?
    a. The firebrand density within a volume of air also needs to be a controlled factor, since the density will most likely contribute to ambient temperature.
    b. Additional parameters to compare alongside ambient temperature may include wind speeds and size of firebrands, which have been studied independently in prior research.
    c. Altitude, air pressure and oxygen levels also need to be controlled, and possibly carbon dioxide or other gases, as well.
    d. At what temperature range will glowing no longer be sustainable?
    e. At what temperature range will smoldering no longer be sustainable?
10. If the width of an effective firebreak should be 2-3 times the height of flames of a flanking wildfire, based on some guidelines, should that principal also apply to the height of a lithoshield?
11. Will a metallic firebrand screen on a wall capture a sufficient amount of firebrands to make a significant difference particularly for lithoshields adjacent to housing developments, knowing that firebrands can flow with the winds hundreds of feet in the air?
12. What dimensions of wire screens offer optimum performance in trapping firebrands and what spacing between wires?
13. How effectively can water sprinklers or robotic nozzles with different configurations, water pressures, numbers of water jets and nozzles, distances, heights and angles,

    a. Extinguish advancing flames?
    b. Dampen the movement of firebrands, or at least extinguish a significant number of them?
    c. Cool and humidify advancing warm winds?
    d. Directly protect proximate housing?
14. How much of an improvement in fire protection do sprinklers or robotic nozzles provide compared with lithoshields with no robotic nozzles or sprinklers?
    a. How do traditional water jets in appropriate arrays compare against robotic nozzles in potentially combating wildfires for anticipated scenarios?
15. Are lithoshield structures more effective at the top of a crest as opposed to the base of a hillside or in between to protect housing at the same level or either level based on different profile archetypes as proposed or other variations?
16. Does thinning the wildlands behind a lithoshield offer any more protection than a lithoshield structure by itself?
17. How much thinning of the brush or forest behind a lithoshield structure is necessary to make a significant difference in fire protection and firebrand protection?
18. Does the area have to be completely cleared or can it be logged or thinned in strips while continuing to offer some protection?

These are some of the questions that need scientific studies and testing that may hopefully be facilitated or coordinated by organizations like the NFPA, the US Forest Service, and various academic institutions involved with fire science and protection. No doubt, qualified investigators will refine these questions and think of many more. Testing the limits of efficacy for structures, as proposed or redesigned by investigators, will at least take us to the next step of whether or not these solutions are affordable or what types of fires and location scenarios may be appropriate for deployment. ***We appreciate that many, if not most, of these questions demand advanced engineering skills and possibly unprecedented journeys of investigation.***

We assume that maintenance will be an issue to evaluate at an appropriate time as well, but here we can place this issue in the context of the maintenance already required to sustain our firebreaks and critical infrastructure. In many places we may advance simply by replacing existing firebreaks with comprehensive wildfire lithoshield systems side by side. Although we are not as ambitious as the ancient Chinese dynasties to fortify huge lands with seamless fortresses, we can more modestly assume that protecting large wildlands in strategic places at the perimeter will at least result in significantly less chaos and devastation within the interior. For now, that's the plan at this early stage. These are public lands that we all need to protect for many reasons.

Artificial Intelligence

Wishful thinking, to extend these advanced journeys even further: With the help of artificial intelligence and mapping databases as well as weather and climate data and local wildfire history points, is it possible to derive an optimal wall placement and elements algorithm for various WUI developments? Wouldn't it be great if we could simply pull up a Google Earth map and point to an area to display potential lithoshield placements and dimensions? While we're dreaming, let's add 3D drawing plans like Revit on steroids, and of course, it would be great to include a planning chart with estimated costs and timeline. All this simply by pointing at a section of an urban development to protect. Is this too much to ask, for a good cause? Down the line, if this capacity is developed, large-area lithoshield protection needs assessments can help determine lithoshield funding needed for counties, states and congressional districts, using appropriate parameters. Data included in the WRAP map system layers, described below, will enhance these capabilities even further.

Although the basic technology required to develop these safeguarding infrastructural elements already exists, the most effective and eco-friendly design may pose a development challenge which could possibly be mitigated by the application of artificial intelligence (AI). For example, AI could help to outline the shape and location of lithoshields on hillsides to minimize the possibility of fire and heat jumping over the lithoshield. Virtual models may be tested by AI to decrease costs of mechanical models and to more rapidly eliminate less fruitful investigations.

Metallic windbreaks may also be useful in not only reducing dangerous seasonal winds associated with wildfires, but also in fencing or filtering dangerous firebrands. The questions of implementing such devices center around the most effective placement and dimensions of the metallic fences and all the details that may contribute the most beneficial results for minimal investment. Windbreaks are old technology, but adapting them for this purpose raises naturally a lot of questions, including the impact on ecological resources. AI modeling may get us started in the right direction to determine whether more development funds should be applied.

Tweaking the design of wind turbines may also help to multi-purpose these energy resources as both windbreaks and firebrand filters. The energy they produce can also be used to refrigerate moisture in the air and condense it to be utilized by a built-in sprinkler system. This sprinkler system will be very advantageous when the need arises to filter out firebrands passing by. The water spray will not only add weight to the firebrands to change their trajectory, but also help to extinguish smoldering fuels they contain. None of this technology is new, but to incentivize private investments by related industries, AI modeling may also help to determine the most effective locations and arrangement that may most effectively accomplish the multiple objectives and instigate a more serious look.

A costly quagmire of uninformed decisions and planning has been associated with vegetation treatment, especially when using prescribed burning. Both at the federal level and state level, prescribed burning has been shown to miss the mark when examining results. Turns out that over 99 percent of the areas we deliberately burn are not near the wildfires that actually occur. This may possibly be related to the high wildfire risk areas that predominantly surround wildland urban interface (WUI) developments. Whether for safety or smoke hazards, there are good reasons to avoid these areas with prescribed fires. Yet, some type of vegetation treatment may be needed in these areas, nonetheless. Again, AI modeling or other algorithms may be useful to point out wildland areas that should be given priority.

One example of useful mapping data is offered by Sanborn: *The Wildland Fire Risk Assessment System (WFRAS) is a well defined methodology for describing fuels, assessing current fire risk, and analyzing fire prevention and fuel treatment options for reducing future wildland fire risk.* This author pleads ignorance as to whether or not these mapping services have been widely used by authorities for determining vegetation treatment targets, although it appears that some applications have been useful at least for wildfire management. And, if so, have they been on point?

Google Earth has also been very helpful in tracking wildfires in progress and deserves at least a page in the USDA Forest Service website titled Fire Data in Google Earth. We are hoping that some team members at *Google Brain* may also step up and take a shot on some of the research topics we outline. Likewise may we also tease the IBM Watson team? In China, IBM's Green Horizon project is using an AI system that can forecast air pollution, track pollution sources and produce potential strategies to deal with it. This may also be a useful resource for planning prescribed burning with a little enhancement, especially since smoke pollution is a recognized byproduct of prescribed burning. IBM's Energy and Environment website describes IBM's broad commitment to partnering with many institutions and governments in this arena.

Geometrically Enhanced Mega Firebreak (GEMF)

s Our proposed lithoshields added to these strips would help even more, especially since the vegetation will grow back within ten years, or so. This would constitute a type of geometrically enhanced mega firebreak (GEMF). To avoid excessive barriers to wildlife, breaks in the lithoshields should also be included with overlapping strips. Computer models with AI resources may help to design a more effective geometric pattern, including the optimal path and width along the terrain of the area for a vegetation treatment project. The model will also include graphic information about the types of vegetation in the area, as well as the density, moisture, weather, wind, topology and other factors.

AI is also being applied to avoiding 'environmental catastrophe' at the Centre for Doctoral Training in Application of Artificial Intelligence to the study of Environmental Risks (AI4ER) at the University of Cambridge. Microsoft steps up to the plate with AI for Earth providing a number of focus areas, as well as API's available to all. Focus areas include climate, agriculture, biodiversity and water. Grants are also offered *to support projects that change the way people and organizations monitor, model, and ultimately manage Earth's natural systems.* More resources are highlighted by a recent article published by the Earth Institute at Columbia University titled '*Artificial Intelligence—A Game Changer for Climate Change and the Environment*.'

