LIVING WITH FIRE

ECOLOGICAL FIRE-SAFE LANDSCAPING AND HOME DESIGN FOR CALIFORNIA'S URBAN-WILDLAND EDGE

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INTRODUCTION

For those of us that inhabit the urban-wildland edge, fire is a primary design consideration. It is inevitable that, at some point, fire will touch the landscape where we live. There is only so much we can control when a fire does come. It's the design, planning and preparation that precede the fire that will largely determine a home's survivability. As with most things, last minute preparations before the flames come are bound to be incomplete at best, and ineffective or dangerous at worst.

Figure I.1

The approximately 282,000 acre extent of the Thomas Fire that began in December 2017, and uprooted one of the authors for weeks as the fire swept through the canyon he lived and smoke filled the air. The Thomas Fire destroyed 1,063 structures, damaged 280 others, and caused over $2.2 billion dollars in damages, including $280 million in suppression costs.

This article explores the ideas and concepts of Regenerative Firescaping for the high fire danger urban-wildland edges throughout California. While written from our perspective living on California's Central Coast, the principles and strategies presented here are applicable across many different fire climates.

PART 1: PERSONAL RESPONSIBILITY, BASIC FIRE SCIENCE AND SITE SELECTION

REGENERATIVE FIRESCAPING: A NEW FIRE PARADIGM

So often the regulations that govern mainstream firescaping are interpreted in a way that pits human settlement against nature in an endless cycle of noisy weed wacking, brush removal, chipping and burning that is a HUGE drain on both private and public time, energy and financial resources. What if we could step off this hamster wheel by harmonizing with natural vegetation patterns and employing intelligent design to actually invite fire's renewal energy into our landscapes in a way that reduces risk to people, property and ecology?

We shall endeavor to do just that. Let's begin with identifying the broad, overarching patterns that serve to anchor the Regenerative Firescaping paradigm as we move forward.

Firstly, fire WILL happen - and needs to happen. Many ecosystems, such as prairie, savanna, chaparral and coniferous forests, have evolved with fire as an essential contributor to habitat vitality and renewal. Fires clear out the dead organic material that accumulates and prevents organisms within the soil from accessing nutrients, animals from accessing the soil, and plants from receiving the light or oxygen to germinate. The seeds from many plants in fire-affected environments actually require the heat from fire to germinate. Wildfire suppression not only eliminates these species, but also the animals that depend upon them.

Figure 1.1

The cyclical nature of a healthy fire ecology.

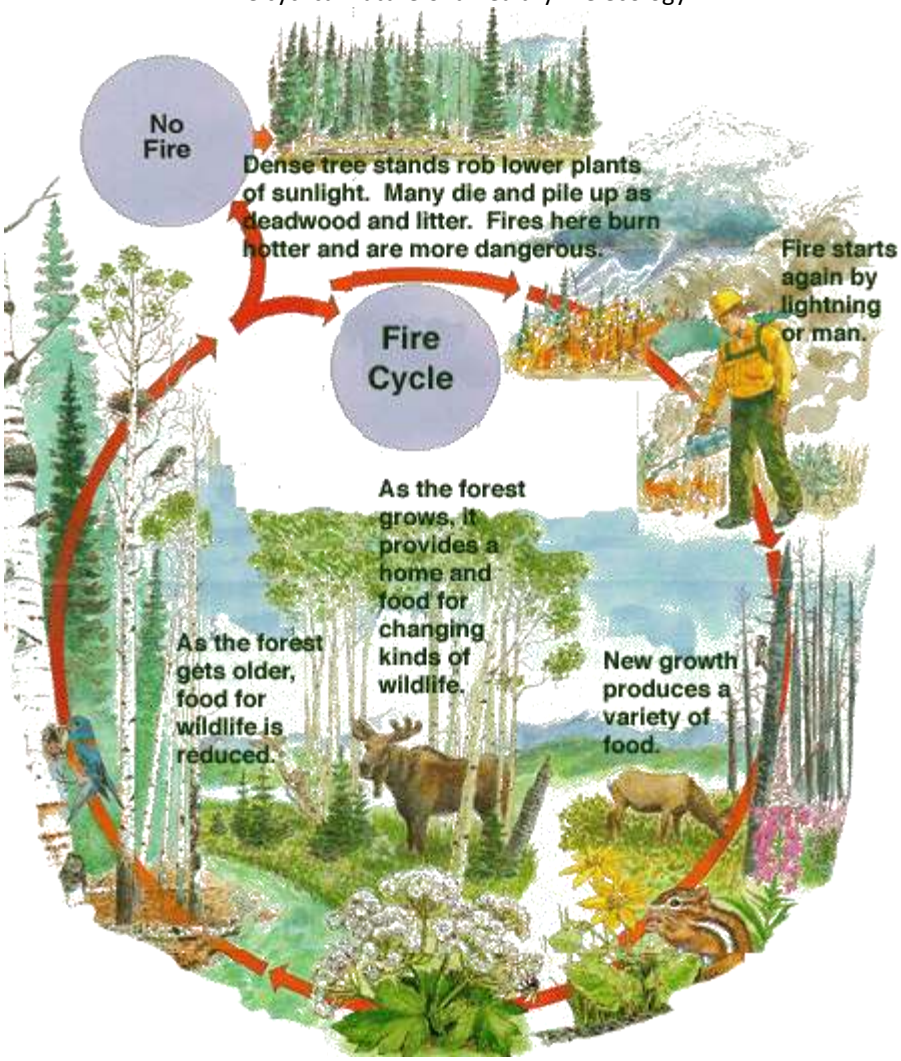


Figure 1.2

The seeds from many of the trees in California actually require fire to germinate, including those of the Lodgepole Pine shown here.

We can choose one of three ways to engage with fire; 1) to engage in year-round mowing, cutting, chipping, and burning to maintain a "defensible perimeter" (more on that later), 2) to do nothing and assume the fire department will protect our property (a big gamble), or 3) to accept, plan for and harmonize with it as one of the natural energetic cycles of the landscape in which we've chosen to live.

The first approach, to fight or suppress fire, works great… until it doesn't. It also costs a LOT of money, time and human energy. This is the expensive approach. The second approach is to abdicate personal responsibility and expect the fire department to protect one's personal property. While fire departments do an amazing job with limited resources doing direct structure protection during a fire, they cannot be everywhere at once, and their safety comes before protecting a home. This is the lazy approach.

Figure 1.3

The endless cycle of mowing is energetically, financially, and environmentally draining.

The third approach puts the onus of responsibility firmly on the individual homeowner and local communities to design, plan and prepare for fire's inevitable visit. This is where the greatest potential for reducing fire danger and damage lies, while simultaneously creating more beautiful and enjoyable places to live. We will spend the remainder of this article coming from this perspective (plenty has already been written detailing the faults of the first two approaches already).

Once we've accepted that fire WILL happen, we have to ask the following question: Of all the factors that influence my family's and my home's chances of surviving the next fire, which ones can I control and which can I not?

Let's start with what we can't control because that's often easier.

- **The weather** - Santa Ana winds blowing? 90 degrees and 3% humidity? Nothing to be done about that.
- **Other people** - We always endeavor to work with our neighbors and local community, especially anyone that we share property lines with, but ultimately, we can control only ourselves, our decisions and our actions.
- **Topography** - If a home is already built, we can't change the surrounding topography to reduce fire danger. If we are siting a home, we can choose where it sits amidst the topography to lessen the fire danger.
- **Public utilities** - Water and electricity service will often be suspended during a fire. If we are on the grid we need to plan for this as a likely scenario.
- **Fire outputs** - Heat and smoke will be present, and their presence must be planned for ahead of time. Potential consumption of available oxygen in immediate air mass following a high-intensity blow-over may also occur for a short period of time - this needs to be considered if forced to shelter in place.

- **Timing of the fire** - Murphy always plays his hand. We may not be present or capable of enacting fire protocols. What redundancies do we have?

Now let's list the things we can control to reduce risk to life and property during a fire.

- **Evacuation Planning** - Pre-planned routes, rally points, communication methods and places to stay. Pre-packed Go-Bags. Everything should be documented, with printed copies in each vehicle and each family member's Go-bag. Rehearse regularly.

- **Firescaping** - Surrounding vegetative fuel load. We can prune to reduce fire ladders and fuel loads, select plants and arrange them for fire resistance. We can create buffer zones using berms, swales, pools, ponds, water tanks and vegetative elements.

- **Access** - Ample road width, turnarounds, elimination of low-hanging branches and/or tree tunnels. Secondary entrance and exit.

- **Built Structures** - Fire resistant design features. Fire resistant or fire-proof materials. Indoor and outdoor fire sprinklers. Floodable gutters. Lots more.

- **Maintenance** - Cleaning gutters of leaves and twigs, removing overhanging branches, sweeping up leaf litter/detritus piled against house. Interaction with landscape immediately surrounding home.

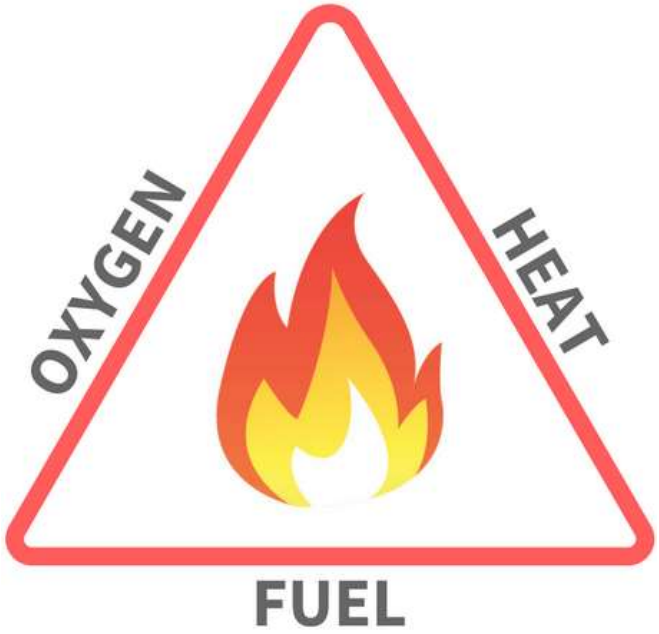
- **Awareness** - Paying more attention to news reports when fire danger is high. Reviewing do's and don'ts with family. Subscribing to text alert systems.

Basic Fire Science

Looking at what we can control is empowering. There is a lot an individual homeowner can do to increase her home's survivability during a wildfire. Before we dive into all those nuts and bolts, it pays for us to take some time to understand fire - what it is, what it needs and what strengthens vs. weakens it.

The Fire Triangle contains the three things needed to sustain fire - Fuel, Oxygen, and Heat. Take away an adequate supply of any one of the three, and the fire will extinguish. Knowing these three essential components to fire aids us in designing fire resistant homes and landscapes where heat or fuel cannot build up to substantial levels to combust (oxygen is omnipresent - this falls into the "Can't Control It" category).

Figure 1.4
The “Fire Triangle” - showing the three elements needed to sustain fire.



Another helpful graphic is the Wildfire Cube - essentially, by introducing high velocity winds with heat and low-humidity conditions, the chances a fire will escape “control” and cause massive damage increase exponentially. When conditions like this occur, our fire awareness should increase accordingly.

Figure 1.5
The Wildfire Cube, showing the addition of the high winds that cause an exponential increase in size.

Fire danger increases as the atmospheric conditions trend towards becoming an "unstable air mass" - especially when fuels are dry (<35%). Things to look out for that fall in the "unstable air mass" category include shearing winds, ground whirlwinds (dust devils), scattered cumulus clouds, and shifting winds.