Planning Resources

To this end, as we get back down to earth for planning support, in addition to the Wildfire Hazard Potential map described above, some advances in visualizing and assessing wildfire hazardous zones with WUI developments have been demonstrated by the Arizona Wildfire Risk Assessment Portal (WRAP) and similar maps in the West. Wildfire risk and threat data layers were developed as part of the West Wide Wildfire Assessment covering the seventeen Western States. Assessment data for Arizona State was clipped from this larger data set for use within Arizona. The Oregon Department of Forestry completed this assessment on behalf of the Council of Western State Foresters with funding from the USDA Forest Service.

When viewing the WHP map through the ArcGIS.com Map, you are provided an HTML interactive view with essentially two layers, 1) WHP and 2) Topography Basemaps. The transparency – opacity level can be adjusted for each layer. Basemaps can be selected from 12 options:

Table 5 WHP Topography Basemaps


Imagery

Imagery with Labels

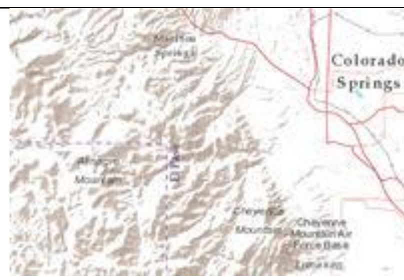
Streets

Topographic

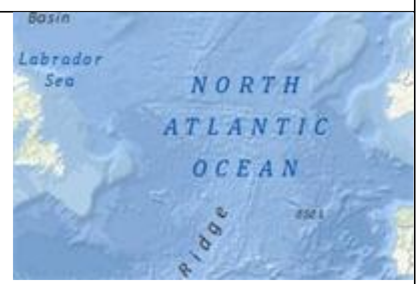
Dark Gray Canvas


Light Gray Canvas

National Geographic

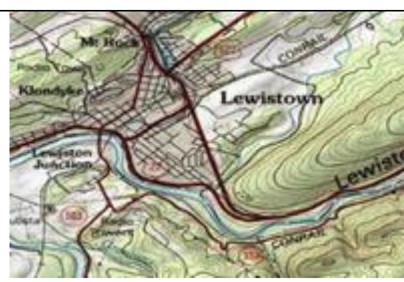


Terrain with Labels



Oceans

OpenStreetMap



USA Topo Maps

USGS National Map

The WRAP interactive map service adds several more layers in addition to those of the WHP. This allows you to customize your view to include not only wildfire hazard zones similar to the WHP map which can additionally be broken down to wildfire risk and wildfire threat, but also other important layers such as WUI perimeters, for example. These layers for Arizona include six categories:

- Wildfire (wildfire risk, wildfire threat)

- Values Impacted (aggregate value impacts, wildland development area impacts),
- Landscape Characteristics (vegetation, wildland development areas (WUI)),
- Historical Fire Occurrence (fire occurrence density, location specific ignitions, ignitions & fire occurrence density),
- Basemaps (light gray map, aerial, streets, ESRI Topographic), and
- Reference (county boundaries, city boundaries, congressional districts, land ownership or management, Firewise Communities, local fire services, public land survey, historic fire perimeters, CWPP Areas).

WUI Development Areas (WDA) housing density is broken down into 9 brackets by color legend:

Not in WDA		**1 house /10 acres to 1 house /5 acres**	
Urban not in WDA		**1 house /5 acres to 1 house /2 acres**	
Less than 1 house /40 acres		**1 house /2 acres to 3 houses /acre**	
1 house /40 acres to 1 house /20 acres		**More than 3 houses /acre**	
1 house /20 acres to 1 house /10 acres			

Fire Occurrence Areas

These layers showing the types of detail as illustrated in the following examples, are accessed by clicking on the [MAP THEMES] menu button.

Figure 19 Color ramp used for WWA classes. Value breaks shown here are for FOA, specifically

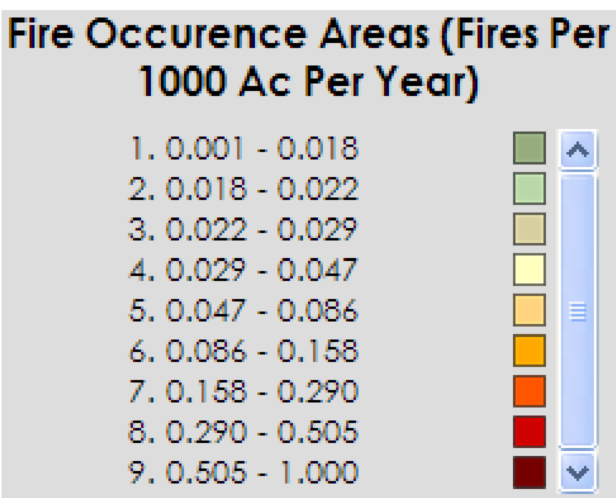
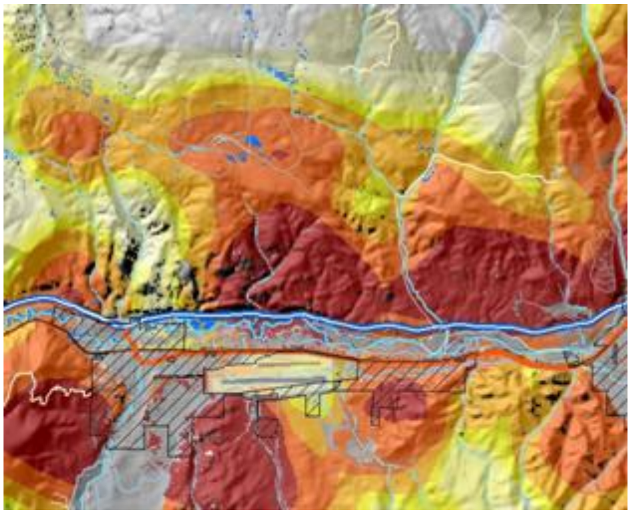


Figure 20 Fire Occurrence Areas



The [ASSESS YOUR LOCATION] menu allows you to select an area at the center of the screen and produce a report including a graphic of the portion of the map in the center circle. This report will be formatted as a PDF document for printing and future reference. The WRAP map reflects fire threats and occurrences to greater detail than the WHP map.

Some western states using the same WRAP database may include more or less overlay views. For example, the Utah WRAP shows more types of assets than Arizona and expands other categories as well. The additional items and categories are highlighted in **green** below. Some items highlighted in *yellow* were listed in Arizona and either omitted or renamed / repositioned in Utah in this composite view now with eight categories:

- Wildfire (wildfire risk, wildfire threat, **wildfire effects**)
- Values Impacts (aggregate value, wildland development area, **forest assets**, **riparian assets** and **drinking water**),
- Landscape Characteristics (**surface fuels**, vegetation, wildland development areas (WUI), **forest assets**, **riparian assets** and **drinking water assets**),
- **Wildfire Behavior (rate of spread – expected, flame length – expected, probability of canopy fire)**
- Historical Fire Occurrence (fire occurrence density, location specific ignitions, ignitions & fire occurrence density),).
- **Boundaries (land ownership or management),**
- Basemaps (light gray map, aerial, streets, ESRI Topographic), and
- Reference (county boundaries, FFSL areas, *city boundaries*, congressional districts, **municipal boundaries**, *land ownership or management*, **FFSL Fuels Projects**, *Firewise Communities*, *local fire services*, **fire stations**, public land survey, historic fire perimeters, CWPP Areas

To see all potential categories and layers, visit the final report from the source, West Wide Wildfire Assessment. Similar map services can also be accessed for Oregon, Washington, Nevada, Texas, Wyoming and other states, although the format varies in some states. California has an array of wildfire hazard maps by county to help with planning, as well as a statewide Communities At Risk From Wildfire map which is dated April 9, 2001, but not with the overlay selections like the WRAP system. There are ample geographic data to identify regions potentially in need of lithoshield systems in all parts of the U.S.. To establish specific placements and designs requires rolling up our sleeves and gathering a local consensus.

Standards

With sufficient and conclusive testing results as appropriate for the questions above and other questions that may be posed by investigators, new standards and guidelines may be suggested. No groundbreaking shovels should be pitched into the earth until we are all confident that lithoshield structures as proposed, or otherwise designed and tested by duly qualified investigators, offer significant benefits beyond their costs when appropriately designed, placed and installed. Standards and codes also depend on jurisdictions.

NFPA Standard 1144, Standard for Reducing Structure Ignition Hazards from Wildland Fire, and NFPA 1141, Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas, address hazards to structures at the wildland interface and appropriate mitigation measures (NFPA, 2013; 2012). Understanding the potential benefits of lithoshield systems and their contribution to mitigate fire risk will help inform future editions of these NFPA standards.

California Wildfire Standards

In California, in the aftermath of horrific wildfire disasters such as the Thomas fire, a story by NPR in December, 2018, reports that even the most recent wildfire safety standards for very high wildfire risk areas have shown vulnerability: “The current California wildland fire codes may also have weaknesses, according to Morelli. They don't cover wooden sheds, carports, or backyard play structures, which can ignite, sending embers towards the house. Nor do they cover skylights that open outwards. And garage doors aren't as fire-resistant as they could be, meaning embers can get sucked underneath them, igniting whatever is inside.” Ventura city Fire Marshal Joe Morelli thinks topography played a role: *The narrow valley that Andorra Lane sits in may have acted as a wind tunnel, funneling embers towards the houses.* "Really what we had was something like a blow torch going through our city," Morelli said. "And even with the fire-resistant construction standards you can still have loss. They're not fireproof standards." *According to CalFire data, 80 percent of houses destroyed in the Thomas Fire had fire-resistant exteriors. And 90 percent had fire-resistant roofs.*

Excessive fuel-vegetation removal can also increase the threat of embers spreading in greater quantities and speeds, according to environmental groups such as the California Chaparral Institute, Sierra Club California, John Muir Project, Endangered Habitats League, Center for Biological Diversity, Friends of Hellhole Canyon, The Chaparral Lands Conservancy, Los Angeles Audubon, Urban Creeks Council, Sequoia ForestKeeper, Earth Research Institute at UCSB, The Urban Wildlands Group, Friends of Harbors, Beaches and Parks, S. Oregon Prescribed Fire Network, Environmental Protection Information Center, Los Padres ForestWatch, and Battle Creek Alliance, in a letter recently (February 25, 2019) addressed to CAL-Fire. This letter references the documented histories of wildfires in California and questions the Notice of Preparation (NOP) action by CAL-Fire to continue the same unsuccessful wildfire protection practices:

> *Despite overwhelming evidence that embers, flying more than a mile ahead of the fire front, are responsible for igniting communities far from wildland areas, the NOP is focusing on the same vegetation treatment strategies that do next to nothing to protect us from wind-driven wildfires. Coffey Park during the Tubbs Fire presents a classic example - embers blew over at least a mile of suburban development and vacant land, in addition to 300 feet of roadway (Highway 101), before igniting the community. This story has been repeated over and over again since the 2003 Cedar Fire in San Diego County. To justify the distant treatments of heavy fuels, some have claimed such treatments will significantly reduce the volume of embers hitting communities. Such a claim is unsupported by research and highly questionable, especially considering the production of embers during fast moving grass fires.*
>
> …
>
> ***The Board, Cal Fire, and the State of California must reexamine the fundamental assumptions about wildland fire to enable it to better protect Californians.*** *It needs to be recognized that the fire threat is not miles away in forests, but within heavily populated suburban environments. We must accept the fact that like earthquakes, we cannot stop wildfires, but we can certainly limit the damage they cause. Unless wildland firefighting assumptions are reexamined and changed to adjust to our changing environment, the types of wildfire disasters we have faced since the 2003 Cedar Fire will continue. In fact, the NOP's approach will likely increase the flammability of the landscape by:*
>
> > *1. Focusing on forested areas far from where California's most devastating fires occur (Fig.1).*
> > *2. Facilitating the movement of embers toward homes through unwise clearance projects (Fig. 2).*
> > *3. Increasing the amount of flashy fuels (non-native grasses and weeds) (Fig. 3).*
> > *4. Increasing fire rate of spread by opening up forests (Figs. 4 and 5).*
> > *5. Failing to address the most dangerous accumulation of dead fuels – homes (Fig. 6).*

Our concern about vegetation clearance is in full accord with the positions of these environmental groups. In addition, we argue that any brush clearance that uses prescribed burning is hazardous and contributes to global warming. Fighting fire with fire is no longer a sustainable option in this age of climate change as discussed above in Seasonal Prescribed Burning. *Prescribed burning should be prohibited entirely in California, or at least confined to areas safely remote from housing.*

Despite such dangers and environmental risks, CAL-Fire includes prescribed burning in the vegetation treatment plan (CalVTP), as well as manual activities, mechanical activities, prescribed herbivory (beneficial grazing or browsing), and targeted ground application of herbicides: *These activities are proposed to be used singularly or in combination, depending upon the treatment type and environmental considerations*. The plan also describes a special focus on WUI protection:

> *As environmental conditions become more conducive to larger and more severe wildfires, development in the wildland-urban interface (WUI) is also on the rise. A 2018 study indicates that the number of houses in the WUI increased nationwide by 41 percent between 1990 and 2010. In response to these changing environmental conditions and the increased risk to California's citizens, Governor Brown issued EO B-52-18, which mandates an increase in the pace and scale of fire fuel treatment programs to reduce wildfire risk. The proposed CalVTP is one tool*

intended to address Governor Brown's mandate to increase the pace and scale of fire fuel reduction efforts across the state.

The metaphors of a *blow torch* and *wind tunnel* by Fire Chief Morelli in describing the fire that devastated a narrow valley of the Thomas Fire emphasizes the need to control both wind and heat that incubate firebrands, which we analyze in Firebrand Incubator. So far, the notion of *Can't see the forest for the trees*, may be a paradigm for ***Can't see the wind for the flames***. We are so blinded by the flames that we ignore the many opportunities available to mitigate the winds that propel devastating heat, flames and firebrands to our neighborhoods. For example, metal windbreak fences in the narrow valley that became a wind tunnel in the Thomas Fire, could have significantly reduced the wind speeds and also filtered out most of the firebrands. *Bad science - no science*. Bad forestry protection practice. Bad public safety practice. Misspent emergency dollars. Poorly managed urban planning and development. Unfortunately, even our independent scientists and environmental experts offer little to no leadership in this arena. Bluntly stated: *We need to invest in our wildfire safety infrastructure to directly baffle winds, filter firebrands and quench heat. The sooner, the better.* ***Firebreaks are useless ornaments in wind-driven wildfires, unless they are coupled with comprehensive lithoshields or metallic windbreaks-emberbreaks. This is obvious, but we continue to foolishly follow our traditional modus operandi because the funding is available to treat wildland fuels and clean out firebreaks. Maybe we should ask for funds for projects that may really make a difference?***

WUI Perimeter High Risk Zones

Areas at the perimeters of wildlands with high wildfire risks perhaps should be given a special coding requirement, going beyond the "hillside" status or simple "WUI", for example, and perhaps labelled a "WUI Perimeter High Risk Zone". This zoning would be intended not only to protect nearby developments, but also for the defense of the wildlands themselves, including important ecological assets, especially since we estimate that 68-70 percent of wildfires are ignited by humans ***mostly within or proximate to the WUI.*** The basic qualifications for this zoning are:

1) Within the WUI,
2) High fire risk or very high fire risk, and
3) Proximity to, or embedded within wildlands perimeter.