Knowing the essential ingredients for fire, and the special sauce that creates wildfires, we can now look at the landscape with an eye to increasing fire survivability simply based on where we choose to site our homes.

Topography And Fire Risk

An understanding of how topography (the arrangement of the natural and artificial physical features of an area) influences the speed and direction that fire takes in a landscape will help us to make informed decisions about where to best site homes, structures, and other elements in order to minimize their exposure to fire and provide residents with the most time to take proper measures.

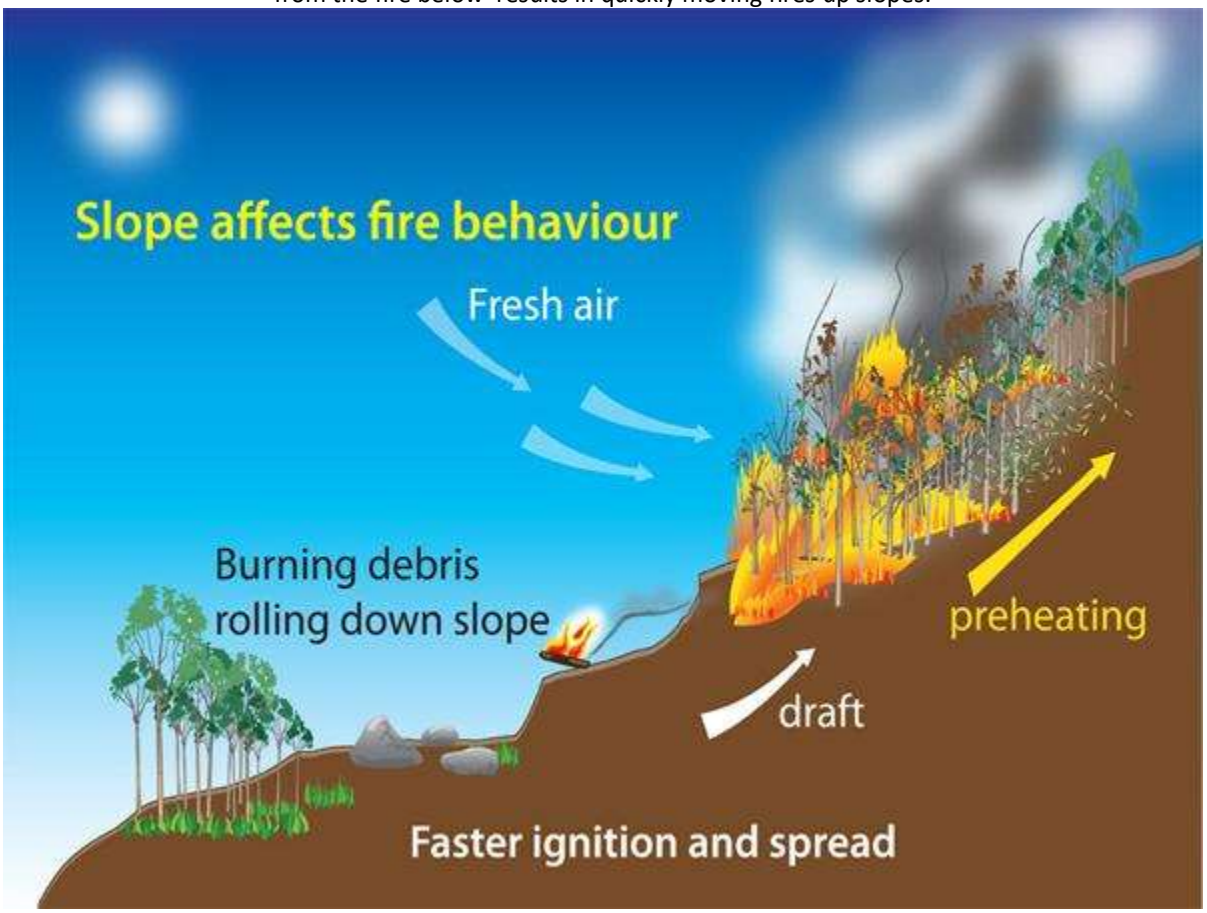
The most important factor in topography as it relates to wildfire is slope. Unlike humans, fires travel uphill much faster than downhill - and the steeper the slope, the faster the fire travels. For every 10-degree increase in angle of upslope, the fire speed and intensity doubles:

- If fire is 5 mph at dead level…
- 10 mph at 10 degrees slope
- 20 mph at 20 degrees slope
- 40 mph at 30 degrees slope.

This is primarily due to two factors: winds typically flow upslope, and increase as slope increases, blowing the fire more quickly that direction, and the fire is able to preheat the fuel further up the hill because the smoke and heat are rising.

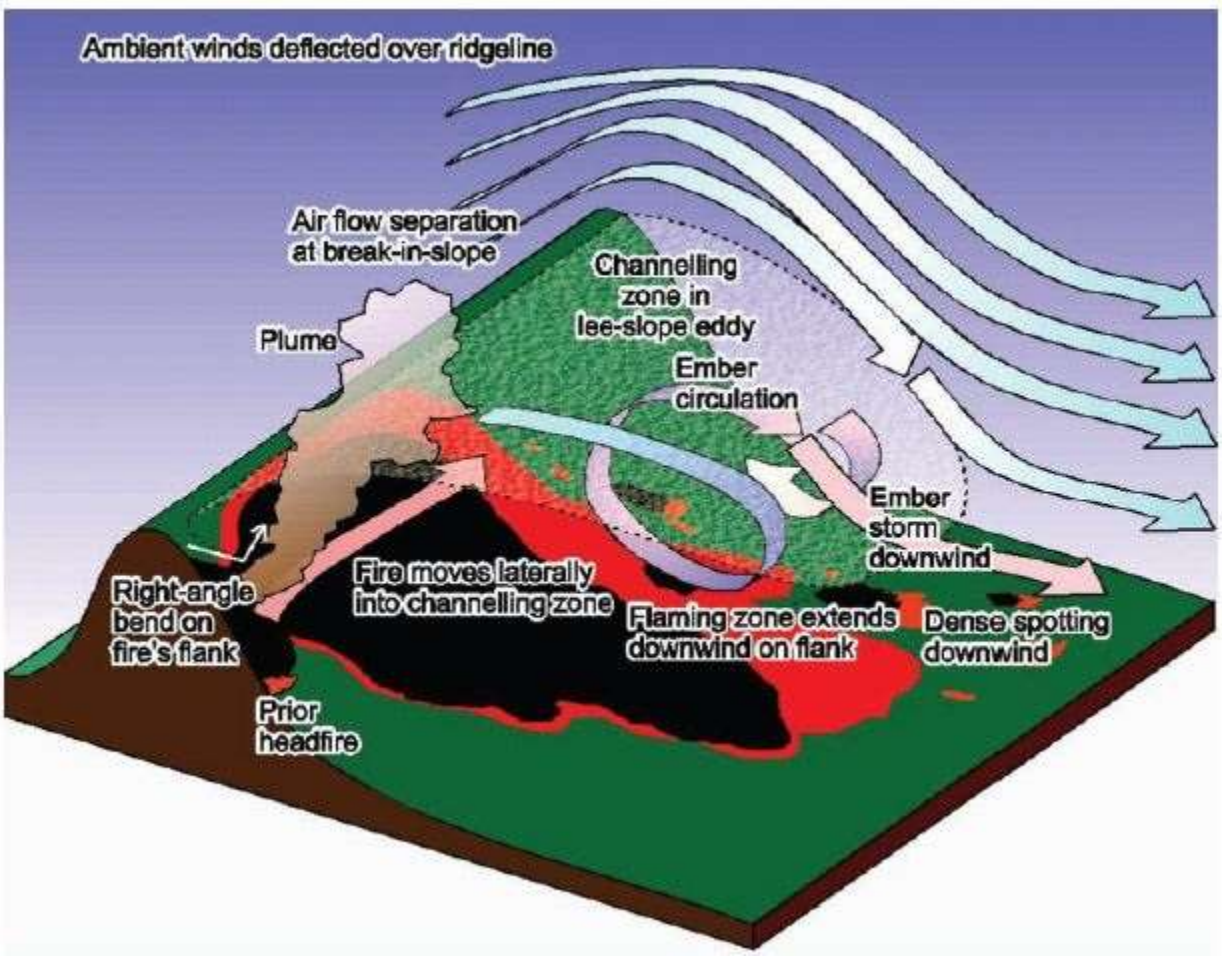
Figure 1.6

Accelerated winds typically blowing uphill coupled with the preheating of the uphill area due to the rising heat from the fire below results in quickly moving fires up slopes.



Armed with this knowledge, it becomes clear that, in fire-prone areas, houses should, if at all possible, be located as far downslope on a hill as possible. Few houses located on sharp ridges or in hill saddles that have diverging ridgelines creating a wind tunnel effect survive wildfire.

Figure 1.7
Wind typically blows uphill near the surface, regardless of if you're on the "windward" side or "leeward" side of a ridge.



A similar wind tunneling effect is created by planting tree species of trees that are especially flammable alongside driveways in rows, creating a blow torch aimed directly at the house.

To reduce the susceptibility of fire moving uphill towards a house, radiant heat barriers (stone walls, patios, etc, discussed in more detail later) should be placed on the downslope side of the house to provide a shield from upslope convective and radiant heat. Houses should never be on stilts in fire-prone areas, as this makes them even more susceptible to embers and convective/radiant heat gain.

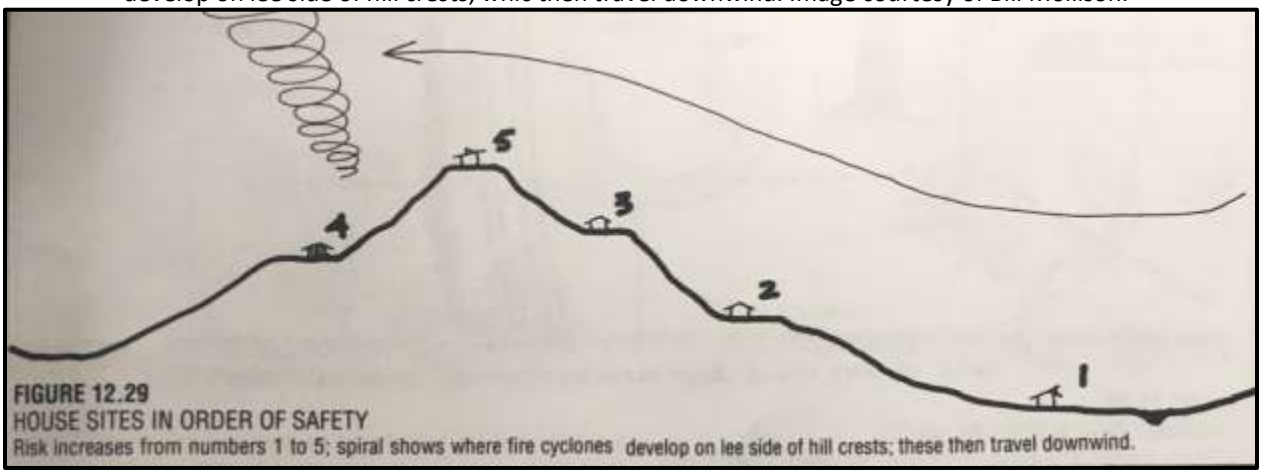
The safest house sites are those that have some or all of the following: consistent moisture, surrounding radiant heat shields and inflammable surfaces/structures, minimized fire sectors, and relatively low winds. These include:

- Damp valley mouths
- Well tended built up areas
- Farms with flood-flow or keyline irrigation fitted areas

- Peninsulas in dams and lakes
- Any plateau site where design and maintenance criteria are rigorously applied

Figure 1.8

The ranked safest home sites on a hill/valley. Risk increases from numbers 1-5; spiral shows where fire cyclones develop on lee side of hill crests, whic then travel downwind. Image courtesy of Bill Mollison.