For the benefit of improved safety, such coding standards may include various restrictions regarding: debris burning, backyard barbeques, the types of equipment that may be used in land maintenance and construction, for example, as well as the use or possession of fireworks and some other incendiary devices commonly used in arson, regardless of the season. Larger lots and expanded defensive space may also be required, as well as higher fire resistance ratings for roofing and building materials.

To make this extra safety zoning more meaningful and effective, the perimeter *proximity* qualifier should be defined very narrowly to only one or two blocks or 1,000-2,000 feet from the wildlands, depending on the local geography and street layout. If and whence such areas are accorded special standard designation, including them in WFP and WRAP maps would be of vital importance for all stakeholders involved.

Micro Perimeter Proximity Exception

For WUI areas without clearly defined wildland perimeters, such as those with housing intermingled with forests and grasslands, the entire area may be included for special zoning as long as high fire risks are assessed. This logic for inclusion is based on the view that each housing location has its own specific and possibly private perimeter or *micro perimeter* within the wildlands. This exception, however, may preclude the options to consider lithoshield location standards for dense housing communities discussed below. The label ***Micro Perimeter Proximity Exception*** may signify this type of scenario.

Minimum Lithoshield Configuration

The *micro perimeter proximity exception* also raises the question of whether there may be some type of lithoshield design that may be more precise and affordable and yet offer a significant amount of protection even for isolated single houses or several improvements within an acre or two? The minimum design configuration we recommend in this case would require a physical structure with both a subterranean heat sink and horizontal heat flue that would extend around most of the property or at least those sides with greater risk exposure. Of course, other components, if affordable, would significantly improve safety, especially the superior sprinkler system, for example. The number of robotic nozzles may also be scaled down to reduce costs, however at least two nozzles would be necessary on opposite corners of a small lot and four or more would offer significantly greater protection for larger lots. Adequate water pressure is a must, as well.

This may be referred to as the ***Minimum Lithoshield Configuration***. The height dimensions would apply to the expectation of extreme risks of crowning, requiring taller structures. Even with a tall wall, however, it's questionable that adequate safety may be provided for a small improved lot in the midst of towering forest trees. In this scenario, the strategy may be to skimp on the wall, based on the terrain, and invest in a beefed-up sprinkler system with at least four high-powered robotic nozzles. To wrap a wall around several edges of a hillside lot, various architectural profiles and combinations should be designed for maximum heat quenching capabilities.

Barebones Lithoshield

It's also possible to build a practical lithoshield with a heat flue sans heat sink, but a heat sink without a heat flue above would not be functional. For terrains that cannot practically accommodate a heat sink, including some steep rocky cliffs, for example, *a lithoshield with a good inclined overhang supporting a lateral heat flue may provide considerably more protection than an otherwise unadorned nonflammable masonry barrier by itself, as long as it includes a singular exhaust vent at the highest point*. The overhang and heat flue should extend for at least 4-5 feet towards the wildlands and be shaped like an arch to capture as much heat and flames as possible. The arch may alternatively be designed like a giant question mark for more structural balance and stability. *Please see Barebones archetype sketch*.

A level heat flue on a level wall simply won't do the job, because the heat has nowhere else to go but straight up! This will result in heat and flames simply rolling over the wall pushed by the winds collateral to the fire. See architectural profiles for more options. There might also be a way for someone to build some type of prefabricated heat flue ensemble that could be designed for this purpose and simply attached to the top of a wall with adequate dimensions. Due to the overhang, some type of buttress would be required for added support, as well. In this scenario, a couple of robotic nozzles is also highly recommended as discussed in roadway integration. Call this the *barebones lithoshield*. Like buying a commuter car without a spare tire. Risky, but better than nothing while balancing risks against budget.

Lithoshield Location Assessment

Looking at Fire Occurrence Areas maps, those areas with the highest risk, have, on average, nearly one fire per 1,000 acres every two years (0.505 – 1.000 per year). The next highest level is about half this frequency (logarithmic scale) of one fire per 1,000 acres every four years (0.290 – 0.505 per year). ***In these areas, it's not a question of IF, it's simply a stochastic expectation of WHEN the next fire will occur.*** Protecting high risk areas will also indirectly protect those medium and low risk areas radially adjacent. Clearly, the cost of installing these lithoshields in these areas will be put to good use on a frequent basis. ***Although we may not prevent these fires from ignition, the lithoshields will potentially reduce the acreage burnt considerably and confine it to areas we determine by the placement of our lithoshield barriers.*** If our housing developments are adequately protected by the lithoshields, we can also free up more firefighting resources to focus on containing the fire fronts or spot fires more distant in the wildlands or other emergencies in the region.

It's a choice between digging out firebreaks after the damage is already done, or installing lithoshields to protect valuable assets in advance, when fires are anticipated at least once every four years? And, what does climate change do to these odds?

These heightened safety criteria for mapping out special zones may be a little too broad for assessing optimum placement criteria for our proposed wildfire lithoshield systems, however. We can't simply seal off the entire perimeter of the wildlands in high risk areas. For example, there's not much bang for the buck in building a wall along a development community with only one house per five acres, even if it qualifies as high fire risk, due to the extreme wall length per residence ratio. But, if the property owners or developers want to build their own lithoshields, whether required or not, the standards and technical specifications that are applicable may be of benefit to their own interests. *Construction standards for lithoshields may also be of importance in many areas with lesser levels of wildfire risks for added security or in anticipation of future global warming hazards. Other areas with high wind and fire hazards outside the WUI, may also benefit by installing similar structures, as appropriate.*

The next step in this assessment may be to establish parameters to refine these criteria to meet more conservative housing density levels and strategic topographies, for example. Once costs per linear foot are determined, priorities for each county or state based on regional interests, assets and threats of most concern should govern policy.

The Noise Control Act of 1971 requires state governments to build sound barriers in between highways and housing ***only when new freeways are built or existing freeways are expanded or realigned***. If a similar *wildfire safety policy* for lithoshield construction on public lands is established, it may require compliance with appropriate standards for new housing developments in designated areas with partial subsidies from the federal dole managed by the state. The historical rate of housing expansion in the WUI over recent decades will predict hundreds of thousands of new homes in the WUI each year for the foreseeable future, with at least a significant portion bound within the designated high fire risk perimeter.

Wildland Perimeter Protected Areas

As a complement to the WUI Perimeter High Risk Zones, a similar special protected zone on the other side of the perimeter border may help to focus on special measures and resources to protect the wildlands internally, which may be designated as "Wildland Perimeter Protected Areas". Here we ask, ***what can we do within the wildlands internally at the edge of the WUI that can provide more protection from threats generated by the behavior of people within the WUI, in addition to the wildfire lithoshield systems proposed at the perimeter or other existing defenses?*** We have already described focused thinning near the proposed concrete lithoshield structures at the perimeter, but, should we look more deeply, as well?

Since about 70 percent of wildfires are initiated in these areas or pass through them, high fire risk zones may demand even more attention than other wildlands. More thinning and expanded firebreaks are obvious steps in the right direction. This discussion goes beyond the focus of this proposal, so we will leave this on the table for more analysis and investigation by others in the future. Some of the questions to consider may be:

1) How deep in area within the wildlands beyond the perimeter should these zones encompass?
2) What are the primary objectives to accomplish in these zones to differentiate from other areas?
3) Should strategies be more proactive or defensive?
4) Should more budget and resources be devoted to these zones, and if so, what goals and timetables should be set to justify additional investments?
5) Should lithoshield systems also be considered beyond the perimeter and into the interior to go a step further than the laborious benefits of firebreaks?
6) Should adding a few wind turbines on mountain crests in strategic locations be another consideration to siphon off extreme mountain wave wind pressures and filter any firebrands in the area?
    a. Plugging such wind turbines into the power grid may also help to subsidize other safety infrastructure like firebreaks, lithoshields and thinning, as long as high standards of safety for power lines are maintained.
    b. Aside from aesthetic issues, bird and bat safety and other ecological issues also need to be considered, such as noise pollution, for example.
    c. Can a firebrand screen on a blade somehow be designed to protect birds and bats in some way – special sounds, lights, shapes, patterns, padding, webbing, netting?
    d. The small risk of wind turbine fires ignited by the wind turbines themselves may be mitigated by integrating a lithoshield with the wind turbine. The lithoshield will both protect the turbine from wildfires and protect the wildlands from the turbine.

This is not to infer that existing land management and fire fighting agencies do not already focus in some ways on these same implied objectives. But, even if they do, perhaps more formality and public awareness may help us all as citizen stakeholders, especially when a sense of panic is felt when we see red skies at night and ashes cover our sidewalks in the morning.

Strategic Mountain Crests & Valleys

Some mountain crests may have strategic value for wildfire protection even if they fall outside the zone of high fire risk or are neither proximate to WUI developments as outlined in strategic topographical *targets*. Due to the mountain wave effect, the hazards posed for the downside of the mountain may be significant within a considerable distance. To repeat this quote from Weather.gov: *Air flowing across a mountain range usually rises relatively smoothly up the slope of the range, but, once over the top, it pours down the other side with considerable force, bouncing up and down, creating eddies and turbulence and also* ***creating powerful vertical waves that may extend for great distances downwind of the mountain range****.* Mountain crests and valleys along the Sierra Nevadas in the domain of high pressure system Diablo winds also warrant special attention in remote areas that ***not only serve as radial conduits, but also help to intensify heat, accelerate wind speeds and evaporate moisture*** from warm winds across hundreds of miles to more proximate hills and valleys at lower altitudes in a type of *domino chain effect*.

Preemptive Tactics

Installing a mountain crest lithoshield on strategic locations not only will establish a reliable perimeter of protection when needed, but will also ***execute preemptive services year round*** *by reshaping wind and cooling air to significantly reduce the fire hazard risks downwind.* ***Interrupting the wind stream may break the domino chain resulting in a beneficial cascading failure or significant reduction of hot air wayward winds transmission down the line****.* The critical importance of cameras and communications antennae as well as observatories on certain mountain crests may also promote consideration for these locations to be included in the category of strategic mountain crests. Falling short of including all mountain crests as targets for lithoshield installations, we would argue for an examination of wildfire history and assets of concern in the strategic placement of lithoshields on mountain crests.

Wind turbines also reduce wind speed after converting the kinetic energy into electric power. ***Many of these same strategic mountain crests and valleys would serve as ideal locations for integrated lithoshield-wind turbine installations, as well.*** Several existing wind farms may already be located in strategic mountains and valleys that also feed Diablo winds and Santa Ana winds. These resources may simply be reconfigured or expanded to more effectively tag dangerous streams of warm wind headed towards the west coast or other vulnerable wildlands. ***An assessment of existing wind farms with this potential application capability would be of great value as well as an evaluation of how effectively they already help in mitigating dangerous winds as currently configured.***

Wind Control – Wind Dam

By reshaping and redirecting wind in various ways with lithoshields and wind turbines, we are controlling the wind much like the infrastructure that is devoted to control floods. We cannot completely stop the wind like a dam can block a stream of water. The weight of water makes it more vulnerable to control by simple dams. ***But, like a dam, we can use our engineered innovations to modulate the flow of wind to some extent and also convert the kinetic energy to electric power: a virtual wind dam.*** Both water and wind also flow uncontrollably above the terrain in clouds and hurricanes. The only control we can devise is at or near the surface of the earth where we need to focus our efforts strategically to protect our land-based resources, forests, farms, homes, buildings and infrastructure. Mountains and ravines are strategically significant locations in the control of both floods and excessive winds. Unlike water, however, excessive winds and gales also proliferate in great plains and deserts. Flash floods, an important exception.

Wind is an essential element of our ecology, vital for pollination and delivering fresh air as well as providing a means of navigation for some of our most ancient feathered species. But nature, at times, can deliver both wind and water in ways that can be very harmful to the environment and human survival, especially at times of extreme climate changes.

Great Plains

East of the Rocky Mountains, many grasslands and plains provide available wind power and likewise embrace both wind farms and wildfires, as described in this study about increasing wildfires in the Great Plains in Nebraska. It doesn't require mountains to cause hazardous winds in the Great Plains and similar areas further south including Texas, for example. ***These windy plains also become strategic locations where existing wind farms may be reconfigured and repurposed to preemptively control wayward winds and firebrands that often cause wildfires or their expansion as shown in this scene in Australia.*** *A few lithoshields in strategic locations may help to* ***confine vast wildfires in the plains****, as well, and control the hazardous winds in a* ***preemptive*** *manner.*

Big Data Integration

The sensory systems, heat sensors, AV cameras and thermal infrared cameras of our lithoshields provide vital information data bits that should be integrated with regional and global networks including satellite sources and weather forecasting in a multi-directional system. We need to anticipate the possibility that something like our proposed lithoshields may become a reality in more than one country and more than one hemisphere. How can we standardize these data exchanges to synchronize all the stakeholders in a functional, safe, secure, accessible and efficient manner?

The Internet Cloud should hopefully become a resourceful cloud that rains critical weather and wildfire hazards information to benefit all communities down to the wireless level of personal cell phones. For those of us on the west coast, wouldn't it would be great to get earthquake warnings and wildfire evacuation alerts on the same system through our mobile phones? Why not plug these mobile phones into the input stream of visual data to update the big picture of wildfire activity, as well? Wireless bandwidth and software for this type of connectivity also needs to be ample and standardized.

Mobile 3D Heat Containment

Although mobile heat control over large areas of space is a challenging conjecture, we pose this question as a possibility for future discussion. Although we can successfully seed rain clouds, we cannot move them to our wildfire skies. We can pour large volumes of water from the sky, but water resources are limited by available resources and costs, and need to be focused on the fire front at ground level.

One strategy may be to draw a 3D line in the sky ahead of the fire front where we can focus our efforts to contain the heat in the air. What else can we throw into this space besides water? Something that converts heat energy into kinetic energy? Some type of synthetic popcorn that expands with heat to absorb calories but will not combust comes to mind. How about if it also consumes oxygen in a safe manner, to reduce the oxygen available to advancing fires? As documented by NASA, low-temperature oxidation innovations are being used for several applications today, such as smokestack emission remediation and indoor air treatment. Wishful thinking, again. A bad habit. But, let's continue.

Since this type of particle requires heat to be useful, the containment line needs to be close enough to the front to access this energy. Our mobile containment line may move like a battle front that advances or retreats strategically. For ecological considerations, maybe we can genetically modify natural corn for a strain that can do what we need with economical advantages? It might be fun to see kernels of corn popping in the air before a fire front, as long as they don't also burn up when the fire approaches. Let these questions glare in the minds of our scientists and engineers for future development. A very tall curtain call for fire fronts, or heat fronts, more specifically. *Maybe we need to put on our infrared goggles to appreciate this problem even better, and the opportunities it suggests?* It's a challenge.

Thermal Infrared Imaging

Figure 21 Forest fire, thermal and RGB camera side-by-side

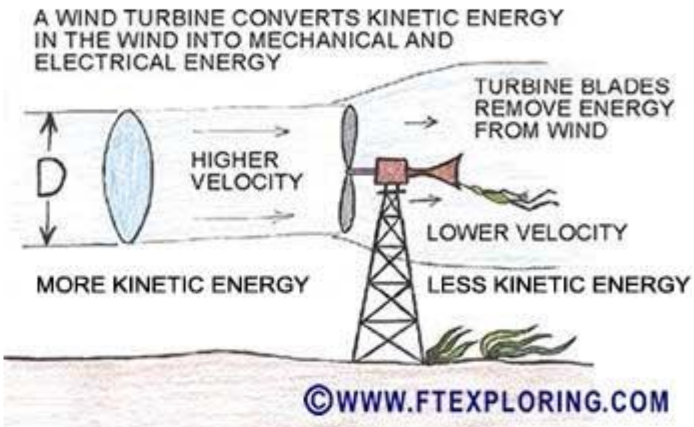
As shown in this image and in documentary videos, live thermal infrared imaging has been used successfully to identify hidden hot spots for tactical targeting, but it has not been used so far for assaulting separate volumes of heat directly. On the right side of the image, several large masses of volatile heat pockets are revealed over the crest before the advancing fire front that feeds such heat pockets with torrents of heat. The RGB camera to the left obscures these heat masses with smoke and vegetation. Notice the linear alinement of these pockets in the distance which reveals their source of energy. This is a good example of the type of extreme fire hazard risk in mountainous areas described above.