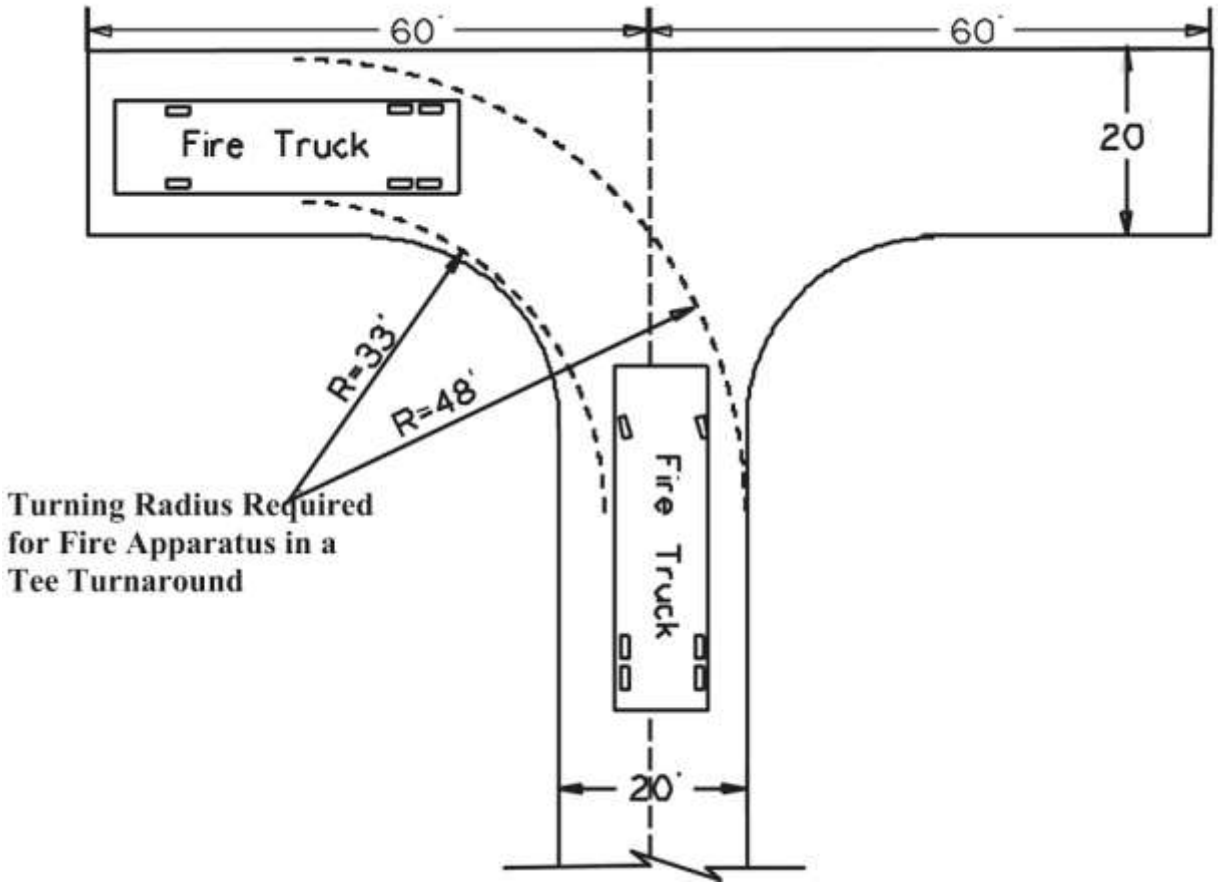
ACCESS

Intimately linked to a home's siting within the landscape is the ease with which it can be accessed (and evacuated from) by fire fighting vehicles. If we want the chance to receive any help from our local fire department during a fire we need to at least ensure that access to the property provides a safe entrance and exit for fire fighting vehicles. Things we can do to ensure access include:

- Maintain ample road/driveway width for large vehicles.
    - Gates all similarly sized and able to be opened manually if needed.
- Keep overhanging branches or vegetation clear of roadway.
- Provide a turnaround or ample space to maneuver a large fire truck and quickly exit the property.

Figure 1.9

The conventional dimensions for a "Hammerhead Tee" turnaround that can accommodate a full size fire truck.



So we've selected our homesite with fire survivability in mind and planned good access for ourselves and fire fighting vehicles. How do we begin to create a regenerative firescape around the house site?

We'll begin by looking at our zones and sectors in Part 2: Regenerative Firescaping - Protecting Your Home With Good Design.

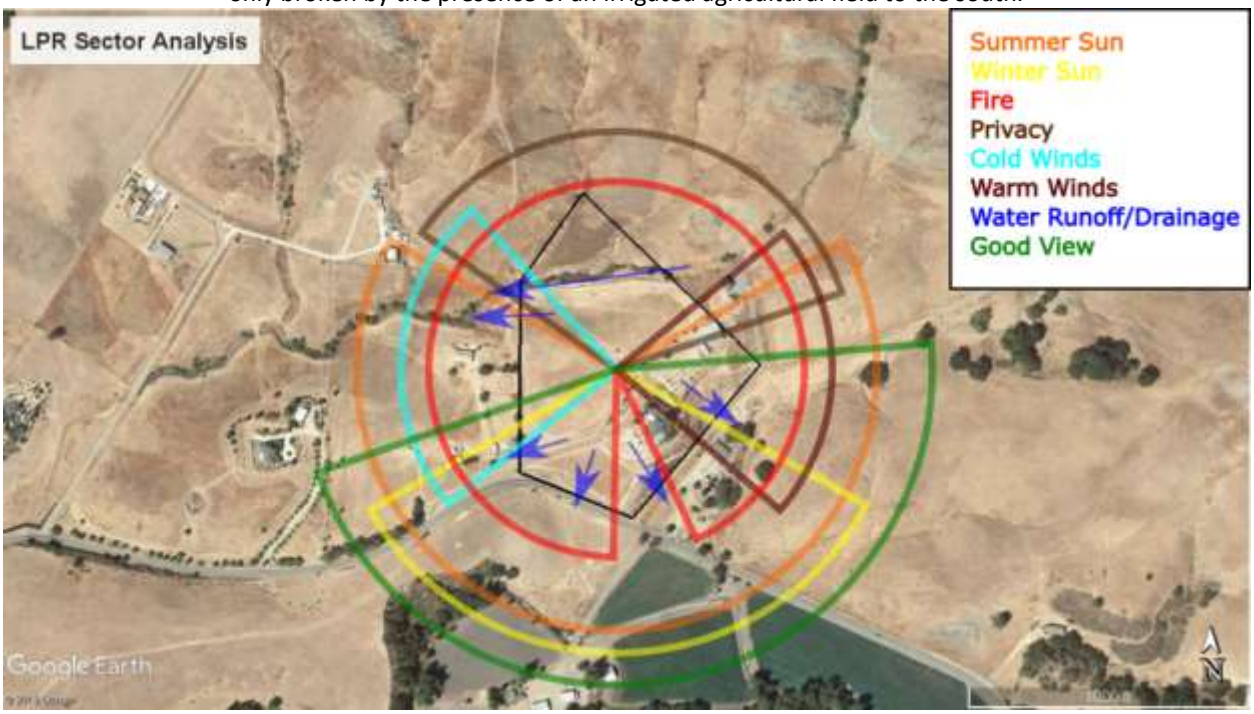
PART 2: REGENERATIVE FIRESCAPING - PROTECTING YOUR HOME WITH GOOD DESIGN

Once a fire-resistant house site has been chosen and ample access planned for, we are ready to begin examining the various zones and sectors of the site and overlay them with best practice recommendations for increasing fire resistance - with a regenerative twist of course. We won't cover how to do zone and sector analysis in this text, as this has been written about extensively already (Gaia's Garden and The Permaculture City by Toby Hemenway, The Basics of Permaculture Design by Ross Mars, and the Zone and Sector Analysis Blog Post by Deep Green Permaculture are good places to begin if you are unfamiliar with the concept).

Once we have identified the most likely avenues ("sectors") of fire approach, including any seasonally high fire danger areas (i.e. Santa Ana winds), we can overlay our zone maps to get an idea of how often we interact with different areas surrounding the house. The frequency with which we interact with the landscape in each zone surrounding the house and the likelihood of fire advancing through that zone will help guide our decision making when it comes to creating a Regenerative Firescape.

Figure 2.1

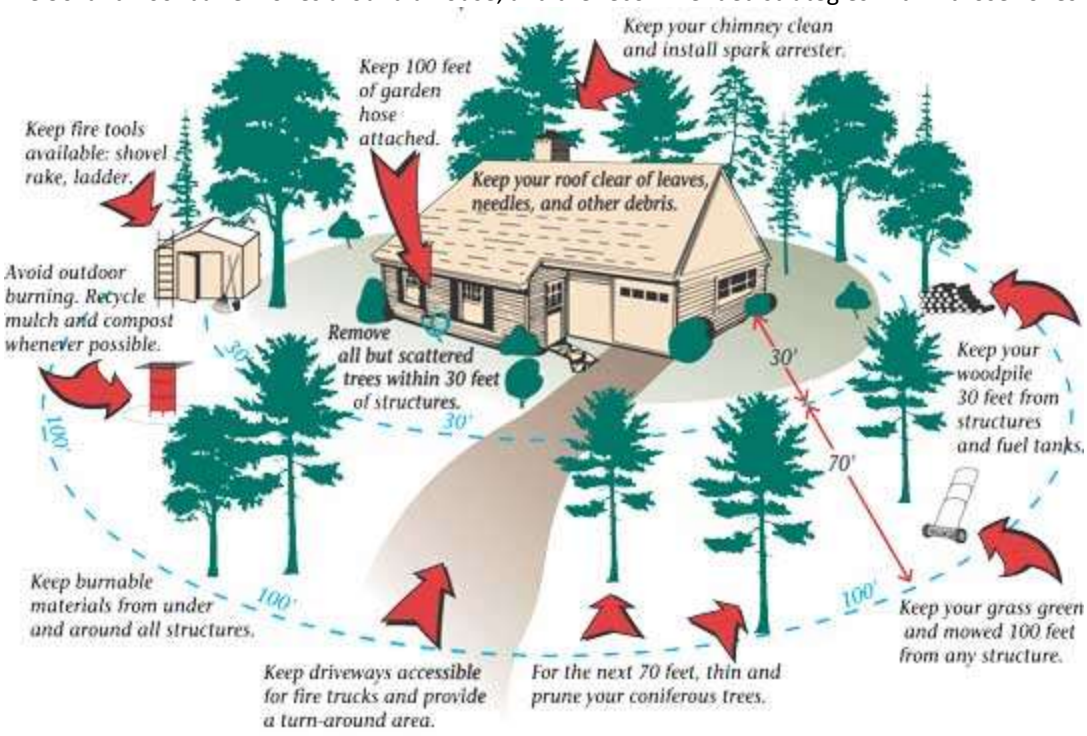
Sector analysis, showing the various natural or uncontrollable external influences on a site.At this particular site, the fire sector extends almost 360 degrees around the site due to the neighbors annual-grass covered landscapes, only broken by the presence of an irrigated agricultural field to the south.