These observations suggest a couple of obvious opportunities. One, dump water, fire retardants or other heat sucking materials over the looming hot pockets to stifle anticipated explosions that will advance the fire front. Two, let's assume that if we had built our proposed lithoshields at the crest of the mountains in advance, the heat may have been baffled at the front before it rolled over the mountains in a preemptive tactic. In the meantime, let's do some more scientific studies with thermal infrared images, including image data from NASA and Google Earth to more thoroughly investigate the dynamics of heat accumulation and pathways to augment wildfire fronts advancement and ultimate 3D fire and heat mitigation and containment.

Wildfire simulator models should also be enhanced to forecast the potential impact of directly quenching not only the main fire fronts, but also pockets of heat separate from fire fronts, in addition to the benefits of installing lithoshield systems and alternatives in strategic locations.

Wind tunnel tests of mountain crest models would also be useful for measuring wind dynamics and mountain wave effects for different shapes and sizes of mountain crests and valleys, as well as the potential impact of lithoshields of various shapes and sizes imposed on mountain crests. The goal is to determine the most effective shape and size of structures imposed on a mountain crest to curtail the mountain wave vacuum effect on the downward slope at different wind speeds. Ideally, most of the advancing wind and heat will dissipate vertically along the unsurmountable lithoshield and leave the downgrade air space unperturbed.

Multipurpose Wind Turbines

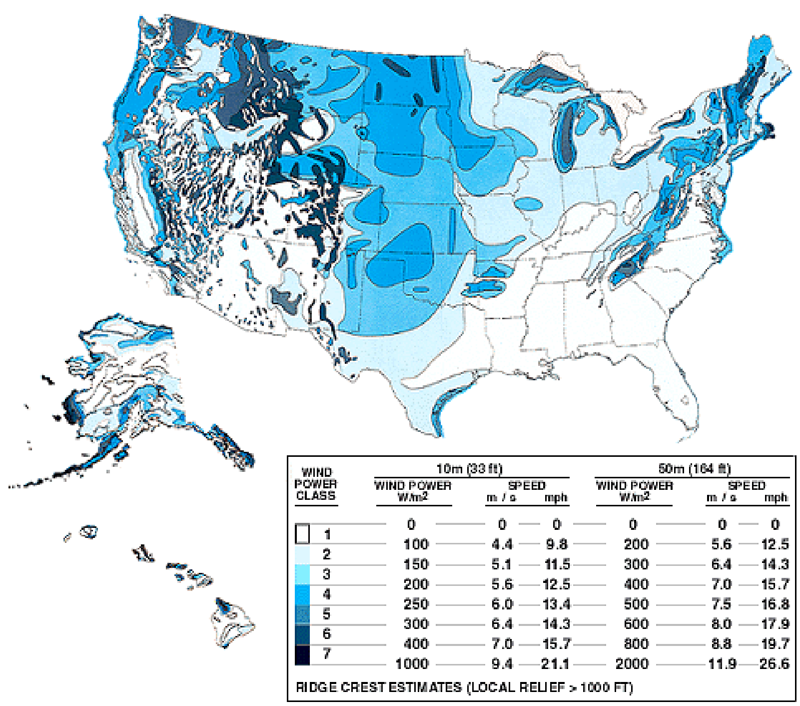


Clean energy is a major resource provided by wind turbines, but here we ask: *Can the same wind turbines on a mountain top or slope also help to reduce the mountain wave vacuum effect that magnifies dangerous downdrafts in wildfires, if placed in strategic locations?* If so, can we also include firebrand screens that will extend along the blades when needed? Many wildfire high-risk areas enjoy the topography that generates substantial wind energy potential (see map below), often to their detriment. Some of that risk can be turned around, however, with a little bit of creative engineering. By well designed tweaking here and there, and strategically placed arrays of wind turbines, we should be able to:

1. ***Reduce dangerous winds and heat dampened by turbine blades,***
2. ***filter volatile firebrands with extendable screens on blades and***
3. ***create clean energy even while firebrand screens are extended.***

All in one neat machine that pays for its own keep on the energy grid! Some of these turbines may also be positioned behind lithoshields for added wind and firebrand control and protection by the lithoshield. The ultimate solution! Please see ***<u>Wind Turbine Integration</u>*** ***above.***

Figure 22 Map of available wind power over the United States in 2008. Color codes indicate wind power density class. Click for more details.



Jurisdictions

Different jurisdictions have their own responsibility and authority in related matters. For example, Federal land jurisdictions include the Bureau of Indian Affairs, Bureau of Land Management, Bureau of Reclamation, Department of Defense, Fish and Wildlife Service, Forest Service, National Park Service, Tennessee Valley Authority and other agencies. However, the US Forest Service alone manages 193 million acres (780,000 km^2) nationwide, or roughly 8% of the total land area in the United States. Any proposed lithoshield structure on federal lands would most likely necessitate the approval, if not funding support by the US Forest Service. This agency will hopefully play a key role in testing the design of lithoshield structures on their managed lands, as well, since many WUI developments in hazardous areas lie adjacent to federal lands.

The same responsibility applies to lands owned and managed by states, especially those with a preponderance of wildfires involving WUI areas, which include most states in the west and other states scattered around the country, including Florida, for example. Each state has a lot to gain by a successful implementation of wildfire lithoshield systems if they are proven to fulfill their promise.

Heat & Wind Suppression Planning

To initiate responsible planning to devote resources specifically to address untreated collateral wildfire heat and wind suppression and mitigation in distinction from direct fire suppression and containment, an initial step of preplanning may be necessary to build an assessment of the problem dimensions. Here we propose that those responsible for public safety at the highest levels begin a process to ***establish a credible knowledgebase*** either through academic research, scientific investigation and / or internal audits to determine:

1. How many dangerous heat and wind vectors and locations, including hotspots, generated by or collateral to wildfires in proximate or distant spaces in quantitative measures historically remain untreated especially at critical moments and places in the sequence of events by current practices of fire suppression and containment?
2. What types of assets currently available are capable of suppressing untreated heat and wind to a significant degree?
3. What strategic benefits can be potentially gained by focusing directly on pockets of heat and streams of wind at various altitudes in the air or in other places currently left unchecked at critical moments and places in the sequence of event by current fire suppression and containment assets and tactics?
4. What strategic benefits can be potentially gained by preemptive measures to mitigate periodic or sustained dangerous heat and winds from known topographical and meteorological sources such as *wayward winds*, possibly at considerable distances from current emergencies and vulnerable assets of value, and what specific tools may be applied to this aim?
5. Which specific mountain ridges and crests along the Sierra Nevada mountain range and other mountains in California and other western states can be mapped as strategically significant targets for the deployment of protective means such as lithoshields and repurposed wind turbines?
6. Preemptive tactics such as seasonal prescribed burning may need to be reevaluated with respect to added risks related to climate change. An assessment of the incidence of accidental

control failure over recent decades is needed to establish a baseline of what additional risks may be anticipated. A clear line of responsibility for making decisions to initiate prescribed burning may need to be accelerated to the highest levels of command. Standards for determining adequate safety and expected objectives to accomplish in justification of risks need to be scrutinized and clarified among all those responsible for execution and all related stakeholders, as well.

7. What steps are necessary and what timeline is reasonable to move ahead with realistic goals in tackling potential problems and opportunities identified in this agenda?