Most fire prevention literature refers to two different buffer zones around a home. The first buffer is from 0 - 30' away from the house, and the second is from 30 - 100' away from the house. Each zone comes with different recommendations for management to increase home survivability during a fire.

Figure 2.2

The 30’ and 100’ buffer zones around a house, and the recommended strategies within those zones.



0 - 30’ Buffer Zone

The 0 - 30’ Buffer Zone is the most critical area for fire *and* watershed safety. It is where we as individuals can have the greatest impact on our home’s survivability. The aspects of this zone that can be designed for include:

- Removal of highly flammable landscaping (annual weeds, select perennial species).
- Installation of non-flammable landscaping - lawns and meadows, border plantings, flower gardens and structures such as pools, concrete decks and recreation areas help reduce fire hazards close to home.
- Installation of landscape plants with high fire resistance (in California, typically the native plants), along with proper design for assemblage and spacing.
- All leaves removed from rain gutters, pipes, drainage devices and roof at beginning of fire season (this translates to nearly year round maintenance in California).
- Regular maintenance of landscaping plants. Periodic overhead watering of native, drought-tolerant plants in drought-prone areas, or regular watering of non-native or non-drought tolerant plants. Regular pruning to reduce fuel loads and eliminate ladder fuels.
    - Specifically, identify and remove 1) dead plant material (branches, leaves) still retained in the canopy and 2) piles of dead, dry plant material at the base of the tree or shrub that would allow a ground fire to climb into the canopy.

- Particularly flammable trees not planted within 30’ of home (this can vary dependent upon crown size of the tree at maturity). If trees are planted immediately adjacent to home (potentially advantageous in regards to home site temperature and wind speed moderation, but does increase fire risk to some degree), try to limit branches overhanging the home. Make doubly sure to eliminate any dead branches in the canopy. Be extra attentive to keeping gutters and roof valleys cleared of leaf and twig build up in these areas.
    - Can run an extension line from an outdoor WEEDS Fire Sprinkler System (more on this system below) to a broad, flat spray radius sprinkler anchored high in the canopy. Assuming you’ve maintained a clear understory and sub canopy, this sprinkler can wet the tree canopy from the inside out, which will create an excellent ember trap and radiation shield (more on those below, too) as well as saturating the drip line of the tree, part of which may overhang the house.

Fire-Resistant Landscaping Principles

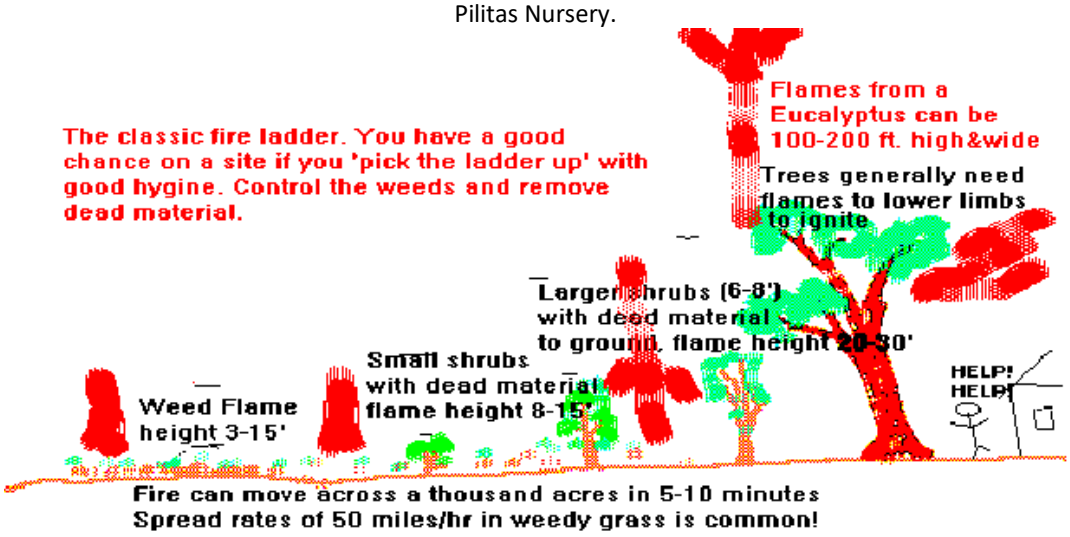
The largest culprits in the rapid spread of fires are the annual grasses and weeds (like mustard, anise, broom, and thistle). These, when dead, are called “flash fuels”, in that they almost instantaneously ignite into 10’ flames, which allows them to spread at an unbelievable rate - 20,000 acres of annual grasses have been consumed in 20 minutes. This burning grass “feeds” the shrubs, which have 5'-30' flames, and these “feed” the trees, which can put up a fire ball 75' tall and 50'+ wide.

Figure 2.3

Invasive annual grasses are quick to ignite, and spread at a rapid pace. They are the largest culprits in some of the most destructive fires in recent California history.

Figure 2.4

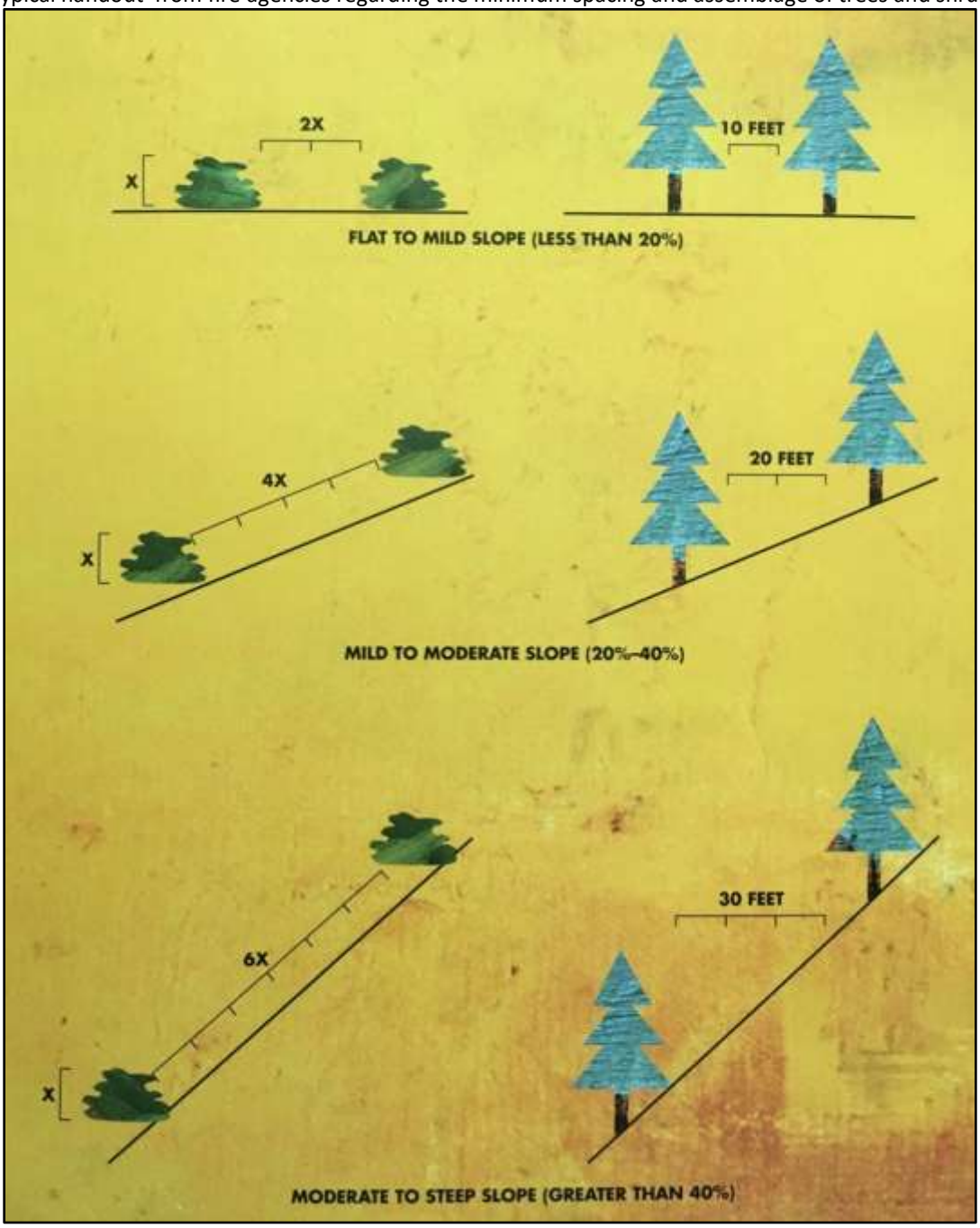
The classic fire ladder, showing how the fire climbs from low-lying grasses to large trees. Image courtesy of Las Pilitas Nursery.



Once the annual weeds have been cleared, the remaining plants and their assemblage can be assessed for fire resistance. Most firescaping instructions give blanket recommendations regarding the spacing and assemblage of plants within the 0 - 30’ Buffer Zone. Instructions from fire management agencies often look like this:

Figure 2.5

A typical handout from fire agencies regarding the minimum spacing and assemblage of trees and shrubs.



Our regenerative spidey senses should be tingling here…

…what about all that BARE GROUND?! Especially on steep, erosion-prone slopes?!

While effective at slowing the advance of a fire and limiting convective and radiative heat gain, leaving this much bare ground will guarantee us three things: (1) that Nature will *constantly* be trying to fill those gaps between deeper rooted perennial plants with the fast-growing weedy annuals that you just removed- the kind that turn brown and crisp by the end of Spring and have a high propensity to ignite and carry a ground fire rapidly towards a home or neighborhood, (2) requiring you to be forever stuck on the weeding- or mowing-go-round, and that (3) year after year that fragile soil will be left unprotected from winter rains, leading to major erosion problems.

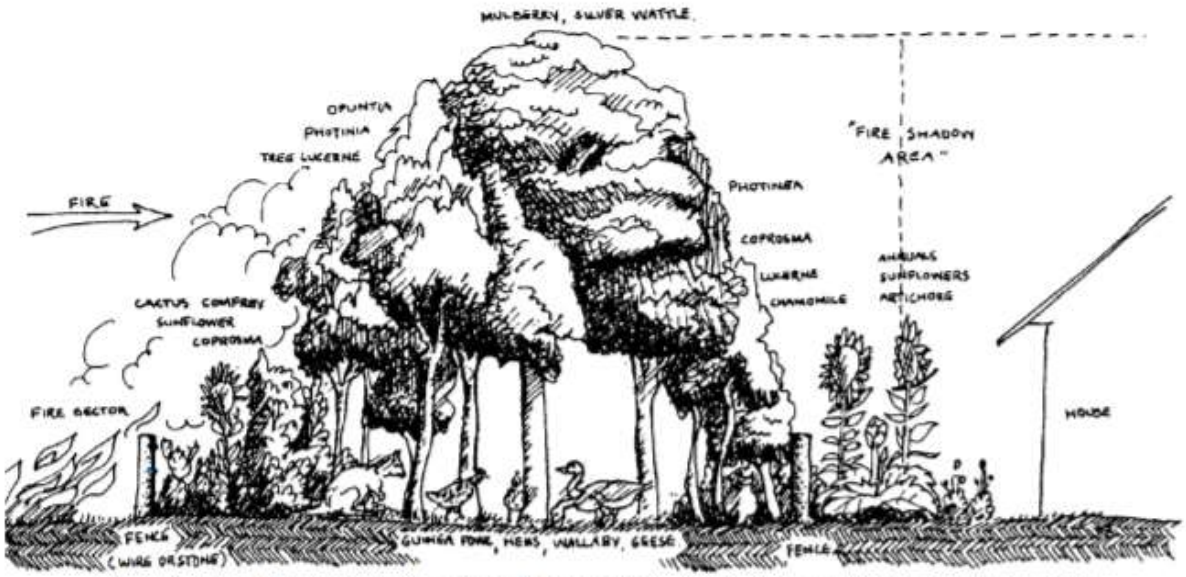
Simply keeping the buffer zone barren or mowed is highly energy intensive, not to mention not the aesthetics will suffer. Somehow we need to marry the dual imperatives of fire resistance and erosion/weed prevention. This is where creation of a **closed canopy** and use of **groundcover,** both utilizing fire-resistant plants that are regularly maintained and watered, and the use of mulch comes into play.

Creating a Closed Canopy Using Fire-Resistant Trees and Shrubs

Creating a **closed canopy** simply means that we plant fire-resistant shrubs and trees in areas of barren soil, and prune and maintain existing shrubs and trees around the home to eventually *nearly* touch each other at mature size, creating a buffer for the soil from sun and rain. Think of a plant shaped like an umbrella (single trunk, large horizontally expanding canopy). We want to avoid whenever possible having bare soil (and all of those dormant weed seeds contained on its' surface) subjected to the cycle of relentless sun followed by the unabated pounding of rain drops. Having a vegetated "umbrella" overhead is very effective at shading out weedy annuals and reducing rain droplet energy prior to it reaching the soil. Additionally, most perennials capable of forming such a canopy will have much deeper root systems than annual grasses, enabling them to survive California's long dry season as well as helping to stabilize loose hillside soils. From a weed and erosion control perspective, this makes perfect sense.

Figure 2.6

Having a properly closed canopy system like the one shown here can be highly effective at keeping the home and surrounding areas safe during a fire. Illustration from Bill Mollison, Permaculture Two.



So how do we go about maximizing closed canopy while simultaneously ensuring that we are maximizing fire resistance? It all comes down to how we *interact* with the environment.

To maximize fire resistance we want to:

- Plant shrub or tree species that are fire resistant (more on that below).
- Keep the understory of trees and shrubs clear of any ladder fuels (dead, dry plant material at the base of the trunk(s) that will allow ground fire to easily climb into the canopy).
- Keep the ground surrounding the trunk(s) clear of dead, dry plant materials (limit fire's ability to even approach the trunk in the first place.
- Plant trees and shrubs close, to maximize shade and coverage, but not so close that at mature size their crowns contact one another (should the fire get into the crown, you don't want it to be able to spread easily to the next tree or shrub canopy).

We can improve the fire resistance of the landscape around our homes by shaping trees and bushes to decrease their susceptibility to fire, selectively removing them where they are too dense, and regularly removing dead plant material from the canopy and the base of the trunks. There will still be holes in the canopy, however, so we must bring in another ally; **Fire Resistant Groundcover.**

Filling in the Gaps with Fire-Resistant Groundcover

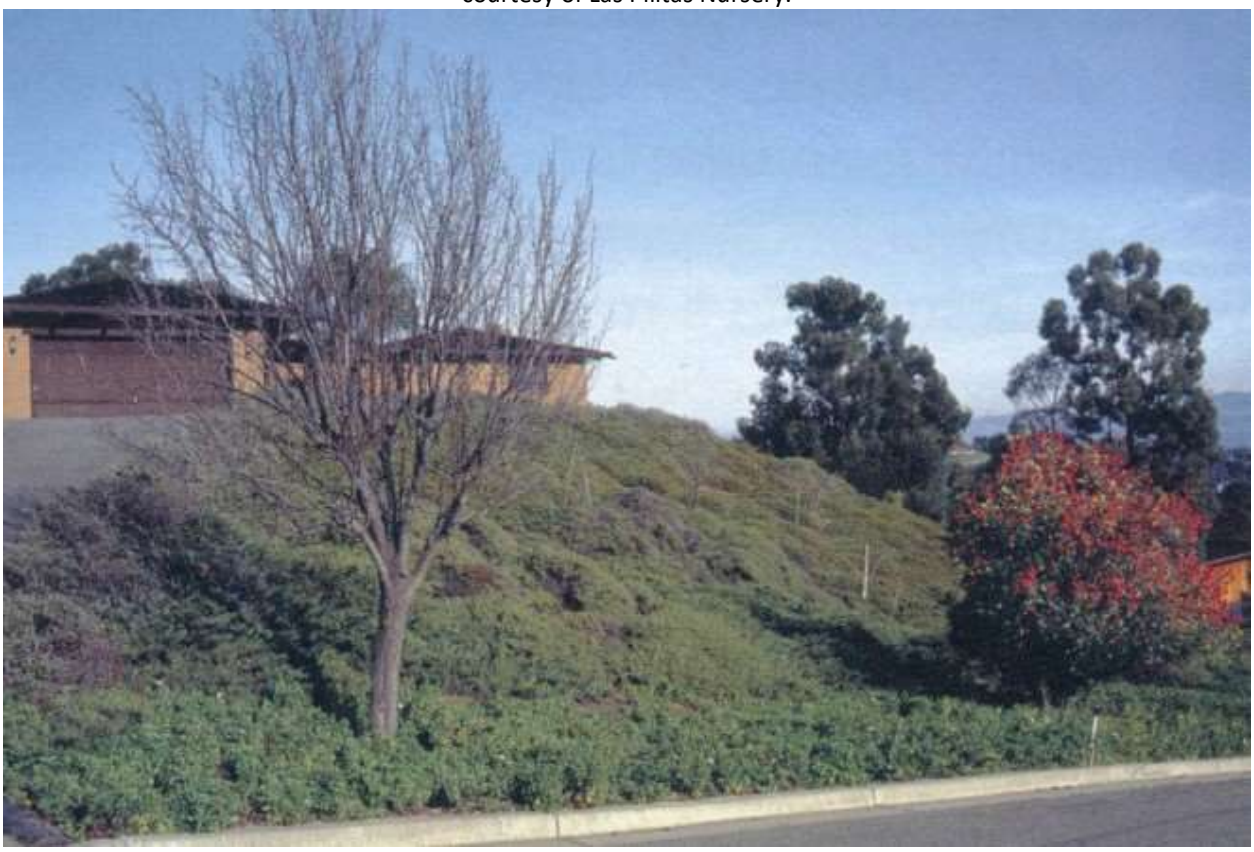
We should employ groundcover (either plants or mulch) to fill in the gaps between closed canopies, thereby ensuring we cover all bare ground with either a vegetative umbrella (canopy) or carpet (groundcover). Using groundcover plants or mulch (such as leaves and decomposed or shredded woody

material) might at first seem to make it easy for fire to advance underneath the canopy towards a home, and, again, in the cases where the ground is covered with weedy annuals or low-growing, high oil content plants, this would be true. However, properly selected ground-cover plant species are highly resistant to fire, and mulch does burn, but creeps along with a smoldering fire that will rarely ignite plants that don't have low-lying branches or leaves and can be easily kicked or raked out. This type of mulch burns with a lot of smoke and little flame- typically 1-2 inches in high winds. If there are no winds, they typically will not even have visible flames, just smoke. Mulch is an especially important component of California's gardens/landscapes and ecology, as the moisture that mulch retains helps keep the plant material hydrated and a little less flammable.

When choosing groundcover plants, selecting appropriate species becomes especially important. Fire-resistant groundcover plants should be low growing (12-18" high), remain green through the dry season, have relatively high moisture content and have relatively low water needs in addition to exhibiting the more general Fire-Safe Plant characteristics listed below.

Figure 2.7

Baccharis pilularis "Pigeon Point" is a native Californian groundcover that has excellent fire resistance. Image courtesy of Las Pilitas Nursery.



By planting fire-resistant groundcover plants and/or spreading mulch underneath the canopy gaps, we get the soil-protective effect of a truly closed canopy while also mitigating the risk of fire crowning near the home. By employing this patchwork of varied canopy heights and fire-resistant groundcovers we also gain an additional fire-preventive element - we've just created an **ember trap.**

Ember Traps

Houses routinely catch fire far ahead of the main fire front due to embers that have been drawn up by hot updrafts, which are then scattered downwind.

Figure 2.8

Embers can be blown downwind for several miles before ultimately landing on the ground (or a house).

Embers that have been drawn into the air by hot updrafts and are then scattered downwind are the main cause of home destruction during wildfires. These embers are often very small (can be less ¼"), can precede the fire front for several miles, and can:

- Catch under open eaves
- Lodge under loose or curved shingles
- Accumulate at the base of the structure
- Enter attic vents
- Enter window and door seams
- Catch in nooks and crannies
- Ignite materials near the structure (no woodpiles against the house!)

An excellent video detailing how embers are an even greater danger to homes than the more visually frightening "wall of fire" can be found here.

By creating impediments with intelligently selected and placed vegetation we can create barriers to embers advancing towards a home, and ideally prevent them from ever making contact with it in the first place. Ember traps halt the advance of embers (also known as firebrands) towards a home in two ways; by direct impedance and by creating small low pressure pockets on the leeward side of trees and bushes that allow airborne embers to drop to the ground. An excellent visual by a junior scientist illustrating how ember traps work can be found here.

Fire Resistant Plant Selection

An incomplete list of fire-resistant trees, shrubs, and groundcovers for California climates is provided in Appendix A. Generally, in California at least, unwatered native plants are more fire resistant than watered non-native plants. Another great resource is the Leaf Burn Times article on the Las Pilitas Nursery website. In general, fire-resistant plants have the following characteristics:

- Have easily distinguished dead vs. living material.
- Require only minimal bending over or ladder work to maintain.
- Have an open, accessible growth habit to allow easy pruning without damaging the plant.
- Have a slow to moderate growth pattern to minimize the frequency of maintenance.
- Have a robust root system to prevent erosion (ideally 6' or deeper).
- Be long lived.
- Have ample enough branching/leafing material to provide direct impedance barrier to rain, thus reducing rain's impact on uncovered soil.
- Re-sprout / grow from the crown following a fire to help reduce re-vegetation costs.
- Have long leaf burn times

Figure 2.9

Ceanothus - some species and varieties, according to Las Pilitas Nursery, are so fire resistant that they can be considered “heat shields”. Image courtesy of Las Pilitas Nursery.

Fire-resistant plants *SHOULD NOT:*

- Have thorns (for ease of maintenance, by you or fire personnel).
- Retain dead leaves within the canopy.
- Have small leaves that stay on the plant once dessicated or dead (sages, buckwheat, chamise).
- Accumulate dead parts difficult to isolate (many ice plants, rabbit bush).
- Produce large amounts of hanging or dropping leaf litter (fan palms, pines, Eucalyptus).

FIREBREAKS

The oft-seen and mandated firebreak is largely ineffectual against airborne embers and cannot be depended upon to save a home. Denuding landscapes around dwellings in hopes of creating a fire break is not only ecologically damaging and unsightly, its less effective at actually reducing fire-risk! Large expanses of open ground turn into bowling alleys for wind driven embers that will keep moving until they hit something solid - and that is usually the house that accompanies the fire break. Firebreaks very close to the home *in conjunction with* ember traps, radiation shields (more on this below), and other fire-resistant landscaping elements can help to create areas of decreased fire intensity allowing for safe operation by fire personnel or homeowners.