Selected WUI wildfires research published titles.

5) When Do You Need Project Deliverables (when is information needed to coordinate with document revision cycles or other deadlines, sense of urgency):

Forecast

In the near future, we may forecast more global warming and more wildfires with alarming dimensions. In California, it is expected that the average area burned by wildfires will increase 77 percent by 2100, and the frequency of extreme wildfires—those that burn more than 25,000 acres—will increase by nearly 50 percent under a scenario with high global greenhouse gas emissions. Across the states, climate changes will increase risks in different ways, based on micro climates, with higher risks spread widely in the west, mostly driven by winds, heat and mountainous topography, as well as the rain shadow east of the Rockies and Sierra Nevada.

The expansion of WUI land developments will continue to grow throughout the western states and the entire country with straight-line rates or even greater. Average yearly housing increases in the WUI over the past two decades have ranged around 500K to 700K. Many of the new developments will, optimistically, include the addition of wildfire lithoshield systems, which may become as common as the ubiquitous noise-abatement walls or sound walls that adorn so many of our freeways, that is, if this proposal moves forward and the results are positive.

An increase in housing protected by wildfire lithoshield systems may also yield commensurate reductions in property losses and insurance costs. Such savings may help to offset possible increased housing prices due to market pressures in these protected areas, much like gated communities with enhanced security on all sides. Outside the walls and gates, more homeless people in the WUBoonies may find obscure niches squatting in makeshift shelters, unless more affordable housing is also developed with secure standards.

Soundwall History

It's helpful to recognize that we all bear the costs of sound walls in the form of taxes, even though in some cases we would prefer to see the city views or landscape views that are hidden by some walls, and most of us passers-by don't either benefit from the walls. It's for safety. It's for health, protecting our peace of mind, if nothing else. But, sound walls didn't always exist on our freeways.

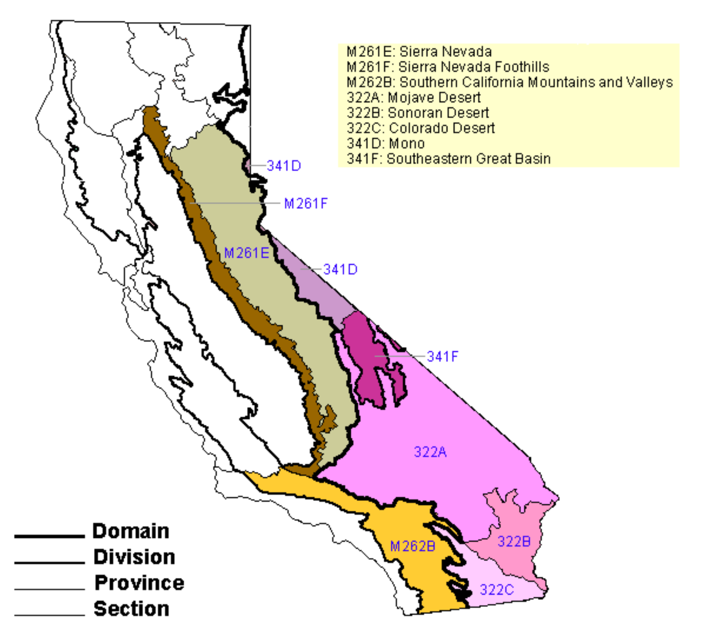
As documented in Reform, in 1968 the California Department of Public Works built what is believed to be the first sound wall along a freeway on a stretch of Interstate 680 in the city of Milpitas. The passage of the National Environmental Policy Act in 1969 helped to legitimize concerns related to development and urban growth, including freeway noise. That led to the creation of the Noise Control Act of 1972, which aims to "promote an environment for all Americans free from noise that jeopardizes their health or welfare." As a result, freeway sound walls began to spread.

Since the first sound walls were built in California in the 1960s, they've risen all over the country, with dimensions up to 20 feet tall. According to the Federal Highway Administration, as of 2010, there were 2,748 linear miles of noise barriers built with federal money along highways in the U.S. — though that number is certainly even larger now. Sound walls stand in every part of the country, except for Alabama, Rhode Island, South Dakota and the District of Columbia.

Pending Policies

Will it take a "Wildfire WUI Safety Act", like the Noise Control Act of 1972, to help finance and build concrete wildfire lithoshield systems on federal properties or other public lands adjacent to urban developments? This may be the time in our history when such a measure is begging for enactment. If not now, when?

Figure 23 Sierra Nevada and Desert Ecological Subsections in California



Absent any new *Wildfire WUI Safety Act* for funding, the opportunity to farm our wildlands for wind energy may be a judicial consideration for funds to bolster our infrastructure in times of need. Especially since they may provide a win-win arrangement to harness our Diablo winds and reduce the threat they pose every year. ***Can we harness the devil to save the City of Angels along with so many other vulnerable towns in the shadows of the Sierra Nevada?*** Ironically, the same massive Sierras that irrigate our fields in the winter, also char our forests in the summer with unrelenting sunbaked winds. *And now we propose to nickel and dime them for wind power, as well!*

The Noise Control Act requires state governments to build sound barriers in between highways and housing only when new freeways are built or existing freeways are expanded or realigned. For those residential areas not covered by the law, housing developers often build their own sound walls to reduce the impact of nearby noise. Likewise, we may predict that housing developers will dip into their own pockets to enhance obvious safety features like wildfire lithoshield systems in the hot market of WUI developments, *especially if appropriate standards are established* and any of their competitors offer such amenities. Consumers will likely learn to expect improved safety while awareness and education advance in this arena. Glaring wildfire headlines in the news and social media will likely address question regarding the need for adequate protection.

National Security Risk

Since we know that the majority of wildfires are ignited by humans, either accidentally or intentionally, there is also the possibility that domestic terrorists or foreign proxies may secretly play a hand in this form of arson called pyroterrorism. Perhaps they have already done so? The arsonists responsible for 21 percent of wildfires charted above may include a number of serial arsonists who may also be terrorists in kind or in fact. An estimated 68% of all incidents from every listed cause collectively were ignited in or near the Wildland-Urban Interface (WUI).

Wildfires represent a **heightened national security risk** for four reasons:

1. Wildfires are easy to ignite by a simple match or incendiary device, cigarette, flare, etc., which can also be concealed with a timed fuse, until the fire becomes large and dangerous. Simple rockets, such as common fireworks sold everywhere, can readily be launched into dry brush or natural fuels. Remotely controlled drones, which are increasingly more popular, relatively cheap and accessible, can also drop incendiary objects into more carefully selected targets. One simple match or discarded cigarette can cause millions of dollars of damage. The warmer winds and thereby more desiccated natural fuels are ready accomplices.
2. Assets at risk include our precious forests and housing, as well as many observatories, communication towers, radar antenna, wind turbines, water tanks and military defense assets that are strategically placed on mountains, hills, valleys and plains that happen to be vulnerable to wildfires. Needless to say, many residents and more firefighters are put at greater risk on the front lines on the ground and in the air, as well, as the devastated acreage increases year by year.
3. Added to the threat of domestic terrorists who may, in some cases, be mentally aberrant, as well as increasing numbers of homeless people who squat in or near the wildlands and who frequently start fires for cooking or to keep warm, there are also those who are motivated by groups like al Qaeda ***to engage in lone wolf attacks, including setting forest fires***, as discussed in an article in Wildfire Today.
4. Climate change could take a serious toll on the U.S. economy by expanding by 50 percent the area that wildfires burn —and raising projected damages by tens of billions of dollars a year by 2050, based on a study published by NRDC in 2014.

The Defense Advanced Research Projects Agency (DARPA) may have an interest in helping to develop wildfire protection systems like the wildfire lithoshield, even if it is deployed primarily to protect vital military resources, ammunition storage, radar antenna and weapon systems, as well as military bases, forts and troops, in areas vulnerable to wildfires. Planning and logistics by the U.S. Army Corps of Engineers would also be a critical asset.