Figure 2.10
The conventional California firebreak, requiring regular energetic, financial, and environmental cost.

Firebreaks are a way of decreasing fire intensity and will most likely not stop a fire and cannot be counted on to do so. They can, however, provide a safe evacuation avenues and space to operate around a home during a fire.

Firebreaks can be formed by roads, marshes, ponds, river areas, summer green vegetation, sappy plant crops in hedgerows (opuntia, for example). A horizontal firebreak (i.e. a bare strip of ground, roadway, line of sappy, green trees) reduces fire front energy, while a vertical firebreak (removal of lower branches, dead materials at base of tree, planting of sappy groundcover under canopies) prevents crowning in trees. If feasible, pairing a firebreak with a radiation shield, described below, makes the firebreak easier to operate in for firefighters.

It should be noted that no firebreak is effective in firestorms/fire tornadoes - firestorms can drop material up to 20 miles downwind.

RADIATION SHIELDS

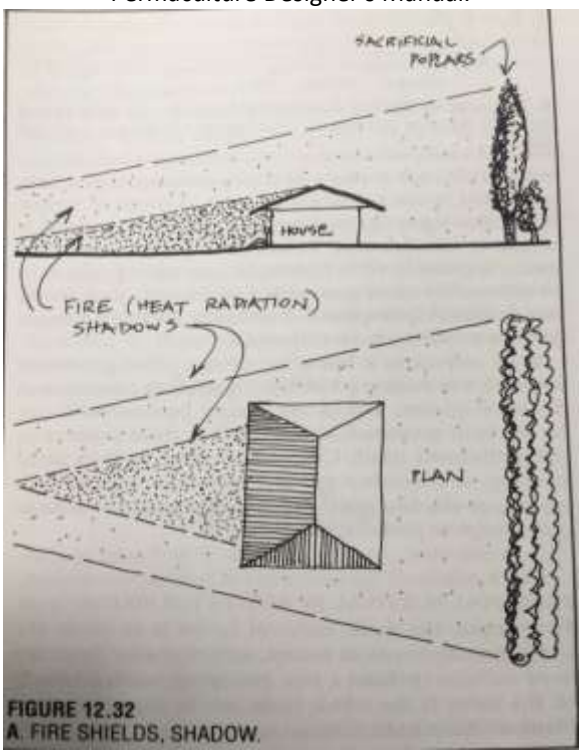
Radiation shields are objects that reflect or harmlessly absorb the radiant heat from the fire front. Radiant heat is the type of heat that can quickly kills plant and animals. These are particularly helpful when used to protect machinery that needs to operate during the fire (water pumps, vehicles).

Radiant heat shielding can be performed by a variety of things, including houses, stone walls, thick tree trunks, hollows or caves, hedgerows and car bodies, brick walls, earth mounds, and densely-planted, sappy, high-moisture shrubs and trees (such as ceanothus). White paint on houses and walls further reduces radiation absorption. Fire-proof or slow to burn insulation in houses (such as mineral wool, seagrass, sawdust, feather, wool) all keep interiors cool and assist fire control.

Fire shadows taper to a point at 4-5 times the height and width of the radiation shield, as illustrated in an image taken from the Permaculture Designer's Manual below - so make sure the shield extends well past the edges of the structure needing protection.

Figure 2.11

Radiation shields can provide relief for a length 4-5 times their height and width. Image courtesy of Bill Mollison, A Permaculture Designer's Manual.



These radiation shields, like all of the other elements discussed thus far, can be selected and placed using permaculture design approaches to serve multiple functions. For example, a radiant shield formed using a ceanothus hedge can also double as a privacy screen, windbreak, and wildlife-attractant (birds, etc). A radiant shield formed from a densely planted edible food hedge ("fedge") can provide an array of food to the homeowner. A series of rocks can form a thermal mass to moderate the nearby temperature for plantings.

Figure 2.12
This Ceanothus hedge not only serves as a radiation shield, but also provides incredible beauty, food for wildlife, and habitat.

30 - 100' Buffer Zone

The 30' - 100' Buffer Zone requires less intensive management than the most critical 0' - 30' Buffer Zone, but still can play a huge part in the survivability of a home. In the 30 - 100' Buffer Zone we look to...

- Perform annual fuels reduction and pruning to reduce vegetation volume. Pay special attention to ground fuels that will allow fire to advance towards a structure.
- Plant long-lived, slow-growing, fire-resistant perennials to cover exposed, bare soil or at minimum cover bare ground prior to rainy season (mulch, jute etc). This is especially important on hillsides.
- Eliminate weed fuels without creating conditions that favor their dominance (i.e. encourage deep rooted perennials that meet the Fire-Safe Criteria).
- Prune trees up 6 - 10' from the ground. Thin accordingly to create breaks in the canopy. Underplant canopy breaks with low-growing fire-resistant perennial groundcovers.
    - Most mainstream fire prevention literature will insist upon 30' breaks between clumps of trees. Depending on what type of tree, how flammable it is, how high the intra-canopy fuel load is, etc., this number can be reduced quite significantly to create a more contiguous forested landscape.

The 30 - 100' Buffer Zone generally puts us into Zones 2 and 3, possibly even 4, using the permaculture zonation concept. As we move progressively further from the home, elements tend to require less attention and have the potential to be larger than those closer in to the home.

EARTHWORKS

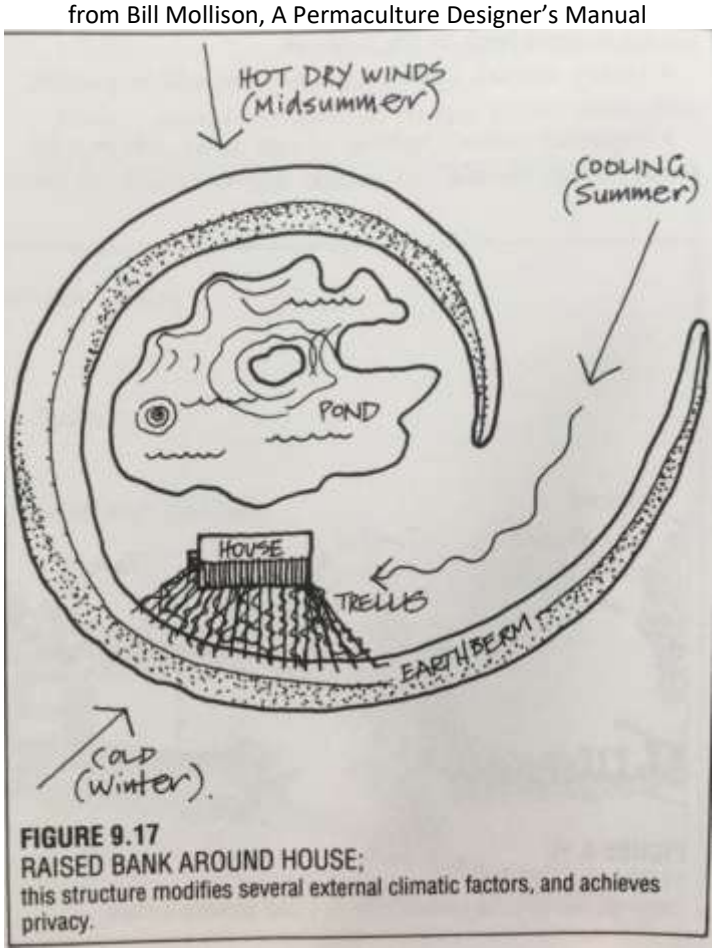
Larger earthwork systems can be very effective at increasing fire survivability, not just for the home but also for other more vulnerable elements (orchards, gardens etc). While earthworking can range greatly in size, and indeed can be applied in many forms in Zones 1 and 2, here we will consider some larger installations that are typically found at the outer edges of Zone 2 and beyond.

Earthworks for fire resistance can include:

- Swales - can be flooded pre-fire, help saturate ground and increase moisture content of associated plantings, and can be used to establish planted fire shields of sappy trees and plants that will slow fire's advance towards a structure.
- Earth berms - often installed to create wind protection or as effective sound barriers, also make excellent radiation shields. They can be planted with sappy, high-moisture content plants, groundcovers and evergreen trees to create additional ember traps and heat shielding.
- Ponds and pools (natural pools, ideally!)- large bodies of water surrounded by high-moisture content vegetation make excellent firebreaks and can be used as a reservoir to keep surrounding vegetation and structures wet.

Figure 2.13

A raised bank around the house modifies several external caltic factors, and also provides primacy. Illustration from Bill Mollison, A Permaculture Designer's Manual



If we wish to use a pool or other water body as a fire suppression reservoir and wish to do better than hauling out water by the bucket, it behooves us to have a gas or propane-powered water pump (needs to be grid independent), high-pressure fire hose, an adjustable fire suppression nozzle, and protection for the operator (eye protection, respirator, heat resistant clothing). Staying at home to suppress flare ups and preserve structures is a risky decision dependent upon entirely too many factors to make a blanket recommendation for. However, if this option is on the table, it pays to be prepared with the right equipment and a very clear plan - as well as a crystal clear way to make the "Do I stay or do I go?" decision.

Figure 2.14

"Should I stay or should I go?"

Figure 2.15

A gas- or propane-powered pump is a necessity if you plan to stay and fight fire.

It's worth noting that if a WEEDS-style Fire Sprinkler system is installed, along with the other appropriate fire-resistant elements detailed in this post, there isn't a whole lot of additional benefit we can add by remaining on-site with a hose, short of protecting landscaping and outbuildings.

Orchards

Home orchards make excellent ember traps provided the tree spacings are offset from one row to the next (i.e. if you have an unobstructed view all the way to the other side of your orchard, you don't have an ember trap, you have a wind tunnel!). They can be irrigated to increase moisture and decrease the intensity of an advancing fire front. Fruit and nut bearing trees are typically quite sappy and have high moisture content. Though they may be damaged or killed in the fire, orchards can provide a tremendous boost to home survivability.

After a Fire

Revegetating the Area

After a fire has passed, we need to look to revegetate the landscape and protect vulnerable hillsides from beginning erosive processes during the coming rainy season. Planting deeper rooted woody plants to stabilize a hillside, while the preferred method, will take several years to become effective - a fast growing herbaceous groundcover is often needed to fill the gap until such plants are established or regrown.

Figure 2.16
The heavy rains that helped to quelch the Thomas Fire ultimately caused massively destructive mudslides, due to the barren soil on the hillsides.

Below is a list of some methods, common and uncommon, to help stabilize denuded soil quickly.

- **Vetiver Grass Planted On Contour** is a relatively fast way to protect friable soils from sheet flow and erosion from direct impact or rain droplets. Plant plugs 4-6" aparts in a 6" deep trench following contour. Provide irrigation to establish. Requires full sun and loves heat (great for exposed southern and western slopes). Roots will ultimately grow between 9 - 15' deep and create a dense, fibrous, interwoven biological retaining wall that will not only retain soil but also root into loose soil that might pile up on top of it. Vetiver grass is highly drought tolerant once established due to its deep root system. Plants do no set seed and have columnar root systems, so are not invasive, and can help create soil conditions (increased moisture, cover, stability) for deep-rooted canopied plants to establish. When vetiver is shaded it will grow less vigorously, and once completely shaded it will die. Can be burned to the ground / frozen and will regrow from the roots.
- **Immigrant Forage Kochia** An evergreen, low-growing groundcover plant with succulent leaves, Kochia is salt and drought-tolerant, perennial, non-invasive and helps natives re-establish following cheat grass invasion. It can survive on as little as 6" of rain a year.

Generally speaking, non-woody groundcovers have an effective root depth of less than 3' ("shallow-rooted"). Shallow-rooted plants should not be used as permanent cover on steep slopes unless they are interplanted amongst taller shrubs and small trees. On fill slopes in particular, interplanting in this fashion is necessary to create stability.

Woody groundcover plants generally have slightly deeper root systems (between 3-6') and can be used amongst taller shrubs and trees. Plants with roots in the 6 - 15' depth range include many of the woodland shrubs that make up the chaparral community. These plants are very drought-tolerant and ideal for stabilizing slopes over the long term. However, they will need to be regularly maintained to keep fuel volumes low and create a closed canopy effect without ladder fuel build up.

Quickly Protecting Bare Soil

If the rains follow too closely on the heels of a fire, it may be necessary to employ other methods to protect and stabilize exposed soils. Some methods are listed below:

- **Check Dams, Chain Link Fences and Boards** - for directing mud flows, building siltation for seeding, and preventing eroded materials from hitting structures.
- **Jute Netting in Conjunction with Seeding -** netting acts as miniature check dams, helps seed establish and helps reduce rain drop-induced soil erosion via direct impedance.
- **Drain Maintenance** to keep drains clear and functioning during the increased run-off after a fire.
- **Sandbags and deflector barriers** to guide mudflows and protect sensitive structures or revegetation zones.
- **Dry Stacked Rubble Walls -** used to prevent slippage of pre-existing cuts. Should be built leaning into the slope, should be seeded/planted along the top
- **Plastic Sheeting** to prevent water from contacting the soil in sensitive areas. Anchor with sandbags on ropes at top of hill - don't use rocks (sharp edges will cut through plastic with wind whip) or stakes (wind whip will create larger and larger holes) to anchor.
    - Ensure proper down-watershed drainage patterning to ensure you're not just creating a larger problem somewhere else.

PART 3: HOME CONSTRUCTION AND RETROFITTING FOR FIRE SURVIVABILITY

Once a house has been sited to best minimize the fire sectors, and the landcape around the homesite has been designed and tended to provide a barrier in the event of fire along those sectors, a home's exposure to fire will be significantly lessened. Attention to home construction will further reduce the chances of loss.

NEW CONSTRUCTION: BUILDING A FIRE-RESISTANT HOME

Historically, homes in fire-prone areas have been built with highly flammable materials. The matchsticks (kiln-dried, highly flammable lumber) that many houses are framed, sided, and roofed with have ensured the demise of many houses in recent times.

Now, the many industrial materials used in modern construction are available in a wide range of fire-resistance levels, and there are many choices in constructing conventional homes for improved fire survivability. That information is readily available from many other sources, such as the National Fire Prevention Association and Ready for Wildfire websites, in far greater detail than we would choose to provide here. So, we will be approaching this section from the less-often discussed end of the home construction spectrum: natural building (this is 7th Generation Design after all!).

FIRE-RESISTANT BUILDING MATERIALS

If we choose to live in a fire climate, it would make sense to build homes with materials that are either highly fire-resistant or even fireproof. The various geological building materials top the list for being fireproof:

Walls

- Cob - mix of clay, sand and straw used to create monolithic walls.

Figure 3.1

Earthen walls like cob are essentially fire-proof - and blend beautifully into the landscape.

- Stone - more often seen in foundations, less frequently in whole house construction.
- Compressed earth blocks, adobe, super adobe.
- Earth bag construction - woven polyethylene bags filled with earth, compressed and stacked in place to form walls, typically coated with earthen or cement plaster.
- Straw bale construction - straw bales are actually very difficult to light on fire, and when covered with layers of cob or earthen plaster are even more so.

Figure 3.2

Straw bale houses have been tested to have 3x the fire resistance of conventionally-constructed homes. This is mainly due to the 1 ¼" of plaster on the exterior of the bales, which is highly fire-resistant, and the bales themselves, which are so tightly bound that oxygen cannot really enter the mix.

- Earth-bermed homes - set into a hillside or sloping ground so that earth quite literally creates the walls. Earthships, WOFATI's and Oehler style earth bermed homes all employ this method.
- Brick

Roofing

- Metal roofing - has high fire-resistance. If radiant heat risk is high during a fire metal roofs can melt or transmit so much heat through them as to combust what is on the inside. Non-flammable or highly fire resistant insulation (mineral wool, seagrass, sawdust, feather, wool) will help reduce this potentiality.

Figure 3.2
Metal roofing has high fire-resistance, but good insulation is required to minimize conductive heat transfer to the wood-framing.

- Slate/stone roofing - expensive, but obviously very fire-proof.
- Fire-resistant shingling - can be purchased or repurposed.
    - If going the repurposed route, creative solutions abound - there are roofs made from old car doors, tin cans, metal barrels cut open and laid flat, and so much more.
- Ferrocement - often seen in Earthship designs for lightweight, curved, waterproof and fireproof roofs, ferrocement is an industrial product and will require a significant amount of metal rebar and lathe/wire to create the form, but it is long lasting and provides a number of very valuable functions to a built structure.

Retrofitting Existing Homes (Conventionally-Built Or Otherwise)

If you own an existing home, there are still many things that can be done to reduce the risk of loss in the event of a fire. Some of these include:

- Screen all vents - ¼" mesh screens will NOT stop embers! Retrofit attic vents, under house vents and any other vent or gap by which embers might enter the home with ⅛" metal screen. Do not use vinyl/plastic screens as they run the risk of melting due to radiant heat.
- Fire shutters - install metal shutters that are closed from the outside, designed to reduce radiant heat transmission through windows to objects inside the home. If windows from the home have direct line of sight to large amounts of fuels within 100' of the home consider this option.

Figure 3.3
Many houses burn from the inside out due to the radiant heat that comes through windows. Double-pane windows will significantly lessen the chances of this - metal shutters even moreso.

- Replace wood shingles - wood shingle roofs dramatically increase a home's chance of igniting and suffering catastrophic damage by as much as 700%. Choose non-flammable or fire-resistant roofing materials and insulation.
- Replace exposed wood siding - while less dangerous than wood-shingled roofs, wooden siding also increases ignition risk significantly. Choose non-flammable or fire-resistant materials if able.
- Consider repainting the home with white paint or a similar light shade to help reduce radiant heat gain in the event of a fire.
- Indoor fire sprinklers - to read more, visit the National Fire Prevention Association website.
- Outdoor fire sprinklers - especially important for homes with extended decks, roofs with valleys, nooks and crannies, or soffets.
- If you have a wooden deck, it either should be very low or very high off the ground. Can you stuff a garbage bag of leaves under your wooden deck? If you can, you need to make your deck a patio of rock or concrete - unless you have a very capable WEEDS Fire System, and even still, fire-proof materials are preferable.

Fire Shelters

Fire shelters are not part of the mainstream lexicon of fire preparedness, which is unfortunate as they have the potential to save lives in the case of a fast moving fire that blows over an area with little to no warning. While in many cases it is safest to evacuate, if you're late to the game and the roads are packed, it may well be safer to be in a properly designed and stocked fire shelter than sitting in bumper to bumper traffic while flames burn all around you.

Ideally a fire shelter would be set into the earth and have a curved "snailshell" style entry way made of heavy geologic materials (stone, cob, adobe, earth bag etc) to prevent direct radiation of heat to the interior. If built above ground, the walls need to be constructed with heavy geologic materials that can protect from radiant heat exposure - cob, adobe, earth bag, stone, other geologic building materials.

Figure 3.4
This bunker, dug into the earth with 6" concrete walls and a $1,000 fire door, saved the lives of a family in an Australian bushfire. Image courtesy of The Advertiser.

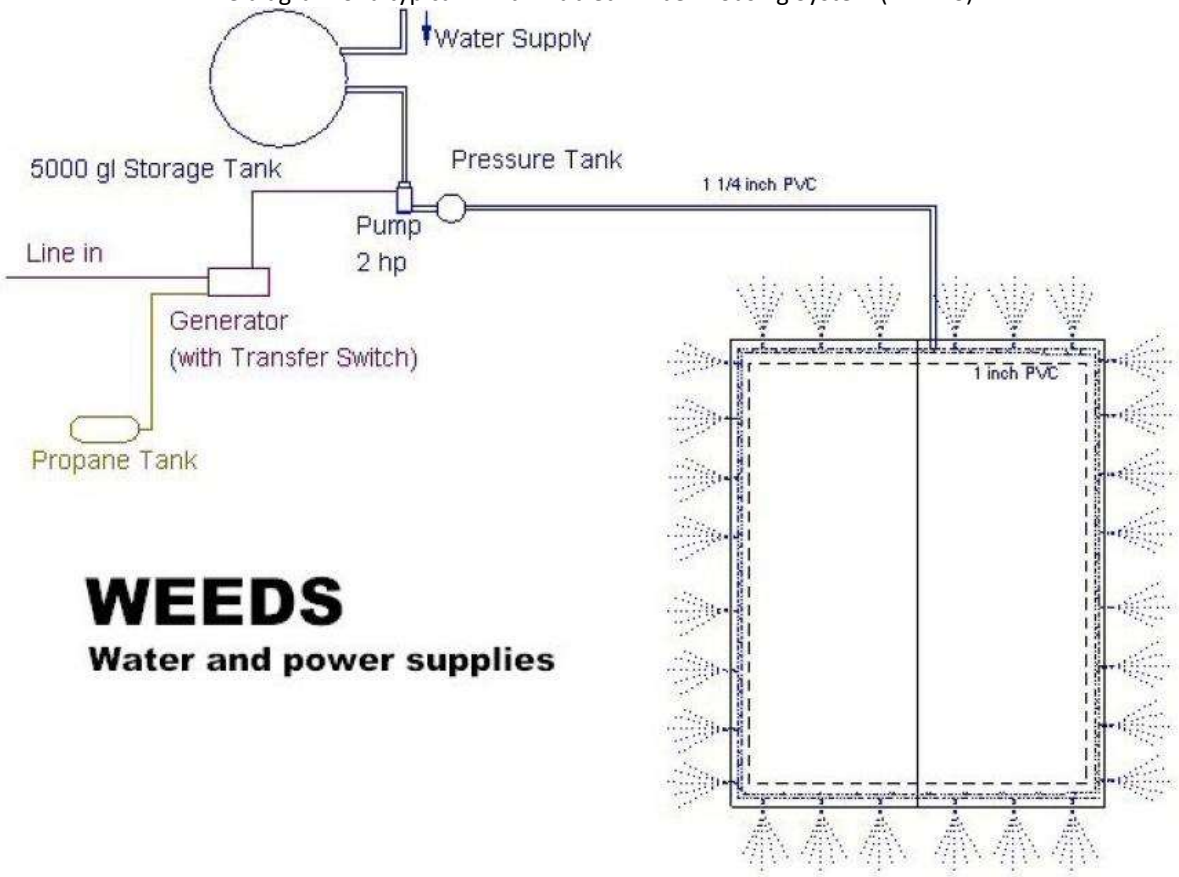
A fire shelter should at minimum be stocked with short to mid-term survival supplies - non-perishable food, water, emergency first aid supplies, blankets. Additional items that can be stored here include home fire-fighting equipment (pumps, hoses, fire suits, respirators, supplemental oxygen and other safety gear), communication gear (radios, off-grid power supplies) and longer term survival necessities (water purification systems, bulk non-perishable food, sleeping gear etc).