In 2003, the Palomar Observatory, near San Diego, was threatened by wildfires and, under the auspices of NASA, was forced to close two observatory dome shutters in order to protect the Hale 200-inch telescope from airborne smoke and ash. In the same year, bushfires in January destroyed more than $40 million worth of facilities and equipment at the Mt. Stromlo Observatory in Australia, including five telescopes, workshops, an important heritage building and seven houses. A year later, 2004, in Safford, Arizona, a mountainside wildfire was within a quarter-mile of a $200 million mountaintop observatory, the Mount Graham International Observatory. Two fires were burning on the southern and western sides of the mountain and also threatened the Mount Graham communities of Columbine and Turkey Flat. The observatory's protection, including a sprinkler system, had been reinforced by strengthened protection lines and prescribed burns. Home to some of the world's most powerful telescopes, the observatory encompasses eight buildings and 8 1/2 acres of pine forest on Mount Graham's 10,470-foot Emerald Peak. Although its metal structures should withstand the flames, officials said smoke and heat could damage delicate instruments.

A year later, 2005, in the Santa Rita Mountains south of Tucson, Arizona, the Fred L. Whipple Observatory was threatened within a mile of the 20,000-plus acre wildfire that burned for more than 12 days. A blessing of rain helped to extinguish the conflagration before it damaged the approximately $100 million dollars worth of facilities and equipment located at the observatory, operated jointly by the Smithsonian Institute and the University of Arizona. It was recently upgraded with a new 6.5-meter mirror and a suite of powerful instruments, including the Megacam imager and Hectospec and Hectochelle spectrographs. A number of other telescopes share the Mount Hopkins site with the MMT. The Harvard-Smithsonian Center for Astrophysics (CfA) is a joint collaboration between the Smithsonian Astrophysical Observatory and the Harvard College Observatory. Also in 2005, several wildfires threatened the University of Texas McDonald Observatory in the Davis Mountains, which motivated local authorities to take protective steps in reducing fuels, such as high grass, brush and trees. Crews also put in firebreaks to stop the spread of an approaching fire and a new fire escape road was also constructed with the help of the Texas Fire Service.

The Griffith Park Observatory in Los Angeles, California, was threatened by wildfires several times in recent years including 2007, 2017 and 2018 (pictured in Mountain Crest Lithoshield). Evacuations were executed but no facilities were damaged in these incidents. Not far from Los Angeles, the Mt. Wilson Observatory was also threatened by wildfires and evacuated in 2009 and 2017. More than two dozen antenna towers cluster on the peak of Mt. Wilson. Hundreds of millions of dollars' worth of communications equipment are located in the area, including federal and county facilities used for emergency communications, commercial television facilities and radio transmitters. Damage to the communications towers could disrupt cellphones, television and radios, as well as interrupt some communications for emergency responders. Of historical significance, In 1929, Edwin Hubble used Mt. Wilson's 100-inch telescope, which turned 100 years old in 2017, to discover that the universe was expanding.

Ten years after the destructive Mt. Stromlo Observatory fire of 2003, in 2013 the Siding Spring Observatory in Australia's Warrumbungle National Park survived a bushfire that overran a portion of the observatory compound. Some support facilities and staff homes were destroyed. Siding Spring is the largest optical observatory in Australia and a major infrared observatory that is home to 10 operating telescopes run by international researchers. Many other valuable observatories as well as communications towers for commercial and scientific networks in mountainous areas throughout the United States and other parts of the world have also been threatened by wildfires or damaged nearly every year.

To protect so many valuable observatories, as well as critical communications towers and scientific resources located in mountainous areas, the same expertise that is used to safely carry astronauts back and forth through our atmosphere at tremendous speeds and temperatures almost routinely, can be applied to developing a shield, such as our proposed wildfire lithoshield system.

As our climate changes and Diablo winds increase, we need a comprehensive wildfire shield custom designed to protect our homes and other precious structures from wildfires in each terrain. NASA, which currently provides satellite views of wildfires and smoke, clearly may have a principal interest in this agenda, both in regards to assets to protect, as well as the needed scientific and engineering knowhow. It may take some political leadership to move the priority for this agenda ahead of landing more people on the moon or populating Mars, or to sandwich it in among other goals and objectives somehow.

Wall Construction Costs

According to the Federal Highway Administration, the average cost of building a sound wall is $30.78 per square foot; between 2008 and 2010 roughly $554 million worth of sound walls were built. About 75 percent of all noise barriers are built of either cinderblock or pre-cast concrete. These costs may serve as a rough guide to the costs of the concrete lithoshield systems we propose, but we can anticipate higher costs for walls with curvatures and other features such as the Superior Sprinkler System, subterranean heat sinks, horizontal heat flues and firebrand screens that may be added. The Department of Transportation in California estimates sound wall costs averages about $450 per linear foot or $2.4 million per mile. Freeway costs per mile vary by the number of lanes and numerous other factors, but generally are in multiple millions as documented by this study. This may help us anticipate the costs of concrete lithoshields to some extent.

Firefighting Costs

Compare these protective costs with those of actual firefighting. A Business Insider article in 2017 reports that the federal government spent more than $2.7 billion on firefighting in its most recently finished budget year, which far surpassed the previous high point of $2.1 billion set two years prior. States like California can also chew through several hundred millions from their emergency funds for fighting wildfires each year, and growing. Many costs of wildfires are also passed on to consumers, whether or not their property is directly damaged, such as through taxes and the cost of fire insurance, for example.

Outlook

Urban planning plays a key role in our outlook for the future. Global warming evidence in our environs alerts us to look for planning adjustments along our coastlines. FEMA is already buying out homes in New Jersey due to submerged foundations. Developments in tornado-prone regions and areas vulnerable to hurricanes, like the recent disasters of hurricane Florence in the Carolinas, also need to make appropriate adjustments, including more secure infrastructure and building codes and where to plan new developments. ***Through nature's lessons, we are reluctantly learning that a more sustainable infrastructure is not just a good investment, it's a necessity. ---For the times they are a-changin'--- From igloos to lithoshields. Each have their place and time.***

Whether or not the rebuild in the Carolinas will include a more sustainable power grid remains to be seen. Solving predictable flooding problems equal to or greater than that already seen in Houston and unfolding in the Carolinas as this text is penned, may require bold engineering solutions similar to those in flood-prone regions like those in Denmark, for example. In the west, as the acreage of scorched wildlands increases every year, traditional practices of seasonal prescribed burning should be reexamined and more sustainable infrastructure standards applied. In addition to risks, we know that deliberate burning on top of wildfires adds even more tons of CO_2 into our global greenhouse, only to accelerate global warming.

Planners and developers share a burden of responsibility for appreciating and protecting against the inherent hazards of developing land in these areas and along the perimeters of wildlands, as well. These agents are the players who set the table. Just because consumers are anxious to live in dangerous environments, does not compel our planners to accommodate such interests, unless adequate safeguards are in place. Urban planners and building safety monitors must also be able to check the compelling greed of some developers. Otherwise, the common costs of fire protection and insurance may simply go beyond our means, and become counter-productive.

Balance of Interests

A balance of interests and ecological equilibrium must be achieved and protected. Where possible, new technological solutions and infrastructure advances may provide amenities to expand our horizons. As adaptable our human species has proven to be over a hundred thousand years or so, we must also recognize our limits, as well, or suffer the consequences, especially when global warming is no longer in question. For those few holdouts who stubbornly refute global warming, let them put their money where their mouth is and invest in the threatened shores of New Jersey, Miami, Osaka, Alexandria, Rio de Janeiro or Shanghai. The writing is on the wall, though you may need a snorkel to read it.

Let's all hope for a smoke-free horizon.

Figure 24 Grant Pass, Oregon 2013

6) Designed By and Date Proposed:

Ray Cruz, Director
Ergonica
1107 Fair Oaks Ave, #887
South Pasadena, CA 91030

Email: ray.cruz@ergonica.com
Web: www.ergonica.com
Date: July 4, 2019