While all this preparation may sound rather dire and morbid, for properties located in high fire danger areas with limited routes in and out, having a fire shelter could mean the difference between life and death. A fire shelter also provides a safe storage location for supplies that could make your life a lot more comfortable following a devastating wildfire, as well as put you in a position to help neighbors and other less fortunate than yourself. And it can be put to good use as a kids fort when times are good!

Outdoor Fire Sprinklers

Fire sprinklers are very effective at dousing wind-borne embers, provided they are spraying where embers are landing. Fire sprinklers are generally installed along the eaves or roofline of a home and spray down and out - to wet both the surrounding ground and the sides of the house. Additional sprinklers may be added in vulnerable spots like soffets and rooftops as well to douse embers that land directly on the rooftop or settle in roof valleys. While there aren't many controlled studies on these types of systems, initial data and ample anecdotal evidence suggests that a Wind-Enabled Ember Dousing System (WEEDS) style fire sprinkler system increases home survivability by 7 times over having just defensible space around a home.

Figure 3.5
A line diagram of a typical Wind-Enabled Ember Dousing System (WEEDS)



The principles for designing an effective outdoor fire sprinkler system following the WEEDS protocol are as follows:

- Direct spray *into* the wind - Use the fire-generated winds to blow spray back onto the structure, this maximizes windward protection, and the water ends up where the embers are (a thorough sector analysis, as described in the permaculture design approach, will identify the avenues of the primary fire + wind threats).
- Use a low flow rate - better to have the system able to run lightly but consistently for a longer period of time, than a heavy deluge for a shorter period of time.
    - < 30 gallons per minute total flow rate will enable a system with a 5000 gallon water tank to run for at least 3 hours.
    - Low spray densities are all it takes to protect from firebrands (this is not the case with radiant heat, however).
- Have a dedicated water supply (tank) to run this system.
    - Often times municipal water will be shut off or pressure will be very low from high demands elsewhere due to the fire, and as such should not be counted on to effectively or reliably run a WEEDS sprinkler system.
    - Ideally the system should be gravity fed (tank sited well-uphill of home).

  - If unable to obtain pressurized water using gravity, then a pump will be required, powered by a dedicated off-grid power source. Grid electricity cannot be relied upon during a wildfire. A propane-powered generator fed via an underground line would be most ideal. Tank, generator, pump and pressure tank protection from radiant heat also needs to be taken into account to ensure function during the time of fire blow-over.

Additional helpful design features might include…

- Metal piping and sprinklers should be used if radiant heat is a risk (i.e. large stands of fuels are within 100' of the structure).
- Larger tanks (10,000 gallon) will increase the duration that the system can operate.
- Remote or automated triggering
  - DO NOT use heat activation - typical of indoor sprinklers. By this time windows may be too hot and shatter from thermal shock.

For a quick risk assessment for your home complete with with fire risk reduction action steps use the **UC Berkeley Home Fire Risk Assessment Checklist** (takes 2 minutes to complete).

After The Fire Blows Over

Once the fire front has passed through, hopefully with an intact and undamaged home, remember that the danger is still high! As soon as it is safe to venture outside it's time to start an ember watch while the fire is still burning closeby. Many times homes appear to survive the inferno only to be ignited several hours later by small embers that have slowly caught larger structures. Having pre-positioned trash cans filled with water and sacrificial towels or burlap sacks for this purpose can be helpful.

If you have a WEEDS fire sprinkler it should be left operating for several hours after the fire (hopefully it has been designed to have this capacity) to help ensure any remaining or new embers (backing winds can bring ember fall out back to previously burned areas) are either extinguished or unable to ignite any larger fuel source.

Evaluate and Adjust: What Can We Learn?

After the fire, once life and property are safe, it is valuable to reflect on the experience and the lessons learned from it. Our society currently has an unhealthy relationship with fire and its place in the natural world. Much needs to change regarding how we live our lives, plan our dwellings and make land management decisions if we are to learn to live in relative harmony with this ever present force of nature. Should you experience fire up close and personal, take some time to sift through the experience once the adrenaline has settled. Write your insights down. This will not only be valuable information for you and your kin, but should you decide to share it with a larger audience you can help erode the dominant paradigm that pits human settlement in a never-ending struggle with fire, and hopefully build a regenerative fire paradigm in its place that accepts fire as a part of living in this landscape and harmonizes with its inevitable occurrence.

PART 4: INTEGRATING FIRE INTO DAILY LIFE

What if we chose to view nature's gift of annually-replenishing fixed carbon sources (i.e. chaparral brush) in high-fire danger areas as an opportunity to harmonize with the annual carbon cycle instead of as a nuisance to be combatted?

Could we improve home safety in the urban-wildland edge and take steps towards living within our annual solar energy budget, while saving money and improving habitat and ecology?

Sounds like pie in the sky? Hang with me.

LET'S BURN WOOD AGAIN

The history of human civilization is littered with examples of human settlement denuding surrounding forests and creating barren wastelands, therefore we understand if the idea of burning wood is unnerving. However, the current state of the urban-wildland edge (devastating wildfires that seem to increase in severity with each passing year, endless treadmilling of mowing, brush-hogging, burning and weed-whacking which in itself starts many fires) tells us that we need to consider another way. Modern society's default position of declaring war on the urban-wildland edge simply cannot continue for that much longer, whether for reasons of rapidly shifting climate, government bankruptcy, soaring costs of living, chronic water shortages etc. *ad nauseum*. Therefore, we'd like to ask you to set aside any personal previously held beliefs, opinions or positions for the next few minutes. We're not trying to change anyone's mind here. Instead let's create a vision for what *could be* possible - and acknowledge it as just that.

Let's imagine...

Imagine that the millions of households that occupy space along the urban wildland edge are actively engaged with that edge, tending it so as to meet their own household needs while also reducing the potential for catastrophic wildfire.

What *could* this look like?

The dry, impenetrable and very flammable wall of chaparral that rings these houses today would be, instead of assaulted by gas powered machines several times a year and looking the part, tended judiciously by the residents, for the many dead branches and dry limbs that would otherwise accumulate and make excellent ladder fuels are actually gathered and utilized daily.

The forest understory is walkable and park-like, because it is being *used* by the people that live there. The canopy is higher, because individual plants have been tended to create an umbrella of living vegetation, increasing shade and moisture retention at ground level, while also providing protection for fragile hillside soil from the seasonally intense rains.

Sticks and small branches that have been gathered are used for heating water in rocket mass hot water heaters for bathing and washing clothes and dishes. They are used to fuel rocket cooktops every morning and evening when the family convenes for breakfast and dinner. They are burned in rocket mass heaters that store the heat in earthen benches situated for thermal solar gain during the winter while acting as passive cooling elements during the long, hot and dry summers.

People enjoy rocket-heated hot tubs fueled by the small caliber fuelwood gathered from the urban wildland edge around them. The giant outdoor grill stations typically found today next to a chlorinated pool have been replaced by rocket ovens, rocket cook tops, parillas and all manner of wood-burning cooking set ups.

For the big stuff, gone are the burnpiles of the past - now, various excess fuel woods are trimmed and sorted by size, then burned in cone pits, trenches, top-lit updraft gasifiers (TLUDs), and other setups designed to create charcoal from the abundant carbon sources. Once inoculated with beneficial microorganisms and fungi, this charcoal becomes biochar - known as black gold for gardeners - supercharging their gardens, and enabling them to grow more and better food from home using less water with each passing year. Biochar fetches a good price at local farmers markets. Industrious groups of kids might set up neighborhood charcoal stands, selling the charcoal made from the brush they helped clear from an elderly neighbor's property. Or, if they are budding gardeners themselves, they'll haul it home themselves for use in their home gardens.

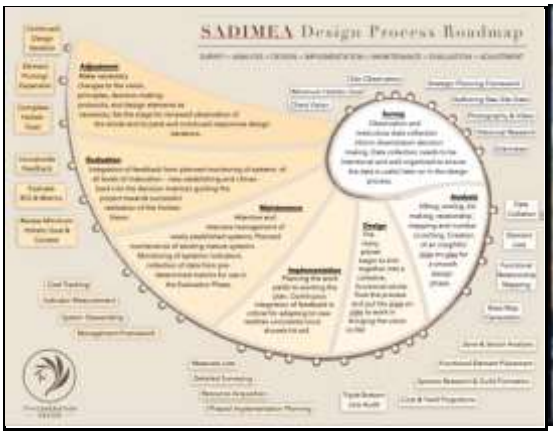
In this way, what today is an annual nuisance has become an annual blessing. The abundant fuel produced by the urban wildland edge creates less reliance upon grid-based sources of fuel and energy, increases the resilience and self-reliance of individual homes and neighborhoods, and helps to build water and nutrient-retentive soils that feed both people and creatures. The regular use of these fuels by the people that live on the urban-wildland edge actually increases the health of the environment. Catastrophic fire risk is reduced, habitat is expanded and soil is protected.

We have but to change our mindset to realize a future like this one. This possible future is one in which the needs of humans and human settlement are integrated with those of the surrounding ecology. By choosing to work with the natural rhythms of place, we can learn to stop *fighting* fire, and instead embrace this powerful energy as part of *daily life* in the urban wildland edge - and in so doing, solve many of the big, intractable problems that characterize our day.

About 7th Generation Design

We are Casey and Wes, and at 7th Generation Design we design, implement and steward regenerative landscapes to create a more prosperous future. We offer a range of services, from introductory walk and talks to project ready whole site design to aerial mapping to heavy equipment operation and supervision, to assist our clients in realizing their visions for their homes and properties. To learn more, please visit our website's About Us page.

You can also download our Design Process Roadmap - an illustrated version of our design and implementation process - as well as our brochure to share what 7th Gen is all about in a nutshell!



Have A Question For Us?

We're happy to help in whatever way we can! Drop us a line via our contact form on our website or by emailing us at info@7thgenerationdesign.com.

Remember To Check Out Our Free Toolkit!

We have compiled some very helpful tools and resources for landowners, ecological stewards, homesteaders and ranchers - all available for free! Visit our Toolkit page to dive in.

With Gratitude, Casey and Wes

7TH GENERATION DESIGN

Appendix A: An Incomplete List Of Fire-Resistant Plants for California Climates

Below is an in-progress list of plants that we've recommended or worked with. For an extensive list of California plants and their leaf burn times, see this Las Pilitas Nursery article.

Groundcover Plants

- Twin Peak Coyote Brush
- Prostrate Acacia
- Immigrant Forage Kochia

Shrubs And Trees

Evergreen

- Holly leafed Cherry (*Prunus ilicifolia*)
- Resprouting, broad-leaved evergreen trees like Oaks
- Catalina Cherry (*Prunus lyonii*)
- Catalina ironwood (*Lyonothamnus floribundus asplenifolius*)
- Ceanothus spp.
- Sugar Bush (*Rhus ovata*)
- Artemisia (some species)
- Coyote Brush *(Baccharis)*

Deciduous

- California Black Walnut (*Juglans nigra*)
- Sycamore (*Platanus racemosa*)
- White Alder (*Alnus rhombifolia*)

For Anchoring Hillsides (Roots > 15' Deep)

    - Scrub Oak (*Quercus berberidifolia*)
    - Laurel Sumac (has been mischaracterized due to its high oil content as a major fire risk - it is also one of the highest moisture content, lowest fuel accumulating and easy to maintain plants - they are very fire resistant when properly maintained).

- Manzanita (some species more fire resistant than others)
- Coyote Brush (*Baccharis pilularis)*